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MORPHO-PHYSICAL CHARACTERISTICS OF EIGHT LOQUAT GENOTYPES CULTIVATED IN CHAKWAL DISTRICT, PAKISTAN

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Abstract

Loquat (*Eriobotrya japonica* Lindl.) originated in china and spread to other countries including Pakistan where it is grown in NWFP and northern parts of the Punjab province. In Punjab, Kalar Kahar and Choa Saiden Shah are two famous loquat growing places in district Chakwal. Present work is a part of the first ever study conducted on loquat in Pakistan. Eight genotypes of loquat were selected and comparison was made on the basis of various morpho-physical characteristics which include fruit length, fruit width, width/length index, fruit weight, flesh seed ratio, number of fruits per bunch, fruit yield per plant, days from full bloom to maturity. Number of seeds per fruit, single seed weight, total seed weight per fruit, leaf length, leaf width, leaf area, number of flowers per panicle, panicle size, and days from flowering to full bloom were also observed. Statistical analysis of the data was performed to have a clear picture of comparison among the genotypes. Fruit skin colour ranged from yellowish white to orange yellow. Yellowish white pulp colour was noted in KK4, CS1 and CS3, whereas other five genotypes had orange pulp. Fruit shape of the genotypes was round or obovoid. Tree habit ranged from upright to spreading. Fruit weight ranged from 10.03 g in KK3 to 21.37 g in CS2. Lowest yield per tree (30.75 kg) was recorded in KK5, while KK2 had the highest yield per tree (49.03 kg).

Introduction

Loquat (*Eriobotrya japonica* Lindl.) is a sub-tropical evergreen fruit tree which originated in China. Presently it is being cultivated in China, Japan, India, Pakistan, Madagascar, Mauritius Island, Mediterranean countries, United States, Brazil and Australia (Hussain *et al*., 2007). In Pakistan, its production is 10,688 tonnes, 98 % of which comes from Punjab and NWFP (Anon., 2008).

Loquat fruit develops during winter and ripens at early spring. Due to its unusual phenology, it is available in the market before any other fruit of the spring season (Cuevas *et al*., 2007). As it is the first fruit of the year, it is very popular and gives good returns (Khan, 2003). Besides being sweet and juicy, it is very nutritious. According to Karadeniz (2003), it contains vitamins (A, B, and C), minerals (phosphorus and calcium) and sugars.Fruit and leaves of loquat have been considered to have high medicinal value (Wee & Hsuan, 1992). Loquat leaves are used to treat skin diseases and to relieve pain and coughing (Sakuramata *et al*., 2004). Loquat seed extract has an inhibitory effect on liver disorders (Hamada *et al*., 2004).

In Pakistan, Kalar Kahar and Choa Saiden Shah are the two main loquat growing places in Chakwal district and are famous for loquat production. Kalar Kahar is a historical place of district Chakwal in the Punjab province and is situated on the main Motorway of the country (Section-M2) having an interchange link and service area. Here, the famous '*Takht e Babari*' (Throne of Babar) is situated in the form of a carved flat rock amid the loquat orchards, where the founder of Mughal Empire, Zaheer-ud-Din Babar used to address his army during the early 16th century. He established the Royal Garden at Kalar Kahar. The other main loquat growing place, Choa Saiden Shah is about 22 km east of Kalar Kahar. Presently, a number of small and big orchards of loquat are

scattered in this area, but there is no record of the cultivars as most of the plants have originated from seeds as a result of open pollination (Hussain *et al*., 2009). No work has ever been reported regarding the description of loquat genotypes originated in Pakistan. Detailed study of these loquat genotypes may provide a base for the proper identification and preservation of the local germplasm, which would be helpful in the establishment of orchards with uniform loquat plants of known cultivars.

Materials and Methods

A survey of district Chakwal was conducted and 5 genotypes of loquat were identified at Kalar Kahar in a private orchard while 3 genotypes at Choa Saiden Shah in the orchard of the district government. Different codes (KK1, KK2, KK3, KK4, KK5, CS1, CS2 and CS3) were assigned to these eight genotypes. Bearing plants of these genotypes with almost same size and apparently good health were tagged to study their characteristics. The experiment was laid out separately at both the locations in Randomized Complete Block Design (RCBD) with three replications, each replication having one tree per genotype.

Morphological characteristics of genotypes included tree growth habit, shape of leaf tip, shape of panicle, shape and colour of fruits and seeds. Physical parameters included length of fruit, width of fruit, width/length index, fruit weight, flesh to seed ratio, number of fruits per bunch, fruit yield per plant, days taken from full bloom to maturity. Furthermore, number of seeds per fruit, weight of single seed and total seed weight per fruit were recorded. Fruit characteristics were recorded at mature stage. When the greenness of the fruits disappeared completely, it was considered as the mature stage (Badenes *et al*., 2000). Moreover, leaf characteristics (leaf length, leaf width, leaf area) and floral characteristics (number of flowers per panicle, panicle size and days from flowering to full bloom) were recorded.

Statistical analysis was carried out using MSTATC package (MSTATC, 1999) and the means were compared by Duncan's Multiple Range test at 5% level of significance (Gomez & Gomez, 1984).

Results and Discussion

General morphology: Tree habit was upright in KK1, spreading in CS1, CS2 and CS3, while semi upright in the remaining genotypes. Blunt acute shape of leaf tip was observed in KK2, KK3 and KK4, whereas it was sharp acute in all other genotypes. Shape of panicle in all the genotypes was same i.e., conical (Table 1). In Spain, loquat varieties, 'Cardona' and 'Italiano-1' have been reported to have an upright and semi upright tree habit respectively, while shape of panicle in both the varieties was conical (Llacer *et al*., 2003).

Fruit and seed morphology: Fruit skin colour was yellowish white in KK5, yellow in KK4, while orange yellow in the remaining genotypes. Yellowish white pulp colour was noted in KK4, CS1 and CS3, whereas other five genotypes had orange pulp. Overall fruit shape was round in KK3 and KK5, while oblong in KK2 and CS3. Other four genotypes had obovoid fruit. Fruit shape at the basal end in all the genotypes was obtuse except in KK4 which was round. Fruit shape at the apex was flat in KK1 and CS3, depressed in KK4, while raised in all other genotypes. Brown seed colour was observed only in KK1 and CS3. On the other hand, all other genotypes had light brown seed colour. Seed shape in all the genotypes was elliptic (Table 2).

Table 1. General appearance of the loquat plants of 5 genotypes at Kalar Kahar.

Genotypes	Tree habit	Shape of leaf tip	Shape of panicle
KK1	Upright	Sharp acute	Conical
KK2	Semi upright	Blunt acute	Conical
KK3	Semi upright	Blunt acute	Conical
KK4	Semi upright	Blunt acute	Conical
KK5	Semi upright	Sharp acute	Conical
CS1	Spreading	Sharp acute	Conical
CS2	Spreading	Sharp acute	Conical
CS3	Spreading	Sharp acute	Conical

Table 2. Fruit and seed morphology of 5 loquat genotypes at Kalar Kahar.

Genotypes	Skin colour	Pulp colour	Fruit shape	Fruit shape at the basal end	Fruit shape at the apex	Seed colour	Seed shape
KK1	Orange yellow	Orange	Obovoid	Obtuse	Flat	Brown	Elliptic
KK2	Orange yellow	Orange	Oblong	Obtuse	Raised	Light brown	Elliptic
KK3	Orange yellow	Orange	Round	Obtuse	Raised	Light brown	Elliptic
KK4	Yellow	Yellowish white	Obovoid	Round	Depressed	Light brown	Elliptic
KK5	Yellowish white	Orange	Round	Obtuse	Raised	Light brown	Elliptic
CS1	Orange yellow	Yellowish white	Obovoid	Obtuse	Raised	Light brown	Elliptic
CS2	Orange yellow	Orange	Obovoid	Obtuse	Raised	Light brown	Elliptic
CS3	Orange yellow	Yellowish white	Oblong	Obtuse	Flat	Brown	Elliptic

In China, orange yellow skin and flesh colour has also been reported in Yangmeizhou 4 (Wu, 2001), while orange skin and pulp colour has been observed in Kumquat loquat and Sour loquat (Huang *et al*., 2007). Ninghaibai has a yellowish white skin while the flesh colour is white with a long round or round fruit shape (Feng *et al*., 2004). In Spain, Magdal and Cardona cultivars have fruits with obovoid and oblong shape respectively, while shape of seeds in both the cultivars was reported to be elliptic (Llacer *et al*., 2003).

Fruit characteristics

Kalar Kahar: Fruit characteristics of the genotypes are given in Table 3a. KK2 was at the top with reference to fruit length (3.45 cm), fruit width (3.15 cm), fruit weight (17.29 g), flesh seed ratio (2.59), and fruit yield per plant (49.03 kg). It was significantly different from the genotypes which followed it. In all these parameters, KK3 has been found at the bottom except for fruit yield per plant and fruit width. Maximum number of fruits per bunch was observed in KK3 (16.27) followed by KK4 (15.05). Least fruit width (2.30 cm) as well as the width length index (0.77) was observed in KK4. KK5 had the highest width length index (1.06) followed by KK3 (0.99), while KK5 had the lowest values with reference to number of fruits per bunch (8.83) and yield per plant (30.75 kg). KK3 took maximum days (131.00) from full bloom to maturity. KK4 required the least time of 115.5 days from full bloom to maturity.

Table 3a. Fruit characteristics of 5 loquat genotypes at Kalar Kahar.

Fruit characteristics	KK1	KK2	KK3	KK4	KK5	CV %
Fruit length (cm)	2.96 B	3.45 A	2.73 C	3.00 B	2.79 C	2.35
Fruit width (cm)	2.39 D	3.15 A	2.70 C	2.30 D	2.97 B	2.55
Width length index	0.81 D	0.91 C	0.99 B	0.77 E	1.06 A	1.74
Fruit weight (g)	15.54 B	17.29 A	10.03 C	10.68 C	15.38 B	7.31
Flesh seed ratio.	2.40 B	2.59 A	1.96 C	2.04 C	2.39 B	3.81
Fruits per bunch	12.52 C	14.50 B	16.27 A	15.05 B	8.83 D	4.32
Days from bloom to maturity	120.0 C	126.3 B	131.0 A	115.5 D	117.2 D	1.36
Yield per tree (kg)	44.85 B	49.03 A	37.22 C	40.67 C	30.75 D	7.02

Means not sharing a letter differ significantly at $p<0.05$

Table 3b. Fruit characteristics of 3 loquat genotypes at Choa Saiden Shah.

Fruit characteristics	CS1	CS2	CS3	CV %
Fruit length (cm)	3.52 A	3.62 A	3.03 B	4.33
Fruit width (cm)	2.70 B	3.21 A	2.64 B	4.35
Width length index	0.77 B	0.89 A	0.87 A	2.12
Fruit weight (g)	15.42 B	21.37 A	11.47 C	6.86
Flesh seed ratio	2.55 A	2.46 A	2.04 B	6.15
Fruits per bunch	16.07 A	12.58 B	11.92 B	8.52
Days from bloom to maturity	120.33 B	125.17 A	127.83 A	1.28
Yield per tree (kg)	47.51 A	38.28 C	42.13 B	5.44

Means not sharing a letter differ significantly at $p<0.05$

Fruit of KK2 was comparable with 'Kumquat loquat' which had a fruit weight of 18.0 g (Huang *et al*., 2007) and even greater than 'Taishan Zhong' having 12.8 g fruit weight (He *et al*., 2007), although it is very low as compared with the fruit weight observed in 'Zhaozhong' (30 g), 'Jidanbai' (35.6 g) and 'Guangyu' (43.61 g), which are some of the prominent cultivars of China (Feng *et al*., 2007). Flesh seed ratio in KK2 (2.59) is comparatively low as compared with many cultivars growing in China, Spain and Turkey. 'Gold Nugget', 'Baffico' and 'Kanro' in Turkey have been found to have a flesh seed ratio of 3.83, 4.16 and 5.42 respectively (Durgac *et al*., 2006). High flesh seed ratios were observed in 'Cardona', Buenet', 'Peluches' and 'Tanaka' (6.20, 7.08, 7.48 and 5.38 respectively) in Spain (Llacer *et al*., 2003).

Fruit yield of KK2 (49.03 kg / tree) is much better than that of 'Kanro' which yielded 24.5 kg / tree, while it was very low as compared with 'Champagne de Grasse' (Karadeniz, 2003) and 'Algerie' (Hermoso & Ferre, 2003), which gave 70 kg and 74 kg fruit per tree respectively.

Choa Saiden Shah: Fruit characteristics of the genotypes are given in Table 3b. Fruit length was highest in CS2 (3.62 cm) which was followed by CS1 (3.52 cm) both being at par. CS3 had significantly low fruit length (3.03 cm). Fruit width was significantly highest in CS2 (3.21 cm) followed by CS1 (2.70 cm). It was least in CS3 (2.64 cm) which was at par with CS1. Width length index was maximum in CS2 (0.89) followed by CS3 (0.87) and was significantly low in CS1 (0.77). Fruit weight was highest in CS2 (21.37 g) followed by CS1 (15.42 g) and minimum in CS3 (11.47 g) showing significant difference in all the three genotypes. Flesh seed ratio was highest in CS1 (2.55) followed by CS2 (2.46) both genotypes being at par. CS3 had significantly low flesh seed ratio (2.04). Significant differences were observed in terms of number of fruits per bunch. It was maximum in CS1 (16.07) and minimum in CS3 (11.92). CS3 took maximum time from full bloom to maturity (127.83 days) while this time was significantly low in CS1 (120.33 days).

Significant differences were noted in terms of yield per tree. It was maximum in CS1 (47.51 kg) and minimum in CS2 (38.28 kg). CS2 was the best one with reference to fruit weight (21.37 g), but had the lowest yield per plant (38.28 kg).

Fruit weight of CS2 (21.37 g) is almost the same as that of 'Baffico' (22.55 g) in Turkey (Durgac *et al*., 2006), but it is smaller than that of most of the other varieties growing in Chian, Spain and Turkey. 'Qingbian', 'Hanwuzhong' and 'Mojia No. 1' in China have fruit weight of 28.70 g, 30.97 g and 53.20 g respectively (He *et al*., 2007). Fruit weight of 'Magdal' and 'Crisanto Amadeo' in Spain has been observed as 45.50 g and 68.70 g respectively (Llacer *et al*., 2003). In Turkey, 'Ottawiani' and 'Dr. Trabut' have been found to have fruit weight of 49.78 g and 43.23 g respectively (Yalcin & Paydas, 1995).

Flesh seed ratio in CS1 (2.49) was very low as compared with that of 'Selezione 2 PA' (4.8), 'Ferdinando' (5.3) and 'Algerie' (6.2) as observed in Italy (Insero *et al*., 2003), 'Kanro' (5.42) and 'Bafico' (4.16) as noted in Turkey (Durgac *et al*., 2006).

Yield per plant in CS1 (47.51 kg) is higher than 'Kanro' (24.5 kg per plant), while lower than 'Champagne de Grasse', (70 kg per plant) 'M. Marie' (69 kg per plant) in Turkey (Karadenez, 2003) and 'Algerie' (74 kg per plant) in Spain (Hermoso & Ferre, 2003).

Seed characteristics

Kalar Kahar: Maximum number of seeds per fruit (3.63) was observed in KK2 followed by KK3 (3.45) both genotypes being statistically at par with each other. Lowest number of seeds per fruit (2.14) was observed in KK5. On the other hand, KK5 had the maximum single seed weight (2.12 g) followed by KK1 (1.49 g) while KK3 had the lowest single seed weight (0.99 g). Total seed weight per fruit was highest in KK2 (4.81 g) followed by KK1 (4.56 g) and KK5 (4.54 g), all the three genotypes having non significant difference. Total seed weight per fruit was lowest (3.39 g) in KK3. Seed characteristics are given in Table 4a.

Algerie in Spain had 2.30 seeds per fruit (Llacer *et al*., 2003), which is slightly higher than that observed in KK5 (2.14), while in China, 'Taicheng 4' (Xie *et al*., 2007) and 'White loquat' (Huang *et al*., 2007) were reported to have only 1.32 and 2 seeds per fruit respectively.

Choa Saiden Shah: Significant differences were observed in terms of number of seeds per fruit. Maximum number of seeds per fruit was observed in CS1 (3.64) followed by CS3 (3.39) with a significant difference. CS2 had the lowest number of seeds per fruit (3.28) and was at par with CS3. Significant differences were noted in weight per seed and total seed weight per fruit. Weight per seed was maximum in CS2 (1.89 g) followed by CS1 (1.20 g) and minimum in CS3 (1.11 g). Similarly, total seed weight per fruit was highest in CS2 (6.18 g) and lowest in CS3 (3.78 g).

Number of seeds per fruit and total seed weight per fruit observed in CS2 are low as compared with those of 'Magdal' (3.70 seeds per fruit and 7.80 g total seed weight per fruit), observed in Spain. But fruit weight of 'Magdal' is more than double the weight of CS2 (Llacer *et al*., 2003). In Italy, 'Selezione 2 PA', 'Nespolone di Trabia' 'Ferdinando' and 'Vainiglia' were observed to have 3.2, 3.8, 3.4 and 3.7 seeds per fruit respectively (Insero *et al*., 2003).

Table 4a. Seed characteristics of 5 loquat genotypes at Kalar Kahar.

Genotypes	Number of seeds per fruit	Single seed weight (g)	Total seed weight per fruit (g)
KK1	3.07 C	1.49 B	4.56 A
KK2	3.63 A	1.33 C	4.81 A
KK3	3.45 AB	0.99 E	3.39 B
KK4	3.22 BC	1.09 D	3.51 B
KK5	2.14 D	2.12 A	4.54 A
CV %	6.39	4.11	5.92

Means not sharing a letter differ significantly at $p<0.05$

Table 4b. Seed characteristics of 3 loquat genotypes at Choa Saiden Shah.

Genotypes	Number of seeds per fruit	Single seed weight (g)	Total seed weight per fruit (g)
CS1	3.64 A	1.20 B	4.35 B
CS2	3.28 B	1.89 A	6.18 A
CS3	3.39 B	1.11 C	3.78 C
CV %	3.40	3.46	3.18

Means not sharing a letter differ significantly at $p<0.05$

Leaf characteristic

Kalar Kahar: KK2 had the maximum leaf length (28.14 cm) followed by KK1 (27.91 cm) both being statistically non significant with each other. KK1 had the maximum leaf width (9.67 cm) followed by KK2 (9.36 cm) while KK2 was at par with KK1 as well as with KK4. Leaf area was highest (167.7 cm^2) in KK1 and was followed by KK2 (166 cm^2) with non significant difference (Table 5a). KK5 was at the bottom with reference to leaf length (13.43 cm), leaf width (4.18 cm) as well as leaf area (39.47 cm^2). In China, 'Hanwuzhong' is a loquat variety which has average leaf length of 26.50 cm and leaf width of 9.00 cm (He *et al*., 2007) This leaf size is somewhat less than that found in KK1, KK2 and KK4 while greater than that of the other two genotypes.

Choa Saiden Shah: Leaf characteristics of the three genotypes are given in Table 5b. Differences were non significant in terms of leaf length while significant in terms of leaf width. Maximum leaf width was observed in CS2 (9.06 cm) followed by CS1 (8.72 cm). CS3 had the minimum leaf width (8.30 cm) with significant difference. Significant differences were also noted in case of leaf area. Leaf area was maximum in CS2 (148.33 cm^2) followed with a significant difference by CS3 (126.71 cm^2) while it was minimum in CS1 (120.40 cm^2). 'Ningbai 1' in China has almost the same leaf size as found in the above genotypes. In this cultivar, leaf length and width have been observed as 25.5 cm and 8.00 cm respectively (Feng *et al*., 2007).

Table 5a. Leaf characteristics of 5 loquat genotypes at Kalar Kahar.

Genotypes	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)
KK1	27.91 A	9.67 A	167.7 A
KK2	28.14 A	9.36 AB	166.0 A
KK3	21.14 C	7.32 C	107.7 C
KK4	26.57 B	9.19 B	156.3 B
KK5	13.43 D	4.18 D	39.47 D
CV %	2.67	4.45	4.85

Means not sharing a letter differ significantly at $p<0.05$

Table 5b. Leaf characteristics of 3 loquat genotypes at Choa Saiden Shah.

Genotypes	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)
CS1	21.84 ns	8.72 B	120.40 B
CS2	22.17 ns	9.06 A	148.33 A
CS3	22.28 ns	8.30 C	126.71 B
CV %	3.40	2.03	5.37

Means not sharing a letter differ significantly at $p<0.05$

Table 6a. Floral characteristics of 5 loquat genotypes at Kalar Kahar.

Genotypes	Number of flowers per panicle	Panicle size (cm)	Days from flowering to full bloom
KK1	150.26 B	16.67 C	42.00 B
KK2	152.02 B	19.58 B	40.17 C
KK3	173.93 A	16.74 C	44.00 A
KK4	177.89 A	20.72 A	38.17 D
KK5	113.41 C	15.44 D	40.33 BC
CV %	5.08	3.73	3.37

Means not sharing a letter differ significantly at $p<0.05$

Table 6b. Floral characteristics of 3 loquat genotypes at Choa Saiden Shah.

Genotypes	Number of flowers per panicle	Panicle size (cm)	Days from flowering o full bloom
CS1	157.68 A	20.47 A	37.83 A
CS2	148.91 B	19.23 B	34.50 B
CS3	144.40 B	18.31 C	39.00 A
CV %	2.48	2.83	3.59

Means not sharing a letter differ significantly at $p<0.05$

Inflorescence

Kalar Kahar: Number of flowers per panicle was highest in KK4 (177.89) followed by KK3 (173.93) with non significant difference. This number is comparable with 'Madgal' variety, which had 178 flowers per panicle in Spain (Llacer *et al*., 2003). Number of flowers per panicle was significantly low in other genotypes. Least number of flowers per panicle was observed in KK5 (113.41) which is comparable with 108.10 flowers per panicle observed in 'Nespolone di Trabia' (Insero *et al*., 2003). Size of panicle was largest in KK4 (20.72 cm). It was followed by KK2 (19.58 cm) with significant difference. The smallest panicle size (15.44 cm) was found in KK5. The genotype KK3 took maximum time (44 days) from flowering to full bloom while KK1 took 42 days. Number of days from flowering to full bloom was lowest (38.17 days) in KK4 (Table 6a).

Choa Saiden Shah: Significant differences were observed in terms of floral characteristics (Table 6b). CS1 had the maximum number of flowers per panicle (157.68) and maximum panicle size (20.47 cm). CS3 had the minimum number of flowers per panicle (144.40) and minimum panicle size (18.31 cm). CS3 took maximum time from flowering to full bloom (39.00 days) while this time was least in case of CS2 (34.50 days). In China, number of flowers per panicle has been noted as 61 in 'Ningbai 2' (Feng *et al*., 2007) and 134 in 'Luoyangqing' (Yang *et al*., 2007).

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