International Journal of Horticultural Science and Technology
Vol. 3, No. 1; June 2016, pp 1-8

Evaluating the Performance of Eleven Olive Cultivars in Fars Province of Iran

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(Received: 26 November 2014, Accepted: 29 May 2016)

Abstract

Olive (*Olea europaea* L.) consumption and production are socially and economically important in Iran. The aim of this experiment was to evaluate the vegetative characteristics, floral biology, fruit characteristics, oil percentage, and yield of eleven olive cvs. ('Arbequina', 'Amygdalolia', 'Bledy', 'Roghani', 'Zard', 'Sevillana', 'Koroneiki', 'Conservalia', 'Gordal Sevillana', 'Manzanilla', and 'Mission') in Kazeroun olive research station, Fars province, Iran. This experiment, conducted in completely randomized blocks design with three replications, was active for five years, 2004 until 2008. The results exhibited morphological trait differences across the cultivars. 'Amygdalolia' and 'Conservalia' were suitable in subtropical areas for canning and oil, 'Sevillana', 'Manzanilla', and 'Gordal Sevillana' as canning 'Arbequina' and 'Koroneiki' can be grown as oil cultivars in subtropical climate.

Key words: can, cultivar, fruit, oil, olive flower.

Introduction

The genus *Olea* (Oleaceae) has about 40 species and is distributed in Africa, Asia, Europe, and Oceania (Green, 2002). Olive has been cultivated for thousands of years, originating in the eastern Mediterranean region (Connell, 1994). There are roughly 1200 named cultivars with over 3000 synonyms throughout the world (Bartolini *et al*., 1993). Limited studies have been done on the high yielding (with high quantity of oil or having fruit with table feature) cultivars (Bartolini *et al*., 1993). Fourati *et al*. (2003) found that 30 olive cultivars varied in physical and chemical characteristics of fruits. Non-Mediterranean wild olive cultivars grow in different regions and have been geographically isolated from the Mediterranean cultivars (Zohary, 1994; Cantini *et al*., 1999; Sheidai *et al*., 2010).

Wild olive cultivars have been adapted when transferring them from the main place and planting them in other places which is different geographically, showing different morphological characters and have therefore been treated as separate species, subspecies, or varieties by different researchers. Sometimes, in various environmental conditions, differences in phenotype of cultivars are appeared in a way which leads to create ecotype, this caused confusion and various naming for a cultivar (Zohary, 1994; Cantini *et al.*, 1999; Besnard *et al*., 2007; Sheidai *et al*., 2010). Morphological and biological characters have been widely used for descriptive purposes and are commonly used to distinguish olive cultivars (Cantini *et al.*, 1999; Mazinani *et al*., 2008).

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Additionally, morphological characters are sometime correlated or associated with disease susceptibility and can be used as markers in breeding (Cantini *et al.,* 1999). The identification of olive cultivars and their area of origin are very important in order to expand cultivation of those commercial cultivars for their adaptation in specific local environmental conditions (Poljuha *et al*., 2008; Sarri *et al.*, 2006).

Iran is rich in olive gene pool which is unique in the world (Mazinani *et al.*, 2008). A scientifically sound knowledge of Iranian olive cultivars forms the basis of further genetic studies of Iranian olive. This will contribute to identify and preserve the genetic variation in olive in the world (Mazinani *et al.*, 2008). Limited morphological studies have been performed on Iranian olive cultivars in the past. The aim of this research was to introduce the cultivars of oily or table olives compatible with regions and environmental conditions of dry region of the south of Iran. Therefore, cultivars with high production, high percent of oil, and proper table characteristics were selected.

Materials and Methods

The present study was carried out during 5 successive years, from 2004 to 2008, in Fars province, Kazeroon city, with hot and dry weather conditions, at an altitude of 960 m, (49° 29' N, 37° 51' E), with maximum annual temperature of 48°C and minimum annual temperature of -5°C, mean annual temperature of 20.8°C, the average annual rainfall of 550.6 mm, and annual relative humidity of 52.33%. Temperature and relative humidity at flowering time were 19.7°C and 49.9%, respectively. Trees were 8-year-old 'Arbequina', 'Amygdalolia', 'Bledy', 'Roghani', 'Zard', 'Sevillana', 'Koroneiki', 'Conservalia', 'Gordal Sevillana', 'Manzanilla', and 'Mission' cultivars which were planted in 1996 at the time of testing.

The olive trees were trained as free-bush with minimum pruning, under irrigated standard cultural practices and cultivated with the same agro-technical treatments. To measure vegetative characteristic, trunk cross-sectional area, first the trunk circumference at a distance of 15 cm above the soil surface were measured with a meter scale, converted to TCA (tree circumference area) by the relation of circumference equal to 2 πr, the radius was calculated and, with the relation of area equal to πr^2, cross-sectional area was measured.

For measuring canopy area of the trees, first the mean radius of canopy was calculated in four main geographical directions and then the area was calculated with the use of the formulation of area. For measuring the current season growth, the total growth of spring and autumn shoots were measured by ruler. Reproductive characters, time of full bloom was considered the times that 75% of the trees blooms were opened. Percent of perfect flowers were measured by counting the number of perfect flowers and the total flowers in 100 collecting clusters from each tree and use the relation of:

Percent of perfect flowers = Total number of perfect flowers in 100 clusters/total number of flowers in 100 clusters

Total number of flowers/inflorescence was gained by collecting 100 flower clusters around each tree from the height of 1.5 m above the ground and using the relation of:

Total flower in inflorescence = Total number of flowers in 100 flower clusters/100

Inflorescence length was calculated by measuring the length of 100 flower clusters with the use of a ruler and using this formulation:

Length of inflorescence = Total length of 100 flower cluster/100

Fruit weights were calculated by selecting 20 random fruits from each tree at the height of 1.5 m above ground. These fruits were weighted with digital balance Tehnica ET-1111 (Iskra, Horjul, Slovenia,

±0.01 g accuracy). An electronic caliper gauge Starrett 727 Series (Athol, NE, USA, ±0.01 mm accuracy) was used to measure fruit and stone length, diameter. For measuring fruit volume, first a certain amount of water was poured in a graduated cylinder, then 20 fruits were dropped in that cylinder and the difference between the volumes of waters was used as an indicator to determine the volume of fruit for each tree. Flesh/stone ratio was measured by the relation of total flesh weight of 20 fruits/total stone weight of 20 fruits for each tree. Time of ripening was estimated by harvesting 100 fruits around each tree at height of 1.5 m above ground surface and using the formulation of Spain Agricultural Research Institute (Hegazi, 2007). For harvesting fruits, M should be equal to 5.

$M= (0 \times n_0)+(1 \times n_1)+(2 \times n_2)+\ldots\ldots\ldots.(7 \times n_7)/100$

n_0= number of fruits with dark green color
n_1= number of fruits with yellow or green to yellowish color
n_2= number of fruits with yellow color along with reddish dots
n_3= number of fruits with red or light violet color
n_4= number of fruits with black skin and completely green flesh
n_5= number of fruits with black skin and half violet flesh
n_6= number of fruits with black skin and violet flesh color like core
n_7= number of fruits with black skin and completely dark flesh

Yield and its efficiency were achieved by dividing yield or amount of production by trunk cross-sectional in each tree. To calculate the percent of oil, 20 black fruits per tree were milled along with the core. The resulting paste was weighed and placed in an oven at 103 °C for 8 h and then weighed again.

Fruit moisture content was achieved by the following formula:

Fruit moisture = The difference of paste weighted before and after placing in the oven/paste weighted before placing in the oven × 100

Fruit moisture was achieved, then 2 g of dry paste was weighed and then oil was caught in soxhlet apparatus (Behr, Labor-Tecnick, Dusseldorf, Germany) with the use of hexane solvent (Hegazi, 2007). Percentage of oil in fresh and dry matter of fruits was calculated by:

Percentage of oil in dry matter = amount of oil in 2 g dry fruit/2 × 100

Percentage of oil in fresh matter = (100- percentage of fruit moistening) × percentage of oil in dry matter/100

To calculate the amount of oil per unit area, we use the following formulation:

Amount of oil per unit area = (yield of the tree × percentage of oil in fresh or dry matter) × number of tree in hectare

The experiment was conducted as a randomized complete block design with three replications of a single tree. The research has been done during five years, since from statistical view effect of year was not significant thus the five year results have been combined. Means were compared by Duncan's multiple range tests at $P\leq 0.05$ using MSTAT-C software.

Results and Discussion

Results showed that significantly higher trunk cross-sectional area (TCA) was obtained on cv. 'Sevillana' (645.91 cm^2), where the lowest TCA was found in 'Amygdalolia' (263.59 cm^2) (Table 1). Hegazi (2007) showed that trunk cross-sectional area was associated with tree vigor. 'Amygdalolia' and low-vigor cultivars had the potential for planting in intensive and semi-intensive production systems. No significant difference was found in canopy area of 'Arbequina' and 'Sevillana (15.74 and 15.2 m^2, respectively) but canopy area of 'Arbequina' was significantly higher in comparison to other cultivars (Table 1).

Table 1. Vegetative and reproductive characteristics of 11 olive cultivars, in olive research station of Kazeroun, Fars province, Iran, during 2004-2008.

Cultivars	Trunk cross-sectional area (cm^2)	Canopy area (m^2)	Current season's growth (cm)	Time of full bloom (Days after bud break)	Total N. flowers/ inflorescence	Inflorescence Length (cm)	Percentage of perfect flowers/inflorescence
'Arbequina'	495.55 bcd†	15.74 a	30.16 a	33.87 ab	14.22 bc	3.04 de	52.87 bc
'Amygdalolia	263.59 e	10.08 de	25.23 b	34.87 ab	15.56 ab	3.34 abc	40.63 ef
'Bledy'	413.92 cd	11.72 cde	28.14 ab	33.67 ab	14.03 bc	3.40 a	56.59 ab
'Roghani'	401.57 cd	9.57 e	25.07 b	34.17 ab	16.67 a	2.83 e	44.28 de
'Zard'	512.97 bc	10.42 de	26.57 b	33.80 ab	13.98 bc	3.07 cde	63.68 a
'Sevillana'	645.91 a	15.20 ab	26.76 b	33.40 ab	13.39 c	3.36 ab	47.69 cde
'Koroneiki'	558.58 ab	12.20 cd	26.91 b	33.33 ab	15.52 ab	3.13abcd	50.89 bcd
'Conservalia'	379.71 d	12.10 cde	26.96 b	32.93 b	16.44 a	3.09 bcde	35.69 f
'Gordal Sevillana'	477.86bcd	9.87 de	22.15 c	33.00ab	13.07c	2.32 f	7.24 h
'Manzanilla'	550.35ab	12.98 bc	25.97 b	34.40ab	14.10bc	3.18abcd	41.88 ef
'Mission'	413.44 cd	10.29 de	26.91 b	34.53a	14.56bc	2.83 e	27.79 g

† Means in column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

It is reported that canopy area was associated with vigor and growth habit (Hegazi, 2012). Growth habits of standing means that branches are slightly tilted with respect to the branching point and the tree is created sweep mode and canopy are become less in wide growth habit branches have a wider angle with respect to branching point and as a result it has more canopy area (Hegazi, 2012). Therios (2009) used rooted cuttings of low vigor cultivars as dwarf rootstocks. Thus, 'Amygdalolia' can be used as self-rooted or as a rootstock for intensive or semi-intensive planting systems. In southern areas of Iran, sun radiation is high and it is necessary to find cultivars with potential of planting in semi-intensive or intensive systems until this problem can be resolved by creating canopy on each other (Sheidai *et al.*, 2010).

Finding and introducing of cultivars with low canopy and with slow growth habit is important. In the southern regions of Iran, olive vegetative growth is so high that prevents reproductive growth. Vegetative and reproductive growing of olives are compared with each other in southern regions of Iran. When the rate of growing is high, the ratio of carbohydrate to nitrogen has been changed in a way which is not suitable for fruiting (Sheidai *et al.*, 2010). A significant variation in current season's growth among olive cultivars was found (Table 1).

The growth was highest in 'Arbequina' where the lowest current season's growth was found for 'Gordal Sevillana' (22.15 cm; Table 1). No significant difference was found between current season's growth of 'Arbequina' (30.16 cms) and 'Bledy' (28.14 cms). The difference in current season growth in the present study might have been contributed by genetic difference in olive cultivars as current season's growth might be influenced by genetic characteristics of cultivar, yield, nutrition, irrigation, pruning, and other factors. Current season's growth presents the potential of fruiting for the next year. Naturally, the more rates of growing causes the more amounts of product (Ferrara *et al.*, 2002).

It was also noticed that full bloom happened sometime later in 'Mission' than 'Conservalia', in 'Conservalia', occurred in late April, but in 'Mission', cultivar is several days later than other cultivars (Table 1). Results of this study are in agreement with the results obtained by

Riberio *et al*. (2006) who reported that the onset and duration of flowering period were mainly determined by environmental factors such as meteorological conditions, soil and, genetic factors of olive cultivars. During 5 years of investigation, changes appear in the time of flowering, beginning, and ending time that was depending on environmental changes in different years.

However, cultivars also showed differences which reflect the influences of genetic factors. Porlingis and Voyiatzis (1999) reported that olive pollen germination was reduced at high temperatures. Early flowering in warm climate is an advantage that can escape the damage from high temperature at fruit set. The best pollination in olive occurs in about 20-30°C. Cultivars that flower earlier, pollinate, and fertilize in lower temperature, are safe from high temperature damage (Galán *et al*., 2005). Total numbers of flower/inflorescence were significantly higher in 'Roghani' and 'Conservalia' (16.67 and 16.44, respectively) than in 'Arbequina', 'Bledy', 'Zard', 'Sevillana', 'Gordal Sevillana', 'Manzanilla', and 'Mission' (Table 1).

Inflorescence length, given in Table 1 indicated that inflorescence lengths were significantly higher in 'Bledy' (3.4 cm) than other cultivars. Fouad *et al*. (1992) found that inflorescence was longer in 'Koroneiki', 'Pocoma', and 'Criolea' olive cultivars than that of 'Picual' and 'Chemlali'. Our results found a difference in inflorescence length between cultivars. Ferrara *et al*. (2002) found that variability between olive cultivars in floral characteristics and fruit set may be due to the influence of the genotype and the climatic conditions.

In this research, the cultivars in similar climate conditions have different length and number of flower in inflorescence which is under genetic condition. Meanwhile, difference in percent of complete flower is related to environmental factors besides genetics.

Percentage of perfect flowers/inflorescences was significantly higher in 'Zard' (63.68) compared to 'Arbequina', 'Amygdalolia', 'Roghani', 'Sevillana', 'Koroneiki', 'Conservalia','Gordal Sevillana','Manzanilla', and 'Mission' cultivars, while it was the lowest in 'Gordal Sevillana' (7.24) (Table 1). These results are confirmed by Hartmann and Panetssos (1961), Shatat and Sawwan (1986), Hegazi (2007), and Hegazi (2012) who reported that percentage of perfect flowers differed according to some factors such as cultivar, growing season, leaf to bud ratio, nutritional status, and water stress during inflorescence development and vegetative vigor. Data presented in Table 2 demonstrates fruit characteristics of the studied cultivars. Fruit weight, fruit diameter, fruit volume, stone weight, and stone volume of 'Conservalia', 'Amygdalolia', and 'Gordal Sevillana' were significantly higher in comparison to other cultivars. The greatest flesh/stone ratio was observed in 'Manzanilla' (5.3) compared to other cultivar and genotypes (Table 2).

These results are in agreement with results obtained by Fourati *et al*. (2003), Hegazi (2007, 2012), and Mazinani *et al*. (2008) who reported that fruit physical characteristics varied with olive cultivars. The fruit size depends on cultivar, age of tree, tree vigor, yield, soil moisture, and cultivation method (Costagli *et al*., 2003; Therios, 2009). For canned olive, fruit shape and size, flesh/stone ratio, firmness of flesh, thickness of skin, size and shape of stone, and taste of processed fruit are important (Therios, 2009). Time of fruit ripening in 'Koroneiki' (260.87) was significantly less than 'Gordal Sevillana' (255.67 days after full bloom). The highest yield was obtained in 'Conservalia' (22.87 kg $tree^{-1}$) cultivar in comparison to other cultivars (Table 3).

Table 2. Fruit characteristics (fruit and stone weight, length, diameter, volume, flesh/ stone ratio) of 11 olive cultivars, in olive research station of Kazeroun, Fars Province, Iran, during 2004-2008

Cultivars	Fruit weight (gr)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume(cm^3)	Stone weight (cm)	Stone length (cm)	Stone diameter (cm)	Stone volume (cm^3)	Flesh/ stone ratio
'Arbequina'	1.41 e†	1.59 g	1.23 d	1.44 e	0.43 e	1.23 e	0.74 g	0.38 e	2.40 ef
'Amygdalolia'	6.15 a	3.03 a	1.89 a	6.05 a	1.11 a	2.12 a	0.91 cd	0.97 a	4.88abc
'Bledy'	2.26 d	2.31 de	1.32 d	2.39 d	0.63 d	1.85 b	0.77 fg	0.55 d	2.86 de
'Roghani'	2.93 c	2.29 de	1.50 c	3.21 c	0.85 c	1.67 c	0.94 bc	0.71 b	2.41 ef
'Zard'	4.14 b	2.40 cd	1.71 b	4.23 b	1.00 b	1.64 cd	0.98 ab	0.91 a	3.35 d
'Sevillana'	3.76 b	2.26 e	1.67 b	3.85 b	0.65 d	1.56 cd	0.81 ef	0.59 cd	5.05 ab
'Koroneiki'	0.76 f	1.44 h	0.93 e	0.70 f	0.27 f	1.04 f	0.95 h	0.28 f	1.93 f
'Conservalia'	5.88 a	2.47 c	1.93 a	5.95 a	1.11 a	1.57 cd	0.99 ab	0.95 a	4.59 bc
'Gordal sevillana'	6.01 a	2.63 b	1.89 a	5.65 a	1.16 a	1.83 b	1.04 a	1.01 a	4.41 c
'Manzanilla'	4.04 b	2.36 cde	1.69 b	4.20 b	0.66 d	1.57 cd	0.86 de	0.67 bc	5.30 a
'Mission'	2.74 c	2.04 f	1.51 c	2.72 d	0.71 d	1.51 d	0.89 cd	0.62 bcd	3.01 d

† Means in column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

Table 3. Time of fruit ripening, yield and oil content in 11 olive cultivars, in olive research station of Kazeroun, Fars Province, Iran, during 2004- 2008

Cultivars	Time of ripening (days after full bloom)	Yield(kg tree^{-1})	Yield efficiency	Percentage of oil (dry matter)	Oil (kg hectare^{-1})
'Arbequina'	212.40 c†	17.53 b	0.04 b	29.20 cd	801.90 ab
'Amygdalolia'	221.33 bc	15.50 bcd	0.06 a	42.40 a	887.50 a
'Bledy'	214.67 bc	12.13 cde	0.03 bc	28.06 cd	531.10 cd
'Roghani'	196.33 d	5.80 f	0.01 d	29.15 cd	301.90 de
'Zard'	216.87 bc	13.60 cd	0.03 bc	30.08 c	645.90 bc
'Sevillana'	229.60 b	13.30 cd	0.02 cd	25.90 d	368.10 de
'Koroneiki'	260.87 a	15.90 bc	0.03 bc	30.31 c	769.00 ab
'Conservalia'	217.27 bc	22.87 a	0.06 a	34.11 b	931.70 a
'Gordal sevillana'	255.67 a	11.54 de	0.02 bcd	29.52 c	425.00 cde
'Manzanilla'	229.93 b	12.57 cde	0.03 bcd	28.16 cd	356.90 de
'Mission'	224.3 bc	8.97 ef	0.02 bcd	18.19 e	212.30 e

† Means in column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

These results were similar to those of Fouad *et al*. (1992) and Ferrara *et al*. (2002) who found that yield varied according to cultivar, season, and environmental conditions. Also, Rosati *et al*. (2010) found that fruit set and yield were determined by genetic and environmental factors. Yield efficiency in 'Amygdalolia' and 'Conservalia' were significantly higher than that of other cultivars. Yield and its efficiency are important and are used to represent yield capacity (Rosati *et al*., 2010).

The results showed that oil content was significantly higher in 'Amygdalolia' than in other cultivars. The obtained results mentioned above were in accordance with the results of Ferrara *et al*. (1999), Fourati *et al*. (2003), and Hegazi (2007) who found that oil percentage and oil quality varied according to olive cultivars. In the oil olives, the most important factor is a high percentage of oil. Dual-purpose olives have canned and oil characteristics.

To the best of our knowledge, no research has been done with the cultivars at least in the current location. Due to the characteristics of olive oil and canned cultivars that was mentioned, cultivars of 'Amygdalolia', 'Gordal Sevillana', and 'Conservalia' are superior to other cultivars in amount of products and other important characteristics (weight of fruit and flesh/stone ratio) they are introduced as the olive table cultivars. Although 'Manzanilla' and 'Sevillana' are high in amount of yield and flesh/stone ratio, they have not been chosen due to low size of fruits. 'Koroneiki' and 'Arbequina' cultivars are superior in the amount of oil in the fruits than other cultivars so that they are introduced as oily cultivars. 'Amygdalolia' and 'Conservalia' cultivars also have the characteristics of table and oily and they have been chosen as dual-purpose cultivars.

References

1. Bartolini, G., C. Messeri, G. Prevost. 1993. Olive tree germplasm: descriptor list of cultivated varieties in the world. Acta Hort. 356:116–118.
2. Besnard, G., P. Henry, L. Wille, D. Cooke, E. Chapuis. 2007. On the origin of the invasive olives (*Olea europaea* L., Oleaceae). Heredity 99:608–19.
3. Cantini, C., A. Cimato, G. Sani. 1999. Morphological evaluation of olive germplasm present in Tuscany region. Euphytica 109:173–81.
4. Connell, J.H. 1994. History and scope of the olive industry. University of California, Division of Agriculture and Natural Resources, Oakland, CA, USA 1-9.
5. Costagli, G., R. Gucci, H.F. Rapoport. 2003. Growth and development of fruits of olive Frantoio under irrigated and rainfed conditions. J. Hort. Sci. Biotech. 78(10):119-124.
6. Ferrara, F., G. Lovusso, and F. Lamparelli. 1999. A study of floral biology and the technological features of seven olive cvs. of different origins. Acta Hort. 474:279-283.
7. Ferrara, E., G. Papa, and L. Lamparelli. 2002. Evaluation of the olive germplasm in the Apulia region: Biological and technological characteristics. Acta Hort. 586:159-162.
8. Fourati, H., M. Khlif, M. Cossentini. 2003. Comparative study of the pomological and physico-chemical characteristics of thirty cultivars of olive. Olivae 96:33-37.
9. Fouad, M.M., O.A. Kilany, M.E. Said. 1992. Comparative studies on flowering, fruit set and yields of some olive cultivars under Giza conditions. Egypt. J. Appl. Sci. 7:630-646.
10. Galán, C., H. García-Mozo, L. Vázquez, L. Ruiz, C. Díaz de la Guardia, M.M. Trigo. 2005. Heat requirement for the onset of the *Olea europaea* L. pollen season in several sites in Andalusia and the effect of the expected future climate change. Inter. J. Biomet. 49:184–188.
11. Green, P.S. 2002. A revision of *Olea* L. (Oleaceae). Kew Bul. 57:91–140.
12. Hartmann, H., C. Panetssos. 1961. Effect of soil moisture deficiency during floral development on the fruitfulness in olives. Proc. Amer. Sci. 78:209-217.
13. Hegazi, A.A. 2007. A comparative study for identification between seven olive cultivars. a-Morphological identification. Egypt. J. Appl. Sci. 22:164-171.
14. Hegazi, A.A. 2012. Performance of 12 Introduced Olive Cultivars under Egyptian Conditions. Res. J. Agr. Biol. Sci. 8(2):98-107
15. Mazinani, M.H., A. Sadeghi, and S.A. Mirman. 2008. Multivariable analysis of intra cultivar variation of a local olive cultivar in the northern part of Iran using morphological trails. Acta Hort. 791:65-71.
16. Poljuha, D., B. Sladonja, K.B. Bubola, M. Radulovic, K. Brscic, E. Setic, M. Krapac, A. Milotic. 2008. A multidisciplinary approach to the characterisation of autochthonous Istrian olive (*Olea europaea* L.) varieties. Food Technol. Biotechnol. 46 :347–354.
17. Porlingis, I.C., D.G. Voyiatzis. 1999. Paclobutrazol decreases the harmful effect of high temperatures on fruit set in olive trees. Acta Hort. 474:241-244.
18. Riberio, H., L. Sautos, I. Abreu, M. Cunha. 2006. Influence of meteorological parameters on *Olea* flowering date and airborne pollen concentration in four regions of Portugal. Grana 45:115-121.

19. Rosati, A., M. Zipancic, S. Caporali, A. Paoletti. 2010. Fruit set in inversely related to flower and fruit weight in olive (*Olea europaea* L.). Sci. Hort. 120:200-204.

20. Sarri, V., L. Baldoni, A. Porceddu, N.G.M. Cultrera, A. Contento, M. Frediani, A. Belaj, I. Trujillo, P.G. Cionini. 2006. Microsatellite markers are powerful tools for discriminating among olive cultivars and assigning them to geographically defined populations. Genome 49:1606-1615.

21. Shatat, F., and J. Swwan. 1986. Effect of inflorescence position on the tree and on shoots on flower development and flower type in the olive. Dirasat 11(2):171-185.

22. Sheidai, M., Z. Noormohammadi, A.R. Dehghani, F. Parvini, H. Hoshiar-Parsiana, M. Hosseini-Mazinanic. 2010. Intra-specific morphological and molecular diversity in brown olive (*Olea cuspidata*) of Iran. Sci. Asia 36:187–193.

23. Therios, I. 2009. Olives. School of Agriculture. Aristotle University. Thessaloniki. Greece.

24. Zohary, D. 1994. The wild genetic resources of the cultivated olive. Acta Hort. 356:62–5.