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An alternative assessment of olive (*Olea europaea* L.) cultivars adaptation in the Mediterranean Saharan context of Algeria

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Abstract

The present study was carried out during five successive seasons (2010 to 2014) on mature autochthonous olive *(Olea europaea* L.) cultivars namely: Azeradj, Chemlal, Neb djemel, Rougette and Sigoise grown under drip irrigation system in Dhaouia's pilot farm in Oued Souf region in Algeria. Yield performance and pomological characteristics of these cultivars were studied. Results indicated that all of studied cultivars had acceptable olive production. Chemlal and Rougette recorded the highest cumulative yield over a five years period (306.6 and 294 kg/tree, respectively) whereas the lowest cumulative yield was from Neb djemel (243 kg/tree). Rougette had a remarkably alternate bearing index (0.18), whereas the other varieties showed a better stability in olive yields by a low alternate index (≤ 0.07). The largest fruit (6.86 g) were from Sigoise whereas Chemlal had the smallest fruit (1.76 g). Highest pulp fraction of total fruit weight (88.14%) was found in Sigoise, while the lowest (70.44%) was determined for Chemlal. Highest oil content in pulp dry weight was recorded in Rougette (36.31%) and Azeradj (32.35%), while the lowest values (20.14%) were recorded in Sigoise, Chemlal (27.71%) and Neb djemel (28.46%). Highest phenolic content in dry fruit pulp (23.56 mg GAE/g) was recorded in Sigoise whereas Azeradj had the lowest content (4.36 mg GAE/g). Based on these results, we recommend cultivating Sigoise and Neb djemel exclusively for table olive production in the Oued souf region, Rougette may be for dual purpose production, taking into account the economic feasibility for olive oil production in these desert areas.

Key words: Olive (*Olea europaea* L.), yield performance, pomological characteristics, field conditions, algerian desert

introduction

Olive (*Olea europaea* L.) cultivation has an important role in agricultural production and economic development of many countries of the Mediterranean regions (Sansoucy, 1984). In fact, olive-growing area in Algeria was more than 400,000 hectares (40% of the national arboreal area) in 2012, where production reached about 130,000 and 50,000 tonnes of table olive and olive oil, respectively (MADR/DSASI/SDSA, 2013).

In recent years, due to higher domestic and foreign demand for olive oil and relying on the government support programs, especially after the creation of the south fund, the cultivation of olive has been expanded to various regions of southern Algeria, along the lines of the north areas. For instance, in the Wilaya of El Oued, south-eastern Algeria, the cultivated olive area reached 2913 hectares in the 2012/2013 campaign, whereas during the 2004/2005 campaign, this area was 350 hectares (DSA, 2014). However, olive cultivation is limited in most of new plantation areas due to the poor soil fertility, scarcity and fluctuating precipitation as well as long hot summer in such regions that leads to poor fruit and oil quality (Arji, 2015; Khaleghi *et al.*, 2015). Despite good vegetative growth, some of the olive varieties do not show good performance. This is due to lack of compatible and stable cultivars in such environmental conditions.

Many researches have confirmed the success of cultivation and production of olive and olive oil in the desert lands (Wiesman *et al.*, 2004; Mora *et al.*, 2007; Zarrouk *et al.*, 2009; Iglesias Picazo *et al.*, 2010; Bustan *et al.*, 2013). Use of new varieties to improve the productivity in Saharan ecosystems is important component of framework of olive sector development and areas expansion. Also these research projects focus on several agronomic and technological traits which includes high yield, absence of alternate bearing and good pomological traits as most important characteristics searched in olive cultivars under these arid conditions.

Although, the arid zones of southern Algeria have a relative agronomic potential for cultivation and agro-industrial expantion of improved olive production; the lack of specialized research institutions and absence of a clear strategy for the assessment of olive cultivars in several environmental conditions lead to less exploitation of potential in this vast area. As new domain of olive production, farmers are beginning to establish semi-intensively managed olive orchard. But the success of the cultivation and production of olive still need many interventions especially in genotypic selection.

Our study focused on five olive cultivars that were introduced to Oued Souf region, to evaluate their productivity and fruit characteristics in order to identify cultivars that improve the olive production under warm desert environmental conditions of south-eastern Algeria.

Materials and methods

Experimentation site: The study was carried out in Dhaouia's pilot farm for a period of 5 years (2010-2014), it is the first attempt in the Oued Souf region for the cultivation of olive trees. Dhaouia's domain is located 5.56 km in the south of El Oued governorate, located in south-eastern Algeria (altitude of 30° 30' north and longitude 6° 47' East, 80 m above sea level) (ANAT, 2012).

The Souf region enjoys a Saharan climate, characterized by a hot and dry summer and a mild winter, the temperature may exceeds 50 °C in the summer and decrease to reach 3 °C in winter (ANAT, 2012). Generally in this region precipitations are low and mostly very irregular within seasons and years. The annual average over the duration of the experiment was 72.47 mm. The dry period spread over the entire year (Fig. 1) (ONM, 2015). The Wilaya of El Oued is a very windy area and the main climatic constraints remains the regular frequency of hot winds with velocity about 2.67 m/s, known as "Chehili" or the sirocco as well as sandstorms during the spring, February is the windiest month (ANAT, 2012).

Our study was performed on five olive (*O. europaea* L.) varieties waw planted in 1999. Each variety was represented by a number of trees depending on availability at the orchard: ten trees each of the Chemlal and Sigoise and five trees each of the Azeradj, Rougette and Neb djemel. The trees were planted in rows with a spacing of 6 x 6 m (270 trees/ha). Distribution of varieties was made in a random manner within the plot.

The experimental orchard was maintained according to the experience of the farmer (Table 1) (Direction of the farm, 2010). The orchard underwent a slight pruning and benefited from a phytosanitary treatment triggered at the first symptoms of the olive fly.

Assessment of production: The olive fruit yields were recorded for trees of each variety over a period of 5 years (2010 to 2014). Fruits were harvested by hand in the first week of November of each year and the total yield (weight of fruits per tree: kg/tree) was determined annually at the black maturity stage**.**

Yield stability was evaluated using alternate bearing index, calculated for all varieties. It was done on the average yield of the trees obtained each year using the following formula (Monselise and Goldschmidt, 1982):

$$ABI = \frac{1}{n-1}\left(\left(\frac{a_2-a_1}{a_2+a_1}\right)+\left(\frac{a_3-a_2}{a_3+a_2}\right)+\cdots+\left(\frac{a_n-a_{n-1}}{a_n+a_{n-1}}\right)\right)$$

where, n is the number of assessment years; a_1, a_2, a_3, ... a_n represent the olive fruits yield in corresponding years.

Pomological characterization

Olive sampling: Pomological characters measurements were carried out on the olive fruits of 5th year (2014), where the healthy olive fruit samples were collected in first week of November, when the farmers of this region usually harvest their olives for oil production. For each sample, about 2 kg of fruits were manually collected from around three olive trees. Olive fruits were immediately transported to laboratory in cool bags, where they were used directly for physical measurements and chemical analysis.

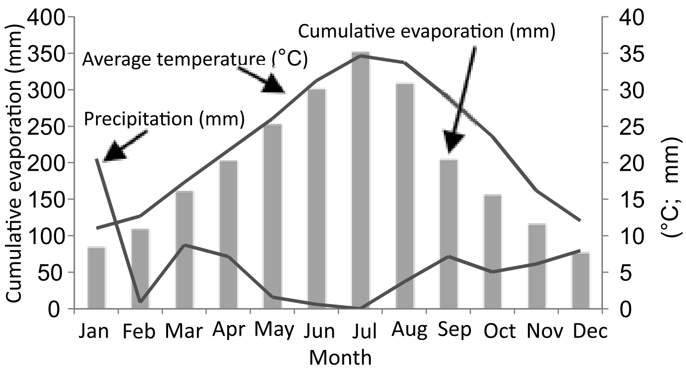

Fig. 1. Weather conditions (average monthly precipitation, average cumulative evaporation and average temperature) for Oued Souf region, Algeria during the trial period (2010 to 2014).

Physical characteristics: The physical characterization was performed according to the "methodology for primary characterization of olive varieties" as outlined by the International Olive Oil Council "IOC" (Barranco *et al.*, 2000) on a samples of fifty healthy fruits which were randomly selected from each cultivar with eliminating small, large and poorly formed fruit. Physical proprieties were assessed as follows: the average fresh weight, length and width of the fruit were measured. The fruits were cut horizontally into half with a stainless-steel knife and the stones were removed. After removing and cleaning the stones, the average fresh weight, length and width of the stones were measured. Shape index (length/width) of fruit and stone was also calculated. For determining the weight of pulp content, the stone weight from the whole olive fruit weight was subtracted. Fresh weight ratio (pulp to stone) was determined by dividing the pulp mass by the stone mass.

The average fruit and stone volumes of each fruit was calculated in mm^3 using the following equation (Burrack *et al.*, 2011): $V = \frac{\pi}{6} \times L \times W^2$

where, V is the fruit volume (mm^3), L is the maximum length (mm) and W is the equatorial diameter (width) (mm).

The fresh weight and the different dimensions (length and width) of the fruits and stones were measured using a precision balance (OHAUS USA, repeatability ± 0.1 mg) and a digital vernier caliper (*HD*® Electronic Digital Caliper 6" LCD (China), repeatability ± 0.01 mm), respectively.

Moisture and dry matter content: Determination of dry matter and moisture content was made according to the procedure of Agar *et al.* (1998): An initial mass of olive fruits was determined by oven drying at 105 ± 1 °C for 48 hours. The dry weight and the water content were calculated as a percentage of the total fruit weight. The measurements were done in triplicate.

Table 1. Trial location and orchard characterstics

Experimentation site	Average rainfall	Soil type		Water and Irrigation System		Fertilization	
		Sandy		Drip 52-150 L/day/tree		Organic	N-*P*=K (unit)
Pilot farm 'Dhaouia'	< 100 (mm/year)	pH	EC	pH	EC	Ovine origin 50-100 kg/tree/3years	0.015-0.2 /tree/year
30° 30' N, 6° 47' E		8.32	0.453 ms/cm	7.35	3.73 ms/cm		

Olive oil extraction: Oil was extracted using solvent extraction method (Lalas *et al.*, 2011). Seeds of olive fruits were removed by hand and dried samples (approximately 100 g) of the olive pulp were reground using a coffee grinder (Cobra Electronics, Algeria) and extracted three times (3x24 h) using 250 mL of n-hexane in an Erlenmeyer flask. The extract liquid was filtered, through filter paper, under vacuum pressure and concentrated using a rotary evaporator (Rotavapor® R-210 BUCHI Switzerland). After solvent evaporation, the flask containing the fat was dried at 105 °C and cooled in a desiccator. To determine the lipid content of olive pulps, remaining lipid phase was weighed. The oil content was expressed as a percentage of dry weight of olive fruit pulp.

Extraction and quantification of olive fruits phenolic content

Extraction procedure: 20 g of residual olive pulp (obtained after the removal of the n-hexane phase in last extraction of olive oil) was taken and extracted again two times (2x24 h) in Erlenmeyer flask, using 150 mL of methanol as solvent. The liquid extract was filtered under vacuum pressure and concentrated using the rotary evaporator. The extract was combined and used for the determination of total phenolic content.

Quantification of total phenolic compounds: The total phenolic content of fruit pulp extracts was determined with Folin-Ciocalteu reagent according to Dewanto *et al.* (2002), using a spectrophotometer (Shimadzu UV-1800). Total phenol values were expressed as gallic acid equivalents (mg GAE/g dry weight) from a calibration curve ($y = 0.0025 x + 0.0106$, $R^2 = 0.9932$).

Statistical study: Data were subjected to variance analysis (one-way ANOVA). Mean averages were compared using the Fisher's LSD test. Statistical analyses were computed using Minitab 17 statistical software.

Principal components analysis (PCA), based on Pearson's product moment correlation at $P < 0.05$, was performed separately for pomological characters. The analysis was performed using the XLSTAT software, Version 2009.4.03 (Addinsoft).

Results and discussion

Production and alternate bearing index (*ABI*): Among the studied olive cultivars, results show that average olive yields over 5 years of production assessment did not differ significantly, whereas the difference in olive yields was significant for every marketing year (Table 2). The highest cumulative yield, over 5 years, was with Chemlal (306.6 kg/tree) and Rougette (294 kg/tree), followed by Azeradj (283.8 kg/tree). The lowest cumulative yield during this period of study was with Neb djemel (243 kg/tree) and Sigoise (277.4 kg/tree) (Fig. 2).

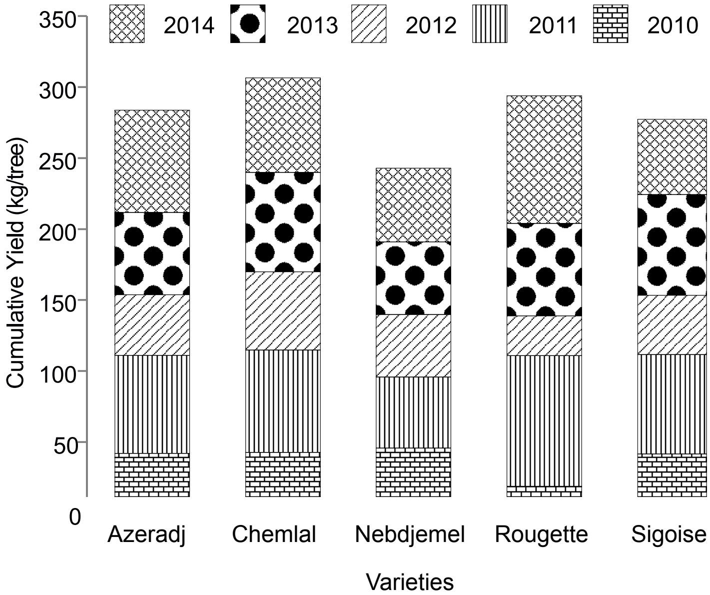

Fig. 2. Cumulative fruit yield (kg/tree) of studied olive (*O. europaea* L.) cultivars, grown under Oued Souf, Algerian conditions between 2010 and 2014.

Similar results were recorded by Leitao (1990) in Portugal, and Tous *et al.* (2000) in Spain; where the authors reported that there were significant differences between cultivars in productivity and ecological factors also have significant impacts on olive yield.

All tested varieties were characterized by an alternate bearing (Table 2). Alternate bearing was more pronounced in the variety Rougette (*ABI* = 0.18) compared with others: Neb djemel, Sigoise, Chemlal and Azeradj (*ABI* ≤ 0.07) were more stable in fruits production.

The alternate bearing index is very important horticultural characteristic related to productivity. It's highly dependent on the endogenous expression and environmental conditions and their interactions (Lavee, 2007; Toplu *et al.*, 2009b). So, the alternate bearing may be one of the main limiting factors for olive production. This phenomenon is attributed to a competition for assimilates during the bud differentiation, the growth of inflorescences, fruit set, fruit growth and vegetative growth (Proietti, 2003; Cuevas *et al.*, 2009). Applied cultivation practices to orchards including pruning, fertilization and irrigation contribute to reduce ABI intensity as reported by Lavee (1996).

Table 2. Average fruit yields (kg/tree) and alternate bearing index (*ABI*) of studied olive cultivars, during 2010 till 2014 in Oued Souf, south-eastern of Algeria

Varieties	Average olive fruit yield (kg/tree)					Average fruit yield of 5 years (kg/tree)	Alternate bearing index (ABI)
	2010	2011	2012	2013	2014		
Azeradj	42.2 a	69 b	42.6 b	58 bc	72 b	56.76 a	0.07
Chemlal	43 a	72 b	55 a	70 a	66.6 b	61.32 a	0.05
Nebdjemel	46 a	50 c	44 b	51 c	52 c	48.6 a	0.02
Rougette	19 b	92 a	28 c	65 ab	90 a	58.8 a	0.18
Sigoise	41.8 a	70 b	41.6 b	71 a	53 c	55.48 a	0.03
P=value and significance level	< 0.001 HS	< 0.001 HS	< 0.001 HS	= 0.001 VS	< 0.001 HS	> 0.05 NS	

Means in the same column not sharing a same letter are significantly different at $P < 0.05$ by Fisher's LSD test.
NS: not significant; VS: very significant; HS: highly significant

Similar results concerning ABI, were recorded by Mora *et al.* (2007) in southern Atacama desert of Chile and Arji (2015) under warm environmental conditions of Sarpole Zehab of Kermanshah in Iran, confirming that several olive cultivars have significant different degrees of alternate bearing index. They recorded mean alternate index from 0.17 to 1 and 0.35 to 0.1, respectively and found a strong association between fruit production and alternate bearing index, thus this character is useful to select suitable cultivar in the tested region. Obtained results in this study were in agreement with their finding for alternate bearing index. Among cultivars, Neb djemel had the lowest ABI (0.02) under environment conditions of Oued Souf region.

Pomological characterization

Physical characteristics of olive fruit: The obtained results showed that all measured characteristics were significantly different between cultivars (Table 3). Among the studied cultivars, the heaviest fruits were from Sigoise (6.86 g) with volume of 6788 mm^3, and the lightest fruits were from Chemlal (1.76 g) with volume of 1697.4 mm^3.

The olive fresh weight showed positive linear correlation with stone fresh weight (r = 0.854). The average stone fresh weight ranged between 0.81 g and 0.52 g for Sigoise and Chemlal varieties, respectively. Other varieties had stones with an average fresh weight between 0.7 and 0.55 g.

Fruit shape varied significantly between cultivars (P < 0.001, Table 3) and may be grouped into three form types (Barranco *et al.*, 2000). Sigoise was spheroid (L/W < 1.25), Neb djemel and Rougette were elongate (L/W > 1.45) and the other cultivars were ellipsoid (1.25 < L/W < 1.45) (Table 3).

According to the results of Kiritsakis and Markakis (1987), the weight and dimensions of olive fruits are of great importance for trade value and to determine their use for oil production or as table olives**.**

Olive pulp content is a varietal character and flesh-stone ratio is an important index in fruit quality determination. According to the categories established by Del Rio and Caballero (1993), the highest pulp to stone ratio was found in Sigoise with a fruit pulp content of 88.14 %, whereas the lowest was determined in Chemlal (70.44 %). However, the other cultivars: Rougette, Neb djemel and Azeradj had medium ratios of 87.54, 83.51 and 82.96 %, respectively (Table 3). A similar finding was reported by Del Rio and Caballero (1993) who reported that olive cultivars varied greatly in their flesh-stone ratio and cultivars with the highest ratios in this respect had more economic value.

Moisture and dry matter content: The obtained results revealed that fruit dry matter and moisture content (%) were significantly different among cultivars (P = 0.001, Table 3). According to the levels established by Del Rio and Caballero (1993)**,** Rougette cv. had the highest fruit dry matter (41.69%) and the lowest moisture content (58.31%), while Sigoise and Azeradj cvs. have the lowest dry matter percentage (34.02 and 36.64%) and highest water content (65.98 and 63.37%), respectively (Table 3).

Also, as an interesting result, there was a strong positive correlation (r = 0.828), between the dry matter and oil percentage of the olive fruits; this relationship was found for Rougette and Sigoise cvs. According to Mickelbart and James (2003), this relationship was not only a strong one, but it was a better indicator and an ideal maturity standard than the commonly used colour index for oil-accumulating fruits. Furthermore, the dry matter percentage can be easily obtained when compared with oil extractions.

On the other hand, water content is an important factor at harvest as it has a strong influence on extraction efficiency during processing. It also has several effects on fruit and oil quality. Sanchez Casas *et al.* (1999) showed that oil contents of the fruit are very much influenced by the pulp moisture of fruit. This antagonistic effect between fruit water and oil contents may be explained by their opposite polarity and their competition in the occupation of cellular spaces (Gianfranco, 1989). Several authors (Pinheiro *et al.*, 1995; Proietti and Antognozzi, 1996) reported that the moisture values are dependent on environmental conditions, including the rainfall and the adopted cultural practice such as irrigation. This effect was further confirmed by Motilva *et al.* (2000) for the olive trees subjected to regulated deficit irrigation (RDI), where the oil content increased when the water content decreased.

Fruit oil content: Table 3 showed that olive oil content based on pulp dry matter was significantly different among studied cultivars (P < 0.001). According to oil content scale established by Del Rio and Caballero (1993), obtained results showed that most of the studied olive varieties were very low in olive oil

Table 3. Fruit pomological characteristics of five olive cultivars grown under Oued Souf, Algerian desert conditions

Varieties	Fruit			Stone			Pulp/ Stone Ratio	Fruit Pulp (%)	Moisture Content (%)	Dry Matter (%)	Oil Content (% DM)	Phenols Content (mg GAE /gDM)
	Weight (g)	Shape (L/W)	Volume (mm^3)	Weight (g)	Shape (L/W)	Volume (mm^3)						
	FM	FS	FV	SM	SS	SV	P/S	P%	MC	DM	OC	PC
Azeradj	4.15b	1.30d	3920c	0.70b	1.92d	606.9b	5.03b	82.96b	63.37ab	36.64bc	32.35b	4.36d
Chemlal	1.76d	1.42c	1697.4e	0.52d	2.08c	393.09c	2.40c	70.44c	61.05b	38.95b	27.71c	7.48c
Nebdjemel	3.48c	1.85a	3399d	0.57c	3.09a	576.4b	5.19b	83.51b	62.99b	37.01b	28.46c	18.16b
Rougette	4.44b	1.54b	4667b	0.55cd	2.65b	592.6b	7.20a	87.54a	58.31c	41.69a	36.31a	19.16b
Sigoise	6.86a	1.25e	6788a	0.81a	1.74e	836.8a	7.56a	88.14a	65.98a	34.02c	20.14d	23.56a
P=value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	=0.001	=0.001	<0.001	<0.001

Means in the same column not sharing a same letter are significantly different at P < 0.05 by Fisher's LSD test.

production under these desert environmental conditions; the amount of oil based on dry matter ranged from 36.31 % for Rougette cv. to 20.14 % for Sigoise cv., whereas the fruits of other cultivars were intermediate as shown in Table 3.

Several research results confirmed that the oil content can vary according to cultivar, harvesting time and environmental conditions such as temperatures and water availability. This has a significant influence on fruit growth, oil accumulation and ripening patterns (Toplu *et al.*, 2009a; Di Vaio *et al.*, 2013; Saadati *et al.*, 2013).

Maximum temperature in this experiment was higher than 40.6 °C during June, July and August for five successive years. This high temperature coincided with low relative humidity, which lead to excessive evapotranspiration throughout the long and hot summer in these desert areas (Fig. 1), where the olive trees were subjected to high thermal stress. The latter lead certainly to physiological drought causing slow growth and development which provoked an undesirable effects during the lipid assimilates biosynthesis and their migration phase to the fruit (García-Inza *et al.*, 2014; Gómez-del-Campo *et al.*, 2014). In addition, the lack of good practices of different farming operations at the orchards of this region due to modest experience of farmers in this new perennial cultivation domain of crop production contributed negatively on the olive oil yield. Several researches have confirmed that the poor management of irrigation, fertilization and pruning decreased the olive fruits caliber and especially their pulp and promoted reduction lipogenesis (Rapoport *et al.*, 2004; Morales-Sillero *et al.*, 2007; Toplu *et al.*, 2009a).

Total phenolic content of fruit pulp: Data in Table 3 showed highly significant differences ($P < 0.001$) between total phenolic content of the studied olive cultivars, calculated on dry weight basis of fruit pulp. The highest phenolic content was detected in Sigoise (23.56 mg GAE/g dry pulp) followed by Rougette (19.16 mg GAE/g) while the lowest content was for fruits of Azeradj and Chemlal cvs. (4.36 and 7.48 mg GAE/g, respectively).

In eastern Algeria, Idoui and Bouchefra (2014) confirmed that for Jijelian Sigoise variety, the total phenolic content in all black olive fruits ranged from 578.40-059.04 µg/mL of dry flesh. Moreover, Greek and Portuguese olive varieties are characterized by polyphenol contents varying within a range of 82 to 171 mg/100g of olive pulp (Boskou *et al.*, 2006) and 165.76 mg/kg of olive fresh weight (Malheiro *et al.*, 2011), respectively. In view of these data, extracts of olive fruit pulp in all studied varieties can be considered as very rich in polyphenols, particularly the Sigoise, Rougette and Neb djemel varieties.

Olive's fruit are particularly rich source of antioxidant phenolics. However, the concentration of phenols depends on several factors, such as cultivar and fruit maturity (Damak *et al.*, 2008; Ziogas *et al.*, 2010). Phenolic content can reach 14% (dry weight) in young fruits and may be close to zero in black-type fruits (Parlati *et al.*, 1993). Also there are many reports confirming the influence of climate and geographical origin on these active substances (Vinha *et al.*, 2005; Di Vaio *et al.*, 2013). Further the more, horticultural practices such as fertilization, irrigation and pruning have a clear impact on the fruit phenols levels (Machado *et al.*, 2013; Rosati *et al.*, 2014).

The phenolic compounds have an important role in human nutrition. They act as antioxidant, anti-inflammatory, anti-viral and anti-cancerogenic agents (Zhao *et al.*, 2005; Kountouri *et al.*, 2007). On the other hand, phenolic compounds in olive fruits are a very important factor in the evaluation of the virgin olive oil quality, since they are responsible for its antioxidation stability (Machado *et al.*, 2013). Also, the size of the fruit, which is a characteristic of the cultivar and irrigation method employed, is related to phenol concentration (Costagli *et al.*, 2003).

An interesting result from this study is a correlation ($r = 0.706$) among fruit volume and their total phenolic content. Also, there is a strong relationship between pulp phenolic content and pulp to stone ratio (P/S) of fruit, where the value of this linear correlation was about 0.767. Whereas a feeble negative correlation ($r = -0.37$) between phenolic and oil content was recorded.

The results obtained in this study are consistent with the results achieved by Motilva *et al.* (2002) and Morelló *et al.* (2004) where the authors found out a reduction in the phenolic content and antioxidant activity with the ripening progress of the drupes. The correlation between phenolic and oil content can be understood according to Di Giovacchino *et al.* (1994) explanations where the oil extraction was more effective with olives of lower water content. Furthermore, phenolic compounds are water soluble, so high values of moisture effectively reduce the phenolic extraction. Several researchers proclaim that water availability induces changes in the enzyme activities responsible for the phenolic compounds biosynthesis, such as L-phenylalanine amonia-lyase (PAL) (Tovar *et al.*, 2002; Machado *et al.*, 2013).

Principal component analysis (PCA): The PCA performed on the pomological descriptors of studied olive fruits is shown in Fig. 3 where the axis 1 makes account for 58.21 % of the total inertia; which is correlated with the fruit fresh weight (FW) and volume (FV), stone weight and volume, respectively (SW, SV); fresh weight ratio of pulp to stone (P/S) and the pulp percentage (P%); pulp oil content (OC) (% dry matter basis) and the fruit moisture content (MC) and finally the fruit dry matter content (DM) (Fig. 3). Axis 2 expresses 25.39 % of the total inertia; which is correlated to the shape index of the stone (SS) and to the total phenol pulp content (PC). Axis 3 expresses 11.93 % of the total inertia; which is correlated to shape index of the fruit (FS). The first two axes give the majority of the inertia (83.6 %), and show only the dispersion of varieties in the first plan of the principal component analysis (Fig. 3).

The projection of individuals in the PCA plan, depicted by the two first axes, show that the studied olive cultivars were separated with important heterogeneity for the studied pomological characterstics (Fig. 3), except Rougette and Neb djemel cultivars which show low convergence of some characteristics.

In conclusion, this study constitutes a first approach of the characterization of the olive (*O. europaea* L.) trees biodiversity in the southern Algeria. During 5 years study period, in the Oued Souf region, some tested olive cultivars such as Sigoise, Rougette and Neb djemel had high cumulative yields and produced fruits of high commercial quality (big fruit, high fruit pulp ratio and rich in polyphenols). The results show that cultivars would be suitable for table olive production. Low olive oil yield was noted with different studied olive varieties, which was influenced by

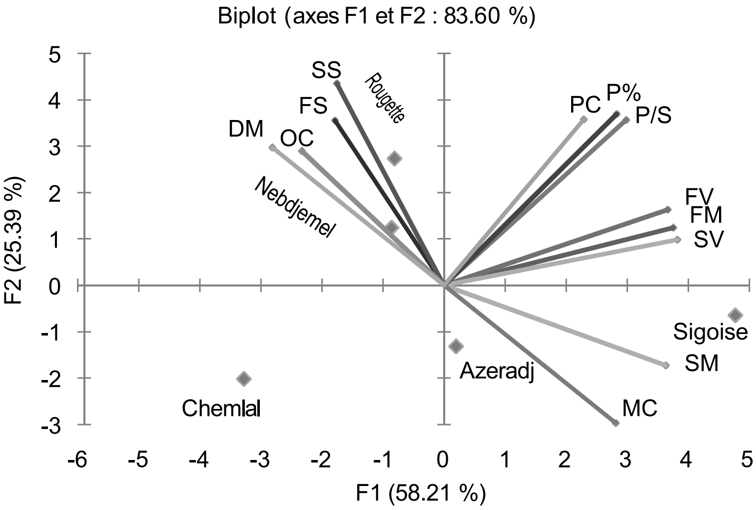

Fig. 3. Biplot based on principal components analysis (PCA) for fruit quality attributes in studied olive genotypes. FW; FV; SW; SV; P/S; P%; MC; OC; DM; PC ; FS; SS (See Table 3). Varieties: Azeradj, Chemlal, Nebdjemel, Rougette, Sigoise.

prevailing climatic conditions of these warm areas. Advanced production technologies such as intelligent irrigation and fertigation systems can be introduced for improved production.

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