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

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ABSTRACT

This study aims at characterizing nineteen cultivars of olive trees cultivated in the region of Chott Mariem in the coastal part of Tunisia under rainfed conditions. For that yield and pomological parameters were followed during four years from 2010 to 2013. We noticed a significant (P < 0.05) varietal differences in terms of yield, physical characteristics of the fruit and the oil content. Moreover, there were some fluctuations in the yield between years and a severe alternate bearing was clearly observed. Each cultivar expressed different pomological characters. 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. Based on our results, 'Meski', 'Roumi', 'Besbessi', 'Picholine' and 'Lucques' produced the highest cumulative yield over the four years of study. The highest oil content was observed in 'Picholine' (19,62%), 'Fougi' (17,42%), 'Chemlali' (14,34%) and 'Chemchali' (14,05%). Finally and based on our results in the Chott Mariem region, 'Dahbia' and 'Lucques' were suggested to be more appropriate for table olive production whereas; 'Fougi' and 'Chemchali' were the most suitable for oil production. 'Picholine' could be considered as a cultivar with double use.

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

INTRODUCTION

The Tunisian olive tree culture constitutes one of the principal economical and agricultural strategic sectors. About 60 million trees are distributed and spread on 1.6 million hectares from the northern to the southern regions, where a wide range of edapho-climatic conditions are prevailing. The olive oil is produced without refinement and has healthy unsaturated fatty acids and antioxidants with claimed preventative and curative effects on cardiovascular disease and cancer (Visioli and Galli, 1998). The olive fruit is a drupe used for both oil extraction and also as a table fruit. It is composed of four main parts: exocarp or skin, mesocarp or flesh, which is an edible part of table olives and part where olive oil accumulation starts, and lignified endocarp, which surrounds and protects an olive semen or seed (Connor, 2005). The evolution of the olive growing sector over time revealed that until the 1950s, the olive culture expanded slowly. After that, traditional planting system has been transformed into more intensive groves (Fernández-Escobar *et al.*, 2013). In Tunisia, there have been many efforts for the intensification, notably by increasing trees density. New orchards are planted at higher densities (200 and 300 trees ha^{-1}) (Aiachi *et al.*, 2014) and many foreigner cultivars were introduced such as 'Picholine' and 'Manzanilla' into new Tunisian 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). As reported in similar studies, the relationship between yield and weather related variables become evident at the critical time of flower growth and ripening. The olive tree is a well-known alternate-bearing species (Lavee, 1997), this is why the high yield year is generally followed by a low yield year even under optimal conditions of cultivation (Aiachi *et al*., 2014). On the other hand, the amount of oil increases gradually through summer and fall and reaches its maximum as fruits become completely black. Oil production, quantity and quality are greatly affected by many factors such cultivar, oil accumulation and harvesting stage. Fruit weight and fruit volume showed continuous increase from the beginning of fruit development till fruit reached its full weight (Desouky *et al*., 2010). The increase in fruit size was generally determined by dry matter accumulation in the endocarp and the mesocarp. 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 such as environment, cultivation and technology (Ebiad and Abu-Qaoud, 2014). 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. The mesocarp and the endocarp responded in different ways, indicating both competition and interaction between developing fruit tissues. Proietti and Antognozzi (1996) showed that irrigation did not influence fruit shape, but increased fruit weight, volume, and pulp/pit ratio.

The objective of this study was to investigate the performance of nineteen olive cultivars in open field in the region of Chott Mariem in Tunisia over a period of 4 years (from 2010 to 2013). The ultimate purposes are to diversify the olive cultivars under cultivation in this region under high density planting and to introduce 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 in a sandy soil between 2010 and 2013 at the experimental station of Chott Mariem in Sousse (35°54'N; 10°33'E) located in the center of Tunisia. This repository experimental station established on an area of 0,5 ha and hosts a collection of local and foreigner olive cultivars 26-year age olive trees, 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 and conducted under rainfed conditions. The climatic conditions were recorded through a meteorological station installed in the experimental station. The area's climate is considered as semi-arid with severe drought and high temperatures in summer (Table 1). A randomized block design was used with three replications per cultivar. For our study, we were interested in 19 cultivars (grouped as oil and table cultivars). The local cultivars are: 'Chetoui', 'Roumi', 'Gerboui', 'Besbessi', 'Meski', 'Sayali', 'Marsaline', 'Chemlali', 'Oueslati', 'R'khami', 'Chemchali', 'Beldi', 'Tounsi' and 'Fougi'. The foreigner ones are: 'Picholine', 'Lucques', 'Dahbia', 'Manzanilla' and 'Ascolana'.

Table 1.Meteorological data of Chott Mariem region in 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

(Source: The Regional Research Center on Horticulture and Organic Agriculture of Chott Mariem).

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 weight of the fruit is considered low when (< 2 g), medium when (2 to 4 g), high when (4 to 6 g) and very high when (> 6 g). Its shape is determined by the length/width ratio and had spherical form when (L/W < 1,25), ovoid when (L/W = 1,25 - 1,45) and elongated when (L/W > 1,45). Concerning the stone weight, it is low when (< 0,3 g), medium when (0,3 to 0,45 g), high when (0,45 to 0,7 g) and very high when (> 0,7 g). The stone shape index, determined by the length/width ratio, is spherical (L/W < 1,4), ovoid (L/W = 1,4 to 1,8), elliptic (L/W = 1,8 to 2,2) or elongated (L/W > 2,2) (Ebiad and 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). 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 was followed in order to analyze the contribution of each cultivar in the total production. The effect of both year and cultivar 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 among years and varied from 3,33% in 2010 to 9,16% in 2013(Figure 1). In 2011, ‘Chemchali’ and ‘Fougi’ didn’t produce olives, 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 our trial conditions, ‘Meski’ was the highest yielding cultivar 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 showed respective increases of 706% and 740% in 2012 compared with 2011 while ‘Meski’ recorded a rise of 181% in the same year (Table 2). 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). There were large cultivar variations in yield and a severe alternate bearing was clearly observed. This result may be explained by the relatively high density of plantation and the absence of complementary irrigation (Grattan *et al*., 2006). 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). 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 cultivar ‘Picholine’. They reported that it should receive special attention according 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 and the most important factor was the oil content. During the 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 while ‘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 during the three years 2011, 2012 and 2013 comparatively with the oil content in 2010 (Figure

2 a, b, c), suggesting that this could be attributed to the climate factors (Mirshekari *et al.*, 2013). Moreover, the changes in fruit oil content (as a percentage of fresh matter) were varietal characteristics and were consequently specific to each cultivar. So, the intensity of oil formation was a genetic trait, but also depended on soil and climatic conditions and crop management (Civantos, 1999). In fact it was proved that 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. Zeleke *et al.*, (2012) showed that if the olive was grown for oil production, a certain degree of water stress during the pit-hardening stage did not affect the oil content. Also, there was no effect of the irrigation regime on the oil content. This corroborated with some studies on individual cultivars of *Olea europaea* showing 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. Our results (Figure 2 d) showed that oil content was closely linked to the maximum temperature registered in the region of Chott Mariem with a correlation coefficient r^2=0,998. From this, we deduced that the increasing of the oil content was correlated with the increase of the maximum temperature in the region of Chott Mariem (Table 1).

Table 2. Productivity (%) of olive 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. Average of production (kg/year/tree) and oil content (%) of olive 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.

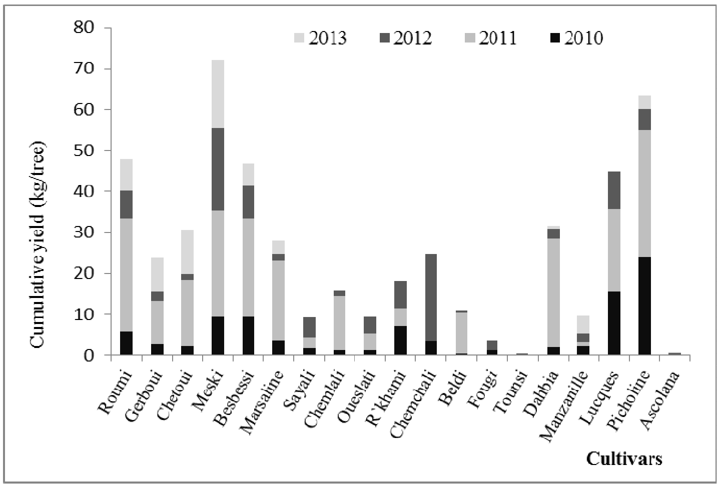

Figure 1. Cumulative yields of olive cultivars grown under Chott Mariem conditions in Tunisia between the four years of study 2010, 2011, 2012 and 2013

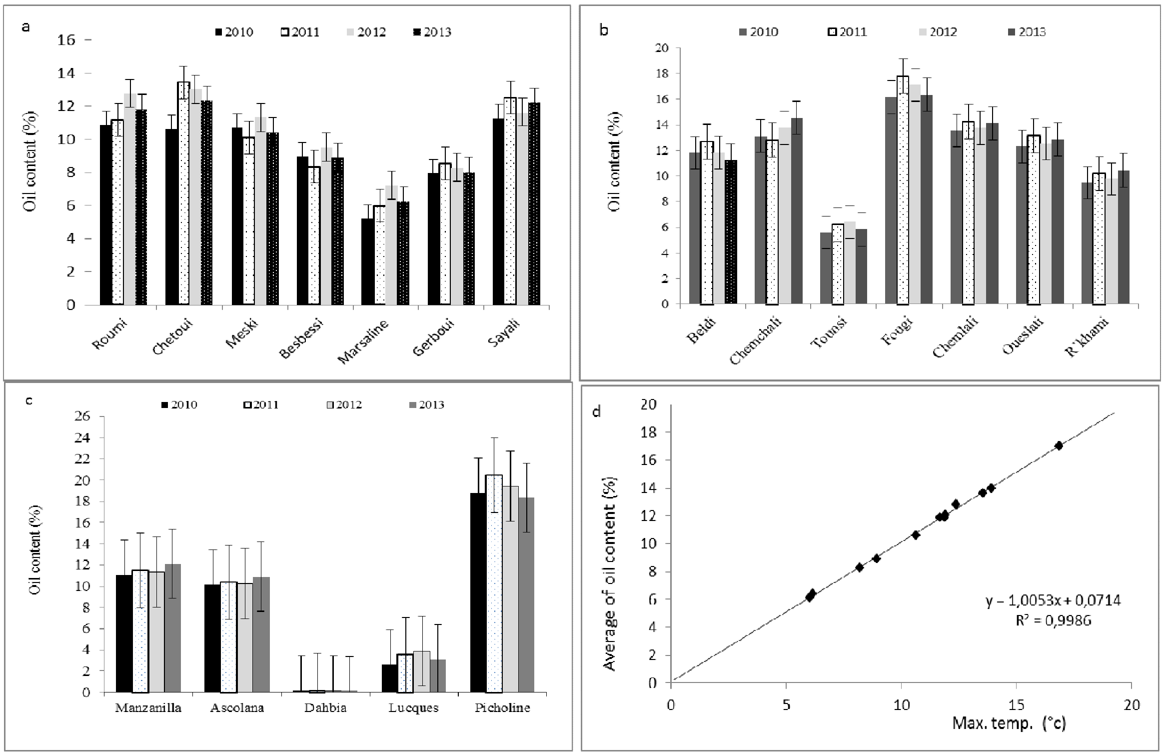

Figure 2. Oil content of local (a and b) and foreigner (c) cultivars of olive grown under Chott Mariem conditions for the years from 2010 to 2013 and relationship between average of oil content (%) of four years of study and mean of maximum temperature (°c) (d)

2. Pomological study

Fruit size is considered as an important commercial parameter and the study of factors affecting it are of great interest. Among the cultivars in this study, the smallest fruits were harvested from the local oil olive cultivars 'Chemlali' (0,74 g), 'R'khami' and 'Chetoui' with 1,9 g (low fruit < 2g). The heaviest fruits were from the table olive cultivars 'Tounsi' (8 g), 'Ascolana' (6,09 g) (very high > 6 g) and 'Marsaline' (5,94 g) (Table 4). Olive fruit size differs greatly among cultivars (Barranco, 1999). The very small size of the olives of the local cultivar 'Chemlali' that represent the major cultivar in the plantation of Sousse according to Mehri and Hellali, (1995) could be explain by the severe conditions in the orchard (high density, absence of irrigation and severe summer). The highest fruit length and width were noted for '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) We could 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). Based to the work of Rosati (2012) and Ebiad and Abu-Qaoud (2014), the final fruit size is related to exogenous factors (environment,

cultivation technology, *etc.*) and to endogenous plant conditions that allow the genetic potential growth to be achieved to a varying degree. This might explain the big heterogeneity found with the fruit of our studied cultivars. 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). Concerning the stone dimensions, the very high stone (> 0,7 g) was found in 'Tounsi' (0,74g) whereas 'Chemlali' had the smallest (0,13g) (< 0,3 g) (Table 5). The highest fruit flesh ratios were found in 'Ascolana' (94,22%) and 'Tounsi' (90,66%) (Table 5). Gucci *et al*. (2009) showed that higher levels of irrigation did not necessarily increase the flesh to stone ratio and that some degrees of water deficit could increase or maintain the ratio compared with that of well-irrigated trees. Furthermore, d'Andria *et al.*, (2004) and Gomez-Rico *et al.*, (2007) showed that irrigation increased the mesocarp-to-endocarp ratio (which affected fruit oil content) when compared with rainfed conditions. 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. 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 was expressed by the following equation: Fruit fresh weight = 0,074 × stone weight + 0,155 (1). This corroborated the results of Hammami *et al.*, (2009) that showed that both the endocarp and mesocarp contribute to final fruit size. 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.
Our results were similar to these of Barranco (1999) that showed that olive fruit size differed greatly among cultivars. Proietti and Antognozzi (1996) showed that if olive production was for pickling, a loss in yield quality could occur due to reduce fruit size as a consequence of water stress. For our study, this result was observed with the cutivars 'Meski', 'Sayali', 'Besbessi', 'Marsaline', 'Beldi' and 'Fougi'. 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. So, in Chott Mariem areas where rainfall is scarce, irrigation can improve the commercial value of olive fruit by increasing weight and size.

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.

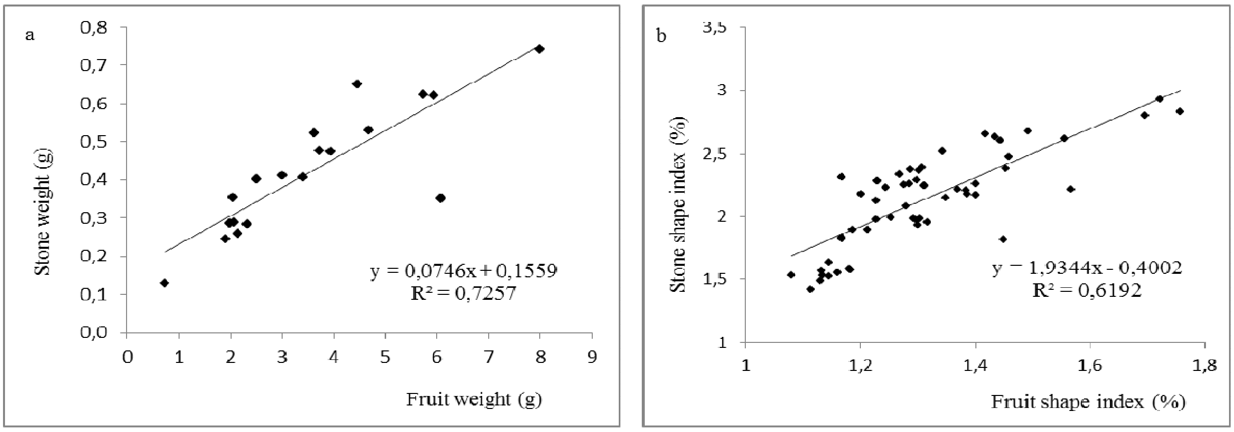

Figure 3. Linear relationship between fresh weight of fruit (g) and stone weight (g) (a) and between stone shape index and fruit shape index (b) of 19 cultivars of *Olea europaea* L. field grown in Chott Mariem, Tunisia

CONCLUSION

This study allowed us to depict nineteen olive cultivars that showed variable yields around the four year of trial. In Chott Mariem areas where rainfall is scarce, irrigation can improve the commercial value of olive fruit by increasing weight, size, pulp/pit ratio and the crop yield production. Based on the oil content, the studied cultivars were divided into three groups: low oil content (< 10%) ('Gerboui', 'Besbessi', 'Marsaline', 'R'khami', 'Tounsi', 'Dahbia', and 'Lucques'), medium oil content (10 to 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 due to its larger fruit sizes, high level of production (15,88 kg/tree) and high content of oil (> 15%). Thus, under our trial conditions, 'Picholine' can be considered as a dual use cultivar and present a good adaptation to semi-arid conditions. 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.

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