Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2015, 6 (9):64-71
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Yield, fruit and oil content of some olive trees (*Olea europaea* L.) field-grown in Tunisia

Sihem Methamem*[1], Hassouna Gouta[2], Atef Mougou[3], Mohsen Mansour[3] and Dalenda Boujnah[2]

[1]*Institut Supérieur Agronomique de Chott Meriem, Chott Meriem, Sousse – Tunisia*
[2]*Institut de l'Olivier. Rue du 1er Juin, Tafala, Sousse Tunisie.*
[3]*Centre Régional des Recherches en Horticulture et Agriculture Biologique, Chott-mariem, Sousse, Tunisia*

ABSTRACT

Olives are one of the largest crops in the Mediterranean region, especially in Tunisia. This research assessed the performance of 19 cultivars of olives in rainfed conditions in the region of Chott Mariem during the 2010 to 2013 crop years. Average rainfall for those years was 422 mm in the area. In this study, varietal differences were considered in terms of yield, physical characteristics of the fruit and the oil content. The cultivars examined had their origins in Tunisia, Italy, Spain, France and Morocco. The effect of variety was highly significant ($p < 0.05$) for all traits. Based on our results, 'Meski', 'Roumi', 'Besbessi', 'Picholine' and 'Lucques' produced the highest cumulative yield over the four years of study. The largest fruits were given by 'Tounsi' and 'Ascolana', averaging respectively 7,98 and 6,09 g, whereas 'Chemlali' (0,74 g) and 'Chetoui' (1,91 g) had the smallest ones. The highest oil content was in 'Picholine' (19,62%), 'Fougi' (17,42%), 'Chemlali' (14,34%) and 'Chemchali' (14,05%). Finally and based on our results, 'Dahbia' and 'Lucques' are suggested for table olives production in the Chott Mariem region whereas; 'Fougi' and 'Chemchali' are the most suitable for oil production. 'Picholine' is considered as a cultivar with double attitude.

Keywords: *Olea europaea* L., olive oil, olive fruit, productivity, yield.

INTRODUCTION

Olive *(Olea europaea* L.) was one of the first fruit tree species domesticated. It is one of the oldest cultivated species in the Mediterranean basin and it is widespread throughout the Mediterranean region. Olives are widely cultivated there and represent one of the most important crops. The economic and historical importance of this species in the Mediterranean area has stimulated a lot of research. Olive oil is a major component of the traditional Mediterranean diet and world consumption. It is produced without refinement and it has healthy unsaturated fatty acids and antioxidants with claimed preventative and curative effects on cardiovascular disease and cancer (Visioli & Galli, 1998). The olive fruit is a drupe that is used both for its oil and also as a table fruit. Olives are widespread in many ecological regions in Tunisia. As in many other countries, new olive orchards are being established to supply the increasing world demand for olive oil and table olive. Because of its favorable ecological conditions, olive has been cultivated for many years in the center of Tunisia. In this region, the local olive cultivars 'Chemlali', 'Chetoui' and 'Oueslati' are traditionally cultivated for oil production. However, 'Picholine' and 'Manzanilla' have been planted more commonly into new orchards between 1996 and 2006. It is well known that ecological and cultivation conditions have significant effects on both yield and quality of olives (Bignami *et al*., 1994; Michelakis, 2002). Yield derives from fruit quality (e.g. weight) and quantity (i.e. number) (Rosati, 2012). Therefore, before introducing any new cultivar to a region, its performance in the region should first be investigated. Selection of the best performing cultivars has the potential to be advantageous for many aspects of production. For example, the use of a number of different table and oil cultivars having different characteristics can extend the harvest period. This would allow quality losses to be reduced as a result of fewer processing delays occasioned by overloading of limited post-harvest facilities.

This study sought to evaluate the productive capacity by studying the crop with their different aspects (yield, productivity, oil content and pomological study) of the nineteen olive trees field-grown spaced 7 x 7 m in the region of Chott Mariem in Sousse over a period of 4 years (from 2010 to 2013). The objective of this study was to investigate the performance of those olive cultivars. The ultimate purpose is to diversify the olive cultivars under cultivation in the Chott Mariem region and under high density planting by introducing some new, superior and well-adapted cultivars having high yields and high fruit quality.

MATERIALS AND METHODS

1. Study site and Plant material:

The trials were carried out between 2010 and 2013 at the experimental station of Chott Mariem in Sousse (35°54'N; 10°33'E) located in the eastern Mediterranean region in the center of Tunisia. This experimental station established on an area of 0,5 ha contains a collection of local and foreign olive varieties 26-year-old, planted in 1991 at a density of 200 trees ha^{-1}. Olive trees were spaced 7m x 7m and were subjected to all common olive cultivation practices. All treatments were on trees in the same soil texture (sandy soil). They were conducted under rainfed conditions. A randomized block design was used with three replications per cultivar. For our study, we were interested in 19 cultivars: 14 local representatives of the main producing regions of the north, center and south of Tunisia and 5 foreign. The local varieties are: 'Chetoui', 'Roumi', 'Gerboui', 'Besbessi', 'Meski', 'Sayali', 'Marsaline', 'Chemlali', 'Oueslati', 'R'khami', 'Chemchali', 'Beldi', 'Tounsi' and 'Fougi'. The foreign varieties are: 'Picholine', 'Lucques', 'Dahbia', 'Manzanilla' and 'Ascolana'.

Climatic conditions were recorded through a meteorological station installed in the experimental station. Meteorological data for Chott Mariem region are presented in Table 1.

Table 1.Meteorological data for Chott-Meriem region in Sousse (Tunisia) during the trial period from 2010 to 2013

	Months											
Years	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Min. Temperatures (°C)												
2010	7,62	7,92	9,73	13,01	15,09	18,08	20,97	21,28	19,94	16,04	11,51	7,33
2011	6,69	6,46	7,81	11,35	14,28	17,93	21,5	20,71	20,81	15,9	13,89	8,65
2012	7,47	4,73	8,89	11,2	13,74	18,78	22,03	22,29	20,09	17,2	13,79	8,26
2013	7,98	6,75	10,56	12,25	15,33	17,12	20,97	21,5	20,93	18,94	11,6	7,98
Mean	7,44	6,47	9,25	11,95	14,61	17,98	21,37	21,45	20,45	17,02	12,70	8,26
Max. Temperatures (°c)												
2010	17,51	19,01	18,55	19,98	24,02	25,83	30,04	30,05	28,66	24,61	21,09	18,25
2011	16,15	15,27	17,56	20,85	23,15	26,39	30,39	30,07	28,72	24,05	20,55	16,91
2012	15,35	13,61	17,14	20,95	23,61	27,68	31,57	32,3	29,21	25,8	22,97	17,83
2013	17,42	16,06	19,6	20,82	23,1	25,15	28,85	30,44	27,91	27,53	20,36	16,51
Mean	16,61	15,99	18,21	20,65	23,47	26,26	30,21	30,72	28,63	25,50	21,24	17,38
Total precipitations (mm)												
2010	14,2	29,2	55	69,6	27	2,8	1,2	0,2	82,4	116,4	39,8	5,4
2011	32,5	35,7	40,5	72,9	66,8	53,6	1,6	0,6	6,2	135	80,4	41,8
2012	31,6	14,4	82,4	113,2	24,6	7,4	1	0,2	88	31	3,8	2,2
2013	27,2	5,2	43,2	67,2	9	0,4	1,8	14,6	23	2,2	26,2	68,8
Mean	26,38	21,13	55,28	80,73	31,85	16,05	1,40	3,90	49,90	71,15	37,55	29,55

2. Yield and fruit study

Fruit were harvested by hand and the total yield (kg/tree) was determined at the black maturity stage for each cultivar from all replicates. The productivity was determined as the ratio (%) of the total production of one cultivar to the total production of all cultivars × 100. In order to see the fruit size categories, 50 fruits were sampled from each replicate of each cultivar (150 fruits per cultivar). The sampling was carried out in the four crops of 2010, 2011, 2012 and 2013. The studied pomological characteristics were Fruit and stone weight (g), fruit and stone width (mm), and fruit and stone length (mm). Fruit and stone shape index (length/width) were calculated. The stone was then removed and flesh and stone were weighed separately. So, the flesh to stone ratio (F/S) was determined. The following characteristics were evaluated and classified for each characteristic, for fruit weight: low (< 2 g), medium (2 to 4 g), high (4 to 6 g) and very high (> 6 g). Its shape is determined by the length/width ratio and classified as: spherical (L/W < 1,25), ovoid (L/W = 1,25 - 1,45) and elongated (L/W > 1,45). For the stone weight, low (< 0,3 g), medium (0,3 to 0,45 g), high (0,45 to 0,7 g) and very high (> 0,7 g). Concerning the stone shape index, determined by the length/width ratio, it is spherical (L/W < 1,4), ovoid (L/W = 1,4 to 1,8), elliptic (L/W = 1,8 to 2,2) and elongated (L/W > 2,2) (Ebiad & Abu-Qaoud, 2014).

3. Oil extraction

Mature drupes healthy, clean and free from pests and diseases were selected and were harvested by hand. No more than 48 hours elapsed between harvesting and pressing to avoid the risk of fermentation and development of defects in the oil. Olive oil was extracted using the extraction method by trituration. It consists in grinding the olives into a paste using a mill, malaxing the paste for 30 mn in a malaxer with 6 vases, separating the oil and water from the solids using a centrifuge (1300 rounds/mn) and finally, separating the oil from water by gravity. The oil content was expressed as a percentage of the fresh weight of the olive fruit. The samples were taken from each replicate of each cultivar. The sampling was carried out in the four crops of 2010, 2011, 2012 and 2013.

4. Statistical Analysis

The means of the various yield and fruit characteristics values are given as mean ± standard deviation (SD) followed by Duncan test as calculated from data measured and carried out to test the significance of the differences between means and assessed at the 5% significance level. The comparison between the behaviors of the 19 cultivars was made using a one-way analysis of variance (ANOVA). Mean separations were determined by Duncan's test ($P < 0,05$). All statistical procedures were performed using a statistical analysis and data management software (Statistical Package for the Social Sciences) SPSS 17.

RESULTS AND DISCUSSION

1. Yield study

The productivity (%) of every cultivar per year gave an idea on the contribution of each cultivar in the total production. The effect owing to variety and to year was highly significant ($P < 0.05$). In 2010, 'Besbessi' and 'Lucques' showed the same level of production (3,33 and 3,44%) (Table 2). The rate of 'Meski' increased around the years from 3,33% in 2010 to 9,16% in 2013, it may be explain by the decrease of the total production and the constancy of its production (Figure 1). In 2011, 'Chemchali' and 'Fougi' didn't product, the same in 2013 for 'Sayali', 'Chemlali', 'Oueslati', 'R'khami', 'Chemchali' and 'Fougi'. In 2012, 'Chemchali' and 'Meski' showed the highest productivity (respectively 7,06% and 6,64%) (Table 2). In the trial conditions, 'Meski' was the highest yielding variety in the four crop years, giving a productivity of 6,64 and 9,16% in respectively 2012 and 2013, followed by 'Picholine' with 8,93 and 4,31% in 2010 and 2011. The yields of the 'Chemchali' and 'Fougi' cultivars given in 2010 and 2012 were considerably higher than the levels recorded the previous seasons (2011 and 2013 were null). Their productivities were showing respective increases of 706% and 740% in 2012 compared with 2011 while 'Meski' recorded a rise of 181% in the same year (Table 2). There were large tree variations in fruit and yield due to alternate bearing patterns. The fruit yield had important fluctuations during the four years of study and reached its lowest values with 'Tounsi', 'Ascolana' and 'Beldi' (respectively 0,13, 0,15 and 0,89 kg/tree) (Table 3). Although, there were some fluctuations in yield between growing seasons, severe alternate bearing was clearly observed. This result may be explained as being the result of the high density of plantation and the absence of irrigation (Grattan *et al.*, 2006). The highest cumulative yields over the 4 years were in 'Meski' (72,17 kg/tree) and 'Picholine' (63,42 kg/tree) (Figure 1). The same result was showed by Tapia *et al.*, (2009) for the variety 'Picholine'. They said that it should receive special attention owing to their high productive capacity in the Huasco valley in northern Chile. The lowest cumulative yields over the 4 years were in 'Tounsi' (0,51kg/tree), 'Ascolana' (0,6 kg/tree) and 'Fougi' (3,56 kg/tree) (Figure 1).

Besides the amount of fruit produced, the study of fruit quality was not lacking in significance. Among the olive, the most important factor was the oil content. During these crop years and in the test conditions reported in this paper, The highest average of oil content values were recorded for the foreign cultivar 'Picholine' (19,62%) and the local 'Fougi' (17,42%) (Table 3). Whereas the lowest values were given for 'Dahbia' (0,28%) and 'Lucques' (3,72%) (Table 3). 'Picholine' had the highest oil content during the four harvest times. 'Dahbia' had the lowest oil content at all harvest times. The oil content values recorded for 'Meski' and 'Roumi' were 10,89% and 12,18% respectively (Table 3). The oil content was increasing for the majority of cultivars for the three years 2011, 2012 and 2013 comparatively with the oil content in 2010 (Figure 2 a, b, c) suggesting that it should be attributed to the climate factors (Mirshekari *et al.*, 2013). Our results showed that this parameter was closely linked with the maximum temperature in the Chott Mariem region based on Figure 2 d with a correlation coefficient r^2=0,998. From this correlation we deduced that the increasing of the oil content was linked to the increasing of the maximum temperature in the region of Chott Mariem.

Table 2. Productivity (%) of olive (*Olea europaea* L.) cultivars field-grown between 2010 and 2013 under Chott Mariem conditions in Tunisia

	Productivity (%)			
	2010	2011	2012	2013
Roumi	2,02±0,9ab	3,90±1,14efg	2,21±2,77a	4,31±2,35bc
Gerboui	0,97±0,31ab	1,51±1,85abcde	0,7±0,47a	4,46±5,07bc
Chetoui	0,82±0,09ab	2,26±0,4abcdefg	0,5±0,13a	5,99±3,88cd
Meski	3,33±2,63b	3,65±3,63defg	6,64±4,59b	9,16±2,84d
Besbessi	3,33±1,14b	3,39±0,64cdefg	2,64±2,49a	2,84±1,14abc
Marsaline	1,31±0,20ab	2,72±0,29bcdefg	0,56±0,20a	1,75±0,38ab
Sayali	0,61±0,15a	0,38±0,10ab	1,57±1,09a	0a
Chemlali	0,45±0,14a	1,85±0,23abcdefg	0,5±0,17a	0a
Oueslati	0,5±0,1a	0,54±0,61ab	1,34±2,24a	0a
R`khami	2,5±1,88ab	0,61±0,56ab	2,24±2,73a	0a
Chemchali	1,18±1,49ab	0a	7,06±0,52b	0a
Beldi	0,11±0,04a	1,41±0,28abcde	0,15±0,06a	0,09±0,08a
Fougi	0,46±0,23a	0 a	0,74±0,62a	0a
Tounsi	0,02±0,03a	0,01±0,01a	0,06±0,05a	0,07±0,03a
Dahbia	0,77±0,02ab	4,10±1,42fg	0,66a	0,27±0,38a
Manzanilla	0,52±0,08a	1,05±1,65abc	0,74±0,5a	1,65±0,91ab
Lucques	3,44±1,74b	1,77±1,5bcdef	2,72±1,65a	0,91±1,58ab
Picholine	8,93±1,07	4,31±1,16g	1,41±0,76a	1,1±1,1ab
Ascolana	2,26±3,92ab	1,18±2,02abcd	1,02±1,54a	0,75±1,25ab

All values are means +/- SD. Values represent the mean of three replications. Means within each column followed by different letters are significantly different (P < 0,05) by the Duncan test.

Table 3. Production (kg/year/tree) and oil content (%) of olive (*Olea europaea* L.) cultivars field-grown between 2010 and 2013 under Chott Mariem conditions in Tunisia

Cultivars	Average of production (kg/year/tree)	Average of oil content (%)
Roumi	11,99±1,69h	12,18±0,55cd
Gerboui	5,93±2,38ef	8,35±0,21
Chetoui	7,70±1,04g	12,56±0,18d
Meski	18,04±1,08	10,89±0,26b
Besbessi	11,65±0,93h	9,16±0,21
Marsaline	6,98±1,43fg	6,53±0,32a
Sayali	2,29±0,93c	11,95±0,21cd
Chemlali	3,98±1,06cd	14,34±0,52e
Oueslati	2,33±0,96c	12,68±0,50d
R`khami	4,55±0,49cde	9,97±0,32
Chemchali	6,17±0,93cdef	14,05±0,50e
Beldi	2,74±0,99bc	11,62±0,55c
Fougi	0,89±0,22ab	17,42±0,51
Tounsi	0,13±0,47a	6,54±0,50a
Dahbia	7,93±1,30fg	0,28±0,13
Manzanilla	2,41±1,07c	11,97±0,55cd
Lucques	11,21±0,68	3,72±0,38
Picholine	15,85±1,17h	19,62±0,45
Ascolana	0,15±0,23a	10,86±0,5b

All values are means +/- SD. Values represent the mean of three replications of four years of trial. Means within each column followed by different letters are significantly different (P < 0,05) by the Duncan test.

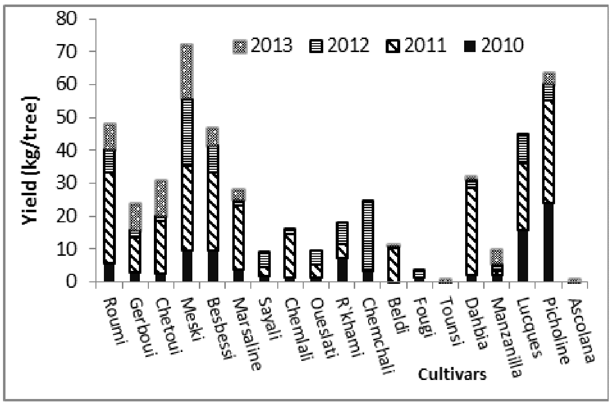

Figure 1. Cumulative yields olive cultivars grown under Chott Mariem conditions for the four years of study 2010, 2011, 2012 and 2013

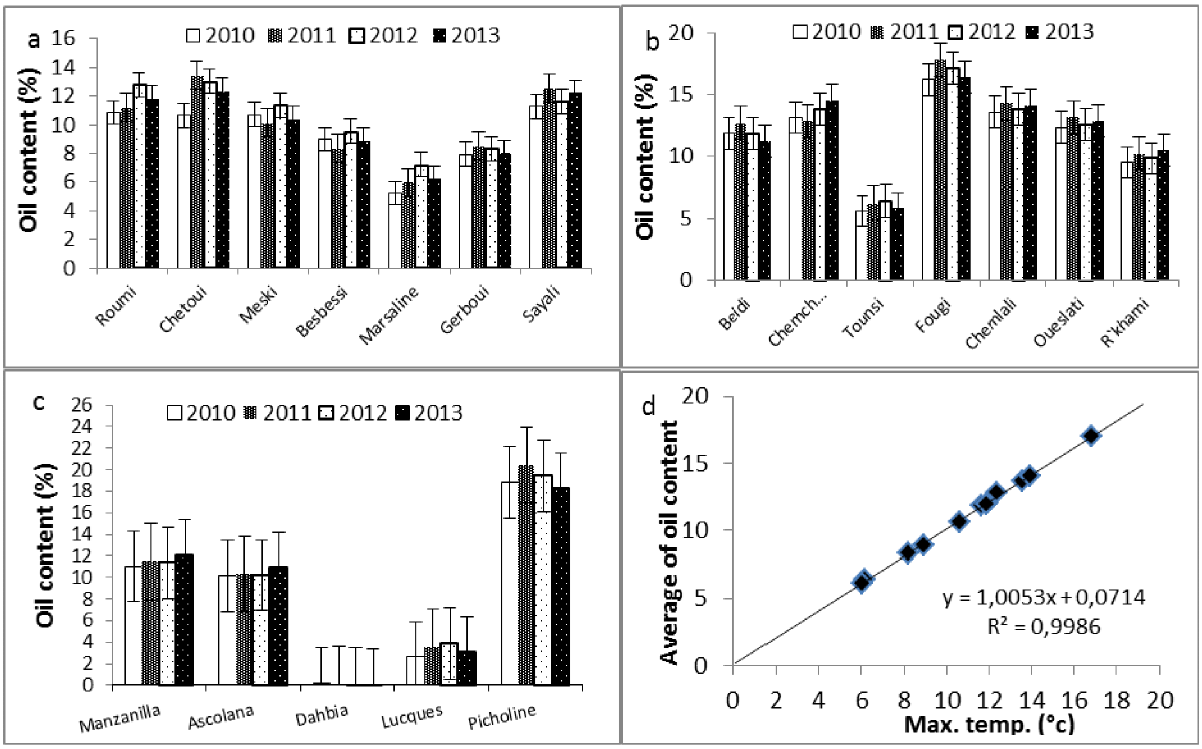

Figure 2. Oil content of local (a and b) and foreign (c) cultivars of olive cultivars grown under Chott Mariem conditions for the years from 2010 to 2013 and relationship between average of oil content (%) of four years of study and mean of maximum temperature (°c) (d)

2. Fruit study

Fruit size is important commercially and the studies of factors affecting it are of great scientific interest. Among the cultivars in this study, the smallest fruits were harvested from 'Chemlali' (0,74 g), followed by 'R'khami' and 'Chetoui' with 1,9 g (low fruit < 2g). The heaviest fruits were from 'Tounsi' (8 g), 'Ascolana' (6,09 g) (very high > 6 g) and 'Marsaline' (5,94 g) (high fruit) (Table 4). The highest fruit length and width were measured in 'Tounsi' (27,56 and 22,36 mm, respectively). The lowest ones were determined in 'Chemlali' (12,73mm for length and 8,74 mm for width) (Table 4). Similar trend was obtained with stone dimensions. Fruit shape varied between cultivars and could be grouped into three form types. 'Chetoui', 'Marsaline', 'Oueslati', 'Chemchali', 'Beldi', 'Tounsi', 'Manzanilla' and 'Ascolana' were spheroid (L/W < 1,25), 'Meski', 'Chemlali' and 'Dahbia' were elongate (L/W > 1,45) and the other cultivars were ellipsoid (1,25 < L/W < 1,45) (Table 4). The very high stone (> 0,7 g) was found in 'Tounsi' (0,74g) whereas 'Chemlali' had the smallest stone (0,13g) (< 0,3 g). The highest fruit flesh ratios were found in 'Ascolana' (94,22%) and 'Tounsi' (90,66%) (Table 5). Results relative to the weight of the stones (g) showed high correlation between the stone and fresh fruit (g) (Figure 3 a). From this correlation we deduced that more than 70% of fruit weights are stone weights. The relationship between these weights is expressed by the following equation: Fruit fresh weight = 0,074 × stone weight + 0,155 (1)

Good dependence of stone shape index to fruit shape index (Figure 3 b) was found and could be expressed as follows: Fruit shape index = 1,934 × stone shape index – 0,40 (2) with a correlation coefficient r^2 = 0,619.

Olive fruit size differs greatly among cultivars (Barranco, 1999). Both the endocarp and mesocarp contribute to final fruit size differences (Hammami *et al.*, 2011). The final fruit size is also related to environmental and endogenous plant conditions that allow the genetic potential growth to be achieved to a varying degree (Rosati, 2012). Fruit and stone mass can vary due to exogenous factors (environment, cultivation technology, *etc.*) (Ebiad & Abu-Qaoud, 2014). So, in our study, we can explain the very small size of the olives of the local cultivar 'Chemlali' that represent the major cultivar in the plantation of Sousse by the severe conditions in the orchard (high density, absence of irrigation and severe summer). If olive production is for pickling, a loss in yield quality can occur due to reduced fruit size as a consequence of water stress (Proietti and Antognozzi, 1996). This is true for the cutivars 'Meski', 'Sayali', 'Besbessi', 'Marsaline', 'Beldi' and 'Fougi'. If the olive is grown for oil production, a certain degree of water stress during the pit-hardening stage does not affect oil content (Zeleke *et al.*, 2012). Also, there was no effect of the irrigation regime on the oil content. Some studies of individual cultivars of *Olea europaea* showed that oil content was generally either slightly affected (Gomez-Rico *et al.*, 2007; Lavee *et al.*, 2007) or not affected (Motilva *et al.*, 2000; d'Andria *et al.*, 2004; Patumi *et al.*, 2002) by irrigation. Oil biosynthesis proceeds very rapidly between the olives when they are at the green stage until they turn completely black, after which oil content stabilizes

(Civantos, 1999) and even records a small decrease at advanced stages of maturity). The intensity of oil formation is a genetic trait, but also depends on soil and climatic conditions and crop management (Civantos, 1999).The changes in fruit oil content (as a percentage of fresh matter) is a varietal characteristic and specific to each variety. Cultivars responded differently to the irrigation regime in terms of oil content and fruit quality. Nevertheless, yields are associated with irrigation. D'andria *et al*., (2009) demonstrated that in cultivars 'Leccino', 'Pendolino' and 'Picual', the fruit size was significantly higher when irrigated. They found significantly lower fruit size and lower fruit weight. Although irrigation increases the mesocarp-to-endocarp ratio (which affects fruit oil content) when compared with rainfed trees (d'Andria *et al.*, 2004; Gomez-Rico *et al.*, 2007). Gucci *et al*. (2009) showed that higher levels of irrigation do not necessarily increase the ratio further, and that some degree of water deficit can increase or maintain the ratio compared with that of well-irrigated trees. Proietti and Antognozzi (1996) showed that irrigation with the cultivar 'Ascolana' did not influence fruit shape, but increased fruit weight, volume, and pulp/pit ratio. Evidently water stress, besides decreasing plant activity, causes a drop in fruit growth, which is only partially reversible after removing the stress. Rapoport *et al*., (2004) showed that water stress during early fruit growth reduced fruit size in 'Leccino' plants grown in pots; the mesocarp and the endocarp responded in different ways, indicating both competition and interaction between developing fruit tissues. However, Patumi *et al*., (1999) reported a constant mesocarp/endocarp ratio for cultivars 'Ascolana tenera', 'Kalamata' and 'Nocellara Del Belice' subjected to different irrigation regimes. The increase in fruit size with increasing watering amount was generally determined by dry matter accumulation in the endocarp and the mesocarp. Differences between treatments were, however, more pronounced for the mesocarp mass than for the endocarp mass, and the mesocarp/endocarp ratio behaved accordingly (d'Andria *et al.*, 2009). As reported in similar studies in other climate areas, the relationship between yield and weather related variables become evident at the critical time of flower growth and ripening. It has been demonstrated that rainfall during fruit ripening exerts a considerable influence on final fruit production in areas with a dry climate, such as the Andalucia region (Galán *et al.*, 2007). In other sites of the Mediterranean area, temperature has been revealed as the main factor (Fornaciari *et al.*, 2005). In Chott Mariem areas where rainfall is scarce, irrigation can improve the commercial value of olive fruit by increasing weight, size, higher pulp/pit ratio, and more the crop yield production.

Table 4. Fruit weight (g), fruit length and width (mm) and fruit shape index of 19 olive cultivars (*Olea europaea* L.) grown between 2010 and 2013 under Chott Mariem conditions

	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit Shape Index
Roumi	2,33±0,63ab	18,41±1,51bcde	14,45±1,33cde	1,28±0,03cde
Gerboui	2,14±0,44a	16,22±2,67bc	12,83±3,32bcd	1,29±0,15de
Chetoui	1,91±0,30a	16,74±1,21bcd	13,63±0,38cd	1,24±0,07bcde
Meski	2,06±0,08a	15,39±0,17ab	10,26±0,29ab	1,50±0,05g
Besbessi	3,41±0,15bcde	17,47±0,39bcde	13,39±0,34cd	1,31±0,01de
Marsaline	5,94±0,09g	23,79±0,16g	20,54±0,18hi	1,16±0,01abc
Sayali	4,47±0,65e	23,46±2,47g	17,52±0,51fg	1,34±0,11def
Chemlali	0,74±0,18	12,73±1,33a	8,74±1,42a	1,47±0,09cg
Oueslati	3,62±1,57cde	20,28±2,37ef	16,69±2,79ef	1,22±0,07bd
R'khami	1,98±0,48a	17,62±1,07bcde	13,04±0,92cd	1,35±0,01ef
Chemchali	2,05±0,08a	17,33±0,85bcde	13,82±0,36cd	1,24±0,07bcde
Beldi	5,74±0,23fg	19,67±0,21def	17,29±0,17efg	1,14±0,01ab
Fougi	2,51±0,56abc	18,88±1,90cdef	14,45±0,68cde	1,31±0,07de
Tounsi	7,98±0,85	27,56±0,31	22,36±0,66i	1,23±0,04bcde
Dahbia	3,73±0,17cde	21,57±0,31fg	12,53±0,36bc	1,73±0,03
Manzanilla	3,00±1,58abcd	18,92±2,53cdef	15,41±3,02cdef	1,24±0,07bcde
Lucques	4,67±0,50ef	24,25±0,25g	16,94±0,11ef	1,43±0,01fg
Picholine	3,94±1,06de	20,27±3,98ef	15,67±3,11def	1,30±0,01de
Ascolana	6,09±0,12g	21,81±0,71g	19,69±0,46gh	1,11±0,03a

All values are means +/- SD. Values represent the average of the four years of study and the mean of three replications per cultivar. Means within each column followed by different letters are significantly different (P < 0,05) by the Duncan test.

Table 5. Stone weight (g), stone length and width (mm), stone shape index and fruit flesh ratio of several olive (*Olea europaea* L.) cultivars grown between 2010 and 2013 under Chott Mariem, Tunisia conditions

	Stone weight (g)	Stone length (mm)	Stone width (mm)	Stone Shape Index	Fruit Flesh Ratio
Roumi	0,28±0,05ab	13,71±0,54bc	6,02±0,41abc	2,28±0,07ef	87,55±1,57cdfg
Gerboui	0,26±0,04ab	12,72±0,41b	6,09±0,78abc	2,12±0,31cde	87,73±1,20cdefg
Chetoui	0,25±0,04ab	13,29±0,89bc	5,84±0,48abc	2,28±0,03ef	87,09±1,73cdefg
Meski	0,29±0,01ab	13,94±0,15bc	5,48±0,39ab	2,56±0,16fg	85,98±0,92bcde
Besbessi	0,41±0,03bcd	14,30±0,26bc	7,34±0,21cde	1,95±0,02cde	88,08±0,60cdefgi
Marsaline	0,62±0,08def	14,91±0,27c	8,50±0,68ef	1,76±0,11abc	89,52±1,45gi
Sayali	0,65±0,22ef	17,18±2,64d	8,16±0,88def	2,11±0,19cde	85,64±3,16bcd
Chemlali	0,13±0,04a	9,80±1,18a	4,74±0,34a	2,07±0,22cde	82,56±1,19a
Oueslati	0,52±0,28cdef	14,42±1,48bc	8,21±2,43def	1,85±0,46bcd	86,11±2,10bcde
R'khami	0,29±0,05ab	13,89±0,91bc	6,08±0,24abc	2,29±0,20ef	85,40±1,24bc
Chemchali	0,35±0,04abc	13,63±0,97bc	5,94±0,36abc	2,28±0,03ef	82,75±1,59a
Beldi	0,62±0,05def	14,42±0,34bc	9,35±0,26f	1,54±0,02ab	89,16±0,49fgi
Fougi	0,40±0,11bcd	14,45±1,76bc	6,90±0,53bcde	2,09±0,11cde	84,09±0,79ab
Tounsi	0,74±0,03f	18,31±0,40d	8,42±0,27ef	2,18±0,06de	90,66±1,10i
Dahbia	0,48±0,02bcde	18,51±0,17d	6,49±0,17abcd	2,85±0,07g	87,21±0,64cdefg
Manzanilla	0,41±0,25bcd	13,83±0,89bc	6,96±2,23bcde	2,09±0,46cde	86,66±1,30bcdef
Lucques	0,53±0,02cdef	17,98±0,04d	6,85±0,07bcde	2,63±0,03fg	88,60±0,91efgi
Picholine	0,47±0,22bcde	15,32±2,02c	7,42±1,36cde	2,09±0,18cde	88,30±2,40defgi
Ascolana	0,35±0,03abc	9,59±0,21a	6,49±0,33abcd	1,48±0,06a	94,22±0,32

All values are means +/- SD. Values represent the average of the four years of study and the mean of three replications per cultivar. Means within each column followed by different letters are significantly different (P < 0,05) by the Duncan test.

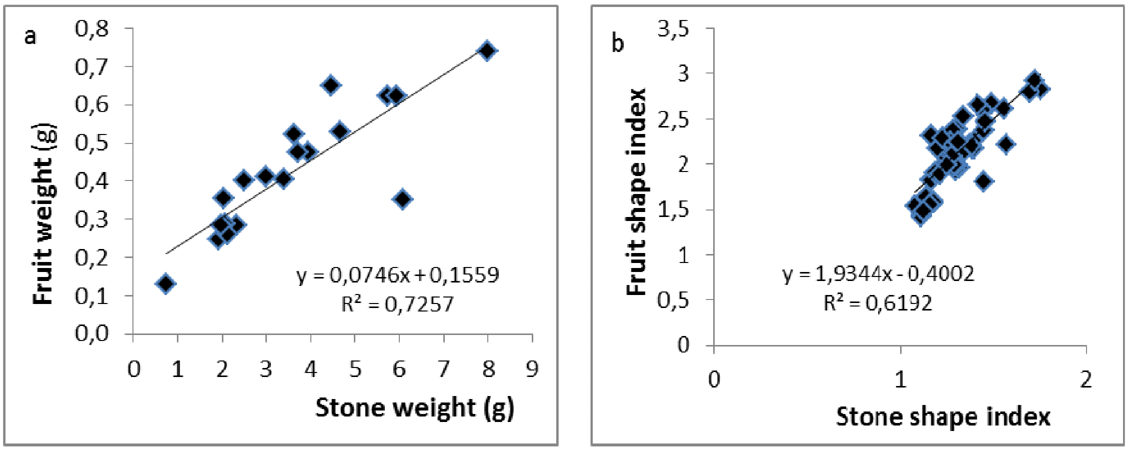

Figure 3. Linear relationship between fresh weight of fruit (g) and stone weight (g) (a) and between stone shape index and fruit shape index (b) determined for 19 cultivars of *Olea europaea* L. field grown in Chott Mariem

CONCLUSION

Based on the oil content, the varieties can be divided into three groups: low oil content (< 10%) ('Gerboui', 'Besbessi', 'Marsaline', 'R'khami', 'Tounsi', 'Dahbia', and 'Lucques'), medium oil content (10 – 15%) ('Roumi', 'Chetoui', 'Meski', 'Sayali', 'Chemlali', 'Oueslati', 'Chemchali', 'Beldi' 'Manzanilla' and 'Ascolana') and high oil content (> 15%)('Picholine' and 'Fougi'). The French cultivar 'Picholine' showed some degree of superiority owing to their larger sized fruits, the high level of production (15,88 kg/tree) and the high content of oil (> 15%). This cultivar was considered with double attitude and had a good behavior in our orchard. The two cultivars of table olives 'Ascolana' and 'Tounsi' required other studies in order to understand the causes of their lowest values of production in the four years of experiment.

REFERENCES

[1]Barranco, D. Variedades y patrones, *in* Barranco, D., Fernàndez-Escobar, R., Rallo, L.(Eds), *El cultivo del olivo*, Ed. Mundi-Prensa, Madrid, **1999**, 63–89p.
[2]C. Bignami, S. Natali, C. Menna, G. Peruzzi, Growth and phenology of some olive cultivars in central Italy, *Acta Horticulturae*, **1994**, 356, 106-109.
[3]M. Civantos, Control de Plagas del Olivar. COI, Madrid, **1999**, 207p.
[4]R. D'andria, A. Lavini, G. Morelli, M. Patumi, S. Terenziani, D. Calandrelli, F. Fragnito, *Journal of Horticultural Science and Biotechnology*, **2004**, 79, 18-25.

[5]R. D'andria, A. Lavini, G. Morelli, L. Sebastiani, R. Tognetti, *Plant Biosyst.*, **2009**, 143, 222–231.
[6]R. Ebiad, H. Abu-qaoud, *Jordan Journal of Agricultural Sciences,* **2014**, 10, 130-143.
[7]M. Fornaciari, F. Orlandi, B. Romano, *Agronomy Journal*, **2005**, 97, 1537-1542.
[8]C. Galán, H. García-Mozo, L. Vázquez, L. Ruiz, C. Díaz De La Guardia, E. Domínguez-Vilches, *Agronomy Journal,* **2007**, 100(1), 100–109.
[9]H. García-Mozo, R. Perez-Badía, C. Galán, *Aerobiologia,* **2007**.
[10]S. R. Grattan, M. J. Berenguer, J. H. Connell, V. S. Polito, P. M. Vossen, *Agricultural water management,* **2006**. 85, 133–140.
[11]A. Gomez-Rico, M. Desamparados-Salvador, A. Moriana, D. Perez, N. Olmedilla,F. Ribas, G. Fregapane, *Food Chem*. **2007**, 100, 568–578.
[12]R. Gucci, E. M. Lodolini, H F. Rapoport, *Tree Physiology*, **2009**, 29, 1575-1585.
[13]S. B. M. Hammami, T. Manrique, H. F. Rapoport, *Scientia Horticulturae,* **2009**, 130, 445–451.
[14]S. Lavee, E. Hanoch, M. Wodner, H. Abramowitch, *Scientia Horticulturae,* **2007**, 112, 156-163.
[15]N. Michelakis, *Acta Horticulturae,* **2002**, 586, 239-245.
[16]M. Mirshekari, N. Majnounhosseini, R. Amiri, A. Moslehi, O. R. Zandvakili, *J. Agr. Sci. Tech.,* **2013**, 15, 505-515.
[17]M. J. Motilva, M. J. Tovar, M. P. Romero, S. Alegre, J. Girona, *J. Sci. Food Agric.*, **2000**, 80, 2037–2043.
[18]M. Patumi, R. D'andria, G. Fontanazza, G. Morelli, P. Giorio, G. Sorrentino, *J. Hort. Sci. Biotech.*, **1999**, 74, 729 – 737.
[19]M. Patumi, R. D'andria, V. Marsilio, G. Fontanazza, G. Morelli, B. Lanza, *Food Chemistry*, **2002**, 77, 27-34.
[20]P. Proietti, E. Antognozzi, *New Zealand Journal of Crop and Horticultural Science,* **1996**, 24, 175-181.
[21]H. Rapoport, G. Costagli, R. Gucci, *J Am Soc Hort Sci,* **2004**, 129, 121–127.
[22]A. Rosati, S. Caporali, S. B. M. Hammami, I. Moreno-Alías, A. Paoletti, H. F. Rapoport, *Functional Plant Biology*, **2012**, in press.
[23]F. C. Tapia, F. Mora, A. I. Santos, *Chilean Journal of Agricultural Research*, **2009**, 69(3), 325-330.
[24]F. Visioli, C. Galli, *Journal of the Agriculture Food and Chemistry,* **1998**, 46, 4292-4296.
[25]K. Zeleke, R. Mailer, P. Eberbach, J. Wünsche, *New Zealand Journal of Crop and Horticultural Science,* **2012**, 40(4), 241-252.