Effect of various pollination treatments on yield characteristics and fruit quality of shaddock fruits

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ABSTRACT— The genus citrus belongs to the family Rutaceae. A Shaddock (*Citrus maxima* L.) or (*Citrus grandis* L.) is one of the most distinctive and easily recognized species of the genus Citrus. The present investigation was conducted during two successive, 2013 and 2014 seasons, grown in clay loamy soil at experimental station of the Faculty of Agriculture, Benha University at Moshtohor, Toukh region, Kaliobia Governorate on 21 trees of Shaddock trees of about 20 years old. All the trees in this investigation were similar in growth, healthy, apparently free from disease and the trees were planted at 5x5 meters a part. This study aimed to investigate the pollination requirements and the suitable pollinizers for Clementine mandarin cultivar in order to increase its production efficiency and fruit quality. Through study the effect of T1- Open-pollination (Control), T2- Self-pollination, T3- Emasculation and bagging, T4- Cross– pollination with Succary orange pollen grains, T5- Cross – pollination with Balady mandarin pollen grains, T6- Cross – pollination with March grapefruit pollen grains and T7-Cross – pollination with Balady orange pollen grains. Data obtained revealed that cross pollination increase some fruit characteristics such as fruit set %, fruit retention, fruit weight, fruit size, pulp weight, pulp/seed ratio number of seeds per fruit, juice %, T.S.S % and Vitamin C of Shaddock fruits compared with self-pollination.

Key words— Shaddock, Citrus maxima, Balady orange, bagging, pulp/seed ratio, Emasculation and Rutaceae.

1 INTRODUCTION

The genus citrus belongs to the family Rutaceae. It is commercially grown in the tropical and sub-tropical regions around the world. It is considered the first economic fruit crop in Egypt and the second in the world. The cultivated area occupies acreage of 541723 feddans according to the statistics of the Ministry of Agriculture, Cairo, Egypt, 2013.

A Shaddock (*Citrus maxima* L.) or (*Citrus grandis* L.) is one of the most distinctive and easily recognized species of the genus Citrus. Shaddock is the largest species of the genus Citrus [1]. It contains vitamin C more than twice than those of other citrus fruits that fulfill the demand of vitamin C [2].

The Shaddock is significantly larger than the grapefruit. Its flesh is sweet and it has a thick skin or rind. The fruit of the Shaddock has a light green colored rind but this gradually becomes mostly yellow when it has fully ripened. The inside of the fruit has a pink color when it is ripe. There is special Shaddock fruit based diet to treat asthma. Shaddock is a dietary fruit; its caloric value is 25-58 kcal per 100 g [3]. The flesh juicy squash vesicles are eaten fresh out of the hand or in the fruit salad and sometimes the juice is extracted for beverage. The white inner part of the peel can be candied after the outer peel containing oil glands has been removed.

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The effect of pollen donor on fruit and seed characteristics (Xenia) is a known phenomenon occurs in several fruit species like date palm [4] and mango [5]. Xenia is defined as the effect of pollen genotype on development and characteristics of fruit, it can affect pericarp, endosperm and embryo weight, also seed and fruit shape, color, chemical composition and maturity time [6].

The term "Metaxenia" was used previously to describe the direct effect of pollen grains on fruit tissues but later [7] mentioned that "Xenia including Metaxenia", such phenomena may have agronomic importance for fruit production. However, the occurrence of these phenomena differed between species.

The aim of this study is to investigate the pollination requirements and the suitable pollinizers for Shaddock in effort to increase their production efficiency and quality.

2 MATERIALS AND METHODS

The present investigation was conducted during two experimental, 2013 and 2014 seasons, grown in clay loamy soil at experimental station of the Faculty of Agriculture, Benha University at Moshtohor, Toukh region, Kaliobia Governorate on 21 trees of shaddock trees of about 20 years old. All the trees in this investigation were similar in growth, healthy, apparently free from disease and the trees were planted at 5x5 meters a part. All the trees received the recommended amount of fertilizers and Irrigation water.

The soil at the experimental orchard was classified as loamy in texture. Values of the daily temperatures, relative humidity and wind speed during the period of flowering and fruit set are shown in Table (1)

TABLE 1. AIR TEMPERATURE, RELATIVE HUMIDITY AND WIND SPEED AT EXPERIMENTAL SITE IN 2013 AND 2014 IN QALUBIYA.

Year	Months	Air Temperature (C°)			Relative humidity%	Wind speed (m/sec)	
		aver	min	max	aver	aver	max
2013	January	15.1	7.8	40	71	0.1	2
	February	16.5	8.8	29.6	66	0.2	1.7
	March	19.2	8.5	30.9	55	0.3	2.2
	April	22.8	12.3	39.3	50	0.2	1.9
	May	26.3	16.5	42.7	46	0.3	2.3
	June	28.6	19.2	43.4	49	0.3	2.3
	July	29.1	22.5	40.6	57	0.2	2.6
	August	29.9	23.7	39.6	58	0.2	1.4
	September	28.4	19	40.6	55	0.2	1.6
	October	24.3	15.6	34.9	58	0.1	2
	November	19.7	10.7	30.5	64	0.1	1.9
	December	16.7	6.2	30.2	65	0.1	1.5
2014	January	13.8	3.7	28.7	56	0.2	2.8
	February	14.9	5.5	29.9	55	0.3	2.9
	March	18.8	10.2	35.7	57	0.2	2.2
	April	20.9	10.8	38	49	0.3	2.5
	May	25.7	16.5	44.1	49	0.3	2.4
	June	27.1	18.7	39.9	52	0.2	2.6
	July	29.3	21.8	40.8	55	0.2	1.4
	August	31.3	23.9	43.9	55	0.2	1.4
	September	30.2	22.2	39.3	53	0.2	1.4
	October	25.8	13.9	36.9	60	0.1	2
	November	20.6	12.8	30.2	72	0.1	1.3
	December	15.5	7.2	23.5	74	0.1	1.7

Central Laboratory for Agricultural Climate (CLAC) (2013 and 2014).

Complete randomized block design with three replicates per treatment (one tree as a replicate) was adapted in this study experimental methods.

POLLINATION TREATMENTS

The following pollination treatments were investigated:

T1- Open pollination (Control)

T2- Self pollination

T3- Emasculation and bagging

T4- Cross – pollination with Succary orange pollen grains

T5- Cross – pollination with Balady mandarin pollen grains

T6- Cross – pollination with March grapefruit pollen grains

T7-Cross – pollination with Balady orange pollen grains

MAJOR POINTS OF INVESTIGATION

This investigation is considered a simple experiment consisted of one citrus cultivar (shaddock) and seven pollination treatments arranged in a complete randomized design. Each treatment was represented by three replicates and each replicate include one tree. As for hand pollination the method described by [8] and [9] was used. All tested treatments, which conducted on each selected tree, were started on 25th of March and ended on 17th of April in both seasons of study. Moreover, all opened flowers as well as too young flower buds were removed periodically, then the nearly matured unopened flowers at the balloon stage (few hours before opening) were emasculated by removing stamens and immediately pollinated and covered with paper bag. Pollen grains collection was done according to the method described by [10]. Hence, a considerable number of flowers at balloon stage were collected from the pollinizer trees before dehiscence of the anthers. The different pollen grains used in hand pollination treatments were Succary orange, Balady mandarin, March grapefruit and Balady orange pollen grains. The flowers were then rubbed by hand over a screen in order to strip the anthers from the filaments and to allow them to fall through the mesh on a clean black sheet of paper. The anthers to be dried were spread out in a shallow layer and the sheets were placed in a warm dry place. After 24 hours, the anthers dehisced pollens and the pollen grains were gathered and put in tubes. Pollens were applied to pollinate the stigmas of the emasculated flowers at balloon stage with a sterilized fine brush. Pollinated flowers were bagged with paper bags to protect them from strange pollens. After the stigmas of the treated flowers had turned to brown colour, the paper bags were removed. Open pollination treatment was done by labelling enough number of flowers at the balloon stage on each tree to be normally pollinated and fertilized without any bagging or artificial pollination. Hand self-pollination treatment was done by bagging the flowers at the balloon stage and before opening up to about 10 days after the end of blooming period to avoid any cross-pollination. The number of treated flowers in each treatment was counted and recorded. Furthermore, the number of fruits in each treatment was counted periodically at 30 day intervals till the time of harvesting and recorded. The response of the four tested cultivars to pollination treatments was handled as follows:

2.1 FRUIT SET AND FRUIT DROP

2.1.1 FRUIT SET PERCENTAGE

After the stigmas of the treated flowers turned to the brown color the paper bags were removed and fruit set was determined by counting the number of setting flowers (30 days after pollination) percentage of fruit set in each various treatments were calculated as follows:

$$\text{Fruit set \%} = \frac{\text{Number of fruits}}{\text{Number of flowers}} \times 100$$

2.1.2 Fruit drop percentage

Fruit drop percentage was determined at three periods as follows and the total fruit drop was calculated in three times (Before June drop, After June drop and pre-harvest drop).

$$\text{Fruit drop \%} = \frac{\text{No. of dropped fruit on a given date}}{\text{Average No. of open setting fruits}} \times 100$$

2.2 Fruit production and their physical characteristics

2.2.1 Retained fruit percentage

Mature fruits were collected during the period from middle of August. Till the first of September in the two seasons.

$$\text{Retained fruit \%} = \frac{\text{No. of retained fruits}}{\text{Average No. of open setting fruits}} \times 100$$

2.2.2 Fruit physical properties

2.2.2.1 Fruit dimensions

Height and width of each individual fruit were measured using a Vernier caliper and the averages were recorded in centimeters.

2.2.2.2 Fruit shape

Values of fruit shape were obtained by dividing the values of fruit height over fruit diameter

$$\text{Fruit shape index} = \frac{\text{Fruit height}}{\text{Fruit diameter}} \times 100$$

2.2.2.3 Fruit weight

Average fruit weight was calculated in gram

2.2.2.4 Fruit size

It was determined by water displacement method

2.2.2.5 Pulp and seed weights

The average weight of the pulp and seed were determined for all fruit samples and were recorded in grams

2.2.2.6 pulp/seed ratio

Values were calculated by dividing the weight of the pulp over the weight of the seed.

2.3 Self-incompatibility index (%)

$$\text{Self-incompatibility index} = \frac{\text{Fruit set by self-pollination}}{\text{Fruit set by cross-pollination}}$$

Self-incompatibility index categories by [11] are presented in Table 2.

TABLE 2. SELF-INCOMPATIBILITY INDEX CATEGORIES.

Self-incompatibility index	State
0	Completely self-incompatible
< 0.2	Severely self-incompatible
0.2 ≤≤ 1	Relatively self-incompatible
≥ 1	Self-compatible

2.4 Fruit chemical properties

a- Total soluble solids (T.S.S) in fruit juice was determined using a hand refractometer.

b- Percentage of titratable acidity in fruit juice was determined according to [12].

c- Total soluble solids /acidity ratio (T.S.S/acidity) was also calculated.

d- Ascorbic acid was determined in fruit juice as mg/l00 ml juice according to [13].

2.5 Statistical analysis

All data obtained during both seasons included in this investigation was subjected to analysis of variance according to [14]. In addition, significant differences among means were differentiated according to the Duncan, multiple test range [15] where capital letters were used for distinguishing means of different treatments for each investigated characteristic.

3 RESULTS AND DISCUSSION

Effect of various pollination treatments on fruit set and fruit retained percentages of shaddock fruits during 2013 and 2014 seasons.

Number of fruits at setting time

Data in Table (3) showed a marked increase when cross pollination with Balady orange pollen grains were used in the two seasons. Followed in descending order when cross pollination with Succary orange pollen grains were used in the two seasons. The least values of number of fruits at setting time was recorded when emasculation and bagging were used.

Fruit set (%)

Data in Table (3) showed the effect of open, self and cross pollination on fruit set % during two seasons. It

cleared that the highest values of fruit set % were registered when cross pollination with Balady orange pollen grains were used in the two seasons. Followed in descending order when cross pollination with Succary orange pollen grains were used in the two seasons. The least values of fruit set (%) was recorded under self-pollination and emasculation and bagging were used.

FRUIT RETAINED PERCENTAGES

Data in Table (3) emphasized that fruit retained percentage were positively responded to the various pollinizer treatments during two seasons. However, the highest values of number of retained fruits and retained fruits (%) in all dates were registered when cross pollination with Balady orange pollen grains were used in both seasons. Followed in descending order by (T4) cross pollination with Succary orange pollen grains and (T5) cross pollination with Balady mandarin pollen grains. Then (T6) cross pollination with March grapefruit pollen grains then (T1) open pollination. While, less fruit retained percentages were noticed when self-pollination (T2) were used. Also, the least fruit retained percentages were obtained under Emasculation and bagging treatments (T3) which gave no fruit after June drop.

These results are confirmed by those obtained by [16], [17], [18], [19], [20] and [21] on citrus trees.

TABLE 3. EFFECT OF VARIOUS POLLINATORS ON NO. OF FRUITS AT SETTING TIME, FRUIT SET %, NO. OF RETAINED FRUITS BEFORE JUNE DROP, RETAINED FRUITS BEFORE JUNE DROP%, NO. OF RETAINED FRUITS AFTER JUNE DROP AND RETAINED FRUITS AFTER JUNE DROP% OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	No. of fruits at setting time		Fruit set %		No. of Retained fruits before June drop		Retained fruits before June drop%		No. of Retained fruits after June drop		Retained fruits after June drop%	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Open pollination (Control)	89.33 c	75.00 b	44.67 c	37.50 b	33.00 d	29.00 d	36.89 d	38.73 b	15.00 b	12.00 b	16.66 b	16.17 b
Self-pollination	60.67 e	60.00 c	30.33 e	30.00 c	10.00 e	7.00 d	11.22 e	9.30 c	5.00 c	4.33 c	5.62 c	5.79 c
Emasculation and bagging	24.00 f	17.33 d	12.00 f	8.67 d	1.67 f	1.33 f	1.83 f	1.73 c	0.00 d	0.00 d	0.00 d	0.00 d
Cross pollination with Succary orange pollen grains	97.67 b	89.33 a	48.83 b	44.67 a	55.33 c	48.33 c	61.92 c	64.50 a	15.67 b	11.67 b	17.56 b	15.54 b
Cross pollination with Balady Mandarin pollen grains	94.00 b	85.00 a	47.00 b	42.50 a	61.33 b	54.67 b	68.73 b	72.90 a	14.67 b	12.67 b	16.45 b	17.00 b
Cross pollination with March Grapefruit pollen grains	74.00 d	69.67 b	37.00 d	34.83 b	35.67 d	30.00 d	39.97 d	40.07 b	13.33 b	13.33 b	14.99 b	17.77 b
Cross pollination with Balady orange pollen grains	102.33 a	92.00a	51.17 a	46.00 a	66.00 a	58.67 a	73.88 a	69.43 a	22.33 a	18.33 a	25.08 a	24.43 a

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

EFFECT OF VARIOUS POLLINATION TREATMENTS ON SELF-INCOMPATIBILITY INDEX, MATURE FRUITS NUMBER AND PERCENTAGES AT HARVEST TIME AND FRUIT DROPPING % OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

SELF-INCOMPATIBILITY INDEX

With regard to the response of self-incompatibility index to the differential seven studied treatments during two seasons. Data obtained are presented in Table (4). In this regard, self-incompatibility index gave a different value with each pollination treatment. From the data it is obvious that open pollination had a self-incompatibility Index (0.679 and 0.804) in the two seasons, respectively and was identified as relatively self-incompatible according to [11].

Furthermore, Emasculation and bagging had a self-incompatibility index (2.566 and 3.470) in the two seasons, respectively and was identified as self-incompatible. Also, cross pollination with Succary orange pollen grains had a self-incompatibility index (0.621 and 0.674) in the two seasons, respectively, and was identified as relatively self-incompatible. Moreover, cross pollination with Balady mandarin pollen grains, or cross pollination with March grapefruit pollen grains or cross pollination with Balady orange had a self-incompatibility index (0.646 and 0.707), (0.822 and 0.862) and (0.593 and 0.654) in the two seasons, respectively, and were identified as relatively self-incompatible. Anyhow, the abovementioned data showed that open pollination and cross pollination had a self-incompatibility index in-between 0.2:1 in the two seasons and were identified as relatively self-incompatible.

The obtained results regarding self-incompatibility index of Clementine mandarin fruits were supported by the

findings of many investigators [22], [23], [16], [17], [18], [24], [25] and [21] on citrus trees.

MATURE FRUITS NUMBER AND PERCENTAGE

As shown in Table (4) there was a significant variation between the different pollination treatments on mature fruits (%) in the two seasons. It is evident that cross pollination with March grapefruit pollen grains (T6) gave the highest values of mature fruits number and percentage. Descendingly followed by cross pollination with Balady mandarin pollen grains (T5), cross pollination with Balady orange pollen grains (T7), cross pollination with Succary orange pollen grains (T4), open pollination (T1), self-pollination (T2) and emasculation and bagging (T3) which gave no fruits at harvest time.

FRUIT DROPPING

In regarding to the percentage of fruit dropping, data in Table (4) revealed almost the opposite trends as observed in mature fruits percentages in the two seasons. The obtained results regarding to mature fruits and dropping fruits (%) of shaddock fruits were supported by the findings of [26], [27] and [28] on citrus trees.

TABLE 4. EFFECT OF VARIOUS POLLINATORS ON SELF-INCOMPATIBILITY INDEX, NO. OF MATURE FRUITS AT HARVEST TIME, MATURE FRUITS AT HARVEST TIME% AND FRUIT DROPPING % OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	Self-incompatibility index		No. of Mature fruits at harvest time		Mature fruits at harvest time %		Fruit dropping %	
	2013	2014	2013	2014	2013	2014	2013	2014
Open pollination (Control)	0.68 b	0.80 bc	3.67 b	2.67 c	4.12 b	3.53 c	95.88 c	96.47 c
Self-pollination	0.00 c	0.00 d	1.67 c	1.33 d	1.85 c	1.77 d	98.15 b	98.23 b
Emasculation and bagging	2.57 a	3.47 a	0.00 d	0.00 e	0.00 c	0.00 e	100.0 a	100.0 a
Cross pollination with Succary orange pollen grains	0.62 b	0.67 bc	4.33 b	3.67 bc	4.87 b	4.90 b	95.13 c	95.10 d
Cross pollination with Balady Mandarin pollen grains	0.65 b	0.71 bc	6.33 a	5.67 a	6.10 ab	7.55 a	92.90 d	92.45 e
Cross pollination with March Grapefruit pollen grains	0.82 b	0.86 b	6.33 a	6.00 a	7.11 a	7.99 a	92.89 d	92.01 e
Cross pollination with Balady orange pollen grains	0.59 b	0.65 c	4.67 b	4.33 b	5.23 ab	5.76 b	94.77 c	94.24 d

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

EFFECT OF VARIOUS POLLINATION TREATMENTS ON FRUIT LENGTH, FRUIT DIAMETER AND FRUIT SHAPE INDEX.

It is quite evident as shown from tabulated data in Table (5) that, three measurements followed to great extent the same trend pertaining their response to the differential investigated pollination treatments. Herein, the open and cross pollination treatments showed no significance in fruit length, fruit diameter and fruit shape index variation when compared together in both seasons. These results are confirmed by those obtained by [29], [28], [30], [31], [32], [33], [34] and [19] on citrus trees.

TABLE 5. EFFECT OF VARIOUS POLLINATORS ON FRUIT LENGTH (CM), FRUIT DIAMETER (CM) AND FRUIT SHAPE INDEX OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	Fruit length (cm)		Fruit diameter (cm)		Fruit shape index	
	2013	2014	2013	2014	2013	2014
Open pollination (Control)	11.45 b	11.63 b	15.07 ab	15.58 b	0.76 d	0.75 c
Self-pollination	13.07 b	12.62 a	15.57 a	16.52 a	0.84 c	0.83 b
Emasculation and bagging	0.00 c	0.00 c	0.00 c	0.00 d	0.00 e	0.00 d
Cross pollination with Succary orange pollen grains	11.47 b	11.73 b	13.77 ab	14.47 c	0.83 c	0.81 b
Cross pollination with Balady Mandarin pollen grains	12.93 a	13.47 a	14.87 ab	15.63 ab	0.87 b	0.86 ab
Cross pollination with March Grapefruit pollen grains	12.93 a	13.30 a	14.13 b	14.58 c	0.91 a	0.91 a
Cross pollination with Balady orange pollen grains	11.30 b	11.67 b	15.23 a	15.63 ab	0.74 d	0.75 c

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

EFFECT OF VARIOUS POLLINATION TREATMENTS ON FRUIT WEIGHT, FRUIT SIZE, SEEDS NUMBER/FRUIT AND NO. OF SEGMENTS/FRUIT OF SHADDOCK DURING 2013 AND 2014 SEASONS.

FRUIT WEIGHT AND FRUIT SIZE

Data obtained during both seasons are presented in Table (6) cleared that, cross pollination with Balady orange pollen grains gave the highest values of fruit weight and fruit size, followed by cross-pollination with March grapefruit pollen grains, open pollination and cross pollination with Balady mandarin pollen grains. While less fruit weight and fruit size values were noticed when cross pollination with Succary orange pollen grains and self-pollination were used in the two seasons.

SEEDS NUMBER/FRUIT

As shown in Table (6) there was a significant variation between the different pollination treatments on number of seeds per fruit in the both seasons. It is evident that cross pollination with Balady mandarin pollen grains gave the highest number of seeds per fruit. Descendingly followed by cross pollination with Balady orange pollen grains, cross pollination with March grapefruit pollen grains, Succary orange pollen grains and open pollination. Herein, the least value of number of seeds per fruit were recorded when self-pollination was used in the two seasons.

NO. OF SEGMENTS/FRUIT

It is quite evident as shown from tabulated data in Table (6) that, three measurements followed to great extent the same trend pertaining their response to the differential investigated pollination treatments. Herein, the open and cross pollination treatments showed no significance in fruit length, fruit diameter and fruit shape index variation when compared together in both seasons.

TABLE 6. EFFECT OF VARIOUS POLLINATORS ON FRUIT WEIGHT (G), FRUIT SIZE (CM3), SEEDS NUMBER/FRUIT AND NO. OF SEGMENTS/FRUIT OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	Fruit weight (g)		Fruit size (cm3)		Seeds number / fruit		No. of segments / fruit	
	2013	2014	2013	2014	2013	2014	2013	2014
Open pollination (Control)	903.7 b	930.0 b	914.3 b	963.3 b	54.67 e	57.33 d	17.67 ab	17.33 b
Self-pollination	853.3 c	880.0 c	867.0 c	895.0 c	45.33 f	49.33 e	18.67 a	19.00 a
Emasculation and bagging	0.00 f	0.00 f	0.00 f	0.00 e	0.00 g	0.00 f	0.00 d	0.00 e
Cross pollination with Succary orange pollen grains	625.7 e	670.0 e	632.3 e	688.7 d	59.67 d	65.00 c	15.67 c	16.00 c
Cross pollination with Balady Mandarin pollen grains	815.7 d	842.3 d	833.0 d	866.7 c	120.33 a	100.33 a	15.67 c	15.67 cd
Cross pollination with March Grapefruit pollen grains	991.7 a	1023.3 a	1009.0 a	1054.3 a	78.67 c	80.33 b	14.67 c	15.00 d
Cross pollination with Balady orange pollen grains	999.7 a	1017.7 a	1016.0 a	1038.3 a	99.67 b	96.00 a	17.00 b	17.67 b

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

EFFECT OF VARIOUS POLLINATION TREATMENTS ON PULP WEIGHT, PEEL WEIGHT AND PULP/PEEL RATIO OF SHADDOCK DURING 2013 AND 2014 SEASONS

PULP WEIGHT

Data obtained during both seasons are presented in Table (7) displayed that, cross pollination with March grapefruit pollen grains gave the highest values of pulp weight, followed by cross-pollination with Balady orange pollen grains, open pollination, cross pollination with Balady mandarin pollen grains, self-pollination and cross pollination with Succary orange pollen grains in the two seasons.

PEEL WEIGHT AND PULP/PEEL RATIO

In regards to the peel weight and pulp / peel ratio, data in Table (7) revealed different trend as observed in pulp weight in the two seasons. Herein, the highest values of peel weight were registered when self-pollination were used in the two seasons. Also it showed a marked increase when cross-pollination with Balady orange pollen grains and Balady mandarin pollen grains were used in both seasons. While the least values of peel weight were noted when cross-pollination with March grapefruit pollen grains and cross-pollination with Succary orange pollen grains were used. In regards to pulp / peel ratio, data in Table (13) revealed almost the same trends as observed in pulp weight in the two seasons. The obtained results regarding pulp weight, peel weight and pulp / peel ratio of shaddock fruits were supported by the findings of many investigators [26], [27] and [28] on citrus trees.

EFFECT OF VARIOUS POLLINATION TREATMENTS ON PEEL THICKNESS, JUICE WEIGHT (GM) AND JUICE PERCENTAGE OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

PEEL THICKNESS

Table (8) reveals that the response of shaddock fruits to some pollination treatments (open, self and cross pollinations) showed a significant increase in peel thickness. Herein, cross pollination with Balady mandarin pollen grains gave the highest value of peel thickness. Descendingly followed by cross-pollination with March grapefruit pollen grains, cross pollination with Balady orange pollen grains, open pollination, cross pollination with Succary orange pollen grains and self-pollination. These results are in agreement with those obtained by [30], [31], [32], [33] and [19] on citrus trees.

TABLE 7. EFFECT OF VARIOUS POLLINATORS ON PULP WEIGHT (G), PEEL WEIGHT (G) AND PULP/PEEL RATIO OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	Pulp weight (g)		Peel weight (g)		Pulp / peel ratio	
	2013	2014	2013	2014	2013	2014
Open pollination (Control)	655.3 c	680.7 c	248.3 b	249.3 b	2.64 c	2.73 bc
Self-pollination	565.7 e	601.3 d	287.7 a	278.7 a	1.97 e	2.16 c
Emasculation and bagging	0.00 g	0.00 f	0.00 f	0.00 d	0.00 f	0.00 d
Cross pollination with Succary orange pollen grains	448.2 f	488.3 e	177.5 e	181.7 c	2.53 d	2.69 bc
Cross pollination with Balady Mandarin pollen grains	586.7 d	607.3 d	229.0 c	235.0 b	2.56 cd	2.95 b
Cross pollination with March Grapefruit pollen grains	799.0 a	832.3 a	192.7 d	191.0 c	4.15 a	4.37 a
Cross pollination with Balady orange pollen grains	750.0 b	765.7 b	249.7 b	252.0 b	3.00 b	3.04 b

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

TABLE 8. EFFECT OF VARIOUS POLLINIZERS ON PEEL THICKNESS (MM), JUICE WEIGHT (G) AND JUICE% OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Type of pollination	Peel thickness (mm)		Juice weight (g)		Juice%	
	2013	2014	2013	2014	2013	2014
Open pollination (Control)	1.58 b	1.50 c	100.7 e	107.3 e	11.13 e	11.55 f
Self-pollination	1.10 c	1.12 d	125.0 d	129.3 d	14.65 c	14.70 d
Emasculation and bagging	0.00 d	0.00 e	0.00 f	0.00 f	0.00 f	0.00 g
Cross pollination with Succary orange pollen grains	1.19 c	1.18 d	135.3 c	130.7 d	21.61 a	19.53 b
Cross pollination with Balady Mandarin pollen grains	1.75 a	1.73 a	159.7 b	165.7 b	19.58 b	19.25 c
Cross pollination with March Grapefruit pollen grains	1.67 ab	1.68 ab	129.0 cd	137.0 c	13.01 d	13.39 e
Cross pollination with Balady orange pollen grains	1.67 ab	1.62 b	197.0 a	203.0 a	19.71 b	19.95 a

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

JUICE WEIGHT (GM) AND JUICE PERCENTAGE (%)

Data in Table (8) showed the effect of open, self and cross pollination on Juice weight and juice percentage. As shown in Table (8), it is evident that cross pollination with Balady orange pollen grains gave the highest values of Juice weight and juice % in the two seasons. Whereas, cross pollination with Balady mandarin pollen grains came in the second rank. On the other hand, the less values of juice weight and juice percentage were recorded when open pollination was used. The obtained results regarding juice weight and juice percentage of shaddock fruits were supported by the findings of many investigators [32], [33], [34] and [19] on citrus trees.

EFFECT OF VARIOUS POLLINATION TREATMENTS ON SOME CHEMICAL FRUIT PROPERTIES OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS.

Total soluble solids (TSS %), tetratable acidity, TSS / Acidity ratio and vitamin C were the investigated chemical properties in response to various pollinizers. Data obtained during two seasons are presented in Table (9) which illustrated the effect of some pollination treatments on chemical properties. It is quite clear that, pollination treatments had an obvious effect on enhance the fruit chemical properties. Whereas, self-pollination seemed to be the most effective treatment for inducing the highest values of total soluble solids percentage and then TSS / Acid ratio, followed in a descending order by cross pollination with Balady mandarin pollen grains in both seasons. While cross pollination with March grapefruit recorded the lowest values of these concerns in both seasons. While, there were a significant effects of different treatments on fruit content of total acidity in both seasons. Herein, cross pollination with Balady orange pollen grains gave the highest values in this concern in both seasons. Followed by cross pollination with Balady mandarin pollen grains. However, other treatments came in between in both seasons of the study. In addition, vitamin C values varied with the pollination treatments. Data obtained during both seasons are presented in Table (9) which displayed that, cross pollination with Balady orange pollen grains gave the highest value of vitamin C. anyhow, it could be obviously concluded that the response was more pronounced and increases were significant when cross pollination with Balady mandarin pollen grains and cross pollination with March grapefruit pollen grains were used.

On the other hand, the least values of vitamin C were recorded when cross pollination with Succary orange pollen grains and self-pollination were used. These results are in agreement with those obtained by [32], [33], [34] and [19] on citrus trees.

TABLE 9. EFFECT OF VARIOUS POLLINATORS ON TETRATABLE ACIDITY, T.S.S., T.S.S./ACIDITY RATIO AND VITAMIN C OF SHADDOCK FRUITS DURING 2013 AND 2014 SEASONS

Type of pollination	Tetratable acidity		T.S.S.		T.S.S. / Acidity ratio		Vitamin C	
	2013	2014	2013	2014	2013	2014	2013	2014
Open pollination (Control)	2.40 c	2.31 c	16.22 bc	16.94 a	6.75 c	7.32 ab	70.36 c	70.17 d
Self-pollination	2.31 d	2.24 de	17.05 a	16.92 a	7.38 a	7.55 a	69.80 c	70.01 e
Emasculation and bagging	0.00 f	0.00 f	0.00 d	0.00 c	0.00 f	0.00 e	0.00 e	0.00 g
Cross pollination with Succary orange pollen grains	2.27 de	2.26 d	16.38 b	16.31 b	7.21 ab	7.23 b	69.00 d	68.15 f
Cross pollination with Balady Mandarin pollen grains	2.71 b	2.61 b	17.00 a	16.80 a	6.27 d	6.45 c	73.40 a	72.96 b
Cross pollination with March Grapefruit pollen grains	2.25 e	2.20 e	16.10 c	16.17 b	7.16 b	7.36 ab	71.36 b	71.85 c
Cross pollination with Balady orange pollen grains	2.92 a	2.90 a	16.17 bc	16.31 b	5.55 e	5.62 d	73.88 a	74.01 a

Means followed by the same letter (s) within each column during each season are not significantly different at 5% level by probability

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