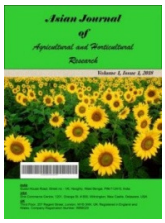

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Evaluation of Some Morphological and Flowering Traits in New Six Olive Genotypes Grown under Egypt Conditions

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was conducted during two growing seasons (2016 and 2017) to evaluate six genotypes of olive trees. The experimental olive trees were propagated by leafy cutting under mist propagation system. The leafy cuttings were already taken from seedy propagated olive trees which have already been planted since 1994 at the farm of Horticulture Research Institute, Giza Governorate, Egypt and were produced from breeding program of Horticulture Research Institute. i.e., Genotype 25 derived from Aggizi cv. open, Genotype 61 derived from ♀ Hamed cv. x Picual cv. ♂, Genotype 97, 91 derived from Manzanillo cv. open, Genotype 66 derived from ♀ Toffahi cv. x Arbiquna cv. ♂ and Genotype 138 derived from ♀ Arbiquna cv. x Hamed cv. ♂. Therefore, the present study was carried out to evaluate some morphological and flowering of the six olive genotypes grown in olive collection farm located at Cairo-Alexandria desert Road (about 64-kilometer distance from Cairo). To determine the most promising genotypes for local conditions. Herein, the greatest values of morphological traits were significantly coupled with genotype (91) during both seasons of study. Moreover, genotype (97) ranked statistically second. Moreover, the start of flowering in six olive genotypes occurred during the period from March 13th to April 3rd in

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the first season and from April 1st to April 10th in the second season. Referring to blooming dates and blooming periods results obtained that dates of full bloom were earliest in the first season than that at the second season. Furthermore, olive genotype (138) was statistically the superior and resulted significantly the highest perfect flowers % during both seasons of study.

Keywords: Olive; genotypes; evaluation; morphological traits; flowering and breeding.

1. INTRODUCTION

Olive (*Olea europaea* L.) is an evergreen tree belongs to family Oleaceae, one of the oldest cultivated trees in the history of the world about 8000 years ago. Olive tree is mentioned in several verses of the Quean and holly books. It is a widely distributed tree grown in many arid zones of the world, native to all countries around the Mediterranean region. The major countries of olive production are Spain, Italy, Greece, Syria, Turkey, Tunisia, Morocco, Portugal, Algeria, Jordan, Palestine and France.

A wide variability in the olive germplasm has been generated, which accounted for more than 2000 cultivars. The importing of olive cultivars is subjected to different ecological and agro ecosystems resulting in positive or negative mutations under different conditions [1].

During the last period, the olive oil has shown rapid changes, due to both technological advancement with new machinery available for harvesting the olive, and the changes in agricultural policies and market liberalization. These changes are occurring both in traditional olive-producing countries and in new countries where the growth of olive is rapidly expanding. Thus, the modern olive oil industry requires new and more competitive cultivars which can adapt better to the new trends in the growth of olive. Hence, these varieties should results to oils and olives with high and stable quality [2].

Today the market demands for cultivars with a high ecological plasticity, adaptable to new agronomical techniques, capable of producing high quality oil and for big table olive with good flavors and good technological properties. It is possible to enlarge the natural genetic variability of the olive through the cross breeding technique in which searching for interesting genotypes is aimed [3].

In Egypt, olive is cultivated from ancient centuries. It is found in pharoes tombs and temples as pictures and fruits. Nowadays, olive trees play an important role in orchard establishment especially in new reclaimed areas. Olive cultivation increased considerably during the last two decades due to the great efforts given by Ministry of Agriculture and Land Reclamation. The introduction of new cultivars and the wide scale propagation of olive cultivars by leafy stem cutting under mist resulted in the extension of olive orchards in new reclaimed areas. The last statistics of the Ministry of Agriculture and Land Reclamation (2016) cited that the total acreage of olive reached 243182 feddans and fruiting area reached 187944 feddans producing 874748 tons with average of 4.654 tons/fed. El-Nobaria, Matruh, El-Fayoum, North Sinai, Giza, Ismailia, Behaira, Sharkia, Menoufia, Alexandria and south Sinai are the most important areas of olive production in Egypt.

In Egypt the problem of the improvement of standard varietals in olive growing has been for generations at the attention of technicians and olive growers. The olive sector represents one of the most promising sectors in Egypt. Olive cultural and all its derivative products are among the most important parts of agricultural economy of rural people in Egypt. Today, we can expect a further expansion of this productive sector, Because The new reclaim area suitable for olive plantings, some fruit trees failed to succeed in the desert because of water salinity, increasing the local consumption of oil due to the awareness about the value of health and nutrient.

Breeding program was initiated in Egypt in 1994, by crossing between local and foreign cultivars. The objective of this breeding program was to obtain new olive cultivars with some of preferable traits such as early bearing, high productivity and oil content, resistance to pest and diseases, vigor suitability for mechanical harvesting and high quality of olive oil. Therefore, an olive breeding program has been initiated in 1996 at Giza, Egypt.

Therefore, the present study was carried out to evaluate some morphological and flowering of six olive genotypes producing from breeding &

selection programs of Horticulture Research Institute grown in olive collection farm located at Cairo-Alexandria desert Road (about 64-kilometer distance from Cairo). To determine the most promising genotypes for local conditions.

2. MATERIALS AND METHODS

The present investigation was conducted throughout the two growing seasons (2016 and 2017) to evaluate six genotypes of olive trees (Genotype 25, Genotype 61, Genotype 97, Genotype 91, Genotype 66 and Genotype 138) which were produced through breeding & selection program of Horticulture Research Institute.

The experimental olive trees were propagated by leafy cutting under mist propagation system. The leafy cuttings were already taken from seedy propagated olive trees which have already been planted since 1994 at the farm of Horticulture Research Institute, Giza Governorate and were produced from breeding program of Horticulture Research Institute.

Genotype 25 derived from Aggizi cv. open,

Genotype 61 derived from ♀ Hamed cv. x picual cv. ♂

Genotype 97, 91 derived from Manzanillo cv. open

Genotype 66 derived from ♀ Toffahi cv. x Arbiquna cv. ♂

Genotype 138 derived from ♀ Arbiquna cv. x Hamed cv. ♂

The investigated olive progenies which propagated by leafy cutting were about 8 years old in olive collection farm located at Cairo-Alexandria desert Road (about 64- kilometer distance from Cairo). The trees planted at 6×3 meter apart in sandy loam soil, under drip irrigation system with the same amount of water and subjected to the regularly recommended culture practices as well as free from pathogens and physiological disorders.

The complete randomized design with three replications, where each replicate was represented by two trees was employed. So, six similar trees from each evaluated genotype were carefully selected.

Soil chemical and physical characteristics and water chemical characteristics were determined by Soil, Water and Environmental Res. Inst. Agric. Res. Center, according to the methods as described by Jackson (1973) and was summarized in Tables 1, 2.

Temperate degrees, average relative humidity percentage and average sun radiation from Jan. to Dec. 2016 and 2017 in Figs. 1-3.

The following characteristics were recorded according to Methodology for primary characterization of olive varieties, according to Barranco and Trujillo [4] and Cimato and Attilio [5].

A. Tree vigor (during in October)

A.1. Trunk cross section (cm^2)

The diameter of the trunk was measured at 10 cm above soil level. According to the following equation: $3.1416\ (D/2)^{2.}$

D = the diameter of trunk

A.2. Tree height (m)

It was divided to 1. Very small (< 2.0m), 2. Small (2.0-3.0m), 3. Medium (3.0-4.0m), 4. Large (4.0-5.0m), 5. Very large (> 5.0m).

A.3. Canopy external section

A.3.1. Canopy surface area CS (m^2)

CS (m^2) = 3.1416x D. H, (where's D is average diameter of canopy = (D1+D2)/2.

The rod placed perpendicularly at two points where the canopy is widest 'D1' and narrowest 'D2', H = canopy height (m).

Canopy surface area divided to: 1. Very small (< 20). 2. Small (20-35). 3. Medium (35-50). 4. Large (50-65). 5. Very large (>65)

A.3.2. Canopy volume CV (m^3)

Canopy volume (m^3): CV = 0.5236 $(D)^2$ H (m) (RESGEN–CT96/97).

Canopy volume (m^3) divided to: 1. Very small (< 20). 2. Small (20-30). 3. Medium (30-40). 4. Large (40-50). 5. Very large (>50).

Table 1. The physical and chemical analysis of the tested soil sample collected from the experiment area

Particle size distribution (%):				S.P.	pH	E.C.	Cations (meq/L)				Anions (Meq/L)		
Sand (%)	Silt	Clay	Texture class			(dS/m)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
84.5	8.50	7.00	Sand loamy	22.86	7.63	3.10	7.4	4.6	5.00	0.36	0.60	7.0	9.03

Table 2. The chemical composition of the irrigation water samples from the experimental area

pH	EC	Macro and micro elements													
		NH_4	P	K	Ca	Mg	SO_4	Fe	Zn	Mn	Na	CO_3	HCO_3	Cl	SAR
7.20	5.21	1.75	0.05	0.12	10.34	7.74	29.85	0.07	0.11	0.05	28.17	-	1.42	15.10	9.40

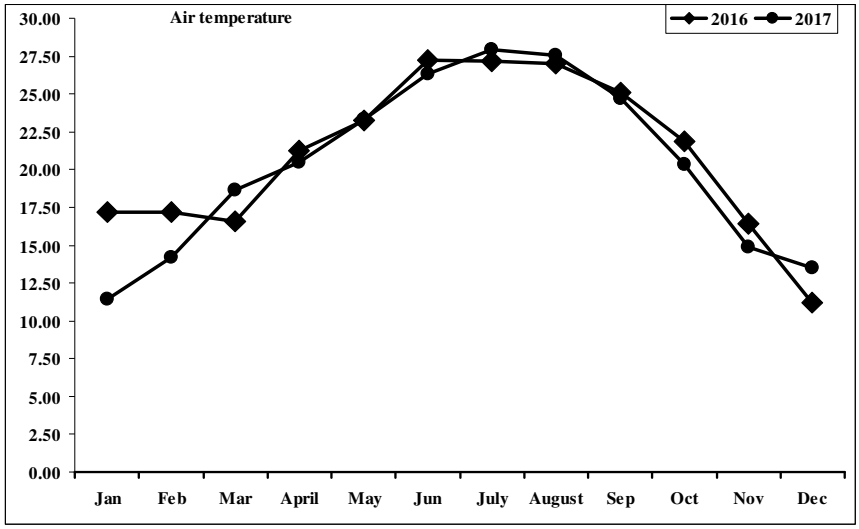


Fig. 1. Average Air Temperature degree from the experimental area during 2016 and 2017

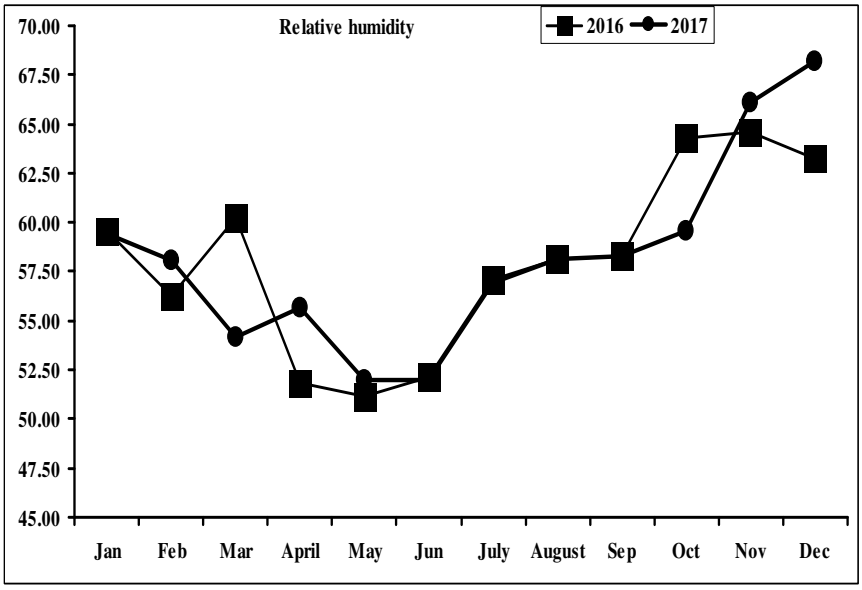


Fig. 2. Average Relative humidity percentage from the experimental area during 2016 and 2017

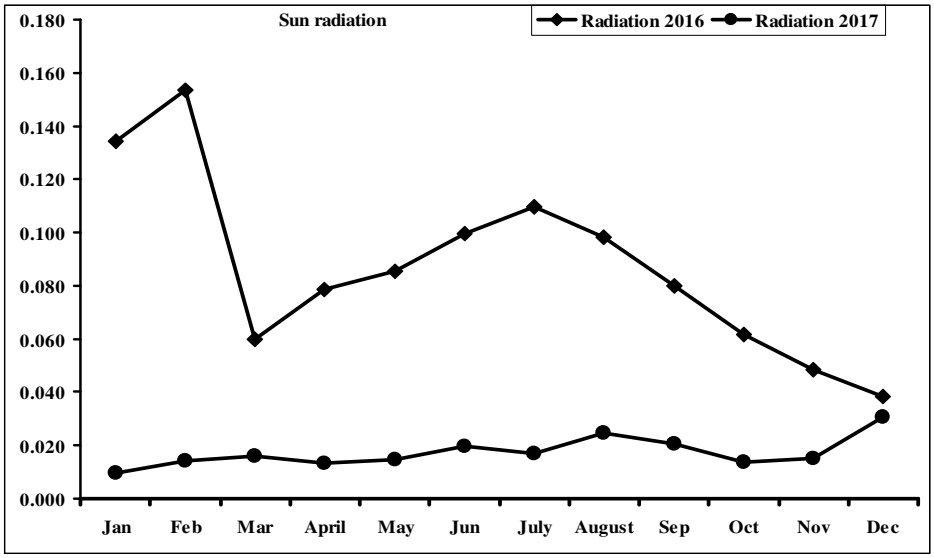


Fig. 3. Average sun radiation from the experimental area during 2016 and 2017

B. Shoot characteristics

B.1. Shoot length (cm)

B.2. Number of nodes per shoot

B.3. Internode length (cm)

Twenty shoots (one-year-old) were randomly selected around each tree canopy (replicate) and labeled in late March to record the average length of internodes/shoot.

Number of nodes per meter = Number of nods x100/shoot length

C. Leaf characteristics

C.1. Leaf length (cm)

C.2. Leaf width (cm)

C.3. Leaf shape index

This determined by the ratio between the lengths (L) and the width (W).

Elliptic: L/W < 4, Elliptic-lanceolate: L/W 4-6, lanceolate: L/W >6.

C.4. The leaf surface area

Average leaf surface area (cm^2): Samples of approximately 40 adult leaves take from the middle section of 8-10 one-year-old shoots chosen from the most representative shoots to determine average leaf surface area (cm^2) according to Ahmed and Morsy [6] using the following equation:

Leaf area =0.53 (length x width) +1.66

D. Flowering characteristics

D.1. Flowering date and duration

Start of flowering date: when 10-25% of flowers were opened.
Full bloom date: when 50-80% of flowers were opened.
End of Flowering date: developed when 25% of set fruits.
Flowering period: was calculated by the days between beginning of flowering and end of blooming

D.2. Inflorescence length (cm)

Sample of twenty inflorescences at balloon stage from each tree were randomly taken from the middle portion of shoots to measure length of inflorescence (cm)

Short > 2.5, medium 2.5-3.5, long < 3.5 [4] and [5].

D.3. Flowering Density

Twenty shoots per each tree were employed to determine average shoot length, number of inflorescence and the average number of

inflorescences per one meter was calculated according to Moffed [7].

Flowering density =No. of inflorescence x100/ shoot length

D.4. Number of total flowers per inflorescence

Sample of twenty inflorescences at balloon stage from each tree were randomly taken from the middle portion of shoots to measure the following inflorescence characteristics.

Total number of flowers per inflorescence was counted

Low >18, medium 18-25, high < 25 according to Barranco and Trujillo [4] and Cimato and Attilio [5].

D.5. Number of Perfect flowers per inflorescence

D.6. Perfect flower percentage

20 inflorescences at balloon stage were collected from the middle portions of shoots, from each tree. Number of perfect on each inflorescence was recorded and percentage of perfect was calculated according to Moffed [7].

Perfect flower percentage was determined according to Snedecor and Cochran [9].

Perfect flower percentage = (No. of perfect flowers/ Total No. of flowers) x 100

2.1 Statistical Analysis

All data obtained during both seasons were subjected to analysis of variance according to Snedecor and Cochran [9] and significant differences among means were distinguishing according to the Duncan's, multiple test range [10].

3. RESULTS AND DISCUSSION

A. Tree vigor of six olive genotypes

In this respect trunk cross section (cm^2), tree height (m), canopy surface area (m^2) and canopy volume were the investigated parameters in six olive genotypes under investigation. Data obtained during both 2016 & 2017 experimental seasons are presented in Table 3.

A.1. Tree height (m)

Table 3 displays obviously that tree height was clearly pronounced with the six olive genotypes during 2016 & 2017 experimental seasons. Anyhow, the superiority of genotype (97) for inducing the tallest tree height during 2016 experimental season, whereas, genotype (66) gave the tallest tree height during 2017 experimental season. The reverse was true with genotype (138) where the shortest tree height (2.93 & 2.28 m) were resulted during 1st & 2nd seasons, respectively.

A.2. Trunk cross section

As shown from Table 3 that trunk cross section of six olive genotypes was more pronounced and reached level of significance to be taken into consideration from statistical standpoint during 2016 & 2017 experimental seasons. Generally it could be noticed the superiority of olive genotype (91) during both experimental seasons. However, olive genotype (138) ranked statistically second, descendingly followed by olive genotype (61), olive genotype (25) and olive genotype (97) than olive genotype (66) which ranked last in this concern. Such trend was true during 2016 & 2017 experimental seasons.

A.3. Canopy surface area (m^2)

It is quite evident as shown from tabulated data in Table 3 that the greatest increase in canopy surface area was statistically detected by both olive genotype (61 & 91) in the first and second seasons, respectively. Moreover, olive genotypes (25, 91 and 97) ranked statistically second particularly in 1st season. However, olive genotype (61) ranked second during 2nd season. On the contrary, olive genotype (138) ranked statistically last in this concern during 2016 & 2017 experimental seasons.

A.4. Canopy volume (m^3)

Table 3 displays obviously that the highest canopy volume was markedly coupled with olive genotype (61) during 2016 & 2017 experimental seasons. Moreover, olive genotypes (25 & 91) ranked statistically second in this concern during 1st and 2nd seasons, respectively, statistically followed by olive genotypes (91 & 25). The reverse was true with olive genotypes (66 & 138) which induced significantly the lowest values of canopy volume during 2016 & 2017 experimental seasons, respectively.

Generally, it could be safely concluded that all olive genotypes under study showed significant differences in their vigor during 2016 & 2017 experimental seasons. Moreover, the present result goes partially in the line with that pointed out by several investigators i.e., [11] who noted that, trunk cross section in 131 cultivars ranged from 35 to 209 cm2. In addition, [12] studied sixty olive varieties at Buaraba (Australia), he found that mean tree height ranged from, 1.94 to 4.44 m between varieties. Similarly, results of [11-19] showed significant different in tree vigor.

Genotype 25

Genotype 61

Genotype 66

Genotype 91

Genotype 97

Genotype 138

Plate 1. Tree shape and vegetative growth of six olive genotypes

Table 3. Tree vigor (tree height, trunk cross section, canopy surface area and canopy volume) of six olive genotypes during 2016 and 2017 experimental seasons

Parameters	Tree height (m)		Trunk cross section (cm^2)		Canopy surface area (m^2)		Canopy volume (m^3)	
Olive genotypes	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
25	3.65B	3.86BC	115.6D	147.4C	45.48AB	67.42BC	30.08B	62.14C
61	3.61B	3.67C	128.6C	154.2C	48.06A	69.92AB	34.73A	73.29A
66	3.18C	4.37A	60.40E	75.05E	28.46D	56.16D	19.48E	38.16F
91	3.45B	3.93B	196.3A	212.5A	42.83B	73.73A	28.08BC	66.42B
97	3.90A	4.00B	125.3C	132.5D	42.97B	64.34C	26.26C	54.65D
138	2.93D	3.28D	154.2B	166.0B	33.77C	53.09D	20.52D	45.37E

Values within each column followed by the same letters are not significant at 5 % level.

B. Shoot characteristics of six olive genotypes

In this concern shoot length, number of nodes per shoot and internode length were the investigated three shoot characteristics, data obtained during both 2016 & 2017 experimental seasons are presented in Table 4.

B.1. Shoot length (cm)

Table 4 displays obviously that genotype (97) was statistically the superior in this respect, whereas it resulted the tallest shoots (25.62 & 25.09 cm^2) during 1st & 2nd experimental seasons, respectively. Moreover, genotype (91) ranked statistically 2nd in the first season (23.66 cm^2) and genotype (61) in the second season (24.07 cm^2). Meanwhile, genotype (66) showed the lowest value in this respect (17.40 cm^2) in the first season and genotype (138) in the second season (15.17 cm^2).

B.2. Number of nodes/shoot

With regard to the number of nodes per shoot of the six olive genotypes under study. Data obtained during both 2016 & 2017 experimental seasons are presented in Table 4 showed obviously that the greatest number of nodes per shoot was significantly in closed relationship to genotype (61) during both 2016 & 2017 experimental seasons. Moreover, genotype (91) and genotype (25) ranked statistically second during 1st & 2nd seasons, respectively. On the contrary, the least number of nodes per shoot was statistically coupled with genotype (66) and genotype (91) during first and second season, respectively (Plate 1).

B.3. Internode length (cm)

It is quite clear as shown from tabulated data in Table 4 that the internode length varied from one genotype to another, whereas the greatest length was statistically in concomitant to genotype (97) during both seasons of study descendingly followed by genotype (66) and genotype (91). The reverse was true with genotype (61) in the first season and genotype (138) in the second season which recorded significantly the shortest internode length during both experimental seasons.

The result is in general agreement with those found by Bronzini et al. [20] who reported that internodes length in eight olive cultivars ranged from 1.50 to 2.17 cm with variation coefficient 30.29.7%., [13-19]. They recorded variation in internodes length and internode number of different olive cultivars.

Table 4. Shoot length (cm), No. of nodes/shoot and internode length (cm) of six olive genotypes during 2016 and 2017 experimental seasons

Olive genotypes	Shoot length (cm)		Number of nodes / shoot		Internode length (cm)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
25	22.53C	20.00C	14.93C	14.22B	1.51B	1.40CD
61	19.20D	24.07B	16.87A	18.00A	1.14C	1.33D
66	17.40E	19.77C	11.47E	12.53C	1.52B	1.57B
91	23.66B	17.50D	15.67B	12.33C	1.51B	1.42C
97	25.62A	25.09A	14.75C	14.11B	1.74A	1.78A
138	19.42D	15.17E	13.25D	12.47C	1.47B	1.21E

Values within each column followed by the same letter/s are not significant at 5 % level

C. Leaf characteristics of six olive genotypes

In this respect leaf length, leaf width, leaf shape index and leaf area were the investigated leaf parameters of six olive genotypes. Data obtained during 2016 & 2017 experimental seasons are presented in Table 5.

C.1. Leaf length (cm)

Table 5 shows obviously considerable variations in this respect. Herein, the greatest values of leaf length were significantly coupled with olive genotype (25) during both seasons of study. Moreover, olive genotype (61) and olive genotype (91) showed significantly the same as they resulted during 1st and 2nd experimental seasons, respectively and they came second. On the contrary, the shortest leaf length (4.23 and 3.77 cm^2) was in concomitant to olive genotype. (66) which ranked statistically last during 2016 & 2017 experimental seasons, respectively.

C.2. Leaf width (cm)

It is quite clear as shown from tabulated data in Table 5 that olive genotypes (91 & 97) were statistically the superior in this concern. Moreover, olive genotype (25) ranked statistically 2nd after the aforesaid two superior genotypes. On the contrary, the least leaf width was significantly in concomitant to genotype (138) in the first season and olive genotype (66) in the second season. Such trend was true during 2016 & 2017 experimental seasons.

C.3. Leaf shape index

Concerning the leaf shape index of six genotypes Table 5 shows clearly that olive genotype (61) was the superior in this concern, statistically followed by olive genotype (138). Such trend was true during 2016 & 2017 experimental seasons. Since, in most cases the increase in leaf length was relatively higher than leaf width in different olive genotype under study and this could be logically explained on the unparalleled values in leaf shape index with different olive genotypes under study.

Referring to length/width ratio for leaves conformed to the leaf shape in both seasons were (elliptic) in olive genotypes (61, 66 and 138) and (elliptic – lanceolate) in olive genotypes (91 & 97). In addition, in olive genotype (25) was (lanceolate). Such trend was true was true during 2016 & 2017 experimental seasons.

C.4. Leaf area (cm^2)

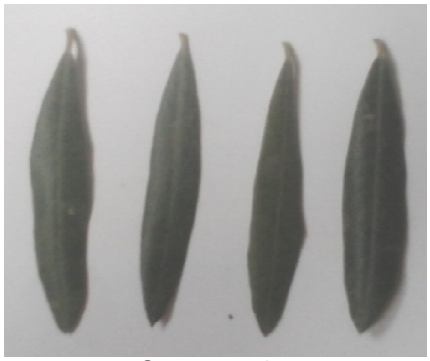
Table 5 shows obviously that olive genotypes (25 & 91) gave significantly the greatest leaf area during 2016 & 2017 experimental seasons. However, olive genotype (97) ranked statistically 2nd regarding its values in leaf area during two seasons of study. On the contrary the smallest leaf area was significantly coupled with olive genotype (138) in the first season and olive genotype (61) in the second season.

Anyhow, findings of several investigators on this concern pointed out the same trend i.e., [21] in a study on eighteen olive cultivars recorded that leaf area ranged from (2.60 cm^2) in Ghiacciolo cv. to (5.96 cm^2) in Correggiolo cv. Moreover [22] found that Manzanillo cv. had an intermediate leaf area (4.41cm^2). As well as, [23] noted that Coratina and Koroneiki leaf area were (4.44, 3.08 cm^2). These resulted also are supported by many researchers [23,24,13,14,25-28,19,29].

Table 5. Leaf length, leaf width, leaf shape index and leaf area of six olive genotypes during 2016 and 2017 experimental seasons

Olive genotypes	Leaf length (cm)		Leaf width (cm)		Leaf shape index		Leaf area (cm^2)		Leaf shape
	2016	2017	2016	2017	2016	2017	2016	2017	Lanceolate
25	6.17A	6.42A	1.24B	1.31B	4.97C	4.90B	5.72A	6.37A	Elliptic
61	5.77B	5.40C	0.95C	0.91CD	6.10A	5.91A	4.56B	4.27C	Elliptic
66	4.23E	3.77E	1.23B	0.90D	3.54E	4.19C	4.41B	3.45D	Elliptic
91	5.44C	5.87B	1.42A	1.44A	3.84D	4.08C	5.74A	6.22A	Elliptic-Lanceolate
97	5.11D	5.18D	1.42A	1.45A	3.62DE	3.59D	5.49A	5.84B	Elliptic-Lanceolate
138	5.02D	5.58C	0.94C	0.97C	5.36B	5.76A	4.15C	4.53C	Elliptic

Values within each column followed by the same letter/s are not significant at 5 % level



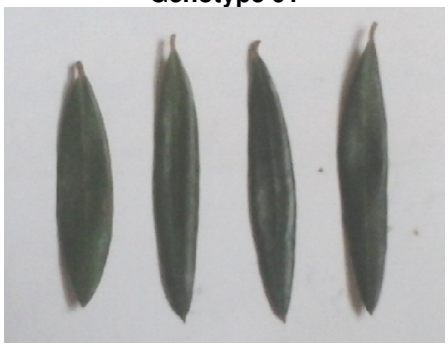
Genotype 25

Genotype 61

Genotype 66

Genotype 91

Genotype 97



Genotype 138

Plate 2. Leaf shape of six olive genotypes

D. Flowering characteristics of six olive genotypes

D.1. Starts of flowering, full bloom and end of flowering of six olive genotypes

In this regard, start of flowering date, full bloom date and end of flowering date were the evaluated parameters of differential olive genotypes. Data obtained during both 2016 & 2017 experimental seasons are presented in Table 6.

As shown from Table 6 that the start of flowering of six olive genotypes occurred during the period from March 13th to April 3rd in the first season and from April 1st to April 10th in the second season. Anyhow, start of flowering started earliest in the first season that in the second season in all genotypes. Such trend was true during 2016 and 2017 experimental seasons. In this concern, olive genotypes (97 & 138) were the earliest during 2016 & 2017 experimental seasons, respectively. Meanwhile, olive genotypes (91 & 61) were the latest genotypes in this regard during 1st & 2nd seasons, respectively (Plate 2).

Referring to blooming dates and blooming periods of the investigated olive genotypes,

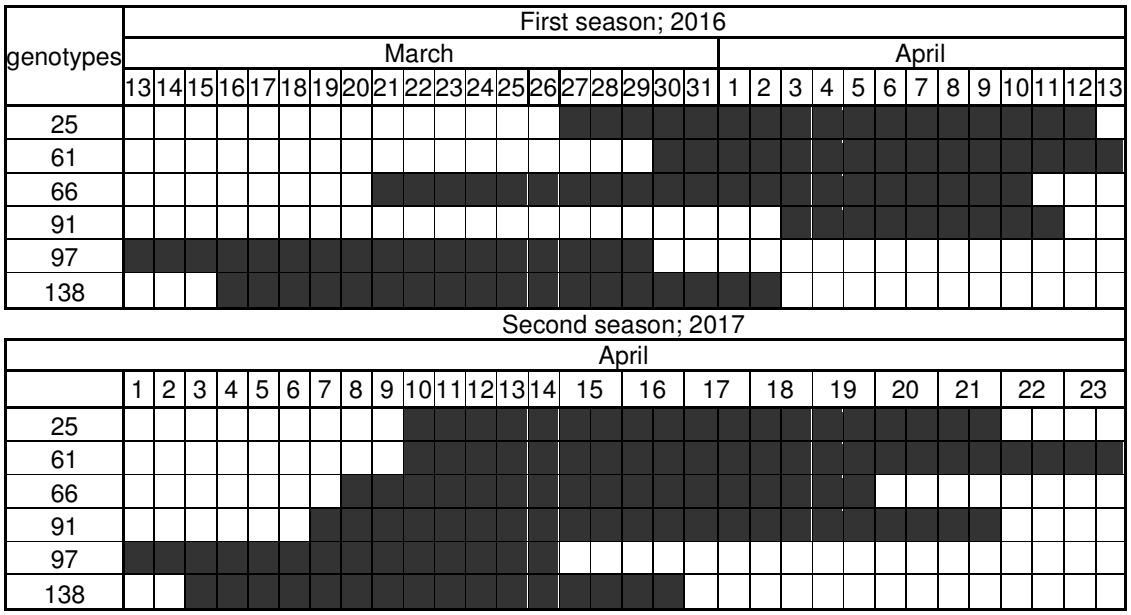
Table 6 displays obviously that dates of full bloom were earliest in the first season than that at the second season. Since, at the first season full bloom started in March 21st to April 8th. Meanwhile, full bloom in the second season started at April 8th to April 17th. Such trend was true during both seasons of study. In this concern olive genotype (97) started full bloom early during 2016 & 2017 experimental seasons, followed by olive genotype (138) and olive genotype (66) during 2016 & 2017 experimental seasons, respectively. Meanwhile, olive genotype (91) was the latest one in this concern during both seasons of study.

As for the end of flowering dates of six olive genotypes under investigations, Table 6 displays clearly that dates of end the flowering period were earliest in the first season than that in the second season. Anyhow, end of flowering started in the first season at March 29th to April 13th. Meanwhile, end of flowering started in April 14th to April 23rd in the second season. In addition, olive genotype (97) was the earliest one in this concern during both seasons of study, followed by olive genotypes (138, 66, 91and 25) during 2016 & 2017 experimental seasons, respectively. Meanwhile, olive genotype (61) was the latest genotype in both studied seasons.

The finding is in harmony with those obtained by Sweeney [30] who reported that the actual full bloom times differed in different regions of Australia. it is notice from the results that the duration of flowering differed according to cvs. and varied from one season to another. This can have interpreted by that, the cultivars differed in its thermal requirement and their physiological status. Moreover, the phonological behavior of olive tree is largely influenced by environmental factors such as temperature [31].

Table 6. Flowering (start of flowering, full bloom and end of flowering) of six olive genotypes during 2016 and 2017 experimental seasons

Olive genotypes	Start of flowering		Full bloom		End of flowering	
	2016	2017	2016	2017	2016	2017
25	March 27th	April 10th	April 3rd	April 16th	April 12th	April 21st
61	March 30th	April 10th	April 7th	April 17th	April 13th	April 23rd
66	March 21st	April 8th	April 3rd	April 13th	April 10th	April 19th
91	April 3rd	April 7th	April 8th	April 12th	April 11th	April 21st
97	March 13th	April 1st	March 21st	April 8th	March 29th	April 14th
138	March 16th	April 3rd	March 24th	April 11th	April 2nd	April 16th



D.2. Inflorescence length (cm)

With regard to inflorescence length of differential investigated olive genotypes Table 7 displays obviously that olive genotype (91) was the superior in the first season and olive genotype (138) also was the superior in the second season. In addition, differences between olive genotype (91) and olive genotype (138) were not significant in this regard, especially during 1st season, while olive genotype (66) and olive genotype (97) were the least effective in this concern during 1st and 2nd seasons, respectively. Moreover, other olive genotypes were in between the aforesaid two extremes. Such trend was true during 2016 & 2017 experimental seasons.

D.3. No. of Inflorescence per shoot

It is quite clear as shown from tabulated data in Table 7 that olive genotype (97) showed significantly the greatest No. of inflorescences per shoot during 2016 & 2017 experimental seasons. However, olive genotype (61) ranked statistically 2nd after the aforesaid olive genotype. On the contrary, the least No. of inflorescences per shoot was significantly in concomitant to genotype (66) and olive genotype (25) during 1st and 2nd seasons, respectively.

D.4. Flowering density

Tabulated data in Table 7 revealed that olive genotype (61) was statistically the superior and resulted significantly in the highest flowering density in the first season. Meanwhile, olive genotypes (97 & 138) were statistically the superior in the second season. However, olive genotype (97) and olive genotype (61) both ranked statistically second and showed the same flowering density from the statistical point of view during 2016 & 2017 experimental seasons, respectively. Whereas, olive genotype (91) and olive genotype (25) tended to be the last in this regard during 1st & 2nd seasons, respectively.

This result goes generally with those found by Cuevas and Rallo [32] they reported that flowering density has direct and indirect effects on olive tree productivity, showed that flowering density affected the percentage of perfect flowers, i.e., tree of low flowering has a high percentage of perfect flowers, and competition between the developing inflorescence was probably the main factor in this phenomena. Also, [33] reported that flowering density can be considered the major factor in determining fruit set, potential crop and fruit quality. While, [34] evaluated nine olive cultivars he found that flowering density of the studied cultivars ranged from 50.6 to 88.22 per meter and [26] who found that Maraki had the highest flowering density (83.00 & 99.48) in the two seasons and Koroneiki at the second season (100.2); Coratina in the first season and E52 in the second season gave the lowest flowering density (55.60 & 32.02 respectively).

D.5. No. of total flowers per inflorescence

As shown in Table 8 that the greatest number of flowers per Inflorescence was statistically detected by both olive genotypes (25 & 66) during both 2016 & 2017 experimental seasons, respectively. Moreover, olive genotype (61) ranked statistically second during both seasons of study, descendingly followed by olive genotype (91) in the first season and olive genotype (25) in the second season. The reverse was true with olive genotype (138) which recorded significantly last in this concern during 2016 & 2017 experimental seasons (Plate 3).

Table 7. Inflorescence length (cm), No. of inflorescences and flowering density of six olive genotypes during 2016 and 2017 experimental seasons

Olive genotypes	Inflorescence length (cm)		No. of inflorescence / shoot		Flowering density/ meter	
	2016	2017	2016	2017	2016	2017
25	2.51B	2.47D	14.87B	10.66D	65.95C	53.40D
61	2.37C	2.52D	15.33B	19.07A	79.83A	74.03B
66	2.34C	2.98B	9.33E	14.27B	53.60D	72.23B
91	3.21A	2.90C	10.67D	10.83D	45.06E	61.94C
97	2.54B	2.25E	19.75A	19.55A	77.08B	78.00A
138	3.13A	3.47A	12.58C	11.73C	64.86C	77.83A

Values within each column followed by the same letter/s are not significant at 5 % level

Genotype 25

Genotype 61

Genotype 66

Genotype 91

Genotype 97

Genotype 138

Plate 3. Inflorescence characteristics of six olive genotypes

D.6. No. of perfect flowers per inflorescence

It is quite evident as shown from tabulated, data in Table 8 that olive genotype (66) was statistically the superior and showed the greatest number of perfect flowers per inflorescence i.e., (11.23 & 12.24) during 2016 & 2017 experimental seasons, respectively. Whereas, differences between olive genotype (66) and olive genotype (25) were too little to be taken into consideration from the statistic stand point in this regard, especially during 1st season. Anyhow, the least number of perfect flowers per inflorescence was significantly in concomitant to olive genotype (61) in the first season and olive genotype (91) in the second season.

D.7. Perfect flowers percentage

Referring the perfect flowers percentage of six genotypes under study Table 8 displays clearly that olive genotype (138) was statistically the superior and resulted significantly in the highest perfect flowers percentage (84.77 & 88.70) during 1st and 2nd seasons, respectively. Moreover, olive genotype (97) also had the same significantly as the superior one particularly in 1st season. The reverse was true with olive genotype (61) in the first season and olive genotype (91) in the second season which induced significantly the lowest perfect flowers percentage values. In addition, other olive genotypes were in between the aforesaid extremes during both experimental seasons.

Table 8. No. of total flowers/inflorescence, No. of perfect flowers/ inflorescence and perfect flowers (%) of six olive genotypes during 2016 and 2017 experimental seasons

Olive genotypes	No. of total flowers/inflorescence		No. of perfect flowers/inflorescence		perfect flowers percentage	
	2016	2017	2016	2017	2016	2017
25	16.17A	15.50C	11.27A	11.00B	68.47C	70.95C
61	15.37B	17.21B	3.77D	5.27D	24.54E	30.59F
66	14.37C	17.92A	11.23A	12.24A	78.16B	68.30D
91	14.55C	13.57D	8.81C	4.77D	60.52D	35.13E
97	12.13D	11.70E	10.43B	9.97C	85.98A	85.13B
138	11.00E	12.17E	9.33C	10.80B	84.77A	88.77A

Values within each column followed by the same letter/s are not significant at 5 % level

The obtained results regarding the positive effect of olive genotype in enhancement of the abovementioned flowering aspects are in general agreement with that found by Griggs et al. [35] stated that the relative proportion of perfect and staminate flowers varies with varieties and with the particular year. Also, [36-38] found that the percentage of perfect flowers in olive vary from year to year, tree to tree, shoot to shoot and inflorescence to inflorescence.

4. CONCLUSION

It can be recommended from the results of this study that, all the six olive genotypes suitable for Egypt conditions. Anyhow, olive genotypes (91 and 97) were the best in the most morphological traits. Meanwhile, olive genotype (138) was the superior and resulted highest perfect flowers percentages during two seasons of study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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