

## Flowering, Fruiting of Two Table Olive Cultivars “*Olea europaea* L.” Grown in Southern Egypt

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**O**LIVE is an evergreen tree that is well adapted to hot and dry climate, but requires specific chilling units for flowering. Olive is grown for table usage and oil production that is known for its organoleptic properties and health benefits. The area of olive production is increased in the new cultivated land such as in south Egypt. The present study is conducted to evaluate the flowering behavior and fruit characteristics of two table olive cultivars (cvs.) ‘Toffahi’ and ‘Aggizi’ that firstly grown in southern Egypt (Qena) during seasons 2016 and 2017. The growth season began early in February as the flowering bud appeared. There was variation in floral behavior between the studied cultivars. ‘Toffahi’ cv. had significantly longer flowering shoot with higher number of inflorescence (IFC) compared to ‘Aggizi’ cv. The IFC in the top and middle of the shoots were longer than that in the base in both cultivars, however, the flower number per IFC located in the shoot top and middle was higher in ‘Toffahi’ than ‘Aggizi’ cv. Despite that there were significant differences in flower number/ IFC and perfect flower percentage between ‘Toffahi’ and ‘Aggizi’, the fruit set percentage was not significant. Although the initial fruit number per shoot was higher in ‘Toffahi’ than ‘Aggizi’, the dropped fruits number was higher that making the final fruit number per shoot not significantly higher. The fruit characteristics such as: weight, size, length, width, flesh/stone ratio, moisture and oil contents were similar to the typical known for both cultivars.

Our results showed that both table olive cultivars ‘Toffahi’ and ‘Aggizi’ were able to adapt the new condition and maintained the regular floral behavior and good fruit characteristics, suggesting that these cultivars can successfully be grown under southern Egypt conditions.

**Keywords:** Flowering behavior, Inflorescence structure, Fruit set, Fruit characteristics.

### Introduction

Olive trees has been cultivated in the Mediterranean region for thousands years. Olive is considered as a strategic crop for the economy of most Mediterranean countries. Table olive and olive oil are the common and main components of the Mediterranean diet. Due to their organoleptic characteristics and medicinal values, olive consumption spread outside the Mediterranean region (Bertrand, 2002). Because of the increase in demand, cultivation areas need to be increased. However, the suitability of a region for olive cultivation must be evaluated to avoid the negative effect on the fruit production and oil quality (Tous & Romero, 1994 and Weiying et al., 1998).

Previous reports illustrated that various factors

such as seasonal ecological conditions, cultivar genetic makeup and agricultural practices had a substantial influence on the vegetative growth, flowering and fruiting of the trees as well as the oil production and quality (Martin et al., 2005). High temperatures during fruit growth led to slowing down several critical functions and thus reducing fruit size and causing fruit shriveling (Ahmed & Taha, 2018 and Lombardo et al., 2008). Flower bud induction and differentiation depends on many factors such as environmental conditions, hormonal balance and nutrition, while chilling during winter is required for flower bud opening (Fabbri and Benelli, 2000). The panicle structure, length and flower number varies among cultivars, trees and even shoots (Lavee et al., 2002 & Seifi et al., 2008). Insufficient chilling units and other environmental conditions of a region affect

the compatibility within olive cultivars (Connor & Fereres, 2005, Lavee et al., 2002, Martin et al., 2005 and Mookerjee et al., 2005).

Several olive cultivars are grown in the northern region of Egypt mainly for table usage and oil extraction. In Upper Egypt, olive is not common due to the harsh climate with warm winter and hot summer that is not expected to provide the thermal requirements for bud induction, flowering and acceptable fruit quality of different cultivars. Southern Egypt region presents olive on about 1% of the total olive area in Egypt. To increase the cultivated area, field trial is one of the effective ways for examining the suitability of this area to a specific olive cultivar that would lead to high economic returns for the grower. The present study is a field trial conducted in Qena governorate, Egypt. Qena has a climate that is very hot in summer and warm in winter. There is a wide range between day and night temperatures ( $\approx 16^{\circ}\text{C}$ ), and low precipitation is recorded. Therefore, this study aims to investigate the floral habits, the productivity and fruit quality of two table olive cultivars grown under Qena governorate to recommend their suitability under prevailing conditions.

### **Materials and Methods**

The present study was carried out at the research center of Horticulture Department, South Valley University, Qena, Egypt, during 2016 and 2017 seasons. Average of the monthly temperature through 2016, 2017 seasons was obtained from the meteorological stations located near the study area in Qena city. Chilling units of this region was calculated by summing of all hours below  $12^{\circ}\text{C}$  for the period from November to March of each season (2016 and 2017) according to Pérez López et al., 2008. Uniformity 5 trees of 7 years old were randomly selected from each table olive cultivar: 'Toffahi' and 'Aggizi' to evaluate the flowering and fruiting attributes as follows:

#### *Flowering attributes*

The date of all growth habits from floral bud swelling, inflorescence appearance, flower opening, fruit set, fruit color change until harvest, were recorded for each cultivars. All dates were recorded when about 10-15% of the phenomenon showed up on the trees.

Twenty of one year old flowering shoot were tagged to study their characteristics: the shoot  
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length, total number of buds, number of flower buds, number of inflorescences per shoot and the distribution of flower buds on each shoot. The inflorescences distribution on the shoot (Top, middle, base) and the inflorescence length, also flower number per inflorescence were recorded. Fifty inflorescences from each tree were tagged to observe the panicle main structure (shape, number of branches, number of flowers per branch, and total number of flowers per panicle) that found in each olive cultivar, according to Seifi et al., 2008. Another fifty panicles were tagged to determine the panicle length, flowers number, perfect flowers percentage (number of perfect flowers/total number of flowers %), initial fruit set percentage (number of fruits/total number of flowers), and the initial fruit number per panicle. Twenty shoots were tagged to record the initial fruits number per shoot and twenty days after that the final fruit number and the dropped fruit number per shoot were recorded.

#### *Fruiting*

At harvest, a group of 100 fruits from each tree were collected randomly to determine: fruit weight, length, width as well as stone and flesh weight. Fruits were oven dried at  $105^{\circ}\text{C}$  for 48 hrs to determine fruit moisture percentage, and the oil content based on the fruit dry weight by Soxhelt (A.O.A.C., 2000).

#### *Statistical analysis*

The experimental design of this study was the randomized complete blocks design. The mean values between cultivars in both seasons 2016 and 2017 were analyzed by T test at probability level of 5 % ( $P \leq 0.05$ ). Means comparisons for the flowers number and for the IFC length of different IFC positions for each cultivars were analyzed by LSD test at  $P \leq 0.05$  using PROC GLM procedure of Statistical Analysis System (SAS) version 9.2 for Windows, SAS Institute Inc., Cary, NC, USA (SAS®, 2009).

### **Results and Discussion**

Table 1 presented the average temperature for Qena Governorate during 2016 and 2017 seasons, the number of chilling hours below  $12^{\circ}\text{C}$  for this region was found to be 550 and 790 hr for the 2016 and 2017 seasons, respectively. In this study, results provide evaluation of flowering behavior and fruit characteristics for the two table olive cultivars 'Toffahi' and 'Aggizi' that firstly grown in southern Egypt (Qena governorate).

**TABLE 1. Monthly temperature for Qena Governorate during 2016 and 2017 seasons.**

	Season 2016		Season 2017		
	Max. (°C)	Min. (°C)	Max. (°C)	Min. (°C)	
Nov 2015	29.8	16.6	Nov 2016	29.6	15.7
Dec 2015	22.5	9.6	Dec 2016	21.4	8.4
Jan 2016	20.6	6.8	Jan 2017	21.9	7.6
Feb 2016	26.6	10.8	Feb 2017	23.3	8.4
Mar 2016	30.5	16.1	Mar 2017	28.2	13.2
Apr 2016	36.5	20.4	Apr 2017	34.8	19
May 2016	39.2	23.5	May 2017	38.6	23.2
Jun 2016	39.7	25	Jun 2017	39.4	24.5
July 2016	40.5	26.6	July 2017	39.5	25.7
Aug 2016	40.6	26.1	Aug 2017	41.1	25.9
Sep 2016	38.9	23.2	Sep 2017	38.3	22.2
Oct 2016	35	20.5	Oct 2017	34.3	20.5
Number of chilling hours $\leq 12$ from November to March					
550		790			

*Blooming and fruiting dates*

'Toffahi' and 'Aggizi' are early cultivars as the growing season began in the third week of February when the flower buds appeared. The

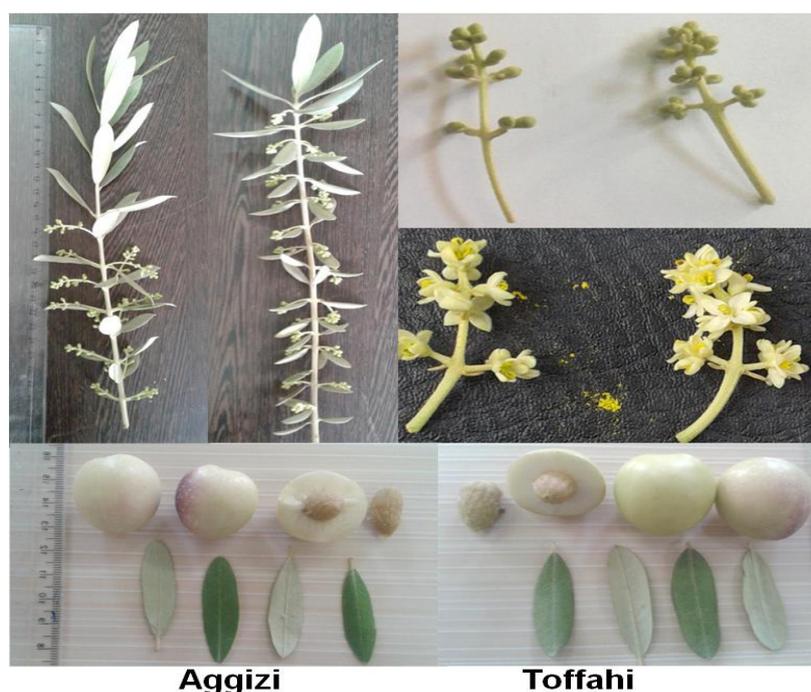
initial boom was in the second week of March for 'Toffahi' and the last week of March for 'Aggizi' (Table 2).

**TABLE 2. Dates of flowering and fruit growth for two table olive cultivars during 2016.**

Cultivar Season	Toffahi		Aggizi	
	2016	2017	2016	2017
Flower bud appearance	14-Feb	19-Feb	20-Feb	13-Feb
Flowering	8-Mar	13-Mar	27-Mar	23-Mar
Fruit set	15-Mar	18-Mar	1-Apr	28-Mar
Fruit appearance	15-Mar	20-Mar	3-Apr	30-Mar
Color Change to white	25-Jun	20-Jun	25-Jun	20-Jun
Color Change to purple	1-Aug	25-Jun	1-Aug	25-Jun
Harvest date	6-Aug	1-Aug	6-Aug	1-Aug

The full bloom and fruit set began in the second and last week of March for both cultivars. By the end of blooming, small new fruits were noticed in the second week of March in 'Toffahi' and in the first week of April in 'Aggizi'. Fruits color began to change from green to white in June 20<sup>th</sup>, and to purple in August 1<sup>st</sup> for both cultivars. When about 10-15% of the fruit changed their color to purple, both cultivars were harvested (Fig.1).

The dates of Blooming/fruiting of these cultivars were two weeks earlier under southern regions conditions than under the northern region of Egypt (Abbas and El-Khoreiby, 1988) and similar to that under Sohage condition (Saad El-Din et al., 2010). Beginning of the growing season and the duration of blooming varied from cultivar to cultivar and were affected by the environmental factors and topography of different region (Orlandi et al., 2005 and Pérez López et al., 2008).



**Fig. 1. One year old shoot, inflorescence, fruit of two table olive cultivars 'Aggizi' left and 'Toffahi' right.**

#### *Floral behavior*

The floral characteristics of one year old shoot are presented in Table 3. The average shoot length of 'Toffahi' was longer (23.4cm) than that of 'Aggizi' (20.7cm). The average number of buds per shoot was 20.8 and 18.3 for 'Toffahi' and 'Aggizi', respectively. The number of flower buds per shoot was significantly higher in 'Toffahi' (13.5) than that of 'Aggizi' (7.5). 'Toffahi' had shoot with significantly higher number of buds with double inflorescences (3.8), that reflect the higher number of inflorescences per shoot (18.6) compared to 'Aggizi' cultivar (Table 3).

Several factors influence bud induction and differentiation in olive such as winter temperature, tree nutritional status and hormonal balance (Lavee et al., 1996). The shoots tended to bear their floral buds on the third node and along the shoot to the top in 'Toffahi' while 'Aggizi' shoots bore floral buds on the first two thirds of the shoot (Fig. 1), this behavior may be unique characteristic for each cultivar.

Influence of the inflorescence position, on the shoot (Top, middle, base), on inflorescence length and flower number per inflorescence were presented in (Table 3). In both studied cultivars, *Egypt. J. Hort.* Vol. 46, No.1 (2019)

the top and the middle position of the shoot had long panicles, but the panicle in the top had significantly the highest number of flowers while the shortest panicle in the base had significantly lower number of flowers. This trend was similar in both growing seasons. These results are in agreement with the previous report cleared that the location of the inflorescence on the shoot had significant effects on the panicle length and the flowers number in olive cultivars grown in different regions (Seifi et al., 2008).

#### *Inflorescence structure and characteristics*

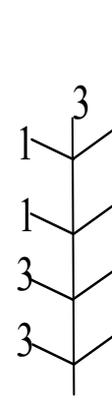
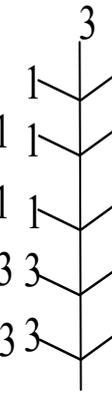
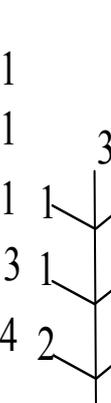
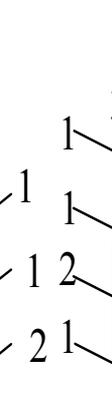
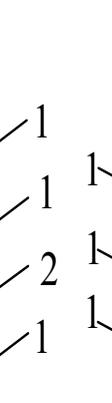
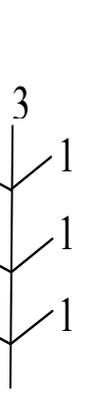
Inflorescences of different olive cultivars were noticed to have several structure patterns. There are 6 panicle structures were observed in the studied cultivars, and labeled by numbers from 1 to 6 (Fig. 2).

All of them were found on the 'Toffahi' shoots except structure #5 with flowers number ranged between 11-29. The main structures were noticed in 'Aggizi' shoot (2,3,4 and 5) with flowers number ranged between 9 and 22. The inflorescence architecture was found to be as wide-ranging from cultivar to another in olive trees according to Seifi et al. (2008).

**TABLE 3. Flowering shoot characteristics and inflorescence position effect on inflorescence characteristics of the two table olive cultivars .**

Shoot characteristics (2016 season)						
	Shoot length (cm)	Bud/shoot (No)	Buds with IFC (No)	Buds with two IFC (No)	Buds with IFC location	IFC/shoot (No)
Toffahi	23.4±0.32*	20.8±0.40*	13.5±0.32*	3.8±0.02	3-18±0.10	18.6±0.27*
Aggizi	20.7±0.27	18.3±0.33	7.5±0.22	2.4±0.11	3-13±0.13	12±0.20
Shoot characteristics (2017 season)						
Toffahi	25.4±0.31*	24.3±0.23*	15.2±0.28*	3.8±0.02	3-20±0.08	17.6±0.22*
Aggizi	23.3±0.40	20.4±0.52	9.6±0.26	3.2±0.09	3-14±0.11	13.1±0.18
Inflorescence position on shoot (2016 season)						
	Top		Middle		Base	
	IFC length (cm)	Flower (No)	IFC length (cm)	Flower (No)	IFC length (cm)	Flower (No)
Toffahi	3.5±0.04 <sup>A</sup>	25.2±0.21 <sup>*a</sup>	3.5±0.04 <sup>A</sup>	25.6±0.24 <sup>*a</sup>	1.5±0.04 <sup>B</sup>	11±0.11 <sup>b</sup>
Aggizi	3.5±0.03 <sup>A</sup>	20.2±0.17 <sup>a</sup>	3.5±0.03 <sup>A</sup>	15±0.20 <sup>b</sup>	2.0±0.06 <sup>B</sup>	12±0.15 <sup>c</sup>
Inflorescence position on shoot (2017 season)						
Toffahi	3.5±0.02 <sup>A</sup>	29.0±0.18 <sup>*a</sup>	3.5±0.04 <sup>A</sup>	22.0±0.31 <sup>*b</sup>	1.5±0.02 <sup>B</sup>	11±0.08 <sup>c</sup>
Aggizi	3.5±0.03 <sup>A</sup>	22.3±0.23 <sup>a</sup>	3.5±0.03 <sup>A</sup>	13±0.25 <sup>b</sup>	2.0±0.04 <sup>B</sup>	11±0.09 <sup>b</sup>

IFC= Inflorescence, No= number, \* represents the significance between the cultivars means within a season, (rep=5 and n=100). Mean comparisons for the flowers number and for the IFC length of different IFC positions for each cultivars were made using LSD test.. Different letter indicates significant difference within a row at  $P \leq 0.05$ .

Inflorescence shape						
	1	2	3	4	5	6
Flower No	19	22	11	13	9	29
Toffahi	√	√	√	√		√
Aggizi		√	√	√	√	

**Fig. 2. Inflorescence main structures observed on the two table olive cultivars 'Aggizi' and 'Toffahi', (rep = 5 and n = 500).**

Results in Table 4 show that inflorescence length and flower number varied from shoot to shoot, tree to tree, cultivar to cultivar and from year to year as early reports (Lavee et al., 1996, Lavee et al., 2002 and Seifi et al., 2011). Panicle length of 'Toffahi' and 'Aggizi' cvs. was not significantly different, but the flower number was higher in 'Toffahi'. The number of flowers on panicles varied due to their main structures that have different number of flowers (Fig. 2). These results demonstrate that inflorescence characteristics are different with olive cultivars and could be used to identify each cultivar.

The perfect flower percentage was higher in 'Aggizi' cv. (7.6- 72%) compared to 'Toffahi'

that had 37.3- 47.4% in 2016 and 2017 seasons, respectively. Despite this high percentage in 'Aggizi', the percentage of initial fruit set was not significantly different in both cultivars. These results may be relatively due to self-incompatibility or other factors that affect pollination such as high temperature or dry wind (Connor & Fereres, 2005 and Moutier, 2002). The average initial fruit retention per inflorescence after fruit set ranged between 4.4-6.4/IFC, and 15.3- 20/shoot for both cultivars, and sharply decreased after 20 days to be from 1.4 to 2.6 fruits/ IFC and 7.3 to 8.2 fruits/shoot as a result of competition. The dropped fruit number was lower in 'Aggizi' (6.3) than 'Toffahi' (11.7 fruit).

**TABLE 4. Inflorescence characteristics of the two table olive cultivars.**

Aggizi		Toffahi		Inflorescence characteristics
2017	2016	2017	2016	
2.5±0.02	2.9±0.04	2.9±0.03	3.1±0.05	IFC Length (cm)
14.1±0.08	16.1±0.12	22.6±0.23*	20.6±0.17*	Flower No / IFC
72.6±0.33*	57.6±0.40*	47.4±0.45	37.3±0.69	Perfect flower (%)
21.3±0.28	23.1±0.34	23.8±0.28	20.2±0.33	Initial fruit set (%)
4.4±0.12	6.4±0.08	5.3±0.19	6.2±0.21	Initial fruit No / IFC
1.5±0.04	1.4±0.04	2.6±0.04	2.1±0.05	Final fruits No / IFC
15.3±0.17	16±0.25	20±0.26*	19±0.23*	Initial fruit No /shoot
7.5±0.15	8.2±0.18	8.1±0.12	7.3±0.14	Final fruit No/shoot
6.3±0.28	6.8±0.31	10.5±0.04*	11.7±0.04*	Dropped fruit No
Fruit physical characteristics				
2017	2016	2017	2016	
8.9±0.20	9.2±0.19	9.6±0.19	9.8±0.17	Fruit weight (g)
2.4±0.04	2.5±0.04	2.7±0.04	2.7±0.03	Fruit length (cm)
2.3±0.03	2.3±0.02	2.5±0.03	2.5±0.02	Fruit width (mm)
7.8±0.05	8.1±0.08	8.2±0.09	8.4±0.13	Flesh weight (g)
1.0±0.02	1.1±0.04	1.1±0.02	1.2±0.02	Stone weight (g)
87.8±0.44	88.5±0.58	85.2±0.54	85.6±0.64	Flesh/fruit (%)
11.4±0.36	12.0±0.53	11.2±0.22	11.4±0.19	Stone/fruit (%)
69.9±0.53	70.7±0.48	73.4±0.61	72.8±0.52	Moisture (%)
11.5±0.40	11.3±0.51	11.4±0.33	10.7±0.43	Oil content (%)

IFC= Inflorescence, No= number, \* represents the significance between the cultivars means within a season, (rep=5 and n=500).

This may be due to the variation in fruit set time, so the early fruits set became larger and retained while the late set fruit did not continue growing and fall. In parallel with the previous report, it showed that the competition between fruit at bloom and after fruit set is inversely proportion to the size of flower and fruit (Rosati et al., 2010).

#### *Fruit characteristics*

Fruit characteristics of the studied cultivars during 2016 and 2017 seasons are presented in Table 4. 'Toffahi' and 'Aggizi' fruits were big in size and weight. 'Toffahi' had fruit weighed of 9.8g while 'Aggizi' was 9.2g. There were no significant differences between the cultivars for the fruit size, flesh weight, stone weight. These values for the fruit characteristics of 'Toffahi' and 'Aggizi' cvs. is dramatically affected by the hot summer and dry wind during fruit growth that increases water evaporation from the fruit (Ahmed and Taha, 2018, Fayek et al., 2014 and Shaheen et al., 2011). 'Toffahi' and 'Aggizi' cvs. are table olive so that the fruits were harvested when the color began to turn light green or shade purple (Fig. 2). The oil content for these two cultivars is known to be low, results in Table 4 show these values (10.7 and 11.5 %) that are lower than that reported for both cultivars previously (Saad El-Din et al., 2010). Oil biosynthesis in olive fruits is affected by cultivar genetic makeup and growing conditions (Al-Maaitah et al., 2009 and Lavee & Wodne, 2004). Fruit moisture ranged between 69.9 and 3.4% for both cultivars. These values were lower than those reported earlier about these cultivars (Saad El-Din et al., 2010). It is suggested that hot weather and low precipitation during fruit ripening may accelerate evaporation process and increase the respiration rate, which reduces the moisture contents in the fruit (Al-Maaitah et al., 2009 and Tombesi et al., 1994).

#### **Conclusion**

The present study results demonstrated that the table cultivars 'Toffahi' and 'Aggizi' can successfully adapt to the new conditions of southern Egypt. Each cultivars have normal growth and regular floral bearing habit, flowering behavior and fruit production that prove their tolerance to the specific condition of southern Egypt.

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#### *Conflict of interest*

No conflicts of interest were declared.

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## الازهار والاثمار لصنفين من زيتون المائدة النامية تحت ظروف جنوب مصر

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يعتبر الزيتون من اشجار الفاكهه المستديمة الخضرة والتي تتأقلم مع المناخ الحار والجاف بسهولة. ولكن تحتاج لعدد ساعات معينه من البرودة لتكوين البراعم الزهرية. يزرع الزيتون لغرض التخليل او استخراج الزيت المعروف بخواصه العالية الجودة والمفيدة للصحة. المساحة المنزرعة بالزيتون تزيد كل يوم فى الاراضى المستصلحة الجديدة وخاصة فى جنوب مصر. الهدف من هذه الدراسة هو تقييم لبعض السلوك الزهرى وخصائص الثمار لصنفين من اصناف زيتون المائدة (التفاحى والعجيزى) تحت ظروف جنوب مصر (محافظة قنا) خلال موسمي ٢٠١٦ & ٢٠١٧. بداية موسم النمو كانت فى اول فبراير عند ظهور البراعم الزهرية، كان هناك اختلاف معنوى للسلوك الزهرى للصنفين:

- الفرع الحامل للازهار كان اطول واكثر فى عدد العناقيد الزهرية فى التفاحى عن العجيزى.
  - العناقيد الزهرية فى قمة ووسط الفرع كانت اطول وبها ازهار اكثر من التى فى اسفل الفرع.
  - عدد الازهار للعنقود الزهرى كانت اكبر فى التفاحى عن العجيزى.
  - نسبة الازهار الخنثى للتفاحى كانت اعلى ولكن عقد الثمار لم يكن مختلف معنويا عن العجيزى.
  - عدد الثمار العاقدة مبدئيا كان عالى وانخفض مع الوقت نتيجة المنافسة .
  - الثمار كانت كبيره الحجم والوزن ولكن لم يكن هناك فروق فى الخواص الثمرية ونسبة الزيت والرطوبة بين صنفى الدراسة.
- من النتائج السابقه يمكن النصح بزراعة هذان الصنفان تحت ظروف قنا لانهما اثبتا تأقلم تام ونمو جيد وازهار طبيعى وصفات جيدة للثمار تحت هذه الظروف.