



Full Length Article

Morphological and Biochemical Markers for Varietal Characterization and Quality Assessment of Potential Indigenous Mango (*Mangifera indica*) Germplasm

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ABSTRACT

Production of quality mango is dilapidated in Pakistan due to infestation of pests, diseases, physiological disorders like mango sudden death syndrome (MSDS) and narrow genetic diversity. The objectives of study were to identify, characterize and recommend new mango scion cultivars to broaden the varietal spectrum, from enormous indigenous germplasm available in Punjab, which is at the verge of extinction due to spontaneous domestication. Data were gathered from three significant mango growing districts (Khanewal, Multan & Muzzaffargarh) of Punjab, Pakistan. The selected samples were described for various characteristics of tree (growth habit, shape), leaf (colour, size, shape & nature), inflorescence (shape, colour, size), fruit (skin, shape, size, weight, harvesting season, keeping quality), stone (fiber, body of stone) and pulp bio-chemical attributes (total soluble solids, titratable acidity). Of the 17 genotypes, only five (Kala Chaunsa, Sufaid Chaunsa, Late Ratole No. 12, Camal Wala & Faiz Kareem) showed distinctive fruit characters and market potential. The studies helped to develop suitable morphological and biochemical markers for improvement of mango germplasm to establish suitable varieties for domestic and export markets. © 2011 Friends Science Publishers

Key Words: Varietal identification; Indigenous germplasm; Conservation; Description

INTRODUCTION

The Mango (*Mangifera indica* L.), also known as king of fruits belongs to family Anacardiaceae, order Sapindales (Jha *et al.*, 2010). It is amongst the widely grown tropical and subtropical fruit of the world and its cultivation in Pakistan is very ancient, although no authentic historical records are available. The picturesque "Shalamar Garden" which dates back to the period of Shah Jahan (1641-42 A.D.), was planted with groves of mango (Khan & Ahmad, 1964). Pakistan produces 1.7 million tons of mango on an area of 151.5 thousand hectares and ranks 5th among the mango growing countries of the world (Maqbool & Malik, 2008). Consumption of tropical and sub tropical fruits have increased significantly in the world due to their nutritional and bioactive properties (Poovarodom *et al.*, 2010). It is a matter of concern for the mango industry of Pakistan that production of quality mango is not increasing at a level, needed to compete in the international market. One of the most important causes is the lack of genetic diversity, in addition to pests and diseases like mango sudden death syndrome (MSDS). Improvement in plant material can be

done by genetic mutation, selection of chance seedlings, hybridization, chromosome doubling etc., with in species or varieties (Mian & Nasir, 1989). However, in mango breeding, hand pollination is remarkably unrewarding, as success rate of three fruits per 1000 pollinations have been recorded (Mukherjee *et al.*, 1968). Therefore, none of the present commercial cultivars in Pakistan have evolved from controlled breeding (Iyer & Subramanyam, 1991; Khan *et al.*, 1995; Chaikiattiyos *et al.*, 2000; Asif *et al.*, 2002), although exceptions are there, like Mallika, Amrapalli, Ratna (Chadha & Pal, 2004) in India. One should recognize that all the germplasm available is useful one way or other (Knight, 1993). If it is lacking marketable value, then it may be suitable for some other purposes, like disease resistance, climatic adaptation, home gardening etc. (Campbell, 1995).

In Pakistan more than 260 mango varieties were reported to exist in 1965 (Ahmad *et al.*, 2007). However, with the passage of time due to demographical and industrial developments during the last three decades, agricultural lands have been urbanized unprecedentedly, causing relentless genetic erosion. Presently, only 10-15 old

cultivars (Anwar Ratole, Chaunsa, Dusehri, Fajri, Langra, Malda, Sindhri, Began Palli, Sunehra & Swarnarekha) are cultivated commercially (Amin & Hanif, 2002). There is a lengthy delay between the discovery of these existing ancient commercial mango cultivars of Pakistan (Ahmed, 2004) and current dynamic market needs as after their discovery, mango growers and breeders rested content, which left a rich unexplored field for future. Germplasm is a source of variation for new assortment and the time has come to conserve these precious genetic resources and to improve the yield and range of available varieties through collection of local indigenous germplasm.

Varietal characterization is an important component of mango improvement and breeding. It lays the foundation for further scientific progress in developing new cultivars. Since morphological and bio-chemical characterization of mango germplasm is difficult and lacks expertise in Pakistan, it has never been addressed properly, though mango remains the second most important fruit crop of Pakistan.

Punjab province contributes more than 65% of the total mango production in Pakistan mainly from Khanewal, Multan and Muzaffargarh districts (MinFAL, 2006). However, due to thermo-geographic advantage early mango fruit harvest comes from Sindh. Production from Punjab reaches in the market when harvest from Sindh is in last phases, causing severe glut resulting in decline in trade prices. Mango being climacteric (Lebrun *et al.*, 2008) ripe very quickly and need immediate marketing. The advantage of Sindh being early has created a desire and an opportunity to seek late maturing varieties in Punjab to avoid competition, look for late season advantage and higher prices (Mian & Nasir, 1989). Punjab, being the largest mango producer also has diverse genetic base compared to other provinces. The objectives of the study were to identify, characterize and recommend mango germplasm in three important mango growing districts of Punjab, to broaden the varietal spectrum and increasing the mango harvesting window, by selecting late maturing germplasm with good fruit characteristics to suit the dynamic market needs. Another goal was to select key morphological and biochemical markers in mango as future guidelines for varietal identification and breeding work.

MATERIALS AND METHODS

An explorative study was carried out in three mango growing districts (Khanewal, Multan & Muzaffargarh) of Punjab (Figs. 1 & 2). Of the germplasm surveyed, 17 varieties were selected due to potential characteristics for detailed studies (Table I). Data for tree characteristics were recorded at site, while leaves and fruit samples were taken to the Pomology Lab., Institute of Horticultural Sciences (IHS), University of Agriculture, Faisalabad, for further evaluation after ripening at ambient storage (30±2°C) conditions.

Physical studies: Data were gathered from flowering to

fruit harvest. For viable comparisons, 50 leaves, inflorescences and fruit of each cultivar were used for germplasm description. A special proforma was prepared to gather data as suggested by Singh (1968), with some modifications. Special remarks about the general cultivation of each germplasm were made and quality characteristics of fruit were also studied by consulting a panel of scientists.

Modified proforma: The general characteristics of mango varieties included their names, whether grafted or seedlings raised from seeds, locality, growth habit of tress and harvesting time i.e. early (1st June-15th July) mid (16th July-15th August) and late (16th August & onwards). Leaf characters of varieties recorded were: colour of newly emerged and mature leaves, size of mature leaves and other leaf characters e.g., shape, orientation, apex and nature. The inflorescence characters were shape, colour and size (length×breadth). Fruit characters included shape (ovate, oblong, round, elliptic), presence and absence of beak, fruit size, weight (small, 150-250 g; medium, 251-350 & large 351 & above), ripening time, shelflife (at room/ambient temperature), peel characters (colour, surface & adherence to pulp), pulp character (organoleptic analysis by a panel of judges for texture, colour, flavour, fiber & juice quality), stone shape (ovate, oblong, round, elliptic), stone weight, markings on stone (prominent, level, depressed), fiber on stone (scanty, much, abundant) and body (full, empty). General fruit quality characters recorded were: excellent, good, fair, ordinary or poor, while special remarks were recorded for recommendations regarding the potential suitability for general cultivation.

Bio-chemical studies: Longitudinal slices of fruit pulp were used to extract juice with the help of standard commercial juicer. The juice was extracted from each sample and homogenized to study the bio-chemical parameters.

Total soluble solids: A hand held refractometer (Atago, Japan) was used for the determination of total soluble solids (TSS). A drop of juice was placed on the prism of refractometer, the lid closed and TSS (°Brix) was noted directly from the scale at room temperature (30±2°C).

Titrateable acidity: Titrateable acidity (TA) was determined as stated by Hortwitz (1960). Ten mL fruit juice was taken from each sample in a beaker, diluted (1:4) with distilled water and titrated against N/10 NaOH solution after adding 2-3 drops of phenolphthalein (C₂₀H₁₄O₄) as indicator. The results were expressed as % citric acid. Calculations were made by the formula:

$$\text{Titrateable acidity (\%)} = \frac{\text{N/10 NaOH used} \times 0.0064 \times 100}{\text{Volume of sample used}}$$

Statistical analysis: Data were subjected to analysis of variance under one factor randomized complete block design using statistical soft ware MSTAT- C (Michigan State University, USA). LSD values at P>0.05 were obtained for comparison of mean values (Steel *et al.*, 1997).

RESULTS

The present study revealed that morphological and bio-chemical markers are useful tool for identifying assorted mango germplasm (Table III). This study also demonstrated that vernacular name given to the germplasm had association either with the locality of production, ('Basti Nao', a small village near Nawab Pur, Multan, 'Tube Well Wala', plant emerged as chance seedling near salinity reclamation project tube well in Multan) or the name/family name of the land owner ('Syal Wala', 'Makwal Wala', 'Joyan Wala', 'Faiz Kareem') where the chance seedling first emerged and or have some quality characteristics related to popular commercial cultivars ('Late Ratole No 12', 'Sufaid Chaunsa', 'Kala Chaunsa'). Table I and II refer to the list of selected experimental plant locations and their salient characteristics. New flush/leaf colour and fruit shape were identified as key distinguishing morphological and bio-chemical markers (Table III). The detailed phenotypic and bio-chemical descriptions are given below:

Sufaid Chaunsa: Grafted trees of 'Sufaid Chaunsa' are tall and spreading. Leaves were ovate lanceolate and wavy in nature. Leaf apex was acuminate and new leaves were light yellow, while mature leaves were bright green in colour. Inflorescence was pyramidal in shape with pale green colour. Fruit was large (580.1 g), ovate oblong in shape, basal sinus slight, ventral shoulder somewhat prominent and higher than the dorsal, sinus slightly marked with rounded prominent beak. Apex of fruit was obtuse, ground colour canary yellow with smooth surface and obscure small glands. Skin adhering to pulp, flavour mild, taste sweet with scanty juice and fiber. Medium sized stone was oblong, full and thick. Markings slight, fiber scanty and fine tuft was present on the ventral edge only. It was late maturing (September/October) variety with large fruit size but susceptible to wind. It had excellent fruit taste and 8-10 days keeping quality. In view of its characteristics it can be an excellent choice for domestic as well export markets.

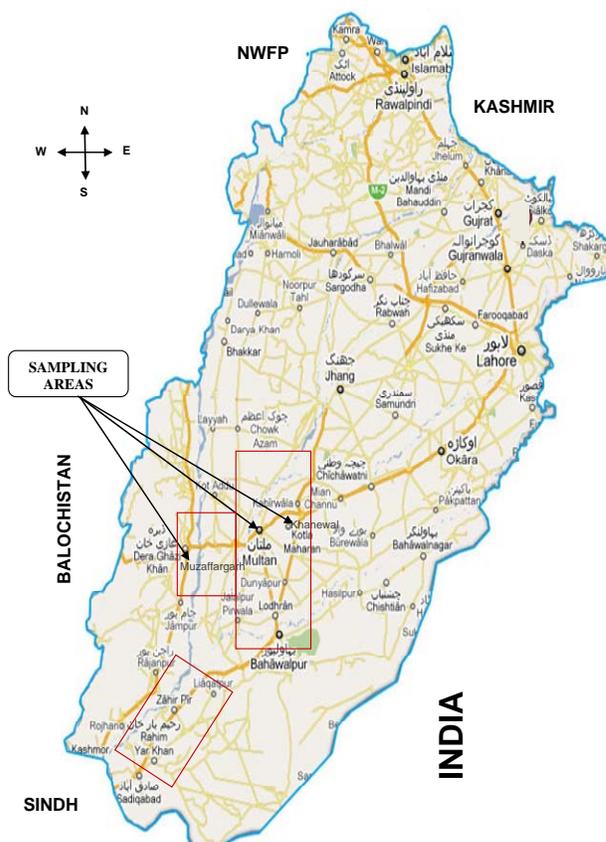
Late Ratole No. 12: Medium sized erect grafted tree with ovate lanceolate wavy leaves having acuminate apex. New leaves were dark green, while mature leaves were green in colour. Inflorescence was broadly pyramidal, yellowish green with crimson patches. Fruit was small in size (233.3 g), oblong in shape, basal sinus slightly depressed, ventral shoulder higher than dorsal, sinus not marked, beak prominent rounded with round apex. Fruit colour was lemon yellow with moderately smooth surface, gland prominent and small, skin thin, non-breakable and adhesive to pulp which was yellowish orange and fine in texture. Flavour pleasant, taste chilli milli sweet with scanty fiber and much juice. Stone was oblong, full and thick with slightly grooved markings. Fiber much all over, more on ventral side. Good fruit qualities (4-5 days keeping time), late maturity time (End Aug-Sept). It can be an excellent choice for domestic market due to its fairly good fruit characteristics, late harvesting time and prolific bearing qualities.

Fig. 1: Harvest calendar of some commercial and recommended mango cultivars in Pakistan

*= Newly recommended mango cultivars

MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
MALDA					
	DUSEHRI				
	SINDHRI				
	LANGRA				
	ANWAR RATOLE				
	S.B. CHAUNSA				
	FAIZ KAREEM*				
		FAJRI			
		RATOLE No.12*			
		CAMAL WALA*			
		KALA CHAUNSA*			
				SUFAID CHAUNSA*	

Fig. 2: Geographical location of mango production and sampling areas in Punjab, Pakistan. The areas highlighted by red rectangles indicate the mango production region of Punjab



Tube Well Wala: Grafted tree was of medium size and had a spreading canopy. Leaves were slightly folded, ovate-lanceolate with sub-acuminate apex. Emerging leaves were pinkish, which get dark green at maturity. Conical shaped inflorescence was of yellowish green colour. Medium sized (300.0 g), ovate shaped fruit had prominent sloping shoulders, acute beak, curved back, shallow basal sinus and rounded apex. Surface of fruit was smooth, yellowish

Table I: Characteristics of selected mango germplasm in Punjab, Pakistan

Germplasm Name	Locality	ALS (cm) (L×B)	APS (cm) (L×B)	AFS (cm) (L×B×T)	AFW* (g)	HS**	KQ (days)
Sufaid Chaunsa	Faiz Chaman Multan	18.1×6.1	38.8×22.5	14.2×9.8×8.9	580.1a	Late	8-10
Late Ratole No 12	Faiz Chaman Multan	14.7×4.3	26.1×40.8	9.8×6.8×6.2	233.3g	Late	4-5
Tube Well Wala	Hafeez Lychee Farm Multan	14.6×4.7	30.4×12.1	10.1×8.7×8.1	300.0e	Late	5-6
Chun Wala	Hafiz Kaleem Ullah Farm Muzaffargarh	14.2×4.1	32.7×26.5	9.9×6.4×5.6	200.0h	Late	3-4
Makwal Wala	Mian Arshad Farm Muzaffargarh	14.0×4.4	28.1×28.2	8.7×6.6×7.5	237.0g	Mid	2-3
Kala Chaunsa	Faiz Chaman Multan	14.1×4.8	30.4×12.3	12.1×7.0×7.0	350.0c	Late	2-3
Joyan Wala	Faiz Chaman Multan	13.2×4.1	32.3×10.4	9.7×6.7×6.2	260.5f	Late	3-4
Shahanshah	Khadim Farm Khanewal	15.1×4.0	38.5×12.6	8.6×6.5×7.1	237.3g	Late	5-6
Faiz Kareem	Faiz Chaman Multan	14.7×4.5	30.5×22.5	9.9×8.4×7.8	340.5c	Mid	4-5
Bubar Wala	Jamil Farm Khanewal	18.4×7.7	21.1×15.5	9.4×7.5×8.1	295.3e	Mid	3-4
Adil Wala	Khadim Farm Khanewal	14.4×4.0	38.3×60.1	9.9×8.0×7.9	320.3d	Early	4-5
Camal Wala	Khadim Farm Khanewal	14.1×4.0	39.9×20.2	12.6×6.7×5.9	295.4e	Late	5-6
Hafeez Pasand	Hafeez Lychee Farm Multan	15.7×5.5	42.2×23.3	10.4×7.3×7.4	287.0e	Mid	2-3
Gola	Mian Arshad Farm Muzaffargarh	16.3×4.9	46.4×33.3	9.6×7.5×7.3	251.4fg	Mid	3-4
Basti Nao	Hafeez Lychee Farm Multan	15.1×4.7	23.2×11.4	12.6×8.5×7.5	380.3b	Late	5-6
Allah Abadi	Mian Arshad Farm Muzaffargarh	16.0×4.4	37.3×37.5	8.8×7.0×6.7	244.3fg	Late	4-5
Syal Wala	Jamil Farm Khanewal	14.3×4.0	17.4×9.9	9.3×6.5×5.9	201.1h	Late	3-4

ALS= Average leaf size; APS= Average panicle size; AFS= Average fruit size; L×B= Length × Breadth; L×B×T= Length × Breadth × Thickness; AFW= Average fruit weight; HS**= Harvesting season (as mentioned in materials and method); KQ= Keeping quality; LSD= Least significant difference = 19.59 ($P \leq 0.05$); *= statistically significant; Any two means not sharing same letter differ significantly at 5% level of probability

orange in colour, with prominent glands. Thick peel adheres firmly to light yellow pulp of the fruit, which bear firm texture, sweet taste and juice in abundant quantity but had turpentine flavour. Fiber was scanty, only on the ventral edge of stone. Tube Well Wala was a late season variety, matured in September. Keeping quality was fairly good (5-6 days at room temperature). Juicy nature of fruit permitted its use in processing industry but turpentine flavour will be needed to remove during processing. However, it cannot be recommended for fresh consumption in local as well as export markets.

Chun Wala: Grafted tree was medium in size and spreading with ovate lanceolate flat leaves. Colour of new leaves was light red, while mature leaves were medium to dark green. Inflorescence was broadly pyramidal and pale yellow in colour. Small size (200.0 g) fruit was ovate oblong in shape, basal sinus absent, shoulders not prominent, back curved, sinus deep, beak acute with obtuse apex. Surface of peel was smooth and dark yellow with many glands. Peel was adherent to pulp, which was light yellow in colour, turpentine flavour, acidic to sweat taste, much juice and fiber. Stone was oblong, full and thick with fine fiber all around. Late harvesting season (September) with average keeping qualities (3-4 days). Ordinary fruit qualities, abundant fiber and poor taste rendered it unsuitable for commercial as well as home gardening.

Makwal Wala: Medium sized grafted spreading tree with elliptic lanceolate flat leaf. Emerging leaves were light yellow, while mature leaves were dark green. Pyramidal inflorescence was bright brown in colour. Fruit was small (237.0 g) round ovate, basal sinus shallow, ventral shoulder higher than dorsal, back curved, sinus slightly depressed, beak as well as apex rounded. Peel colour yellow with orange tinge, surface smooth, numerous small glands. Peel thick and adhered to pulp, which was light yellow with soft texture, slight flavour, sub acidic taste, medium juice and

absent fiber. Stone was oblong full and thick with veins on the level surface, fiber fine and scanty. Small and ordinary quality fruit with mid harvesting time and poor keeping quality (2-3 days) made it unsuitable for commercial cultivation.

Kala Chaunsa: Grafted tree of Kala Chaunsa was tall and spreading. Leaves were ovate-lanceolate and wavy. Colour of new leaves was dark red while mature leaves were dark green. Inflorescence was conical in shape, light brown in colour with off-white tinge. Fruits were medium sized (350.0 g) oblong with sloping shoulders, ventral shoulder slightly higher than dorsal one. Back of fruit was curved and sinus was absent (point only). Colour of skin was orange yellow, surface was smooth. Glands obscure, peel medium thick adhering to the flesh. Pulp was of yellow colour, with soft texture. Fruit taste very sweet, with abundant juice and delightful aroma. Long fine fibers were abundantly found in the flesh of fruit. Stone was long thin, without prominent veins. Fruits were generally of good quality but with very short shelf life i.e., 2-3 days. Late harvesting time (August to September), fairly good fruit size, resistance against wind damage, moderately regular bearing and heavy yielding qualities showed its potential to be used for commercial plantations.

Joyan Wala: Grafted trees were compact medium sized with elliptic lanceolate wavy leaves. Apex acute with reddish emerging leaves, while dark green mature leaves. Inflorescence conical in shape and pinkish yellow in color. Medium sized (260.5 g) oblong ovate fruit with basal sinus absent, shoulders level, back slightly curved, beak prominent, apex rounded and acute. Peel smooth with greenish dark yellow colour, gland obscure. Pulp light yellow, texture fine, flavour mild, taste sweet with much juice and fine little fiber. Stone was small with thin body and non-prominent veins. Fiber on the ventral side of the stone only. Fairly good harvesting time (October), and

keeping quality (3-4 days) however, it was shy bearer with small fruit (Table I). Not suitable for commercial plantation, but recommended for home gardening due to less tree growth and small size.

Shahanshah: Medium sized compact grafted tree was having flat and ovate lanceolate leaves. New leaves were yellow, while mature leaves were dark green in colour. Inflorescence was conical with light green colour. Fruit was small (237.3 g) ovate, basal sinus was shallow, shoulders sloping, ventral shoulder was higher than dorsal, sinus absent, back curved, beak absent, apex rounded with golden yellow peel colour and small sparse glands. Peel adhesive to pulp which was yellow with firm texture, turpentine flavour, sweet taste, moderate juice and scanty fiber. Stone was oblong, full and thin with grooved veins and fiber on the ventral edge only. Late harvesting time (September) and good keeping quality (5-6 days). Small fruit size and turpentine flavour made it unsuitable for commercial plantation.

Faiz Kareem: It was a new hybrid variety (Anwar Ratole x Chaunsa) developed by Malik Abdul Qadir Rajwana at his own farm Faiz Chaman, Multan. Grafted trees of Faiz Kareem were spreading and medium in size with elliptical lanceolate and wavy leaves and sub-acuminate apex. Emerging leaves were light yellow, while mature ones were light green in colour. Inflorescence was semi circular and spreading with crimson colour. Medium sized (340.5 g) fruit was round ovate, basal sinus shallow, ventral shoulder higher than dorsal, back curved, sinus not marked and non prominent, beak round. Peel colour, bright yellow with smooth surface, occasionally having small sunken irregular brown lenticels. Peel was thin and unbreakable adhesive to pulp, which was light yellow in colour, with firm and fine melting texture, aromatic flavour, sweet, juicy and little fiber. Stone was small, elliptical and full with no fiber and non prominent veins. Good keeping quality (4-5 days), mid to late maturity time (August), very small stone, delightful aroma and taste made it good candidate for commercial plantation, however, for export, less than 10% of the fruits/tree developed black sunken spots on fruit peel that needed to be investigated thoroughly.

Bubar Wala: Medium sized, spreading grafted tree with flat, ovate lanceolate acute apexed leaves. New flushes were pink, while mature leaves were light green. Pyramidal inflorescence with yellowish green color. Fruit medium (295.6 g), irregular, basal sinus depressed, shoulders level, back curved sinus absent with no beak and round apex. Thick creamy peel with light greenish tinge, lenticels little and small. Pulp light yellow, soft, odd flavour, sweet and juicy. Fiber short and coarse. Stone small, oblong with thick body and full. Veins slightly depressed fiber abundant, present all over the body, beak raised. Irregular and rough fruit with mid season (Aug.) harvesting time and keeping quality of 3-4 days. Not suitable for commercial plantation.

Adil Wala: Grafted trees were medium in size with a compact canopy. Ovate lanceolate leaves were wavy with

Table II: Biochemical and quality characteristics of mango germplasm after storage at ambient temperature (30±2°C)

Germplasm Name	TSS* (°brix)	Acidity* (%)	Flavor/taste	General quality
Sufaid Chaunsa	26a	0.31g	Mild/Sweet	Excellent
Late Ratole No 12	25b	0.38b	Chilli Milli/Sweet	Excellent
Tube Well Wala	22e	0.29h	Turpentine/Sweet	Ordinary
Chun Wala	22e	0.32f	Turpentine/Sweet	Ordinary
Makwal Wala	20f	0.35d	Slight/Acidic	Ordinary
Kala Chaunsa	26a	0.27i	Delightful/V. Sweet	Excellent
Joyan wala	24c	0.38b	Mild/Sweet	Ordinary
Shahanshah	23d	0.29h	Turpentine/Sweet	Ordinary
Faiz Kareem	26a	0.35d	Aromatic/Sweet	Good
Bubar Wala	20f	0.32f	Odd/Sweet	Ordinary
Adil Wala	22e	0.29h	Pleasant/Sweet	Fair
Camal Wala	20f	0.29h	Mild/Mild	Good
Hafeez Pasand	25b	0.39a	Mild/Sweet	Ordinary
Gola	22e	0.36c	Turpentine/Acidic	Poor
Basti Nao	24c	0.29h	Pleasant/Sweet	Ordinary
Allah Abadi	22e	0.39a	Mild/Sweet	Ordinary
Syal Wala	23c	0.33e	Mild/Sweet	Ordinary
LSD	0.89	0.01		

LSD= Least significant difference ($P \leq 0.05$); *= Statistically significant; Any two means not sharing same letter differ significantly at 5% level of probability

Table III: Key morphological and biochemical markers for varietal identification and quality assessment of indigenous mango germplasm in Punjab, Pakistan

Germplasm Name	New leaf color	Fruit shape	TSS/acidity ratio*
Sufaid Chaunsa	Light Yellow	Ovate oblong	83.87b
Late Ratole No 12	Dark green	Oblongish	65.79fg
Tube Well Wala	Pinkish	Ovate	75.86cd
Chun Wala	Light red	Ovate oblong	68.75ef
Makwal Wala	Light yellow	Round ovate	57.14h
Kala Chaunsa	Dark red	Oblong	96.30a
Joyan Wala	Reddish	Oblong ovate	63.16g
Shahanshah	Yellow	Ovate	79.31bc
Faiz Kareem	Light yellow	Round ovate	74.29d
Bubar Wala	Pink	Irregular	62.50g
Adil Wala	Light yellow	Ovate	75.86cd
Camal Wala	Light brown	Long elliptic	68.97ef
Hafeez Pasand	Yellow	Ovate	64.10fg
Gola	Pink	Ovate	61.11gh
Basti Nao	Light yellow	Oblanceolate	82.76b
Allah Abadi	Light pink	Ovate	56.41h
Syal Wala	Yellow	Oblong	69.70de

acuminate apex. New flush had light yellow colour leaves, which on maturity, attained pure green colour. Crimson green inflorescence had a spreading nature. Medium sized (320.3 g), ovate shaped fruit had slopping shoulders. Back of fruit was curved, with very slight basal sinus and was slightly pointed, sinus absent with obtuse apex. Ground colour of fruit was bright orange with red blush on the shoulders. Surface of fruit was smooth and had scanty glands. Peel was thin, unbreakable and adhesive to bright orange colour pulp. Fruit taste sweet, with pleasant flavour and contained much quantity of juice with very small ratio of fine fibers. Fruit can be harvested from end of June to

July. Keeping quality of fruit is good (4-5 days). Medium sized fruit may be utilized for home gardening only.

Camal Wala: Small sized drooping grafted tree with elliptic lanceolate wavy and acuminate leaves. New leaves were light brown, mature leaves were medium to dark green. Inflorescence pyramidal with crimson colour. Fruit, medium (295.4 g) in size, long and elliptical in shape. Basal sinus absent, shoulders non prominent, back slightly curved, sinus deep, beak acute, apex rounded. Peel colour yellow, thick with pink blush starting from the shoulders, surface smooth, glands medium, strongly adhered to pulp. Colour of pulp is light orange, firm, mild flavour and sweetness with scanty juice and fiber. Stone long elliptical, full and thick with scanty fiber. Medium fruit size, 5-6 days keeping quality, late season harvesting time (Late Aug.) as well as beautiful red blush with mild TSS/Acid ratio (69.0) made it suitable candidate for sugar conscious consumers and was recommended for commercial cultivation under high density plantation scheme.

Hafeez Pasand: Tall and spreading grafted tree with oval lanceolate, wavy and acute apexed leaves. New leaves were yellow, while mature were light green in colour. Inflorescence spreading and crimson. Fruit medium (287.0 g) ovate, basal sinus slightly depressed, shoulders sloping, beak non prominent, apex obtuse. Peel thin, adhering to pulp, yellow with mild pinkish tinge, smooth surface and numerous glands. Pulp light yellow, soft textured, mild flavour, sweet, juicy with scanty fiber. Stone oblong body full and thick, veins slightly raised with fiber on the ventral edge only. It was probably a chance seedling of Chaunsa and was a mid season variety (Early Aug.), with medium fruit size and poor keeping quality (2-3 days). Panel of experts did not recommend it for commercial plantation.

Gola: Small compact seedling tree. Leaves were ovate lanceolate wavy with acute apex. New leaves were pink, while mature leaves were light green in colour. Inflorescence, pyramidal and yellowish brown. Fruit medium (251.4 g), ovate, basal sinus shallow, ventral shoulder slightly prominent than dorsal, back curved, sinus absent flat, beak acute while apex rounded. Peel greenish yellow at ripening, texture soft, flavour turpentine, sub acidic taste, juice scanty while fiber much, coarse and short. Stone ovate, full, thick, veins slightly depressed with fiber on ventral edge only. Matured in mid August with average keeping quality (3-4 days) and possessed very small fruit size and poor fruit qualities. Not recommended for any type of commercial plantation.

Basti Nao: It is a medium sized, seedling tree with spreading growth habit. Leaves were ovate lanceolate with acuminate apex wavy in nature. New leaves were light yellow, while mature leaves were medium to dark green. Pale yellow coloured inflorescence was conical in shape. Medium to large sized (380.3 g) fruit were oblanceolate in shape, with deep basal sinus and prominent shoulders, ventral shoulder higher than the dorsal one. Apex of the fruit was acute with minute sinus and beak. Glands were scanty.

Thick, breakable peel was adhesive to off white, crisp textured pulp. Fruit was juicy, pleasantly flavoured, and sweet in taste, with scarce fibers. Stone thick with fibers on the ventral shoulders only. Medium to large fruit size which was very juicy in nature. Harvesting season was late (September) and fruit has shelf-life of 5-6 days, so it can be recommended for home gardening as well as for processing industry.

Allah Abadi: Grafted trees were medium sized, spreading with ovate lanceolate flat leaves having acuminate apex. Emerging leaves were light pink, while mature leaves were dark green. Inflorescence, broadly pyramidal and yellowish green. Fruit small (244.3 g), ovate, basal sinus slight, ventral shoulder higher than dorsal, back curved, beak not prominent, sinus unmarked with round apex. Peel thick, adherent to pulp, greenish yellow, smooth with obscure glands. Pulp light yellow, mildly flavoured, sweet, juicy, fiber much, coarse and short. Stone oblong, body full and thick with level surface. Fiber much and all around. Small fruit size with ordinary fruit and tree characteristics however, possess fairly good keeping quality (4-5 days), yet not recommended for commercial cultivation.

Syal Wala: Grafted trees were medium sized, with spreading habit of growth. Leaves elliptic lanceolate, twisted, apex obtuse, new leaves yellow, while mature leaves were light green in colour. Inflorescence pyramidal, light brown with yellow tinge. Fruit small (201.1 g), oblong, basal sinus absent, shoulders level, back curved, sinus slight, beak rounded, apex round. Peel thin, adhering to pulp, light green with yellow blush. Pulp light orange, mild texture and flavour, taste sweet juicy with little and fine fibers. Stone oblong with tapered basal end, body full and thin, veins prominently raised, fiber much found on the ventral edge. Late harvesting variety (Aug. - Sept.), ordinary fruit and tree characteristics however, possess fairly good keeping quality (3-4 days), yet not recommended for commercial cultivation due to very small fruit size.

DISCUSSION

Most of the germplasm studied possess spreading/compact/erect growing habit except Camal Wala, which had drooping tree shape. Differences in leaf shape and size were also observed, however, common leaf shape was lanceolate with some variability to ovate lanceolate to oval or elliptic lanceolate. Ibrahim (1952) observed variations in mango leaf shape as well as size and considered them a good basis for varietal differentiation. Shape of inflorescence varied from pyramidal (Sufaid Chaunsa) to broadly pyramidal (Late Ratole no 12) conical (Kala Chaunsa), semi circular for Faiz Kareem and spreading for Hafeez Pasand. In another study, Hartless (1913) used the floral characters in classifying mango varieties for the first time with special emphasis on the length and shape of inflorescence. Unquestionably, fruit is the most important classification and portrayal character. In

this study fruit shape and size differed from variety to variety and varied from ovate (Shahanshah) to ovate oblong (Sufaid Chaunsa), round ovate (Faiz Kareem), oblong lanceolate (Kala Chaunsa) and elliptical (Camal Wala). Irregular round shape was also observed in Bubar Wala.

Higher average fruit weight was observed in Sufaid Chaunsa (580.1 g) followed by Basti Nao (380.3 g) and Kala Chaunsa (350.0 g), while lowest in Chun Wala (200.0 g) followed by Syal Wala (201.1 g) and Late Ratole No. 12 (233.3 g). Four germplasm (Tube Well Wala, Chun Wala, Camal Wala & Gola) had acute beak, while in others beak was absent or slightly prominent (Sufaid Chaunsa, Late Ratole No. 12 & Joyan Wala). All the varieties/germplasm studied had mid to late harvesting time (for Punjab province) except Adil Wala, which is an early variety (Table I). Fruit colour is the most appealing character for commercial acceptance of a variety. Jintanawong *et al.* (1992) determined the quality standards for Thai mango by observing the fruit size, shape colour, weight, flavour, texture and fiber. In the present studies the selected germplasm expressed yellow to orange skin colour except Camal Wala that had pink blush on the shoulders.

Highest TSS/Acidity ratio was recorded in Kala Chaunsa (96.3) followed by Sufaid Chaunsa (83.9) and Basti Nao (82.7), whereas lowest ratio was observed in Allah Abadi (56.4). Haryati *et al.* (1993) stated that the appropriate harvesting time of mango cultivar 'Malam' for fresh consumption was 81 days after fruit set. At that stage of maturity, mango flesh indicated TSS of 5.9 °brix, 1.5% titratable acidity and TSS/Acidity ratio of 3.8. At ambient conditions, picked fruit showed normal ripening after 8-9 days of storage and showed bright orange flesh colour, sweet taste (15 °brix of TSS) and less (0.29%) acidity with TSS/Acidity ratio of 52.4. The present study also revealed some germplasm with good shelf life but low fruit quality characters due to turpentine flavour [Tube Well Wala, Chun Wala, Makwal Wala (poor shelf life of 2-3 days), Shahanshah, Bubar Wala and Gola]. They may still be selected for breeding purpose to utilize other enviable attributes (Campbell, 1995).

Sufaid Chaunsa, Kala Chaunsa, Late Ratole No. 12, Camal Wala and Faiz Kareem expressed great promise for commercial acceptability due to their attractive fruit colour, fruit size, bearing ability and shelflife. Al-Edany *et al.* (1991) in an evaluation study on mango seedlings in Basrah selected only five trees out of 43 after assessment for fruit weight, pulp to fruit ratio, fruit length, fruit diameter, ripening time and general qualities. Fruit firmness is the most widely used marker of fruit quality (Jha *et al.*, 2010). Fruit of Sufaid Chaunsa was large in size, firm at ripe stage, possessed good shelf life and matured in September to mid October, while Kala Chaunsa, Camal Wala and Late Ratole are prolific bearer having late maturity time. Faiz Kareem was a promising new hybrid cultivar (Rajwana *et al.*, 2008) having good fruit size and excellent taste as well as keeping quality (Table I). These germplasm may be utilized as

commercial cultivars for new mango orchard plantation or in breeding programs so that their beneficial characteristics can be exploited.

In conclusion, changes in land use (domestication/urbanization) over many decades have adversely affected the indigenous mango germplasm resources; however, large amount of potential genetic material is still waiting for its recognition, exploitation and preservation, in various mango growing pockets of Pakistan. Key morphological and biochemical markers noted in this study can be used for varietal identification and future breeding programs. Mango harvesting window in Punjab can be expanded by planting the selected late maturing and promising mango varieties like Sufaid Chaunsa, Kala Chaunsa, Late Ratole No 12, Camal Wala and new hybrid Faiz Kareem.

REFERENCES

- Ahmad I., A.U. Malik, M. Amin and R. Anwar, 2007. Comparative studies on the performance to two commercial mango cultivars under ambient ripening conditions. *Life Sci. Int. J.*, 4: 463–467
- Ahmed, S., 2004. *Mangoes in Pakistan*. Horticultural Foundation of Pakistan, Islamabad, Pakistan
- Al-Edany, T.Y., A.K. Athman and A.O. Ibrahim, 1991. Evaluation studies on fruits of mango seedling trees in Basrah. *Basrah J. Agric. Sci.*, 4: 33–42
- Amin, M. and M. Hanif, 2002. *Cultivation of Mango in Dera Ismail Khan*, pp: 1–18. Agricultural Research Institute, Ratta, D.I. Khan, Pakistan
- Asif, M., M. Usman, M.J. Jaskani and M.M. Khan, 2002. Comparative study of flower sex ratio in different cultivars of mango (*Mangifera indica* L.). *Int. J. Agric. Biol.*, 4: 220–222
- Campbell, C.W., 1995. Mangoes in the United States: A yearlong supply. *Proc. Florida State Hort. Soc.*, 107: 303–334
- Chadha, K.L. and R.N. Pal, 2004. Mango culture far and near. In: Ahmad, S. (ed.), *Mangoes in Pakistan*, pp: 150–162. The Horticultural Foundation of Pakistan, Islamabad
- Chaikiattiyos, S., R. Kurubunjerdjit, P. Akkaravessapong, S. Rattananukul, P. Chueychum and P. Anupunt, 2000. Improvement and evaluation of the selected 'Kaew Sisaket' mango in Thailand. *Acta Hort.*, 509: 185–192
- Hartless, A.C., 1913. The flowering of mango. *Agric. J. India*, 8: 9
- Haryati, T., Purwati, H.S. Soemarno, S.D. Sabri and Sunarmani, 1991. Quality evaluation of mango fruit cv. Malan of Yogyakarta at several stages of maturity. *J. Hort. Indonesia*, 1: 57–60
- Hortwitz, W., 1960. *Official and Tentative Methods of Analysis*, 9th edition, pp: 320–341. Association of the Official Agriculture Chemist. Washington, DC
- Ibrahim, M., 1952. A study of the distinguishing characters of Punjab Mangoes. *M.Sc. Thesis*, University of Agriculture, Faisalabad, Pakistan
- Iyer, C.P.A. and M.D. Subramanyam, 1991. Breeding mangoes for developing new varieties. *Acta Hort.*, 91: 151–173
- Jha, S.K., S. Sethi, M. Srivastav, A.K. Dubey, R.R. Sharma, D.V.K. Samuel and A.K. Singh, 2010. Firmness characteristics of mango hybrid under ambient storage. *J. Food Eng.*, 97: 208–212
- Jintanawong, S., H. Hiranpradit and S. Chandraparnik, 1992. Quality standardization of mango (*Mangifera indica* L.). *Acta Hort.*, 321: 705–707
- Khan, M.D. and R. Ahmad, 1964. *Mango Growing in West Pakistan*. Department of Agriculture Government of West Pakistan, Tec. Bull. No 22
- Khan, I.A., M.J. Jaskani and S.N.H. Ali, 1995. *Mango Orchard Survey and Research Prospects*, p: 73. National co-ordinated research project on mango crisis. Pakistan Agriculture Research Council, Islamabad. Pakistan

- Knight, R.J., 1993. Evaluating important fruit characters in mango germplasm. *Fruit Var. J.*, 47: 25–31
- Lebrun, M., A. Plotto, K. Goodner, M.N. Ducamp and E. Baldwin, 2008. Discrimination of mango fruit maturity by volatiles using the electronic nose and gas chromatography. *Postharv. Biol. Technol.*, 48: 122–131
- Maqbool, M. and A.U. Malik, 2008. Anti-sap chemicals reduce sapburn injury and improve fruit quality in commercial mango cultivars. *Int. J. Agric. Biol.*, 10: 1–8
- Mian, I.H. and M.A. Nasir, 1989. New Sammar Bahisht Strains of mango. *The Punjab Fruit J.*, 41: 50–51
- MinFAL, 2006. *Fruit and Vegetable Statistics of Pakistan*. Food and Agricultural Division, Ministry of Food Agriculture and Livestock, Islamabad, Pakistan
- Mukherjee, S.K., R.N. Singh, P.K. Majumder and D.K. Sharma, 1968. Present position regarding breeding of mango in India. *Euphytica*, 17: 462–4677
- Poovarodom, S., R. Haruenkit, S. Vearasilp, J. Namiesnik, M. Cvikrová, O. Martinincová, A. Ezra, M. Suhaj, P. Ruamsuke and S. Gorinstein, 2010. Comparative characterization of durian, mango and avocado. *Food Sci. Technol.*, 45: 921–929
- Rajwana, I.A., N. Tabassam, A.U. Malik, S.A. Malik, M. Rehman and Y. Zafar, 2008. Assessment of genetic diversity among mango *Mangifera indica* (L.) cultivars using DNA markers. *Sci. Hortic.*, 117: 297–301
- Singh, L.B., 1968. *The Mango*. Leonardo Hill, London
- Steel, R.G.D., J.H. Torrie and D.A. Dicky, 1997. *Principles and Procedures of Statistics: A Biometrical Approach*, 3rd edition, pp: 352–358 McGraw Hill Book Co. Inc., New York

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