

Morphological Characterization and Pollen Grain Fertility of Selected Orange (*Citrus sinensis* L.) Varieties

A.A. Tawfik, H.A. Sayed, R.M. Khalaf, N.A. Hassan , A.A. El-Homosany and M.A. Khalifa

*National Gene Bank and Genetic Resources (NGBGR),
Ministry of Agriculture and Land Reclamation, Cairo, Egypt.*

AMONG the national objectives of the National Gene Bank and Genetic Resources (NGBGR) in Egypt are the collection, characterization, evaluation and conservation of agricultural genetic resources. The present study investigates the morphological characterization and pollen grain fertility and sterility of 15 orange (*Citrus sinensis* L.) varieties namely Balady, Balady red, Balady succari, Central, Hamlin, Jaffa (Shamouti), Khalili red, Khalili white, Mafred, Mezazie, Mouzambique, Roja, Tanneriffe, Tunisi and Valencia.

Thirty-eight morphological characteristics were studied to describe the tree, leaf, inflorescence, fruit, and seed. The morphological characterization showed wide range of differences among varieties. Characterization of tree shape resulted in four ellipsoid varieties, seven spheroids and four were obloid. The morphological characterization of leaf lamina shape showed one elliptic variety, one ovate and 13 lanceolate. Fruit shape studies indicated that eleven varieties were spheroid and four were ellipsoid. Shape of fruit apex demonstrated that five varieties were round, nine were truncate, and one was depressed. Differences in flavido (rind skin) color among varieties revealed that one was light yellow, two were light orange, and eight were orange. The rest of the varieties were dark orange. As to the color of the pulp (flesh), results indicated that two varieties were yellow, 10 were orange and three were orange-red. The average number of carpeles per fruit ranged from 5-9 carpeles in four varieties, and from 10-14 carpeles in 11 varieties. The average number of seed per fruit revealed that nine varieties had one to four seeds; four varieties contained five to nine seeds and two varieties showed 10-19 seeds per fruit. Other morphological studies are investigated and will be presented.

Studies of pollen grain fertility showed that Blood orange, Jaffa, and Mezazie varieties demonstrated the highest pollen grain fertility 99.04, 99.13, 98.96% respectively. Contrarily, the highest pollen sterility was found in Mouzambique (7.18%), Hamlin (6.18%), and Tunisi (5.91%) varieties.

Keywords: National Gene Bank - Egypt - Orange varieties - Morphological description - Pollen grain fertility and sterility.

Orange (*Citrus sinensis*) is one of the most important subtropical fruit crops grown in Egypt for their unique flavor and nutritional values. Egypt is one of the top 10 producers of orange in the world (FAO, 2006). The area harvested (ha) during 2005 year was 88.00(1000 ha). Their respective total production (1000 tones) was 1, 789, 00. The average productivity per hectare during the same year was 20.329,50 (Kg/ha). Although, the Egyptian exports of oranges raised from 258120 MT in 2001 to 127130 and 168190 MT in 2002 and 2003, respectively, it increased to 750,000 MT in 2007.

Among the objectives of the National Gene Bank and Genetic Resources (NGBGR) in Egypt are conservation, characterization, evaluation, and dissemination of information to plant genetic resources (PGR) national and international programmes for its current and future use. The NGBGR pays much attention to indigenous and locally adapted varieties, in particular, due to their contained useful genetic variation and their rapid disappearing rate through replacement by high yielding varieties.

Characterization of genetic resources is an essential identification process in monitoring of the genetic quality during improvement and conservation (IPGRI, 1999). It has been accepted that the success of genetic resources activities is dependent upon the available descriptive information of the PGR provided by a Gene Bank to the breeders. In this regard, characterization descriptors are comprised of highly heritable qualitative traits that can be equally expressed in all conditions (IPGRI, 1999). It may also include a limited number of additional traits thought desirable by a consensus of users.

The characterization of cultivar is an essential stage in the certification program, improvement and conservation of germplasm, and monitoring of the genetic quality (IPGRI, 1999). In this regard, characterization descriptors are comprised of highly heritable qualitative traits that can be equally expressed in all conditions (IPGRI, 1999).

In realizing the importance of maintenance a larger diversity of commercial orange varieties in healthy and desirable quality, the NGBGR started to survey, characterize, and evaluate orange varieties grown in Egypt to enhance orange fruits industry and export.

The objectives of the present investigation were to study the morphological characteristics of 15 orange varieties as well as their pollen grain viability.

Material and Methods

Morphological characterization.

Morphological characterization and pollen grain viability of 15 orange varieties, under the present investigation, was carried out on 18-20 years old orange trees grafted on sour orange and grown at the Moshtohor Faculty of

Agriculture Research Farm, Zagazig University during 2004 and 2005 years. Trees were planted at 3x5 m in loomy soil and flood irrigated.

The morphological characteristics used to characterize and discriminate the 15 orange varieties were based on those previously prescribed for citrus by the International Plant Genetic Resources Institute (IPGRI, 1999) taking into consideration all the precautions reported. In this respect, 15 quantitative and 23 qualitative morphological characteristics were selected for the present investigation.

The study was performed using three trees for each variety; each tree was considered a replicate. Table 1 presents traits used for morphological characterization as well as their codes. In this respect, tree shape and growth habit were characterized in the natural state and immediately after harvest.

TABLE 1. Code of morphological traits used in orange varieties characterization.

Trait	Code	Trait	Code
1. Quantitative Traits		Leaf lamina attachment	LLA
Leaf lamina length	LLL	Leaf lamina shape	LLSh
Leaf lamina width	LLW	Leaf lamina margin	LLM
Ratio of leaf lamina length/ width	RLW	Leaf apex	LA
Flower pedicel length	FPL	Absence or presence of petiole wings	PWing
Number of petals per flower	P/F	Length of anthers relative to stigma	LA/S
Petal length	PL	Fruit shape	FrSh
Petal width	PW	Shape of fruit base	ShFrB
Fruit weight	FrWt	Shape of fruit apex	ShFrA
Fruit diameter	FrD	Fruit rind color	FrEC
Fruit length	FrL	Texture of rind surface	TES
Fruit rind thickness	FrRT	Adherence of mesocarp to endocarp	AME
Juice content in endocarp	JC	Density of oil gland on fruit surface	DOGFrS
Seed length	SeL	Color of fruit pulp	CFrP
Seed width	SeW	Number of carpeles per fruit	NSeg/Fr
Seed weight	SeWt	Thickness of carpeles walls	TSegW
2. Qualitative Traits		Number of seeds per fruit	NSe/Fr
Tree shape	TSh	Seed shape	SeSh
Tree growth habit	TGH	Seed surface	SeS
Intensity of green color of leaf blade	IGCLB	Seed color	SeC

Thirty mature and fully developed leaves per tree (mature leaves from one year old branches) were collected and characterized for intensity of green color of leaf blade, leaf lamina attachment, leaf lamina length and width, ratio of leaf lamina length/width, leaf lamina shape, leaf lamina margin, leaf apex, and absence or presence of petiole wings.

Data were recorded for flower pedicel length, length of anthers relative to stigma, number of petals per flower, petal length and width.

All observations on the fruit and its related parts were made at the optimum maturity stage according to IPGRI (1999). Fruit characteristics were observed on 10 typical fruits per each tree of the three replication trees. Data were documented for fruit weight, diameter, length, and shape. Records also included shape of fruit base and fruit apex, fruit flavedo (rind skin) color, texture of flavedo (rind skin) surface, adherence of mesocarp to endocarp, density of oil gland on fruit surface and fruit rind thickness. The study comprised also number of carples per fruit, thickness of carples walls, color of fruit pulp and juice content in endocarp.

Fully developed seeds were extracted from 10 fully rippened fruits taken from each tree of the three replications. In this respect, average number of seeds per fruit, seed shape, seed surface, seed color, seed length, seed width and seed weight.

Pollen grain viability

Ten randomly selected flowers per each of the three trees of the studied varieties were collected at an appropriate stage (before opening). Flowers were immediately fixed in a 3 alcohol: 1 acetic acid solution for 24 hr. Then flowers were washed several times with distilled water followed by storage in 70 % ethanol. Squash preparations of pollen mother cells (PMCs) were made in acetocarmen as described by Fayed *et al.* (1984). Twenty slides were prepared using the previously randomly selected 10 flowers for each variety.

The percentage of viable and aborted pollen grains was estimated by testing their satiability in the acetocarmen staining. Round and dark stained pollen grains were considered viable and functional, while non-viable ones were the shriveled or the light stained pollen grains as described by Fayed (1990).

All data were arranged in a randomized complete block design and were statistically analyzed according to Snedecor and Cochran (1982). The Fishers protected least significant difference (LSD) at $P \leq 0.05$ was employed to separate the treatment means.

Results and Discussion

Morphological characterization

Quantitative characteristics

Table 2 presents leaves and flowers quantitative traits of the 15 orange varieties under the present investigation. Results showed that Tanneriffe variety

exhibited the highest leaf lamina length (LLL) of 14.8 cm followed by Jaffa (12.8 cm) and Balady orange (12.0 cm) varieties. The lowest LLL was presented by Tunisi (4.7 cm), Valencia (4.5 cm) and Central (2.4 cm) varieties. The rest of the varieties showed intermediate values of leaf lamina length. Jaffa, Balady orange and Tanneriffe varieties showed the greatest leaf lamina width (LLW) of 5.3, 4.8 and 4.8 cm, respectively. However, there was no significant difference between the Balady orange, Tanneriffe, Mouzambique (4.1 cm) and Tunisi (4.2 cm) varieties, in this respect. The lowest LLW values were obtained by Roja (2.9 cm) variety followed by Mezazie variety (3.5 cm). The rest of varieties demonstrated midway LLW values ranged from 3.5-3.9 cm. The uppermost ratio of leaf lamina length/width (RLW) was showed by variety Khalili white (3.8) followed by Tanneriffe (3.1) and Roja (2.9) varieties. The lowest ratio was characterized in Valencia (1.1), Tunisi (2.3) and Succari (2.4) varieties (Table 2).

TABLE 2. Quantitative characteristics of leaves and flowers of 15 orange varieties¹.

Variety	LLL ² (cm)	LLW ² (cm)	RLW ²	FPL ² (cm)	P/F ²	PL ² (cm)	PW ² (cm)
Balady orange	12.0 c	4.8 ab	2.5 g	0.91 dc	5.0 a	1.93 bcd	0.75 d
Blood orange	9.7 fg	3.8 c	2.6 f	0.93 d	4.0 b	1.91 bcd	0.80 c
Central	2.4 j	3.8 c	2.5 g	0.60 j	4.0 b	1.44 f	0.67fg
Hamlin	10.6 dc	3.9 c	2.7 e	0.78 h	5.0 a	1.74 de	0.65 g
Jaffa	12.8 b	5.3 a	2.4 h	0.97 c	4.0 b	2.02 ab	0.74de
Khalili red	10.2 ef	3.7 c	2.8 d	0.72 i	5.0 a	1.76 cde	0.68 f
Khalili white	10.8 de	3.7 c	3.8 a	0.90 e	5.0 a	1.70 e	1.36 a
Mafred	10.1 ef	3.6 c	2.8 d	0.91 de	5.0 a	1.95 abc	0.80 c
Mezazie	10.1 ef	3.5 cd	2.9 c	0.70 i	5.0 a	1.90 bcd	0.66fg
Mouzambique	11.3 d	4.1 bc	2.7 e	1.01 b	4.0 b	2.14 a	0.84 b
Roja	8.3 h	2.9 d	2.9 c	0.82 g	5.0 a	2.04 ab	0.66fg
Succari	9.0 g	3.8 c	2.4 i	0.56 k	4.0 b	1.62 ef	0.72 e
Tanneriffe	14.8 a	4.8 ab	3.1 b	1.06 a	4.0 b	1.90 bcd	0.75 d
Tunisi	4.7 i	4.2 bc	2.3 j	0.87 f	5.0 a	2.08 ab	0.73de
Valencia	4.5 i	4.0 c	1.1 k	0.80 gh	4.0 b	1.62 ef	0.72 e

Means followed by the same letter within the same column are not significantly different ($P \leq 0.05$; LSD test)

¹Characteristics were described for citrus by the International Plant Genetic Resources Institute (1999).

²LLL: Leaf lamina length, LLW: Leaf lamina width, RLW: Ratio of leaf lamina length/width, FPL: Flower pedicel length, P/F: Number of petals per flower, PL: Petal length, PW: Petal width.

The Tanneriffe variety showed the highest value (1.06 cm) of flower pedicel length (FPL). The lowest ones were exhibited by the Succari (0.56 cm), Central (0.60 cm), Khalili red (0.72 cm) and Mezazie (0.70 cm) varieties. Whereas the rest of the varieties illustrated intermediate values.

Balady orange, Hamlin, Khalili red, Khalili white, Mafred, Mezazie, Roja and Tunisi varieties showed five petals per flower (P/F), whereas the rest of the varieties exhibited four petals per flower (Table 2). The petal length (PL) was different among the varieties where Mouzambique (2.14 cm), Tunisi (2.08 cm), Roja (2.04 cm), Jaffa (2.02 cm) and Mafred (1.95 cm) varieties presented the highest measurements. On

the contrary, Central, Succari and Valencia varieties had the lowest PL of 1.44, 1.62 and 1.62 cm, respectively.

The varieties Khalili white, Mouzambique, Blood orange and Mafred presented the highest petal width (PW) of 1.36, 0.84, 0.80 and 0.80 cm, respectively. On the other hand, the respective lowest PW values of 0.65, 0.66, 0.66, 0.67 and 0.68 cm were showed by the varieties Hamlin, Mezazie, Roja, Central and Khalili red.

The quantitative characteristics of fruit and seed are demonstrated in Table 3. Jaffa variety showed the highest significant fruit weight (337.5 g) followed by Valencia (182.3 g) variety. On the other hand, variety Balady orange had the lowest fruit weight (104.2 g). The rest of the varieties gave intermediate fruit weights (Table 3).

TABLE 3. Quantitative characteristics of fruits and seeds of 15 orange varieties¹.

Variety	FrWt ² (g)	FrD ² (cm)	FrL ² (cm)	FrRT ² (cm)	JC ² ml/Fr	SeL ² (cm)	SeW ² (cm)	SeWt ² (g)
Balady orange	104.2 o	5.70 f	5.50 g	0.30 d	60.0 i	1.24 bcde	0.71 bc	0.23 cde
Blood orange	179.7 c	7.12 b	7.50 bc	0.40 c	70.0 f	1.50 abcd	0.75 bc	0.24 cd
Central	144.8 i	6.54 bcde	6.96 cde	0.30 d	60.0 i	1.20 cde	0.70 bc	0.19 f
Hamlin	133.2 k	6.25 cdef	6.25 efg	0.50 b	37.0 l	1.60 ab	0.85 b	0.32 a
Jaffa	337.5 a	8.13 a	10.75 a	0.70 a	124.0 a	1.20 cde	0.76 bc	0.23 cde
Khalili red	179.0 d	7.00 bc	6.90 cde	0.50 b	76.0 c	1.55 abc	0.75 bc	0.27 b
Khalili white	172.5 f	6.38 bcdef	7.50 bc	0.40 c	75.0 d	1.10 e	0.66 bc	0.16 g
Mafred	163.3 g	6.87 bcd	7.00 cde	0.50 b	65.8 h	1.35 abcde	0.77 bc	0.23 cde
Mezazie	140.3 j	6.50 bcde	6.10 fg	0.40 c	66.0 g	1.24 bcde	0.72 bc	0.22 de
Mouzambique	126.6 l	6.20 def	6.60 def	0.40 c	53.0 k	1.16 de	0.60 c	0.13 h
Roja	115.3 n	6.00 ef	6.00 fg	0.30 d	60.0 i	1.31 abcde	0.73 bc	0.24 cd
Succari	177.2 e	7.00 bc	7.86 b	0.40 c	76.0 c	1.50 abcd	1.00 a	0.22 de
Tanneriffe	153.8 h	7.00 bc	6.10 fg	0.30 d	74.0 e	1.30 abcde	0.80 b	0.21 ef
Tunisi	122.6m	6.37bcdef	6.25 efg	0.30 d	55.0 j	1.40abcde	0.80 b	0.25 bc
Valencia	182.3 b	6.90 bcd	7.20bcd	0.20 e	80.0 b	1.66 a	0.73 bc	0.24 cd

Means followed by the same letter within the same column are not significantly different ($P \leq 0.05$; LSD test)

¹Characteristics were described for citrus by the International Plant Genetic Resources Institute (1999).

²FrWt: Fruit weight, FrD: Fruit diameter, FrL: Fruit length, FrRT: Fruit rind thickness, JC: Juice content
SeL: Seed length, SeW: Seed width, SeWt: Seed weight.

Although variety Jaffa exhibited the greatest fruit diameter (8.13 cm), it had no significant differences as compared with the Blood orange (7.12 cm), the Khalili red (7.0 cm), the Succari (7.0 cm), the Tanneriffe (7.0 cm), the Valencia (6.90 cm), the Mafred (6.87 cm), the Central (6.54 cm), the Mezazie (6.50 cm),

the Khalili white (6.38 cm) and the Tunisi (6.37 cm) varieties. On the contrary, the Balady orange displayed the lowest fruit diameter (5.70 cm). However, no significant differences were detected as compared with Balady orange, Hamlin, Khalili white, Mouzambique, Roja and the Tunisi varieties. Variety Jaffa also exhibited the most significant fruit length (10.75 cm) followed by the Succari variety (7.86 cm). The least fruit length was demonstrated by the variety Balady orange (5.50 cm). However, no significant differences were obtained as compared with the varieties Hamlin (6.25 cm), Tunisi (6.25 cm), Mezazie (6.10 cm), Tanneriffe (6.10 cm) and Roja (6.00 cm). Table 3 also, shows the greatest fruit rind thickness was observed in variety Jaffa (0.70 cm) followed by the varieties Hamlin (0.50 cm) and Mafred (0.500 cm). Conversely, the variety Valencia revealed the lowest (0.20 cm) rind thickness. The remaining varieties had midway values ranged from 0.30 to 0.40 cm.

The amount of juice content (ml/Fr) was also different among varieties, being the greatest (124.0 ml) in the variety Jaffa followed by the Valencia (80.0 ml). The least juice content was obtained from the variety Hamlin (37.0 ml), whereas the rest of the varieties showed intermediate juice amounts.

The variety Valencia proved the highest significant seed length (SeL) value (1.66 cm), whereas the variety Khalili white showed the least seed length (1.10 cm). Although the varieties Blood orange, Hamlin, Khalili red, Roja, Succari, Tanneriffe and Tunisi showed midway seed length values it had no significant differences as compared with the Valencia variety. Similarly, varieties Blood orange, Central, Jaffa, Mafred, Mezazie, Mouzambique, Roja, Tanneriffe and Tunisi showed no significant differences in comparison with the Khalili white variety.

The largest seed width (SeW) was detected in the variety Succari (1.0 cm) followed by the varieties Hamlin (0.85 cm), Tanneriffe (0.80 cm) and Tunisi (0.80 cm). While the lowest one was demonstrated by the variety Mouzambique (0.60 cm). However, the varieties Balady orange, Blood orange, Central, Jaffa, Khalili red, Khalili white, Mafred, Mezazie, Roja and Valencia exhibited intermediate seed width values between the group of Hamlin, Tanneriffe and Tunisi varieties and the Mouzambique variety.

Table 3 indicates that the Hamlin variety had the greatest average seed weight (SeWt, 0.32 g) followed by the Khalili red (0.27 g) and the Tunisi varieties, while the Mouzambique variety showed the least seed weight (0.13 g). The rest of the varieties exhibited intermediate average seed weight values.

It is concluded that Jaffa variety has the best quantitative traits proved by the highest fruit weight, diameter, length, rind thickness, and juice content as well as the low seed length, width and weight.

Qualitative characteristics

Table 4 presents the qualitative traits of tree, leaf and flower of the 15 orange varieties under the study. The varieties Balady orange, Blood orange, Khalili red and Tunisi demonstrated obloid tree shape (TSh), whereas the Central, the Hamlin, the Mezazie and the Tanneriffe varieties had ellipsoid one. The rest of the varieties showed spheroid tree shape.

The degrees of tree growth habit (GH) included erect, spreading or drooping growth habit. None of the varieties under the study demonstrated drooping growth habit. The tree growth habit of the varieties Blood orange, Central, Hamlin, Khalili red, Mezazie, Mouzambique and Tanneriffe was erect while that of the rest of the varieties was spreading.

The intensity of green color of leaf blade (IGCLB) was recorded on fully developed leaves. All varieties showed dark green color of leaf blade except for the Blood orange, the Central and the Mafred varieties that showed green color and the Khalili red that had light green color of leaf blade (Table 4). The characterization degrees of leaf lamina attachment (length of petiole relative to length of leaf lamina) included sessile (petiole absent), Brevipetiolate (petiole shorter than leaf lamina) and Longipetiolate (petiole longer than or same length as leaf lamina). In this regard, all the varieties showed Brevipetiolate leaf lamina attachment (LLA) except for the variety Balady orange that demonstrated sessile leaf lamina attachment. The study of leaf lamina shape (LLSh) included elliptic, ovate, obovate, lanceolate, orbicular and obcordate. None of the investigated varieties under the present study indicated obovate or orbicular leaf lamina shape. All varieties exhibited lanceolate LLSh except for the Balady orange and Succari varieties that showed elliptic and ovate leaf lamina shapes, respectively. None of the varieties had crenate leaf lamina margin (LLM). The varieties Hamlin, Mezazie and Roja showed entire LLM, whereas the varieties Jaffa, Khalili white, Mouzambique and Valencia demonstrated dentate LLM. The rest of the studied varieties exhibited sinuate leaf lamina margin. The categories under which leaf apex (LA) of the different varieties was evaluated were attenuate, acuminate, acute obtuse, rounded or emarginated leaf apex. Not any of the studied varieties showed obtuse or rounded leaf apex. The varieties Balady orange, Central, Jaffa, Khalili red, Mouzambique and Tunisi proved acute LA, whereas Khalili white and Tanneriffe varieties confirmed emarginated leaf apex. The rest of the varieties, however, exhibited acuminate leaf apex. The absence or presence of petiole wings (PWing) were evaluated for the different varieties (Table 4). The Balady orange, the Mouzambique and the Tanneriffe varieties demonstrated absent PWing, whereas those of the rest of the varieties were present.

The length of anthers relative to stigma (LA/S) was studied against orange varieties under the study where no variety showed anthers longer than the stigma (Table 4). On the other hand, the Blood orange, the Central, the Hamlin, the Jaffa, the Mezazie, the Succari and the Valencia varieties exhibited medium length of anthers to stigma, while the rest of the varieties revealed shorter anthers relative to stigma.

Table 5 illustrates the fruit qualitative characteristics of the 15 orange varieties under the study. In this regard, all the varieties under the study showed either spheroid or ellipsoid fruit shape (FrSh). None of the varieties proved pyriform, oblique, obloid or ovoid fruit shape. While the varieties Jaffa, Mouzambique, Succari and the Valencia showed ellipsoid fruit shape, the rest of the varieties exhibited spheroid fruit shape. None of the studied orange varieties had necked or collard with neck shape of fruit base (ShFrB). Only the Succari variety showed concave collard shape of fruit base. The varieties Blood orange, Hamlin, Jaffa, Mafred, Mouzambique and Roja revealed convex fruit base shape, whilst the rest of the varieties exhibited truncate one. Regarding shape of fruit apex (ShFrA), only the variety Mafred showed depressed shape of fruit apex, whereas Hamlin, Jaffa, Khalili white, Mouzambique and Roja demonstrated rounded ShFrA (Table 6). The remaining of the varieties displayed truncate shape of fruit apex.

The fruit epicarp color (FrEC) included 12 colors ranged from green to red orange. The variety Jaffa had green yellow epicarp color while that of the Mezazie and Succari varieties was light orange (Table 5). The fruit epicarp color of Blood orange, Hamlin, Khalili red and Mouzambique varieties was dark red. The rest of the varieties exhibited orange fruit epicarp color. The Blood orange and Jaffa varieties were the only ones showed bumpy and pitted texture of epicarp surface (TES), respectively (Table 5). The Varieties Khalili red, Mafred, Succari and Tanneriffe proved papillate epicarp surface texture, whereas Hamlin, Mezazie and Mouzambique showed smooth surface. The rest of the varieties had rough texture of epicarp surface. Only the Mezazie variety presented weak adherence of mesocarp to endocarp (AME), whereas the Central, Hamlin, Jaffa, Tanneriffe, Tunisi and Valencia showed strong one. The remaining varieties exhibited medium adherence of mesocarp to endocarp. The variety Mouzambique only showed high density ($>70.\text{cm}^{-2}$) of oil glands on fruit surface (DOGFrS). In contrast, the varieties Hamlin, Jaffa, Khalili red, Khalili white and Roja proved low density ($<40.\text{cm}^{-2}$). The rest of the varieties presented intermediate density ($45-65.\text{cm}^{-2}$) of oil glands on fruit surface. Yellow color of fruit pulp (CFrP) was in the Hamlin and Roja varieties only, whereas it was orange red in the Blood orange, Khalili red and Mouzambique varieties (Table 5). The rest of the varieties (67%) showed orange color of fruit pulp.

TABLE 4. Qualitative characteristics of tree, leaf and flower of 15 orange varieties¹.

Variety	TSh ²	TGH ²	IGCLB ²	LLA ²	LLSh ²	LLM ²	LA ²	PWing ²	LA/S ²
Balady orange	Obloid	Spreading	Dark	Sessile	Elliptic	Sinuate	Acute	Absent	Shorter
Blood orange	Obloid	Erect	Green	Brevipetiolate	Lanceolate	Sinuate	Acuminate	Present	Medium
Centrial	Ellipsoid	Erect	Green	Brevipetiolate	Lanceolate	Sinuate	Acute	Present	Medium
Hamlin	Ellipsoid	Erect	Dark	Brevipetiolate	Lanceolate	Entire	Acuminate	Present	Medium
Jaffa	Spheroid	Spreading	Dark	Brevipetiolate	Lanceolate	Dentate	Acute	Present	Medium
Khalili red	Obloid	Erect	Light	Brevipetiolate	Lanceolate	Sinuate	Acute	Present	Shorter
Khalili white	Spheroid	Spreading	Dark	Brevipetiolate	Lanceolate	Dentate	Emarginate	Present	Shorter
Mafred	Spheroid	Spreading	Green	Brevipetiolate	Lanceolate	Sinuate	Acuminate	Present	Shorter
Mezazie	Ellipsoid	Erect	Dark	Brevipetiolate	Lanceolate	Entire	Acuminate	Present	Medium
Mouzambique	Spheroid	Erect	Dark	Brevipetiolate	Lanceolate	Dentate	Acute	Absent	Shorter
Roja	Spheroid	Spreading	Dark	Brevipetiolate	Lanceolate	Entire	Acuminate	Present	Shorter
Succari	Spheroid	Spreading	Dark	Brevipetiolate	Ovate	Sinuate	Acuminate	Present	Medium
Tanneriffe	Ellipsoid	Erect	Dark	Brevipetiolate	Lanceolate	Sinuate	Emarginate	Absent	Shorter
Tunisi	Obloid	Spreading	Dark	Brevipetiolate	Lanceolate	Sinuate	Acute	Present	Shorter
Valencia	Spheroid	Spreading	Dark	Brevipetiolate	Lanceolate	Dentate	Acuminate	Present	Medium

¹Characteristics were described for citrus by the International Plant Genetic Resources Institute (1999).

²TSh: Tree shape, TGH: Tree growth habit, IGCLB: Intensity of green color of leaf blade, LLA: Leaf lamina attachment, LLSh: Leaf lamina shape.

LLM: Leaf lamina margin, LA: Leaf apex, PWing: Absence or presence of petiole wings, LA/S: Length of anthers relative to stigma.

TABLE 5. Qualitative characteristics of fruit of 15 orange varieties¹.

Varieties	FrSh ²	ShFrB ²	ShFrA ²	FrEC ²	TES ²	AME ²	DOGFrS ²	CFrP ²
Balady orange	Spheroid	Truncate	Truncate	orange	Rough	Medium	Intermediate	orange
Blood orange	Spheroid	Convex	Truncate	Dark orange	Bumpy	Medium	Intermediate	Orange red
Centrial	Spheroid	Truncate	Truncate	orange	Rough	Strong	Intermediate	orange
Hamlin	Spheroid	Convex	Rounded	Dark orange	Smooth	Strong	Low	Yellow
Jaffa	Ellipsoid	Convex	Rounded	Green yellow	Pitted	Strong	Low	orange
Khalili red	Spheroid	Truncate	Truncate	Dark orange	Papillate	Medium	Low	Orange red
Khalili white	Spheroid	Truncate	Rounded	orange	Rough	Medium	Low	orange
Mafred	Spheroid	Concave	Depressed	orange	Papillate	Medium	Intermediate	orange
Mezazie	Spheroid	Truncate	Truncate	Light orange	Smooth	Weak	Intermediate	orange
Mouzambique	Ellipsoid	Convex	Rounded	Dark orange	Smooth	Medium	High	Orange red
Roja	Spheroid	Convex	Rounded	orange	Rough	Medium	Low	Yellow
Succari	Ellipsoid	Concave collared	Truncate	Light orange	Papillate	Medium	Intermediate	orange
Tanneriffe	Spheroid	Truncate	Truncate	orange	Papillate	Strong	Intermediate	orange
Tunisi	Spheroid	Truncate	Truncate	orange	Rough	Strong	Intermediate	orange
Valencia	Ellipsoid	Truncate	Truncate	orange	Rough	Strong	Intermediate	orange

¹Characteristics were described for citrus by the International Plant Genetic Resources Institute (1999).

²FrSh: Fruit shape, ShFrB: Shape of fruit base, ShFrA: Shape of fruit apex, FrEC: Fruit epicarp color, FrST: Fruit surface texture, AME: Adherence of mesocarp to endocarp, DOGFrS: Density of oil gland on fruit surface, CFrP: Color of fruit pulp.

The qualitative characteristics of fruit carpeles and seed are presented in Table 6. As to number of carpeles per fruit (NSeg/Fr), the majority of the varieties showed 10-14 segments per fruit. While the Central, Succari, Tunisi and Valencia varieties demonstrated only 5-9 carpeles per fruit. No varieties showed <5, 15-18 or >18 carpeles per fruit. The varieties Central, Mezazie and Valencia were characterized by thin carpeles walls (TSegW), whereas the rest of the varieties (80%) revealed medium thickness.

TABLE 6. Qualitative characteristics of fruit segment and seed of 15 orange varieties¹.

Variety	NSeg/Fr ²	TSegW ²	NSe/Fr ²	SeSh ²	SeS ²	SeC ²
Balady orange	10-14	Medium	10-19	Semi deltoid	Smooth	Brown
Blood orange	10-14	Medium	1-4	Semi deltoid	Smooth	Yellowish
Central	5-9	Thin	1-4	Semi deltoid	Wrinkled	Yellowish
Hamlin	10-14	Medium	1-4	Semi deltoid	Wrinkled	Cream
Jaffa	10-14	Medium	1-4	Semi deltoid	Smooth	Cream
Khalili red	10-14	Medium	1-4	Semi deltoid	Smooth	Yellowish
Khalili white	10-14	Medium	5-9	Spheroid	Smooth	Cream
Mafred	10-14	Medium	5-9	Semi deltoid	Wrinkled	Cream
Mezazie	10-14	Thin	5-9	Clavate	Smooth	White
Mouzambique	10-14	Medium	1-4	Clavate	Smooth	Yellowish
Roja	10-14	Medium	10-19	Semi deltoid	Wrinkled	Cream
Succari	5-9	Medium	5-9	Semi deltoid	Wrinkled	Yellowish
Tanneriffe	10-14	Medium	1-4	Semi deltoid	Wrinkled	Cream
Tunisi	5-9	Medium	1-4	Clavate	Wrinkled	Cream
Valencia	5-9	Thin	1-4	Semi Spheroid	Wrinkled	Yellowish

¹Characteristics were described for citrus by the International Plant Genetic Resources Institute (1999).

²NSeg/Fr: Number of carpeles per fruit, TSW: Thickness of carpeles walls, NS/Fr: Number of seeds per fruit

SeSh: Seed shape, SeS: Seed surface, SeC: Seed color.

The average number of seeds per fruit (NSe/Fr) was generally low in most of the varieties tested (Table 6). The highest counted number of seeds per fruit (10-19) was evident in the varieties Balady orange and Roja. The varieties Khalili white, Mafred, Mezazie and Succari showed 5-9 seeds per fruit. The remaining of the varieties (60%) presented 1-4 seeds per fruit. The Valencia and Khalili white varieties were the only ones presented semi-spheroid and spheroid seed shapes (SeSh), respectively. Only three varieties namely the Mezazie, Mouzambique and Tunisi showed clavate seed shape (Table 6). Seed shape of the rest of the varieties (67%) was semi-deltoid. None of the varieties showed fusiform, cuneiform or ovoid seed shape. Among the studied varieties, the Balady orange, Blood orange, Jaffa, Khalili red, Khalili white, Mezazie and Mouzambique demonstrated smooth seed surface (SeS). The residues of the varieties had wrinkled seed shape. No variety showed hairy seed surface. Only the Mezazie variety showed white seed color (SeC), whereas the Balady orange had brown seed. The Hamlin, Jaffa, Khalili white, Mafred, Roja, Tenneriffe and Tunisi varieties revealed cream seed color. While the Blood orange, Central, Khalili red, Mouzambique, Succari and Valencia showed yellowish seed.

Pollen grain viability

The percentage of pollen grain fertility and sterility of the 15 orange varieties are presented in Table 7. Figure 1 demonstrates the external appearance of orange fertile and sterile pollen grains. Number of pollen grains examined ranged from 1100-1500 for all the studied varieties.

TABLE 7. Percentage of pollen grain fertility and sterility of 15 orange varieties.

Variety	Pollen grains examined	Viable pollen grains	% Pollen Fertility	% Pollen Sterility
Balady orange	1161	1127	97.07 ef	2.93 e
Blood orange	1559	1544	99.04 a	0.96 k
Centrial	1384	1365	98.63 b	1.37 j
Hamlin	1229	1153	93.82 h	6.18 b
Jaffa	1382	1370	99.13 a	0.87 l
Khalili red	1349	1313	97.33 d	2.67 g
Khalili white	1425	1381	96.91 f	3.09 d
Mafred	1597	1553	97.24 de	2.76 f
Mezazie	1353	1339	98.96 a	1.04 k
Mouzambique	1254	1164	92.82 i	7.18 a
Roja	1202	1169	97.26 de	2.74 fg
Succari	1368	1333	97.44 d	2.56 h
Tanneriffe	1288	1262	97.98 c	2.02 i
Tunisi	1337	1258	94.09 g	5.91 c
Valencia	1153	1117	96.88 f	3.12 d

Means followed by the same letter within the same column are not significantly different ($P \leq 0.05$; LSD test).

Data exhibits differences of pollen grain fertility and sterility among the studied orange varieties. Percentage of pollen grain fertility, among orange varieties, ranged from 92-99%, while that of sterility was from 0.9-7%. The varieties Blood orange (99.04%), Jaffa (99.13%) and Mezazie (98.96%) exhibited the highest percentage of pollen grain fertility and the lowest sterility percentage (Table 7). They were followed by the varieties Centrial (98.63%) and Tanneriffe (97.98%). The lowest percent of pollen grain fertility was determined in the varieties Mouzambique (92.82%), Hamlin (93.82%) and Tunisi (94.09%). The rest of the varieties showed intermediate values of pollen grain fertility

percentage. Percentage of pollen grain sterility showed the opposite trend of varieties being the highest in Mouzambique, Hamlin, and the Tunisi varieties. The high level of pollen grain fertility of some orange varieties might indicate low frequency of chromosomal aberration in these varieties. In contrast, the reduced percentage percent of pollen fertility in some of the varieties might be attributed to disturbance in chromosome separation during meiosis.

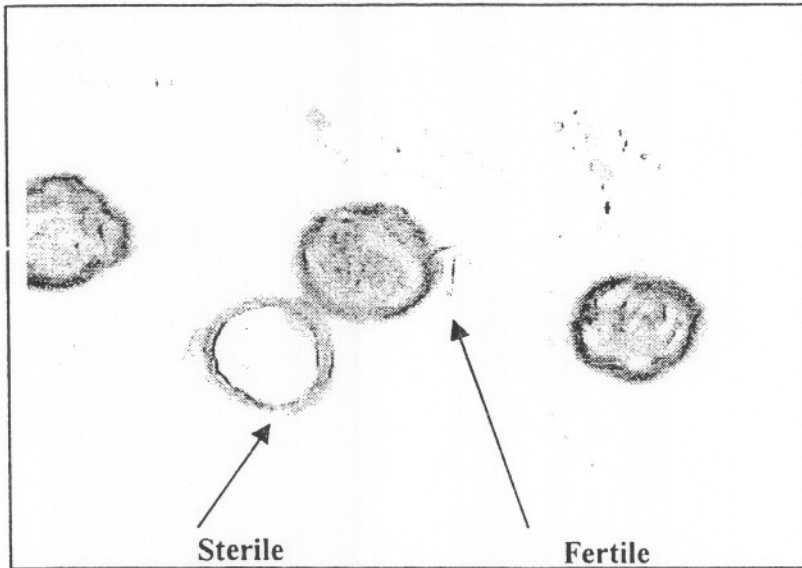


Fig. 1. External appearance of fertile and sterile pollen grain.

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التوصيف الظاهري وخصوبة حبوب اللقاح لبعض أصناف البرتقال

أحمد عبد المنعم توفيق، حسام عبد المقصود سيد، رأفت محمد خلف، نيفين عبد الفتاح حسن، أحمد عبد الوهاب الحمصاني، محمد عبد الحميد خليفه
البنك القومى للجينات والموارد الوراثية، وزارة الزراعة وإستصلاح الأراضى -
القاهرة - مصر.

تتضمن المهام القومية للبنك القومى للجينات والموارد الوراثية بجمهورية مصر العربية عمليات جمع وحفظ وتوصيف وتقييم الموارد الوراثية الزراعية. وتهدف الدراسة الحالية إلى التوصيف الظاهري واختبار حيوية حبوب اللقاح لعدد ١٥ صنف برتقال (*Citrus sinensis* L). وكانت الأصناف تحت الدراسة هي البلدى، البلدى الأحمر، سنتريال، هاملن، ياقا (شموتى)، خليلي أحمر، خليلي أبيض، مافرد، مزيى، موزامبيق، روجا، السكرى، تانيريف، تونسى، فالنشيا. وقد تم دراسة عدد ٣٨ صفة مورفولوجية على الشجرة، الورقة، النورة، الثمرة، الفصوص، البذرة. وقد أظهرت دراسة أنصاف الظاهرية تباين واضح بين الأصناف تحت الدراسة. وقد أوضحت دراسة شكل الشجرة إتحاد أربعة أصناف فى الشكل ellipsoid، وسبعة أصناف فى الشكل spheroids، وأربعة فى الشكل obloid. وقد أوضحت نتائج دراسة شكل الورقة (Leaf lamina shape) وجود صنف واحد يتميز بالشكل elliptic، وصنف آخر يتميز بالشكل ovate، ١٣ صنف تتميز بالشكل lanceolate. أظهرت دراسة شكل الثمرة وجود ١١ صنف تتميز ثمارها بالشكل spheroid، أربعة أصناف تتميز بالشكل ellipsoid. وقد اختلفت الأصناف أيضاً فى شكل قمة الثمرة حيث تميزت خمسة أصناف بصفة القمة المستديرة round، تسعة بالصفة truncate، وصنف واحد بالصفة depressed. أوضحت دراسة لون قشرة الثمرة وجود صنف واحد ذو لون أصفر فاتح، عدد صنفان يتميزا باللون البرتقالى الفاتح، ثمانية أصناف تتميز باللون البرتقالى، أربعة اصناف تتميز باللون البرتقالى الغامق. أوضحت دراسة لون لحم الثمرة وجود صنفان يتميزان باللون الأصفر، عشرة أصناف تتميز باللون البرتقالى وثلاثة يتميز لون اللحم فيها باللون البرتقالى المشوب بالحمرة. أوضحت دراسة عدد الفصوص بثمار الأصناف المختلفة جود عدد أربعة أصناف يتراوح عدد الفصوص (الكرابل) بها من ٥-٩ فصوص، بينما تراوح عدد الفصوص فى ١١ صنف آخر من ١٠-١٤ فص. تراوح متوسط عدد البذور بالثمرة من ١-٤ بذور فى عدد تسعة أصناف، ٥-٩ بذور بالثمرة فى عدد أربعة أصناف، ١٠-١٩ بذرة بالثمرة فى عدد صنفين.

كما أوضحت دراسة خصوبة حبوب اللقاح تميز الأصناف أحمر بدمه (٩٩,٠٤%) ، اليافاوى (٩٩,١٣%) والمزيى (٩٨,٩٦%) بدرجة خصوبة عالية. بينما تميزت الأصناف موزامبيق (٧,١٨%) ، هاملن (٦,١٨%)، تونسى (٥,٩١%) بأعلى نسبة عقم بحبوب اللقاح. بينما أظهرت بقية الأصناف تحت الدراسة درجات متوسطة فى خصوبة حبوب اللقاح.