Effect of Various Pollinizers on Fruit Set and Some Fruit Properties of Koronaki Olive Cultivar

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Abstract-The present investigation was conducted during two successive, (2014) and (2015) seasons, on Koronaki olive trees of about 15 years old. The trees have been grown in a private farm at Nasr-city, Cairo, Egypt. 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 and the soil at the experimental orchard was classified as sandy in texture. This study aimed to investigate the suitable pollinizers for Koronaki olive cultivar in effort to increase their production efficiency. Through study the effect of open, self and cross-pollinations by Kalamata pollen grains, Picual pollen grains and Manzanillo pollen grains. Results cleared that cross pollination increase some fruit characteristics such as fruit set %, fruit retention, fruit weight, fruit size, seed weight, pulp weight and oil percentage of Koronaki olive cultivar compared with self-pollination and this increase may be attributed to the effect of cross-pollination in reduce the aborted seed and increase the percent of double seeds fruits. Furthermore, open pollination gave a good resulting increasing the production efficiency of Koronaki olive trees. Which was a wind-pollinated species and generally considered to be self-incompatible also cross-incompatibility exists between some cultivars.

Keywords-Koronaki olive, self-incompatibility, fruit set %, Picual pollen grains and oil percentage.

1 INTRODUCTION

THE olive tree (*Olea europaea* L.) Family Oleaceae, is a widely distributed tree grown in many arid areas of the world, Olive cultivation plays an important role in the economy of many countries in the Mediterranean basin, it is not only increase the land value where the soil is unsuitable for other crops, but also contributes to soil conservation and helps to overcome environmental problems [1].

Olive trees were cultivated in Egypt thousands years ago, according to statistics of [2], the cultivated area in Egypt increased rapidly from 6000 feddan in 1960 to 146934 feddan in 2013, this increase is due to the high stress tolerance of olive. The most important cultivars in Egypt are: Chemlali, Agaizi, Toffahi, Balady, Molouky, Mission, Manzanillo, Arbqueen, Leccino, Picual, Koronaki and Kalamata.

Olive is a wind-pollinated species and generally considered to be self-incompatible also cross-incompatibility exists between some cultivars. Since, most olive cultivars are self-incompatible, fruit set may be very low when a self-incompatible cultivar is grown in an isolated area without suitable pollinizers.

In addition, a beneficial effect of cross pollination has been demonstrated in various olive cultivars, so it is necessary to add the proper pollinizer to ensure maximum fruit production with a good quality. However, the choice of the pollinator is based on our knowledge of its capacity to fertilize the variety that has to be pollinated [3]

This study aimed to investigate the pollination requirements and the suitable pollinizers for Koronaki olive cultivar in effort to increase their fruit production and oil quality.

2 MATERIALS AND METHODS

The present investigation was conducted during two successive seasons 2014 and 2015 on Koronaki olive trees of about 15 years old. The trees have been grown in a private farm at Nasr- City, Cairo, Egypt. All the trees in this investigation were similar in growth, healthy, apparently free from disease and the trees were planted at 5x5 meters apart. All the trees received the recommended amount of fertilizers and irrigation water and the soil at the experimental orchard was classified as sandy 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)

The randomized complete block design with three replicates per treatment (one tree replicate) was adopted in this study.

POLLINATION TREATMENTS

The following pollination combinations were investigated:

1- Open pollination

2- Bagging only

3- Emasculation and bagging

4- Cross-pollination with Kalamata pollen grains

5- Cross-pollination with Picual pollen grains

6- Cross-pollination with Manzanello pollen grains

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TABLE 1. THE MAIN AIR TEMPERATURE, RELATIVE HUMIDITY AND WIND SPEED IN 2014 AND 2015 IN CAIRO.

Year	Months	Air Temperature [°C]			Relative Humidity [%]	Wind speed [m/sec]	
		Aver.	Min.	Max.	Aver.	Aver.	Max.
2014	January	15	1.7	25.6	72	0.3	2.6
	February	16.4	6.4	29.9	67	0.5	2.4
	March	19	6.8	33.1	55	0.6	2.6
	April	22.8	12.7	38.1	49	0.7	2.9
	May	26.1	14.4	43	46	0.7	2.6
	June	28.5	18.5	43.8	48	0.8	2.8
	July	29.1	22.3	40	56	0.7	2.6
	August	29.9	23.1	39.2	56	0.6	2.5
	September	28.5	18.2	40.8	53	0.6	2.4
	October	24.2	14.1	35.9	57	0.4	2.9
	November	19.6	9.9	31.6	65	0.3	2.2
	December	16.5	5.8	30.5	67	0.3	2.3
2015	January	13.6	3.6	27.2	57	0.5	3.3
	February	14.8	5.4	30.6	56	0.5	3.5
	March	18.9	8.4	36.8	56	0.7	3.2
	April	20.8	9.8	38.8	48	0.8	3.3
	May	25.7	16.7	44.3	48	0.8	3.4
	June	26.9	19.1	39.3	52	0.8	2.9
	July	29	21.7	38.9	55	0.8	2.6
	August	31.4	24	43.5	52	0.8	2.9
	September	30	21.3	38.4	52	0.8	2.6
	October	25.7	13.1	35.3	59	0.6	2.8
	November	20.8	12.1	28.3	65	0.4	4.3
	December	15.6	7	22.8	68	0.4	3

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

PROCEDURE OF COLLECTING POLLEN GRAINS FROM DIFFERENT POLLINIZERS

Flowers from each olive paternal tree were collected at the bloom stage and were kept on paper sheets for a night, at normal room temperature, to encourage anthers dehiscence to pollinate the emasculated maternal flowers.

PROCEDURE OF POLLINATION

At the commencement of flowering time (when 5-100) of terminal buds reached the burst stage), several branches were selected and labeled, around the maternal trees "Koronaki trees" and great attention was paid, for the selection of flowers at about the similar stage of development and when the stigmas were at the optimum receptive stage. The flowers chosen for cross- pollination were manually emasculated using hand forceps at the bloom- stage and each flower was enclosed by pergamint bags to prevent insect pollination.

Fruit production and their physical characteristics:

2.1 FRUIT SET DETERMINATIONS

After the stigmas of the treated flowers turned to the brown in color the protected bags were removed and fruit set was determined by counting the number of setting flowers (15 days after pollination). Percentage of fruit set in each treatment was calculated as follows:

$$\text{Fruit set \%} = \frac{\text{Number of fruits}}{\text{Number of flowers}} \text{X100}$$

2.2 HARVEST OF MATURE FRUITS

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

$$\text{Retained fruit \%} = \frac{\text{No. of retained fruits}}{\text{No. of open setting fruits}} \text{X100}$$

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 [4] are presented in Table 2.

2.4 FRUIT QUALITY

2.4.1 FRUIT DIMENSIONS

Length and diameter of each individual fruit were measured using a Vernier Caliper and the averages were recorded in centimeters.

2.4.2 FRUIT SHAPE INDEX

Values of fruit shape index were estimated by dividing the values of fruit length over fruit diameter

2.4.3 FRUIT WEIGHT

Average fruit weight was calculated in gram.

2.4.4 FRUIT VOLUME

It was determined by water displacement method.

2.4.5 PULP AND STONE WEIGHTS

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

2.4.6 PULP/SEED RATIO

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

2.4.7 FRUIT OIL PERCENTAGE

Fruit oil content was determined by means of the Soxhlett fat extraction apparatus using Hexan of 60-80o C boiling point as described by [5].

OIL EXTRACTION

Oil was extracted from the samples using chloroform: methanol mixture (2:1, v/v) according to the method described by [6]. The extracts were centrifuged to remove insoluble material and evaporated to dryness on rotary evaporator. The extracted oil was kept in brown glass bottles at 4o °C until analysis.

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

STATISTICAL ANALYSIS

The data were subjected to analysis of variance and Duncan's multiple range test was used to differentiate means at 5% [7].

3 RESULTS AND DISCUSSION

Effect of some pollinizers treatments on No. of fruits at setting time, fruit set %, No. of fruits at harvest time and fruit retained percentages of Koronaki olive fruits during 2013 and 2014 seasons.

3.1 NUMBER OF FRUITS AT SETTING TIME

Data in Table (3) showed the effect of open, self and cross pollinations on No. of fruits at setting time of Koronaki olive fruits during 2013 and 2014 seasons. It is showed a marked increase when cross pollination with Picual pollen grains were used which gave (33 and 31) in the two seasons, respectively, followed in descending order when cross pollination with Manzanello pollen grains were used in the two seasons. The less values of No. of fruits at setting time (7.0 and 6.67) was recorded when self-pollination were used in the two seasons, respectively. The least values of No. of fruits at setting time (4.33 and 3.33) was recorded when emasculation and bagging were used in the two seasons, respectively.

3.2 FRUIT SET (%)

Data in Table (3) showed the effect of open, self and cross pollinations on fruit set % of Koronaki olive fruits during 2013 and 2014 seasons. It is showed a marked increase when cross pollination with Picual pollen grains were used which gave (16.5% and 15.67%) in the two seasons, respectively, followed in descending order when cross pollination with Manzanello pollen grains were used (14.5%and 15.0%) in the two seasons, respectively. The less values of No. of fruits at setting time (3.50% and 3.33%) was recorded when self-pollination were used in the two seasons, respectively. The least values of No. of fruits at setting time (2.17% and 1.83) was recorded when emasculation and bagging were used in the two seasons, respectively.

3.3 NUMBER OF FRUITS AT HARVEST TIME

Data in Table (3) showed the effect of open, self and cross pollinations on No. of fruits at harvest time of Koronaki olive fruits during 2013 and 2014 seasons. It is showed a marked increase when cross pollination with Picual pollen grains were used which gave (14.67 and 14.67) in the two seasons, respectively, followed in descending order when open pollination with was used in the two seasons. The less values of No. of fruits at setting time (3.67 and 3.33) was recorded when self-pollination were used in the two seasons, respectively.

3.4 FRUIT RETAINED PERCENTAGES

Data in Table (3) emphasized that fruit retained percentage were positively responded to the various pollinizers treatments during two seasons. However, the highest values of fruit retained (%) were registered when cross pollination with Picual pollen grains were used in the both seasons. Followed in descending order by (T6) cross pollination with Manzanello pollen grains, (T1) open pollination and (T4) cross pollination with Kalamata pollen grains. 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). These results are confirmed by those obtained by [8], [9] and [10] on olive trees.

EFFECT OF VARIOUS POLLINIZERS ON FRUIT LENGTH (CM), FRUIT DIAMETER (CM) AND FRUIT SHAPE INDEX OF KORONAKI OLIVE FRUITS DURING 2013 AND 2014 SEASONS

Data in Table (4) showed the effect of open, self and cross pollination on fruit length, fruit diameter and fruit shape index of Koronaki olive cultivar during two season.

Data in table (4) emphasized that fruit length, fruit diameter and fruit shape index were positively responded to the various pollinizers treatments during the two seasons. However, the highest values of these parameters were registered when cross pollination with Kalamata pollen grains were used. Followed in descending order when Picual pollen grains and open pollination pollen were used in both seasons. The least values of these parameters were recorded when self- pollination were used especially when emasculation and bagging were used. Additionally, when Picual pollen grains were used gave high significant increments in the most cases in the both seasons.

The effect of pollen donor on fruit and seed characteristics (Xenia) are known phenomenon to occur in several fruit species like Pistachio [11], apple [12], almond [13] and pear by [14],

TABLE (3) EFFECT OF VARIOUS POLLINIZERS ON NO. OF FRUITS AT SETTING TIME, FRUIT SET %, NO. OF FRUITS AT HARVEST TIME AND RETAINED FRUITS % OF KORONAKI OLIVE FRUITS DURING 2014 AND 2015 SEASONS

Type of pollination	No. of fruits at setting time		Fruit set %		No. of fruits at harvest time		Retained fruits %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T1:open pollination	25.0 c	24.67 B	12.50 c	12.33 b	14.67 a	13.67 a	40.58 ab	46.83 a
T2: Bagging only	7.00 d	6.66 c	3.50 d	3.33 c	3.67 c	3.33 d	11.06 d	10.75 d
T3:Emasculation and bagging	4.33 e	3.33 d	2.17 e	1.83 d	0.00 d	0.00 e	0.00 e	0.00 e
T4: cross pollination with Kalamata pollen grains	27.33 bc	28.67 a	12.50 bc	12.33 b	11.00 b	12.33 b	29.41 c	32.12 c
T5: cross pollination with Picual ollen grains	33.00 a	31.00 a	16.50 a	15.67 a	14.67 a	14.67 a	44.70 a	46.83 a
T6: cross pollination with Manzanello pollen grains	29.00 b	30.00 a	14.00 b	15.00 a	9.67 b	10.00 c	33.60 bc	39.56 b

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

Xenia is defined as the effect of pollen genotype on the development, and characteristics of the fruit, it can affect pericarp, endosperm, and embryo weight, also seed and fruit shape, color, chemical composition and maturity time. the term Metaxenia was used previously to describe the direct effect of pollen grains on fruit tissues but later [15] mentioned that "Xenia including Metaxenia". Moreover, such phenomena may have agronomic importance for fruit production. However, the occurrence of this phenomenon differed between species.

These results are confirmed by those obtained by [9], [10], [16] on olive trees and [13] on pear trees.

EFFECT OF VARIOUS POLLINIZERS ON SELF-INCOMPATIBILITY INDEX, FRUIT WEIGHT AND FRUIT SIZE OF KORONAKI OLIVES FRUITS DURING 2014 AND 2015 SEASONS

3.5 SELF-INCOMPATIBILITY INDEX

Data in Table (5) showed the effect of open, self and cross pollination on self-incompatibility index of Koronaki olive cultivar during two season. From the data it is obvious that open pollination had a self-incompatibility index 0.267 and 0.275 in the two both seasons, respectively and was identified as relatively self-incompatibility. Also, cross pollination with Kalamata, Picual and Manzanello pollen grains gave the same trends as observed in open pollination in the two seasons.

TABLE (4) EFFECT OF VARIOUS POLLINIZERS ON FRUIT LENGTH(CM), FRUIT DIAMETER (CM) AND FRUIT SHAPE INDEX OF KORONAKI OLIVES FRUITS DURING 2014 AND 2015 SEASONS

Type of pollination	Fruit length (cm)		Fruit diameter (cm)		Fruit shape index	
	1st	2nd	1st	2nd	1st	2nd
T1: open pollination	1.76 b	1.77 b	1.16 a	1.12 a	1.59 c	1.18 a
T2: Bagging only	1.72 c	1.68 d	0.81 c	0.99 d	1.80 a	1.69 a
T3: Emasculation and Bagging	0.00 d	0.00 e	0.00 d	0.00 e	0.00 d	0.00 b
T4: cross pollination with Kalamata pollen grains	1.78 ab	1.78 b	1.06 b	1.07 b	1.67 b	1.68 a
T5: cross pollination with Picual pollen grains	1.78 a	1.81 a	1.10 a	1.12 a	1.62 bc	1.67 a
T6: cross pollination with Manzanello pollen grains	1.73 c	1.73 c	1.04 b	1.03 c	1.65 b	1.64 a

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

Results showed that cultivars Kalamata, Picual and Manzanello behaved as relatively self-incompatible. The olive is a wind-pollinated species, however, self-incompatibility has been reported in many cultivars including Koronaki which is one of the most important cultivars for oil production in the world. The obtained results regarding self- incompatibility index of Picual olives cultivar are in agreement with the findings of many investigators [17], [18] and [16]

3.6 FRUIT WEIGHT AND FRUIT SIZE

As shown in Table (5) there was a significant variation between the different pollination treatments on fruit weight and fruit size in the both seasons.

It is evident that cross pollination with Kalamata pollen grains gave the highest values of fruit weight and fruit size followed by open pollination and cross pollination with Manzanella pollen grains, low fruit weight and fruit size values were noticed when Picual pollen grains were used. While, the lowest fruit weight and fruit size values were obtained under self- pollination and emasculation and bagging.

These results are confirmed by those obtained by [19], [20] and [21] on olive trees.

TABLE (5) EFFECT OF VARIOUS POLLINIZERS ON SELF-INCOMPATIBILITY INDEX, FRUIT WEIGHT (G) AND FRUIT SIZE (CM3) OF KORONAKI OLIVES FRUITS DURING 2014 AND 2015 SEASONS

Type of pollination	Self-incompatibility index		Fruit weight (g)		Fruit size (cm3)	
	1st	2nd	1st	2nd	1st	2nd
T1: open pollination	0.267 b	0.275 b	1.36 a	1.36 a	1.30 a	1.31 a
T2: Bagging only	0.000 c	0.000 b	1.01 e	1.01 c	0.98 c	0.98 c
T3: Emasculation and Bagging	1.600 a	2.000 a	0.00 f	0.00 d	0.00 d	0.00 d
T4: cross pollination with Kalamata pollen grains	0.308 b	0.296 b	1.28 c	1.25 b	1.23 b	1.22 b
T5: cross pollination with Picual pollen grains	0.333 b	0.333 b	1.38 b	1.38 a	1.33 a	1.33 a
T6: cross pollination with Manzanello pollen grains	0.286 b	0.275 b	1.25 d	1.27 b	1.21 b	1.23 b

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

3.7 EFFECT OF VARIOUS POLLINIZERS ON SEED WEIGHT, PULP WEIGHT AND PULP/SEED RATIO OF KORONAKI OLIVES FRUITS DURING 2014 AND 2015 SEASONS

Data in Table (6) showed the effect of self, open and cross pollination on seed weight, pulp weight and pulp/seed ratio of Koronaki olive fruits during two seasons. As shown in Table (6) Koronaki cv. produced no fruits with Emasculation and bagging treatment. There was a slight effect of different pollination treatments on these characteristics of Koronaki olive fruits.

It is evident that cross pollination with Kalamata pollen grains gave the highest values of seed weight and pulp weight in the both seasons. Followed by open pollination, but cross pollination with Manzanello pollen grains and Picual pollen grains came in the Middle. The lowest pulp weight and seed weight values were noticed when self-pollination was used in the two seasons. These results are in agreement with [22] who reported that open and cross pollination improved fruit characteristics compared with self-pollination and the effect of cross-pollination differed according to the used pollinizer, but in general it was better than self-pollination.

Data in Table (6) emphasized that pulp/seed ratio positively responded to the various pollinizer treatments during the two seasons. However, the highest values of pulp/seed ratio were registered when cross pollination with Manzanello pollen grains and Picual pollen grains were used, followed in descending order when Kalamata pollen grains and open pollination were used. The lowest values of pulp/seed ratio were recorded when self-pollination was used.

These results are confirmed by those obtained by [19] who found that the average seed weight, pulp weight and pulp/seed ratio were significantly higher under open pollination than under self-pollination.

TABLE (6) EFFECT OF VARIOUS POLLINIZERS ON SEED WEIGHT (G), PULP WEIGHT (G) AND PULP/SEED RATIO OF KORONAKI OLIVE FRUITS DURING 2014 AND 2015 SEASONS

Type of pollination	Seed weight (g)		pulp weight (g)		Pulp/seed ratio	
	1st	2nd	1st	2nd	1st	2nd
T1: open pollination	0.37 a	0.33 a	1.00 a	1.05 a	2.68 b	3.15 ab
T2: Bagging only	0.27 d	0.25 c	0.74 c	0.75 c	2.76 b	2.95 b
T3: Emasculation and bagging	0.00 e	0.00 d	0.00 d	0.00 d	0.00 c	0.00 c
T4: cross pollination with Kalamata pollen grains	0.30 bc	0.30 b	0.97 b	0.95 b	3.19 a	3.13 ab
T5: cross pollination with Picual pollen grains	0.31 b	0.31 b	1.00 a	1.05 a	3.18 a	3.37 a
T6: cross pollination with Manzanello pollen grains	0.29 c	0.30 b	0.95 b	0.96 b	3.23 a	3.14 ab

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

[20] found that cross pollination increased some fruit characteristics of olive cultivars compared with self-pollination and this increase may be attributed to the effect of cross-pollination in reducing the aborted seed and increasing the percent of double seed fruits. On the contrary, [23] reported that fresh weight of self-pollinated Manzanillo fruits was 15% higher than that of cross pollination, and this increase may be attributed to the reduction in fruit set under self-pollination.

3.8 EFFECT OF SOME VARIOUS POLLINIZERS ON OIL % OF KORONAKI OLIVES FRUITS DURING 2014 AND 2015 SEASONS

Data in Table (7) showed the effect of open, self and cross pollinations on oil percentage of Koronaki olive fruits during two seasons. It showed a marked increase when using cross pollination with Picual pollen grains in the two seasons, followed in descending order when using cross-pollination with Manzanello pollen grains, open pollination and cross-pollination with Kalamata pollen grains. In other words, self-pollination was the inferior.

The obtained results regarding oil percentages of Koronaki olive fruits were supported by the findings of many investigators [22], [24] and [25] on olive trees.

TABLE (7) EFFECT OF VARIOUS POLLINIZERS ON OIL % (FRESH WEIGHT BASIS) AND OIL % (DRY WEIGHT BASIS) OF KORONAKI OLIVE FRUITS DURING 2014 AND 2015 SEASONS

Type of pollination	Oil % (fresh weight basis)		Oil % (dry weight basis)	
	1st	2nd	1st	2nd
T1: open pollination (Picual open)	22.13 c	23.32 b	52.50 c	53.64 b
T2: Bagging only	21.99 c	21.63 c	49.73 d	49.95 d
T3: Emasculation and Bagging	0.00 d	0.00 d	0.00 e	0.00 e
T4: cross pollination with Kalamata pollen grains	23.45 b	23.87 ab	52.48 c	50.61 c
T5: cross pollination with Picual pollen grains	25.02 a	24.18 a	59.21 a	59.10 a
T6: cross pollination with Manzanello pollen grains	22.93 bc	23.26 b	54.17 b	53.80 b

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

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