Annals of Arid Zone 58(3&4): 79-89, 2019

An Assessment Study of Olive a New Crop Adopted in Algerian Oases: A Case Study of the Oasis of El-Oued Province

Bachir Khezzani[1]*, Hania Zitouna Messaoud[1], Hadia Ghezal[1] and Youcef Halis[2]

[1]*Faculty of Natural Sciences and Life, University of El-Oued, PO Box 789 El-Oued Algeria*

[2]*Scientific and Technical Research Center for Arid Areas (CRSTRA), Biophysical Station, 30240 Nezla, Touggourt, Algeria*

Received: July 2019

Abstract: Olive cultivation occupies an important place in the world, especially in the Mediterranean region. The main aim of this paper is to give an overview on reality and prospects of the olive cultivation sector as a new crop recently adopted in an arid environment (El-Oued province in Algerian Sahara). The study pertains to analysis of statistics series concerning olive cultivation, obtained from Directorate of Agricultural Affairs of El-Oued province covering a period of 20 years. The results of the study showed that the morphological and physiological characteristics of the olive tree helped in its spread in the arid regions. The last statistic of 2018 showed that the province contains more than 1.05 million olive trees covering an area of 2815 ha, where 57% are in the stage of production. About 54.5% of olive tree production are addressed to oil production, while 45.5% are directed to table consumption. The productivity of olive ranged between 3.5 and 20.5 kg tree^{-1}, while oil productivity reached 13 L quintal^{-1}. In 2018, the province produced 20520 quintals of table olive and 3200 hectoliter of oil. Following the success of olive cultivation in this new harsh environment, future efforts should focus on improving quality and quantity of production, as well as selecting new varieties more suitable for dry environments through breeding programs. Besides these efforts, disseminating knowledge of this new crop among local farmers, through the continuous mentoring by technicians and agricultural consultants will boost its production thoroughly.

Key words: *Olea europaea* L., cultivar, oil, olive cultivation, oasis.

Human being have effectively contributed to the breaking of natural dispersal barriers of many organisms as they transported them around the globe. Plants have been introduced into new areas for various purpose either accidentally or voluntarily (Besnard *et al.*, 2007). The olive *Olea* derives its name from Greek *elea* and is one of oldest known cultivated trees in the world, especially in Mediterranean basin (Kiritsakis and Shahidi, 2017). It comprises the oldest group of horticulture plant found in the old word together with grapevine, fig and date palm (Zohary *et al.*, 2012). Historically, olive played an important role in diet of the people as well as in their economy and culture (Esteves da Silva, 2010). The olive tree is ranked 24th among the 35 most cultivated species in the world (Breton *et al.*, 2006). Generally, olive trees are now being grown commercially in about 30 countries located mainly between 30° and 45° north and south latitudes (Aybar *et al.*, 2015).

*E-mail: bachirkhezzani05@gmail.com

The olive tree belongs to the family *Oleaceae* and subfamily *Oleoidaea*, that has a total of 30 genera and 600 species (Kiritsakis and Shahidi, 2017). The genus *Olea* includes at least 30-35 species (Therios, 2009). Olive, an evergreen shrub in their native state, which can attain a mature height of up to 15 m and a spread of 9 m (Doveri and Baldoni, 2007; Wang *et al.*, 2010), is a diploid (2 n = 4 x = 46 chromosomes). It is a relatively slow-growing and perennial tree and fruit production starts five to six year after planting (Chiappetta *et al.*, 2015). If well managed, the perennial olive trees can keep fruiting for hundreds of years (Zohary *et al.*, 2012). In the Mediterranean region, the main olive subspecies are the native *Olea europaea* oleaster (wild olive) and the cultivated *Olea europaea sativa* (Breton *et al.*, 2006).

Recent worldwide research confirm that the olives are not only a significant food source, but also contribute effectively to human health and are becoming popular in health-conscious diets as well (Trichopoulou *et al.*, 2014). It is

strongly recommended for the prevention of cardiovascular diseases, certain cancers, and diabetes and its complication (Ghanbari *et al.*, 2012; Rahmani *et al.*, 2014). Moreover, olive and its derivatives play important role in the cosmetics industry and pharmaceutical products, especially those related to the anti-aging (Rodrigues *et al.*, 2015).

In more modern times, the olive tree has continued to spread outside the Mediterranean region and is today cultivated in places far away from its original habitat. Now, they are planted widely in many countries such as Australia, China, southern Africa, Latin America and Japan (Antonopoulos *et al.*, 2006; Wiesman, 2009). Worldwide, more than 9.8 million hectares has been occupied by the olive cultivation, and it is the sixth most important crop for production of edible oils. Olive tree is generally grown under rainfed conditions and about 15% of olive groves are irrigated only (Fregapane *et al.*, 2010; Kiritsakis and Shahidi, 2017).

The olive is a prominent, and economically the most important fruit of the Mediterranean basin (Breton *et al.*, 2009; Esteves da Silva, 2010). Cultivation of the olive was (and remains) a key characteristic of Mediterranean mixed farming (Wiesman, 2009), because it is a crop well adapted to the environmental conditions prevailing in this region (Torres *et al.*, 2017). Over 750 million olive trees are cultivated worldwide, 95% of which are in the Mediterranean region (Muzzalupo and Micali, 2015). Olive production also comes from Southern Europe, North Africa and the Near East (Kiritsakis and Shahidi, 2017). Mediterranean countries cover 95% of world olive oil production, approximately equal to 2.77 million of tons (Stillitano *et al.*, 2016).

Algeria has an rich history of olive growing. Furthermore, the traditional farming is largely related to management of the olive crops here (Dominguez-Garcia *et al.*, 2012). According to statistics of International Olive Council, the production of olive oil in Algeria increased from 6000 tons in 1990 to 82500 tons in 2017. Olive cultivation is located mainly in the northern part of the country where about 80% of olive groves are located in mountainous regions with poor soils (Dominguez-Garcia *et al.*, 2012).

In Algeria, total area devoted to olive cultivation has reached nearly 0.5 million hectares. Furthermore, about 79% of the olives are directed for oil production, while 21% is addressed for table olive production (Khezzani *et al.*, 2019). According to Ilarioni and Proietti (2014), about 36 olive cultivars exists in Algeria. *Chemlal*, *Sigoise*, *Limli* and *Azeradj* are the most cultivated, and they account for about 70% of the total.

As olive tree was able to sweep new regions different from the original environment (Doveri and Baldoni, 2007; Rodrigues *et al.*, 2015), and in order to combat desertification and develop the agricultural sector, the Algerian state has adopted a set of development policies, that includes introduction of olive cultivation as a new crop in many oases of the southern provinces since 1990s. So, the main objective of this paper is to provide an overview on reality and prospects of this new crop recently adopted in the oasis of El-Oued province (Algerian Sahara) covering various aspects of olive cultivation sector.

Materials and Methods

Study area location and description

El-Oued is one of 48 provinces that forms Algeria country, and is situated in the Eastern South part. This province extends over an area of 44586.8 km^2, and represents nearly 1.87% of the total national territory. Administratively, this province has 30 municipalities with total human population about 820 thousand of inhabitants in 2018 (Fig. 1). Life in this province is based on irrigated agriculture (Khezzani and Bouchemal, 2018b) and animal breeding. In the past, these two activities level subsistence were being carried out, but now they are being developed to become a major commercial activity.

The climate of the study area is hyper-arid, characterized by a very hot and dry summer, and a mild winter. Temperatures can drop to near-freezing point in winter and can reach 45°C in summer, with 26°C as an annual average. The monthly average values of the relative humidity are usually about 30% in summer, and may reach up to 65% during the winter (Khezzani *et al.*, 2016). The precipitation is low, sporadic and oscillatory, with an annual average not exceeding 70 mm that rarely

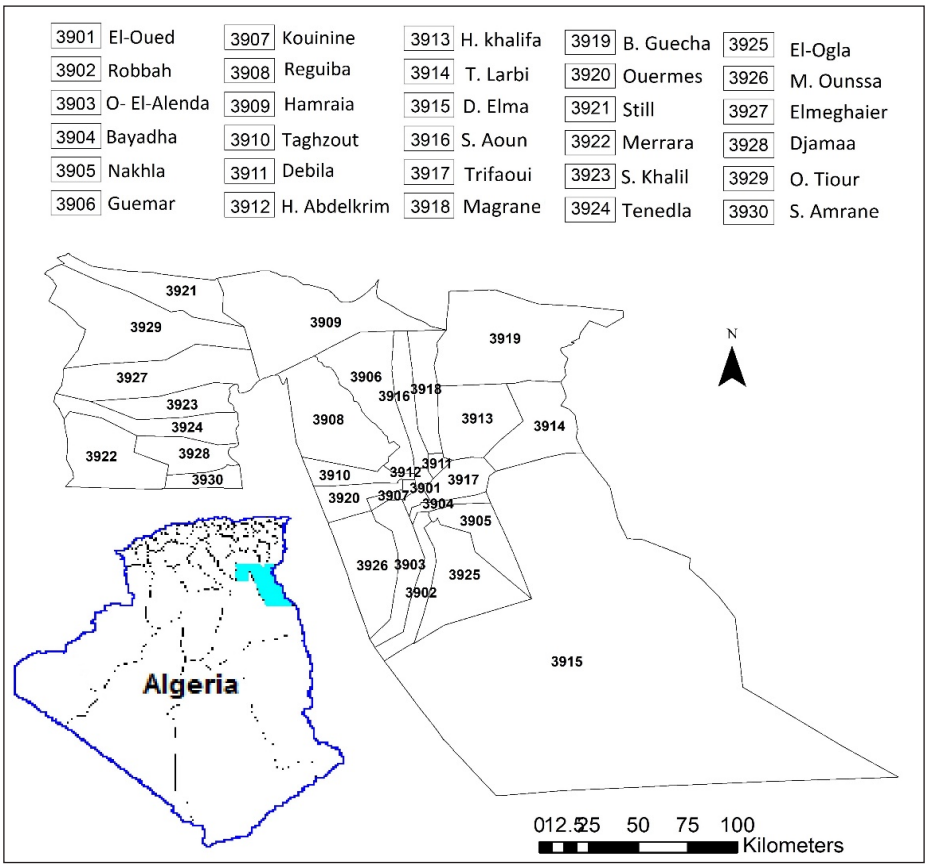

Fig.1. Study area location.

exceeds 100 mm, while the annual evaporation average exceeds 2200 mm (Zaater *et al.*, 2018). Winds are generally mild, but in spring and autumn, they become stormy (Khezzani and Bouchemal, 2017). The elevation above mean sea level range between 100 m in the south and -24 in the north. Annually, the study area is exposed to more than 3500 hours of sunshine.

The soil in the study area is characterized by sandy texture, where the sand forms about 97% and 3% for the silt with some differences between the provinces (Koull *et al.*, 2013; Ghemam Amara *et al.*, 2015). Furthermore, the organic matter content is very low and is within 0.06% (Zaater *et al.*, 2018). In the western north part, the soil is characterized by high salinity (Koull and Chehma, 2016). Generally, the soil is relatively neutral to low alkaline (Ghemam Amara and Senoussi, 2013; Mihoub *et al.*, 2015).

Statistical data and information source

The statistics concerning olive cultivation was provided from Directorate of Agricultural Affairs (DAA) of El-Oued province for the period 1999 to 2018. The main rrecorded parameters were number of planted olives trees (isolated, grouped, productive and total), the planted area (productive and total), production (oil and table olive), productivity (per tree and oil) olive by-products (margins and pomace). The statistics also included an inventory of olive mills located in the study area (location, capacity and type). Some statistics related to agriculture sector in general have also been included in the study. On the other hand, many field visits have been realized to a significant number of olive groves across the province, as well as several interviews were carried out with local farmers and agricultural extension engineers so as to provide a rationale to the conclusions drawn from this study.

Results

The results show that the total numbers of olive trees are rapidly increasing from 9000 trees in 1999 to 1053860 trees in 2018, with an average of 52000 trees per year. This number included 70000 (6.7%) isolated trees (planted between other fruit trees such as date palm), while the remaining occupied an area of 2815 ha

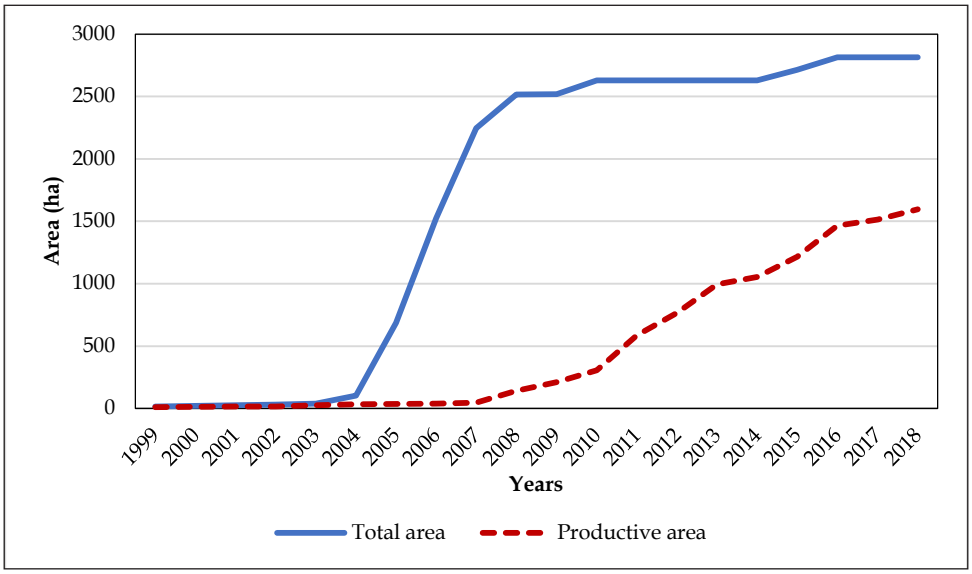

Fig. 2. Development of productive and total area of olive trees in El-Oued province from 1999 to 2018.

instead of 15 ha 1999. In 2018, The productive numbers of olive trees reach 600000 trees (57%) on an area of 1595 ha, in contrast to 2000 trees on an area of 10 ha in 1999 (Fig. 2).

Olive cultivation density ranged between 250 to 400 tree ha^{-1}, with an average estimated to be 350 tree ha^{-1}. Olive cultivation area covers about 7.6% of total area earmarked for fruit trees and occupied second rank after date palm trees (90.5%). All olive groves are subjected to irrigation, of which 99% are by drip system and 1% by flood method. Further, 2.4% are irrigated from Terminal Complex aquifer (at depth between 400 to 600 m) and 97.6% from Phreatic aquifer (at depth between 5 to 60 m).

The cultivar *Chemlal* occupied maximum area in the study region (70%), followed by *Sigoise* with 22%. Only 4% were distributed between *Rougette* and *Azeradj*, while the other varieties such as *Neb djemel*, *Gordal* and *Aharoun* collectively occupied about 4% (Fig. 3).

The total olive production increased from 140 quintals in 1999 to reach 45120 quintals in 2018. About 54.5% of olive production was addressed to oil and 45.5% were table olive. The total olive oil production reached 3200 hectoliter in 2018. About 74% of olive oil production is as extra virgin, 23% as virgin and only 3% of olive oil as ordinary refined oil (Fig. 4). In El-Oued province, olive harvest starts in November and

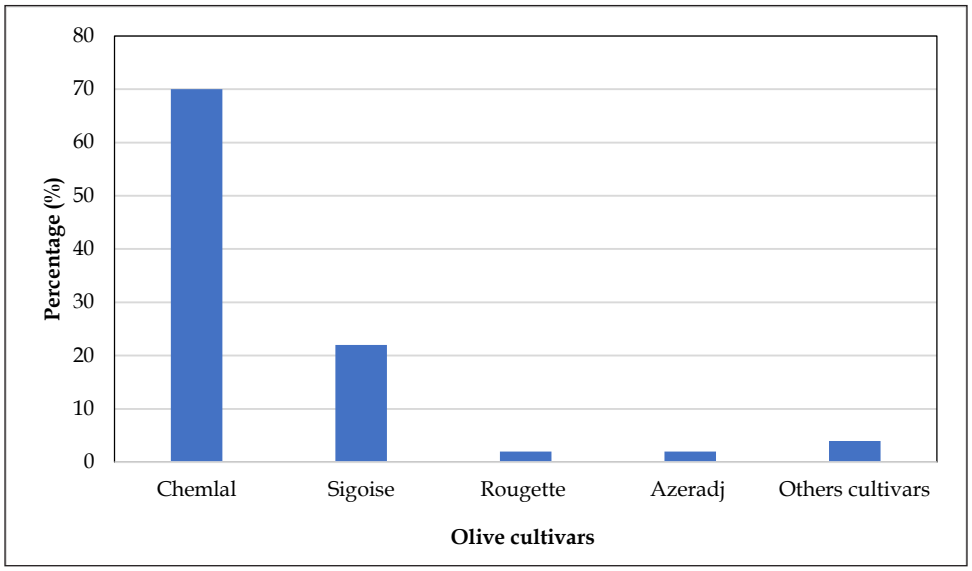

Fig. 3. Olive cultivars adopted in El-Oued province.

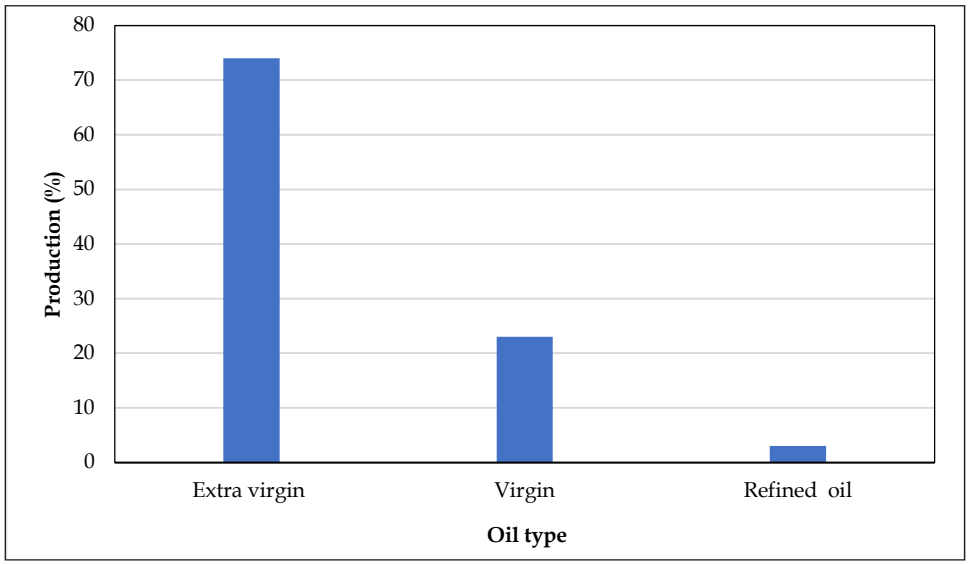

Fig. 4. Types of olive oil produced in El-Oued province for 2018.

continues up to January. Harvesting of olive is done manually and no modern equipment is used in this process still. The extraction of olive oil is processed by 5 local mills, one being traditional with production capacity of 10 quintals day^{-1}, and the 4 other mills with total production capacity of 406 quintals day^{-1}.

The productivity of olive characterized by fluctuation along the study period and its values ranged between 3.5 kg tree^{-1} (in 2014) to 20.5 kg tree^{-1} (in 2002), with an average of 9.3 kg tree^{-1}. Furthermore, in the first half of the study period, the productivity average of olive tree was 12.3 kg tree^{-1}, but in the second half the productivity decreased by 50% to 6.0 kg tree^{-1}.

The oil productivity ranged between 7.6 L quintals^{-1} (in 2008) to 13 L quintals^{-1} (in 2017 and 2018), with an average of 10.8 L quintals^{-1}. The by-product that are derived from olive oil process are pomace and margins. In 2018, more than 9594 hectoliter of margins and 11070 quintals of pomace was produced from oil olive process in various mills.

Further, though all municipalities are involved in olive cultivation (Fig. 5) but Ben Guecha municipality ranked first in cultivated area by 12.7%, followed by Meghaier with 7.6%, Hassi Khalifa with 6.8% and El-Oued with

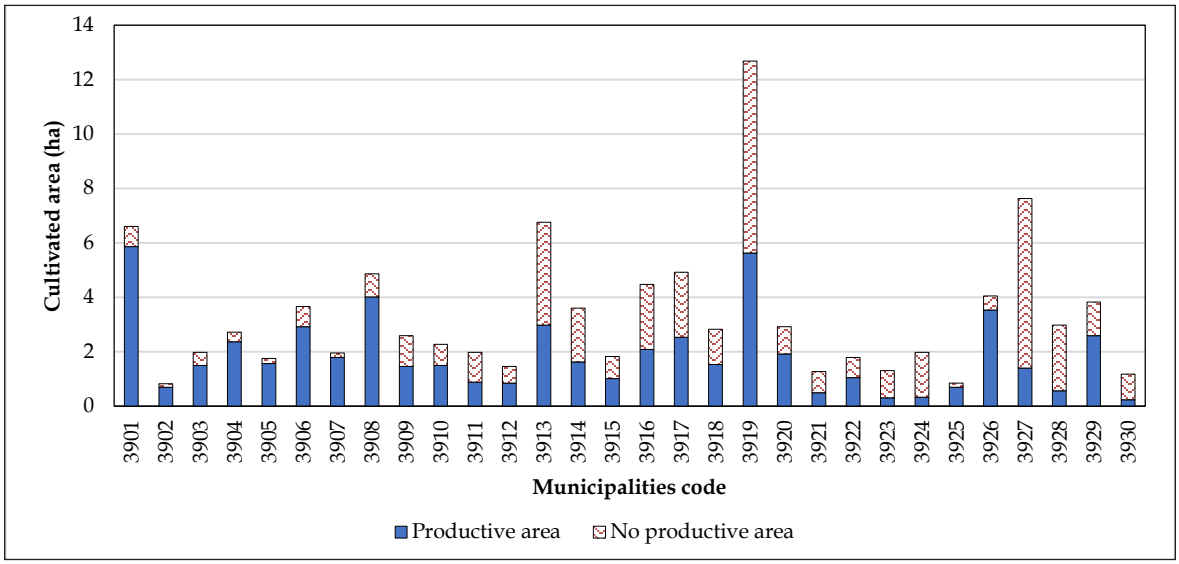

Fig. 5. Distribution of cultivated olive area according to municipalities of El-Oued province in 2018.

6.6. In the other municipalities, olive covers between 0.8 to 6.8% of the total area. For diseases and pests, both farmers and extension workers confirmed that the prevalence of diseases and pests of olive is very limited in the study area except olive fly pest, which is usually eliminated in the early stages of its appearance.

Discussion

Olive tree is considered as exotic plant in our study area. Its introduction is linked with the arrival of French colonists', but the effective beginning was in 1990s period, after the success of some experiments by local farmers, especially which were carried out in Al-Dawia private farm (Khezzani *et al.*, 2019).

Although the human factor cannot be ignored, the unique characteristics of the olive tree has also been a key element in the success of its establishment. According to Gucci and Caruso (2011), olive trees have the ability to adjust to a wide range of different environments due to several specific anatomical and biological characteristics. It can be productive from sea level up to an altitude of 1,200 meters. It needs full sun and a long and hot growing season (Palese *et al.*, 2010) and thrives in well-drained, sandy soil (Palese *et al.*, 2010). Furthermore, it can grow well even in poor, dry, calcareous and gravelly soils, with both medium acid and alkaline pH (Therios, 2009). The nutritive requirements of olive trees are lower than those of many other fruit species (Charfi-Masmoudi and Ben Mechlia, 2009). Olive trees are well adapted to tolerate drought (Tanasijevic *et al.*, 2014; Tugendhaft *et al.*, 2016), salinity and high temperature (Ghrab *et al.*, 2013; Chiappetta *et al.*, 2015). Moreover, olives can grow with no toxicity problems in soils even with a relatively high boron content (Kiritsakis and Shahidi, 2017). Through a review of previous literature on olives, it is very clear that the major requirement of olive tree are met in the study area.

The slow development of olive cultivation sector noted between 1999 to 2004 was due associated risk of investment in a new plant where results were not guaranteed for the local farmer who adopted. According to Doveri and Baldoni (2007), olive cultivation has high cost. Moreover, olive tree becomes most efficient and reaches its productivity peak when the tree reaches 40 or 50 years old (Boardman *et al.*, 1976; Raina, 1995).

After 2005, the success and increase in olive cultivation is owed to the program of National Fund for Agricultural Regulation and Development (NFARD), that helped farmers to establish their olive groves projects through financial support. This support included costs for drilling water well, setup of irrigation system and the supply of various types of olive seedlings. The material and technical support provided by the State initially encouraged local farmers to adopt the idea of planting olives. Subsequent, the encouraging results contributed effectively to the expansion of cultivated area.

The total adoption of irrigation in olive on phreatic aquifer is related to the easiness and low cost in investment compared to deep aquifers Terminal Complex (CT) and Continental Intercalaire (CI). According to Khezzani and Bouchemal (2018a), the phreatic aquifer is most used for irrigation (about 90%), not only for olive cultivation, but for all agricultural purposes, especially in Souf region.

The dominance of the *Chemlal* and *Sigoise* cultivars in the study area, may be due to their high resistance to harsh climatic besides the edaphic conditions prevailing in the arid zones (Cherfaoui *et al.*, 2018; Gharabi *et al.*, 2018). *Chemlal* cultivar occupies about 40% of Algerian olive growing (Dominguez-Garcia *et al.*, 2012), while *Sigoise* cultivar occupies nearly 20%. In the future, greater importance should be given to the selection of the cultivars more suitable for the study area conditions, because the choice of cultivars to be used for the new plantation is strategic for obtaining good results. Therefore, it is necessary to consider the establishment of a local nursery that is interested in the breeding program and production of olive seedlings according to the local conditions.

Olive oil produced in the study area is of high quality as it is with low acidity. The IOC norms determined that the acidity of extra virgin oil should not exceed 0.8% (Benaziza and Semad, 2016), while the acidity of virgin olive oil should range between 0.8 and 2% (Boulfane *et al.*, 2015). So, this product can be a strong competitor in national and global markets. According to Khezzani *et al.* (2019), in the recent years, small quantities of extra virgin

olive oil were exported to international markets, which was produced in the typical farm of the Al-Dawia. Although local production of table olives and olive oil is not currently assuming self-sufficiency, but contribute to cover a significant proportion of local demand.

Many density systems were used in rainfed olive cultivation worldwide, and performance of all are related to rainfall besides cultivars used in plantation. In our study area, we can classify the adopted olive cultivation density (350 tree ha^{-1}) among the medium density range, because the plantation depends on irrigation. The climatic, hydrologic and soil conditions that prevail in the study area, can effectively help in densification of olive cultivation. The process of intensifying olive cultivation leads us in fact to think about the introduction of modern agricultural mechanization, especially in the harvesting operations.

The decreasing productivity of olive trees in the first half of the studied period can be explained as most olive production was initially coming from Al-Dawia private farm, where modern techniques were used in olive cultivation; also, irrigation was done from the terminal complex aquifer which was characterized by low salinity compared to phreatic aquifer (Khezzani and Bouchemal, 2018b). Earlier Acila *et al.* (2017), reported that the productivity average of a sample of olive trees in Al-Dawia farm was estimated at 63.2 kg $tree^{-1}$ for *Chemlal* cultivar, followed by *Rougette* cultivar with 58.8 kg $tree^{-1}$, for the period from 2010 to 2014. In the second half of the studied period, the statistics included the production of small farmers also that is characterized by low productivity and use phreatic aquifer of high salinity for irrigation. Generally, the average of productivity of tree in study area was less than that national average estimated to be 22 kg $tree^{-1}$.

As olive tree reaches the peak production stage between age of 40 to 50 years (Boardman *et al.*, 1976; Vossen, 2007), the first assumption which can explain this status is that the olive trees did not reach the peak production stage, as age of trees was less than 20 years. The second assumption is that significant numbers of olive groves have been neglected by their owners, especially who were being benefited from the support of the State. The reasons of this neglect was also due to the shift to produce fast-growing and more profitable crops (potato, tomato and others) compared to olive cultivation. For these reasons, Directorate of Agricultural Affairs started re-census process of olive trees in El-Oued province since early 2019.

Fluctuation of olive productivity noted along the study period is largely also due to phenomenon of alternate bearing related to olive tree. In its reproductive behavior, the olive tree tends to reflect pronounced alternate bearing. This means a plentiful olive crop in a certain year is directly followed by a dearth in the next (Rapoport *et al.*, 2016). The study of Acila *et al.* (2017), that was carried out on 9 cultivars of olive in Al-Dawia farm (2010-2014), showed that highest value of alternate bearing index in the *Rougette* cultivar (0.18), while lowest value was recorded in the *Neb Djemal* cultivar (0.02). This phenomenon is among the most worldwide problems of the olive cultivation (Baldoni and Belaj, 2009). Further, alternate bearing is not specific to olive tree only, but include wide range of fruit trees such as pistachios, citrus, apple and mango as well (Wiesman, 2009; Sharma *et al.*, 2019).

Both, olive tree culture and the olive oil industry, produce large amounts of by-products (Toscano and Montemurro, 2012). Generally, an olive oil processing industry produces approximately 440 liters margins and 35 kg olive pomace per 100 kg of processed olives (Ghanbari *et al.*, 2012), in addition to about 25 kg (twigs and leaves) per tree (Molina Alcaide and Nefzaoui, 1996), annually through pruning process. But in the study area, no notable uses for these products has been recorded. The pomace is rejected with solid waste, the margins is evacuated with liquid waste, while the pruning residue is burned. It is therefore, important to focus on this component as an effective tool to support the agricultural sector, because the recent studies confirmed that olive by-products can be used in many field, especially in food industries (Caporaso *et al.*, 2018), in animal feeding (Al-Harthi, 2016), in soil fertilization (Lanza *et al.*, 2017) and in cosmetics industries (Rodrigues *et al.*, 2015).

Generally, the spatial distribution of the olive trees is influenced by the potential of each municipality in terms of availability of

agriculture related facilities. For example, Ben Guicha municipality, which occupied the first rank in terms of olive cultivation area, has been benefited from other type of support programs related to combating desertification in the Algerian steppe.

Further, with respect to the biotic stresses, the limited spread of olive diseases, may be due to prevailing climatic conditions, especially the low relative humidity and the long period of sunshine, in addition to tree the high agricultural diversity that has been noted in the study region. Generally, the spread of fungal diseases has strong correlation with high relative humidity (Li *et al.*, 2014). Additionally, the modern studies indicate that agricultural diversity leads to more efficient natural control of pests and diseases in agroecosystems, through the diversity of natural enemies of pathogens, especially insects (Ratnadass *et al.*, 2012).

Conclusion and Future Recommendations

Olive is one of oldest crops in the world, but in El-Oued province it is considered a new agricultural crop for local farmers. Although this type of cultivation is recent, the results confirmed its success in this arid part of Algerian Sahara. This success is due to a many of factors. First, being the ability of olive tree to adapt to a wide range of different environments including dry, basically due to a number of specific biological and anatomical characteristics. Secondly, increase in the financial and technical support offered by the State to the local farmers to boost the olive cultivation.

Along with many other crops, olive has contributed in recent years to the growth of the agricultural sector in the region, where it has become a leader in this field almost like date palm tree. The success of olive cultivation in El-Oued province opens new horizons for the rehabilitation of dry areas and reduction in the likelihood of desertification.

Hence for the success of olive cultivation in this new harsh environment, future efforts should focus on improving quantity and quality of production, reduction in adverse effect of the alternate bearing phenomenon, valorization of olive by-products, as well as selection of new varieties more suitable to arid environment conditions, especially drought and salinity, through breeding programs. In addition, the knowledge of local farmers related to this new crop should be developed, through the continuous hand holding by technicians, agricultural consultants, and regular training workshops.

Acknowledgments

The authors are advancing thanks to *Farhat Nacer*; the Engineer. *Cherif Abdessatar*, from Directorate of Agricultural Affairs in El-Oued province, the administrative responsible and agricultural engineers of Al-Dawia private farmer. Also, to Pr. *Nagaz Kamel* and *Lahzaiene Mustapha* from Arid Regions Institute (IRA) Medenine, Tunisia, for helping us in completion of this research.

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Printed in December 2019