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Characterization of olive cultivation in arid environments: A case study of Biskra, Algeria.

Samira Khamkhoum[1] and Hassina Hafida Boukhalfa[2]

[1]*Laboratory of Ecosystem Diversity and Dynamics of Agricultural Production Systems in Arid Zones "DEDSPAZA," University of Biskra, Algeria.*

[1]ORCID: 0009-0008-1680-2573

[2]*Laboratory of Promotion of Innovation in Agriculture in Arid Regions "PIARA," University of Biskra, Algeria.*

[2] ORCID: 0000-0001-5919-3984

Address; **[1,2]Mohamed Khider University, BP 145 RP, 07000 Biskra, Algeria**

Correspondence Author; *samira.khamkhoum@univ-biskra.dz*

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Abstract

This study delves into the intricacies of olive cultivation in arid regions, 54 farmers surveyed in the field. Comprehensive investigations were conducted covering farmers' profiles, orchard attributes, challenges in olive production, and marketing strategies for olive products. The agricultural diversity found among Biskra and northern farmers contributes significantly to the overall agricultural landscape.

The majority of orchards were established between 2000 and 2004 as part of the National Agricultural Development Plan. Farmers, aiming to enhance crop yields, employ intensive planting systems, according the farmers responses the most common olive varieties in our study area are Chemlal and Sigoise, although the indigenous 'Biskria' variety is said to have great potential for adaptability and production. Labor shortages and simultaneous olive and date palm seasons complicate harvesting.

Furthermore, farmers' misconceptions about olive ripeness and oil content persist, impacting harvesting decisions. The absence of oil processing facilities further steers farmers towards harvesting table olives instead of focusing on oil production. We recommend tailored training programs, enhanced knowledgesharing platforms, increased research efforts to understand farmer motivations better and address inadequate planning and management skills through targeted training

Additionally, the assessment of drainage systems in arid agronomic regions must be installed, as it plays a crucial role in sustaining olive groves by preventing soil salinity issues resulting from irrigation practices. The findings of this research contribute valuable insights that can inform intervention, advancements and sustainability in olive cultivation in arid climates, fostering practices and promoting progress in this arid agricultural filed

Key words

Olive growing, arid environment, investigation, sustainability, production.

1. Introduction

Olive groves represent a prominent category of perennial crops globally, covering approximately 25% of the total permanent cultivated area across 63 nations on all continents, totalling 11.6 million hectares. This constitutes slightly over 0.25% of the entire cultivated land area. Notably, 70% of the global olive grove area is designated for rainfed horticulture, with the remaining 30% allocated to irrigation (Vilar & Pereira, 2018).

The consumption of olive tree products, including olive oil, table olives, and olive leaves, has experienced significant growth due to the nutritional, medicinal, economical, and ecological benefits offered by these products(Boronat et al., 2019a, 2019b; Carnevale et al., 2014, 2018; Davis et al., 2017; Diallinas et al., 2018; El-Azem et al., 2019; Violi et al., 2015).

This surge has fuelled the worldwide expansion of olive cultivation, reaching across diverse climatic regions, from the Mediterranean to unconventional olive oil-producing countries such as Argentina (Pardo et al., 2018), Brazil (Antonialli et al., 2018), Chile (Romo Muñoz et al., 2018), the UK (Martínez et al., 2002), and the arid climate of the southern Algerian desert (Belhacini et al., 2020).

In Algeria, despite its historical origins, the cultivation of olives has encountered various challenges and undergone significant transformations throughout time. The introduction of olive trees to distant areas characterized by arid and desert climates reflects the impact of historical conquests and population migrations. The discovery of ancient olive presses dating back to the Roman period in remote regions serves as tangible evidence of the olive oil trade between Algeria and Rome during that era (Alloum, 1974). According to Camps-Fabrer (1953) , the region around Ain Zaatout in the village of Ath Ferrah, located in the Biskra province, maintained the longstanding tradition of olive cultivation. This practice was sustained by tapping into subsurface water resources and the presence of ancient olive trees and oil mills that trace their origins back centuries.

Biskra, historically recognized as a vital agricultural hub, employs an oasis agricultural system, creating a microclimate conducive to the growth of olive trees alongside date palms. Olive trees, renowned for their adaptability to harsh environmental conditions such as drought and high temperatures, thrive in this region (Fraga et al., 2020; Mafrica et al., 2021).

Contemporary agricultural systems, facilitated by government initiatives and the implementation of modern irrigation methods, have further propelled olive cultivation in Biskra. Initiatives like the National Agricultural Development Plan (Plan National de Développement Agricole - PNDA) in the 2000s have opened new avenues for agricultural development in Saharan regions, catalysing a transition from traditional oasis production to a more diverse system (Agoune & Touati, 2023).

The Biskra province stands out as a predominant producer in the southern area of Algeria. The olive cultivation area has significantly expanded in the last decade, reaching 5209 hectares, representing 33% of the overall planted area in the southern region, encompassing a total of 1,238,219 olive trees (DSA, 2021).

While the prospect for olive cultivation in Biskra appears promising, challenges emerge due to the region's arid climate. Testing the adaptability of olive trees to varying climates presents a unique opportunity for study. Maximizing olive yields with minimal input costs remains a crucial consideration. Challenges encompass Phytopathological issues, water deficits, and extreme temperatures (Lionello et al., 2014; Oteros et al., 2014), underscoring the pivotal role of farmers in decision-making. The profitability and sustainability of olive

cultivation in new locations hinge not only on farmers' choices regarding olive cultivars (Khadari et al., 2019), agricultural practices, and adaptation strategies(Nastis et al., 2019) but also on the successful implementation of these choices, emphasizing the critical role of farmers in both decision-making and execution.

Our extensive field study in the Biskra region illuminates the intricate processes involved in cultivating olives in an arid environment. The study provides valuable insights specific to Biskra province and serves as a comprehensive reference for regions confronting similar challenges in olive cultivation under arid conditions. By emphasizing the pivotal roles of farmers, education, and sustainable methods, our research establishes a solid foundation for the continual expansion and prosperity of olive cultivation in arid regions, contributing to a sustainable future for this agricultural practice.

2. Background of the researches about the olive cultivation in arid climate

This bibliometric review explores a recent trend of studying olive cultivation in arid climates, focusing on research conducted in the past fifty years. It examines various aspects such as olive groves, olive production in arid zones, difficulties, challenges, and potential solutions. We conducted a comprehensive search of the Scopus database until December 2023, utilizing precise keywords pertaining to olive cultivation and cultural practices. Our aim was to gather valuable information from academic articles, conferences, books, and chapters. In order to gain comprehensive bibliometric data, we utilized VOSviewer to analyze the interconnections among nations, authors, keywords, and documents, thus providing contextual information for our research focus. This bibliometric review has presented a thorough summary of papers published each year. Since 1999, there has been a surge in research focused on olive cultivation in arid climates for the purpose of wastewater treatment (Fig. 1A).

The identification of key publications that have significantly contributed to the understanding and progress in the study of olive growing was accomplished by reviewing the 9 most cited or influential papers, representing a comprehensive selection. Analyses of their most productive work identified the most influential authors in the field of Olive growing under arid climate. The authors were grouped together to highlight their areas of expertise and frequent collaborations.The authors' affiliations allowed for the mapping of each country's contribution to the research work. We were able to identify Tunisia, Italy, Spain, France, and Argentina as significant contributors to the study of olive growing (Fig. 1b). The primary areas of study and emerging patterns in the field were identified through keyword analysis.

Fig. 1c shows that certain keywords were commonly linked to olive cultivation, such as arid conditions, irrigation, and various aspects of growing the olive tree (*Olea europaea*). The categorization of documents based on subject area has facilitated the identification of research patterns, international partnerships, and areas experiencing rapid expansion (Fig. 1d). These findings could provide the basis for future agricultural research, decisions, and agricultural advancements

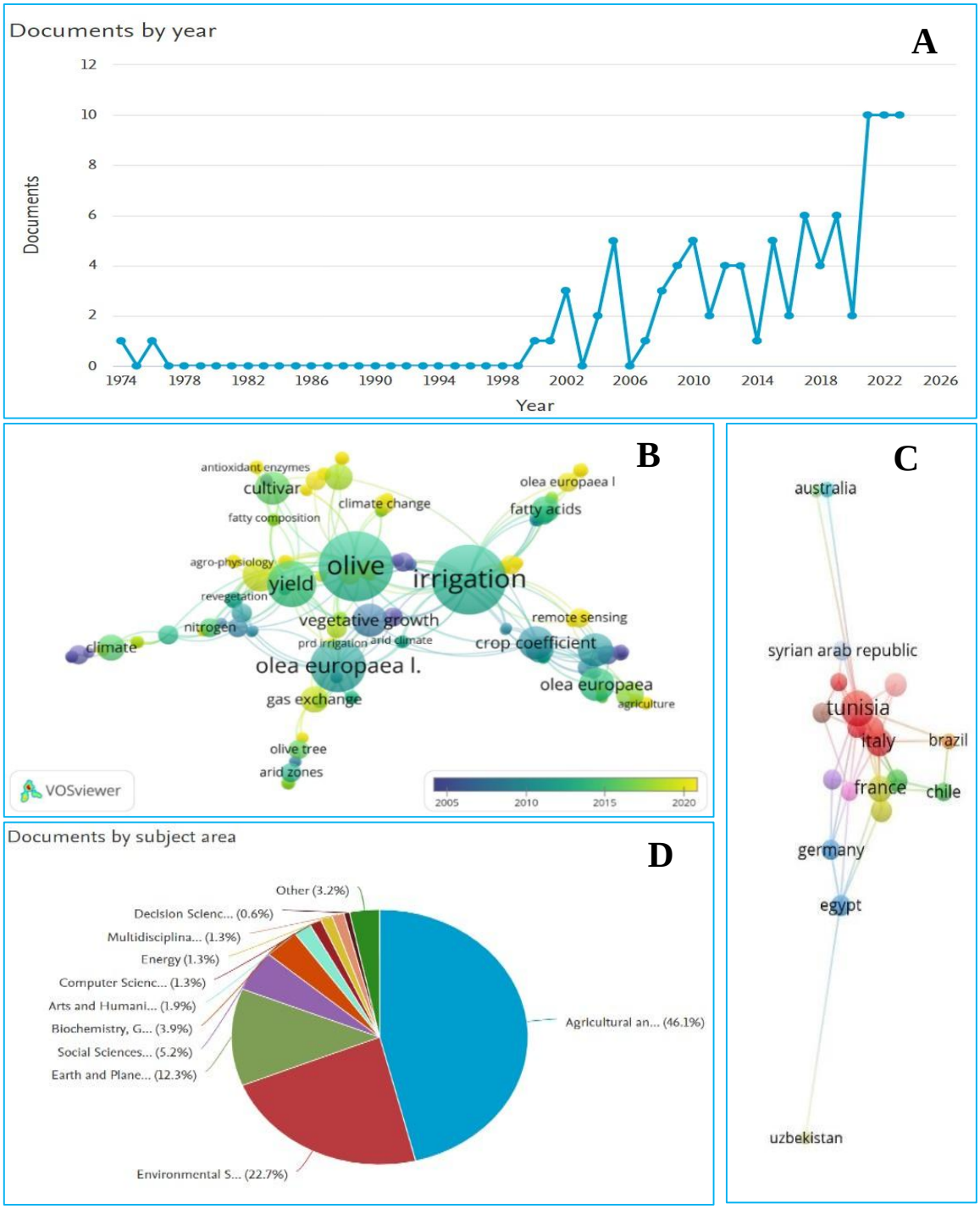

Fig. 1. Documents by (A) year, (B) keywords, (C) countries and (D) subject area.

3. Material and methodsStudy area

This study examines olive cultivation in arid regions, specifically in the province of Biskra, located in central and eastern Algeria at the gateway to the Sahara Desert. This province spans an area of 20,986 square kilometres and includes 33 municipalities distributed across 12 districts, as of 2014. The study region has a hot desert climate, as classified by Köppen (1936) (Kottek et al., 2006). It receives less than 150 mm of precipitation yearly and has an average annual evaporation of 2.5 thousand mm. According to Boudibi et al.(2021), the mean temperature varies between 11°C in January and 35°C in July.

The topography of the research region is primarily flat, interspersed with sporadic undulating hills and elevated mountain ranges. The altitude ranges from a minimum of 43 meters in the Oumache region to a maximum of 283 meters in the western section. The area is geologically classified as belonging to the Quaternary epoch, conducive to the replenishment and presence of groundwater (Boudibi, 2021; Sedrati, 2011).

The soils in this region are diverse, impoverished, and shallow. Saline, gypsum, and limestone deposits are found in the southern region. The eastern region contains alluvial soils and fertile clay soils. Conversely, the soils in the northern region exhibit limited development and low fertility. The northwest plain is distinguished by its clay-sodium soils (Khechai, 2001; Masmoudi, 2012; Sedrati, 2011).

The province of Biskra is a prominent producer in the southern region of Algeria. The area dedicated to growing olives has dramatically increased in the past ten years, now covering 5209 hectares, accounting for 33% of the total cultivated area in the southern region, including 1,238,219 olive trees (DSA, 2021). The table 1 shows informations on areas, productions and locations of olive growing in the region of Biskra according to the statistics of Biskra Agricultural Room for the season 2020/2021.

Table 1. Distribution of olive growing in Biskra during 2020/2021 (BAR, 2021)

Locations	Area trees (ha)	Total production (tree)	Olive fruit oil production (qx)	Olive fruits for production (qx)	Oil olive production (hl)
Eloutaya	1272	325620	15704,3	9826	1657
Mlili	522	161060	3551	1354	224
Oughlal	459	79713	4048	1543	255
Mkhadma	311	93992	3447	1315	217
Oumache	400	116720	5600	2338	404
Elghrous	107	30120	1943	741	122
Doucen	161	53590	3026	1706	220
Branis	142	36930	2400	999	184
Sidi Okba	137	37460	2530,7	1241	225
Chetma	124	42030	2800	1175	202
Ras el miad	31	8060	500	261	0
Besbas	18	4680	195	0	0
Sidi Khaled	21	6430	934	0	0
Echaiba	39	12790	519	0	0
Mchounech	92	30940	1958	1023	190
El houch	45	15590	1590	0	0
Zeribet elouad	126	32940	3150	0	0
Ain naga	88	29810	1847	980	182
Elfaidh	133	35160	3112	0	0
El kantra	101	27060	1841	979	162
Ain Zatout	52	13730	0	1395	243
Djemourah	43	12650	1330	507	84
Tolga	62	16960	1117	426	70
Lioua	266	38815	1992	760	125
Lichana	51	13880	852	325	50
Foughala	32	8940	550	210	35

Bogdj Ben Azzouz	3	1380	95	36	6
M ziraa	111	30000	2713	0	0
Bouchagroun	34	10250	760	290	48
Elhadjeb	111	36250	2844	1085	179
Khangat Sidi Nadji	115	29800	2466	0	0
Total	**5209**	**1393350**	**75415**	**30515**	**5084**
Mean	**325,5625**	**87084,375**	**4713,4375**	**1907,1875**	**317,75**

Sample composition

We selected 54 active farmers to actively participate in our survey. This group was chosen randomly from the list of olive growers provided by the Biskra Agricultural Room for the season 2020/2021. Our survey encompasses fourteen diverse locations, namely: Elhadjeb, Ain Zatout, Ain Naga, Tolga, Sidi Okba, Branis, Oumache, Eurlal, Amlili, Emkhadema, El Outaya, Elgantra, Lioua, Elhouch.

The geographic distribution of these locations is represented by Fig .2 below.

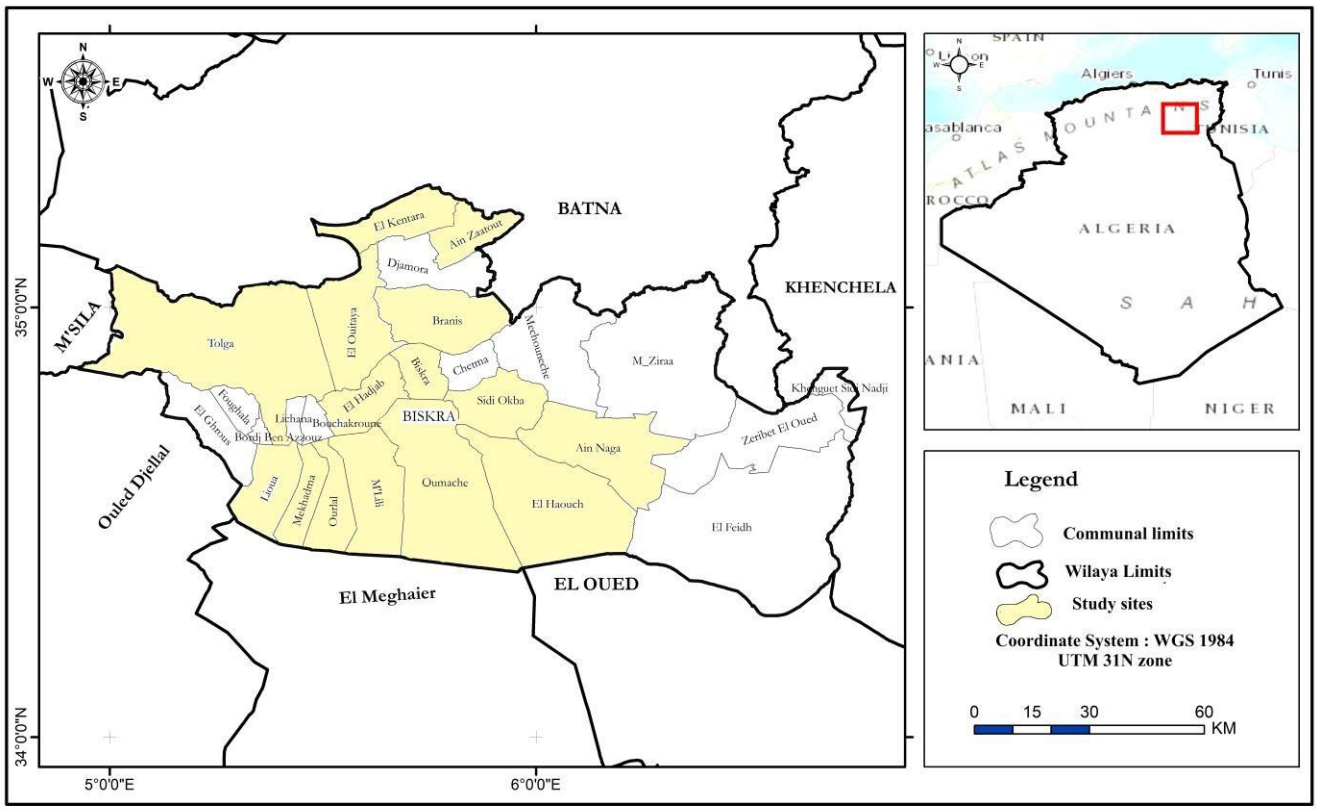

Fig. 2. Location of the study area and the study sites.

We employed a free randomized sampling method to select farmers in the chosen locations, with the number of surveyed farmers in each location reported in Table 2.

Table 2. Number of surveyed farmers in selected locations

Locations	Number of surveyed farmers	Amount of sample (%)
Elhadjeb	5	9,3
Ain Zatout	5	9,3
Ain Naga	3	5,6
Tolga	3	5,6
Sida Okba	3	5,6
Branis	2	3,7
Oumache	8	14,8
Eurlal	3	5,6
Amlili	3	5,6
Emkhadema	3	5,6
El Outaya	9	16,7
El kentara	3	5,6
Lioua	2	3,7
Elhouch	2	3,7
Total	**54**	**100**

Survey steps description

To effectively manage and differentiate questionnaire samples from various locations within our study area, a comprehensive analysis was conducted, considering the size of the study area.

The questionnaire is tailored for farm managers, responsible for both overall management and investment decision-making, aiming to evaluate the methods of olive production in this region. It encompasses various aspects, including farmer profiles, groves identification, plant material used, cultivation practices, and the socio-economic environment.

Data collection occurred from November 2021 to July 2022, adhering strictly to ethical principles. Participants provided consent, and confidentiality was maintained for their personal information. The survey aimed to gather scientific knowledge devoid of personal biases or individual interests.

The collected data underwent processing, coding, and entry for descriptive statistical analysis using Excel 2013 and IBM SPSS (Social Package for Social Sciences) version 27.

4. Results

Surveyed farmers' profiles

The demographic profile of the surveyed participants (Table 3) reveals a predominant male representation, accounting for 92.6% of the sample, while females make up 7.4%. In terms of age distribution, the vast majority of respondents (77.8%) are between the ages of 31 and 50. Notably, the age groups 20-30 years account for 13.0%, 51-60 years for 18.5%, and those over 70 years for 1.9%. The participants' backgrounds are diverse, with 74.1% hailing from cities other than Biskra. It is important to note that these farmers specialize in olive growing in Biskra, our study area. Farmers' educational attainment varies, with 46.3% having completed high school, followed by 29.6% who have completed university. The majority (53.7%) of olive growers have 11-15 years of experience, with 22.2% having received

agricultural training. The remaining respondents (77.8%) have not received formal agricultural training**.**

Table 3. Surveyed farmer's characterization

		Percent (%)
Gender	Male	92,6
	Female	7,4
Age	20-30	13
	31-40	27,8
	41-50	31,5
	51-60	18,5
	61-70	7,4
	More than 70	1,9
Original city	Biskra	25,9
	Other city	74,1
Educational level	None	3,7
	Primary school	3,7
	Secondary shcool	16,7
	Hight school	46,3
	University level	29,6
Experience with olive growing	Up to 5	5,6
	6-10	20,4
	11-15	53,7
	16-20	13
	More than 20	7,4
Training in Agriculture	Yes	22,2

Identification of the Surveyed olive groves

The age distribution of olive trees in the surveyed orchards (Fig.3; A) is as follows: 9 trees, accounting for 16.7% of the total, are between 6 and 10 years old. The age group of 11 to 15 years comprises 24.1% of the total, which corresponds to a count of 13 trees. Out of all the trees, 37% of them, which is the majority, fall within the age range of 16 to 20 years. In total, there are 20 trees in this age range. Finally, 22.2% of the olive trees have an age exceeding 20 years, totaling 12 trees.

According to the survey, farms that were classified as larger accounted for 46.3% of the total and had an area of more than 10 hectares. On the other hand, medium-sized farms made up 29.6% of the total and had an area ranging from 6 to 10 hectares. Additionally, there was a presence of small-scale farms, comprising 20.4% of the total, with sizes ranging from 1 to 5.99 hectares. Furthermore, 3.7% of the farms had a size of less than one hectare. Regarding the size of olive groves, the findings indicate that most farms had extensive orchards, with 53.7%

possessing orchards spanning from 1 to 5.99 hectares. Additionally, smaller orchards were noted, with 24.1% possessing orchards measuring less than one hectare, and 11.1% possessing orchards ranging from 6 to 10 hectares and exceeding 10 hectares (Fig.3; B)

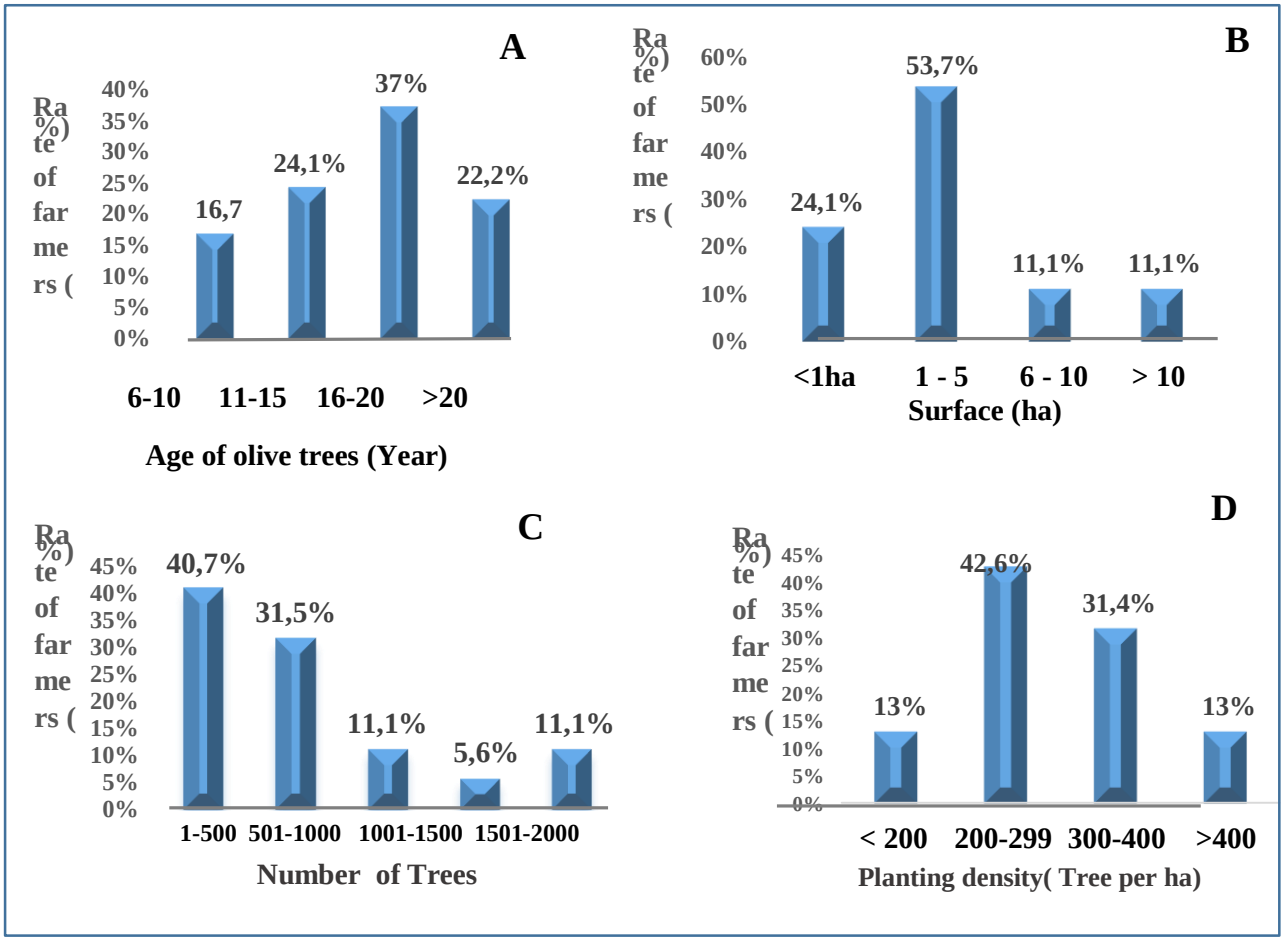

Fig.3. Identification of the Surveyed olive groves.
A: Olive tree age, B: Olive Orchards surface, C; Olive tree number, D; Planting density

The survey specifically examined the quantity and concentration of vegetation present on the agricultural properties. Among the farms surveyed (Fig.3D); a significant proportion had a substantial quantity of olive trees. Specifically, 40.7% of the farms had between 1 and 500 trees, while 31.5% had between 501 and 1000 trees. The density of olive trees exhibited significant variation.

42.6% exhibited a density ranging from 200 to 299 trees per hectare, while 31.4% fell within the range of 300 to 400 trees per hectare. The lower densities consisted of 13% with less than 200 trees per hectare and 13% with more than 400 trees per hectare (Fig.3; C).

The survey revealed that olive groves exhibit variations in their dimensions, tree count, orchard density, and the utilization of either intensive or semi-intensive planting techniques.

Farmers commonly employ high density planting techniques to attain optimal crop productivity and enhance the plants' inherent resilience against wind and various plant species. This information is valuable for comprehending the olive cultivation techniques and preferences of the interviewed farmers.

Regarding planting density, the majority of farmers aim to optimize it by reducing the area while increasing the number of trees. This approach allows them to economize on water and irrigation infrastructure costs. These systems are primarily employed for irrigation and commonly utilize the method of immersion irrigation. The close spacing of the trees optimizes efficiency, reducing the time, labor, and water required for watering.

Plant material

The majority of farmers used certified Plants (61.1%) for planting olive trees. A smaller proportion used uncertified plants (22.2%), while a few farmers had planting material of unknown origin (16.7%) (Fig.4 B).

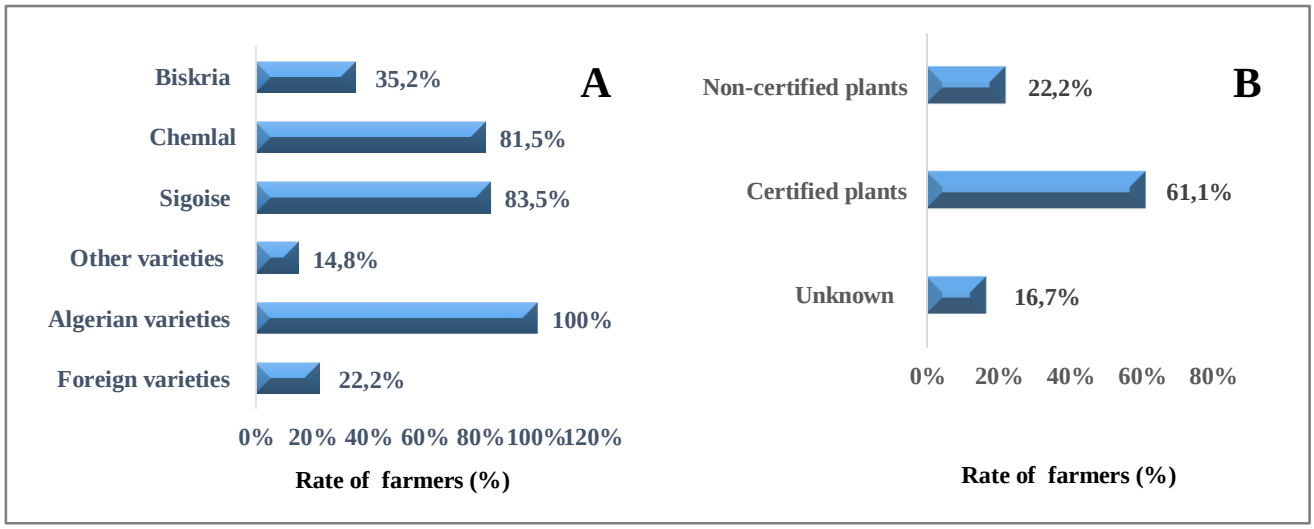

Fig.4. Plant material characterization.
A: Olive varieties information, B: Origin of cultivated olive trees

Olive tree varieties cultivated by the surveyed

In terms of the origin of cultivated olive trees (Fig.4 B); (22.2%) of farmers have chosen to cultivate foreign varieties. However, the vast majority (100%) prefer to grow local varieties, indicating a strong inclination toward varieties adapted to the specific conditions of the arid zone.

Specifically, the Chemlal olive variety is widely cultivated, chosen by 81.5% of farmers, the Sigoise olive variety is also popular, with (83.3%) of farmers growing it, suggesting its prevalence in the region. Nearly a third of farmers (35.2%) opted for the Biskria

variety, indicating a certain diversification of varieties grown in the region Only 14.8% of farmers chose to cultivate other varieties of olive trees, demonstrating some variability in the choice of varieties within the arid zone of Biskra (Fig.4 A).

Conduct of culture

The cultural treatment practices observed among the surveyed farmers in Biskra, our study area, demonstrate intriguing patterns. Regarding plant establishment techniques, 46.3% of individuals utilize seedling planting (Table 4), indicating a systematic approach to tree management, whereas 53.7% do not conform to established planting guidelines. When it comes to tree pruning (Table 4), 70.4% of people choose to engage in training pruning in order to promote better growth, while 29.6% prefer fruiting pruning to improve fruit production.

Regarding fertilization practices (Table 4), the majority (88.9%) of individuals opt for both organic and mineral methods to promote sustainable and eco-friendly agriculture, conversely, 11.1% of individuals do not follow this practice. 42.6% of participants utilize phytosanitary treatments to combat diseases and pests, demonstrating their focus on safeguarding crops. Conversely, 57.4% of participants abstain from using these treatments, suggesting a preference for organic or reduced chemical methods. Regarding weed control(Table 4); 64.8% of participants engage in the activity of weeding as a means to manage the presence of competing weeds, while 35.2% do not incorporate weeding into their agricultural practices**.**

Table 4. Conduction of the olive groves

		Rate of farmers (%)
Standard tree planting		46.3%
Maintenance Purification of the tree	Training size	70.4%
	Fruiting size	29.6%
Organic fertilization		88.9%
Mineral fertilization		88.9%
Weeding		64.8%
Treatments against diseases and pests		20.37%

Irrigation and drainage

Irrigation is universally necessary for agricultural practices (Table 5), with all farmers (100%) actively engaging in irrigation. This is a crucial response to the region's limited water availability.

When analyzing the origins of irrigation water among these farmers (Table 5), it is evident that 68.5% rely on boreholes, indicating a significant reliance on groundwater. Additionally, 16.7% use wells, 9.3% obtain water from wadis (rivers), and 5.6% depend on dams.

Regarding irrigation systems (**Fig.5**); 75.9% of farmers choose localized irrigation methods (Table 5), such as drip systems, which guarantee accurate water distribution to plants. Meanwhile, 24.1% utilize gravity irrigation systems that make use of the natural movement of water.

The frequency of irrigation practices exhibits heterogeneity (Table 5), with 46.3% irrigating every 5 days, 27.8% irrigating every 15 days, and 25.9% employing irregular irrigation practices, possibly influenced by specific crop requirements or the availability of water resources (Table 5).

Table 5. Irrigation and drainage practices

		Rate (%)
Irrigation		100%
Source of irrigation water	Dam	5.6%
	Drilling	68.5%
	Well	16.7%
	Wadi	9.3%
Water analysis	Yes	81.48%
	No	18.51%
Irrigation system	Gravity	24.1%
	Localized system	75.9%
Irrigation rate and frequency	Every 5 days	46.3%
	Every 15 days	27.8%
	Irregular irrigation	25.9%
Drainage system application	No	100%

However, in terms of drainage, all surveyed participants do not have drainage systems in place on their farms, indicating a widespread absence of this specific agricultural infrastructure among all respondents (100%)

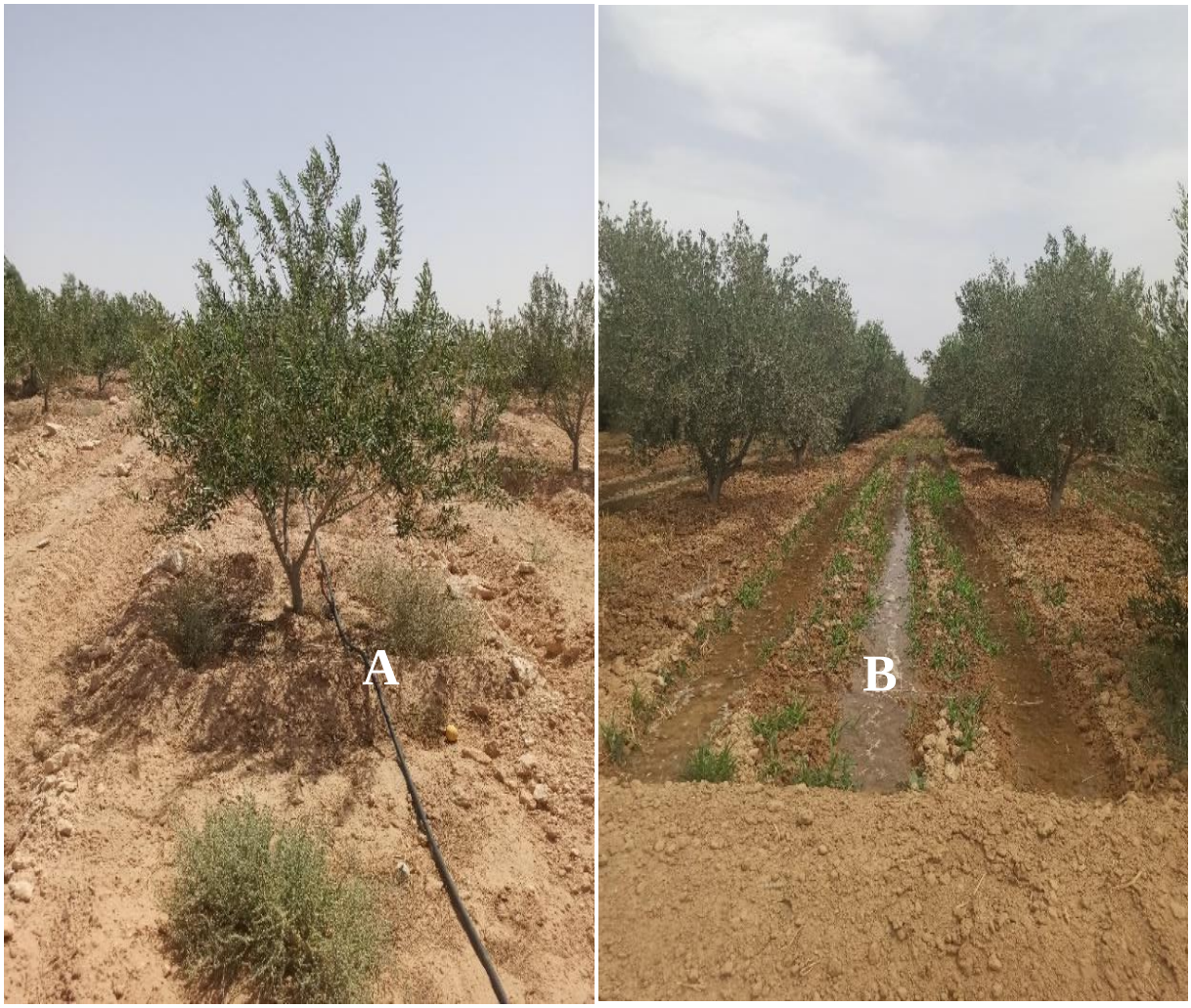

Fig.5. Irrigation systems (Original 28-03-2022).
A: Localized irrigation system B: Gravity irrigation system

Socio-economic environment production informations

The presented data in Table 6, offers valuable insights into different facets of olive production, such as the destination of the olives, the stage at which they are harvested, the estimated yield, the method of harvesting, and the location of the units where olive oil is extracted.

Regarding the distribution of olive production, the largest portion (61.1%) is designated for table olives, while 20.4% is allocated for olive oil and 18.5% is used for a blend of oil and table olives.

When examining the stage at which table olives are harvested, the data indicates that 80.48% are harvested while the fruit is still green, 2.43% when it has turned black, and 17.07% depending on the labor availability.

Table 6. Characterization of Olive production

Settings	Purposes	Rate (%)
Destination of olive production	Table olive	61.1
	Olive oil	20.4
	Oil and table olive	18.5
Harvest fruit stage (Fruit color) for table olive production	Green	80.48
	Black and Green	2 .43
	Depending on the availability of labor	17.07
	Black	38.09
Harvest fruit stage (Fruit color) for table olive production)	Green and Black	19.04
	Depending on the availability of labor	42.85
Estimation of olive yield (kg/ tree)	Less than 20 kg/ tree	50
	More than 20 kg/ tree	33.3
	Uknouwn	16.7
Estimation of olive oil yield (l/ha)	Less than 15L / 1 qx	20.4
	More than 15L / 1 qx	20.4
	Uknown	59.3
Harvesting Methods	Shaking of branches	57.4
	Manual	42.6
	Mechanical	0
Location of olive oil extraction units	Far	60
	Close	40.7

In table olive production, specifically during the black fruit stage, 38.09% of the olives are harvested when they have turned black, 19.04% are harvested at a different stage, and 42.85% are harvested based on the availability of labor.

The olive yield estimation reveals that 50% of the trees produce less than 20 kg, 33.3% yield more than 20 kg, and 16.7% have an unknown yield.

Similarly, the assessment of olive oil yield indicates that 20.4% yield less than 15 liters per 1 quintal, 20.4% yield more than 15 liters per 1 quintal, and the yield of 59.3% is unknown. Regarding the methods used for harvesting, 57.4% of individuals employ the technique of shaking the branches, 42.6% utilize manual methods, and none make use of mechanical harvesting.

The distribution of olive oil extraction units reveals that 60% are situated at a considerable distance from the source, whereas 40.7% are in close proximity.

Workforce

With regards to the workforce (Fig.6), it is worth mentioning that 44.4% of participants depend on permanent workers for their agricultural operations. This substantial proportion indicates a reliable and long-lasting labor force, which contributes to the uninterrupted continuation of agricultural operations. Furthermore, a notable proportion of participants, specifically 42.6%, employ seasonal workers, indicating their ability to adapt to the varying requirements of different seasons. Seasonal labor is incorporated to ensure flexibility in handling agricultural tasks according to seasonal demands. In addition, 7.4% of participants employ family labor, demonstrating the active engagement of the family in diverse agricultural tasks.

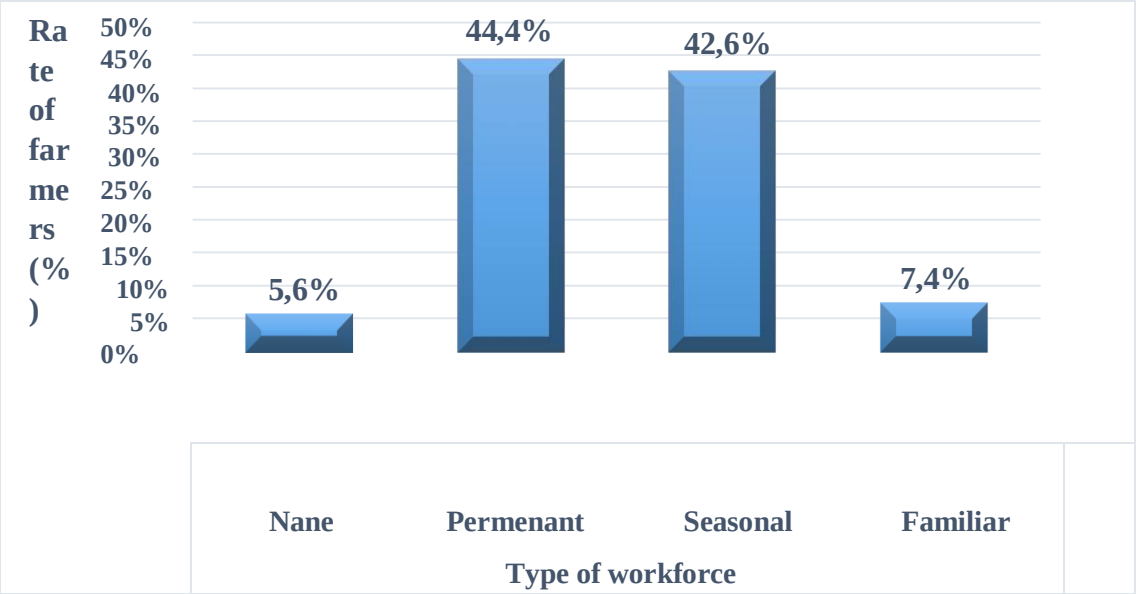

Fig.6. Workforce types

Olive Products flow

When it comes to the olive products flow (Fig.7), a significant 64.8% of farmers primarily grow olives for the local market. This suggests a notable focus on satisfying local demand, which could potentially boost the local economy and fulfill the needs of regional consumers. Regarding exports, 35.2% of the participants engage in olive production specifically for the purpose of exporting. The simultaneous focus on local and international markets highlights the diversification of the olive production landscape. Curiously, none of the farmers solely cultivate olives for personal use, highlighting the business-focused nature of the olive farming practices among this group of participants. This data offers valuable insights into the composition of the workforce and the strategic market focus of olive producers, reflecting the dynamic socioeconomic landscape in the olive cultivation.

Fig.7. Olive products destination

5. Discussion

We conducted a field study in the Biskra region to gain insights into the olive farming sector in a desert climate. The study involved administering a questionnaire with a wide range of questions. The survey was conducted with a sample of 54 farmers who exhibited a range of ages. In terms of educational attainment, the majority of the farmers surveyed (46.3%) had completed high school, while 29.6% had completed university-level education. This illustrates that individuals with a lower educational attainment are less inclined to allocate additional resources towards innovation, which necessitates a higher level of expertise. According to Muhammad-Lawal et al.(2014);there is evidence suggesting that agricultural performance is enhanced by increased levels of education. One possible reason is that effectively utilizing advanced tools requires specialized training and manual analysis to create a product of greater market worth. Moreover, studies conducted by Khaldi (1975) and (Welch, 1971) have substantiated that a greater level of education positively impacts agricultural productivity. Additionally,(Kafando, 2020)has affirmed that each year of education attained by a farm manager leads to a corresponding increase in farmers' income.

About their original hometowns, they can be divided into two groups: native farmers from Biskra and investors from the northern provenance of the country. This diversity enriches the agricultural culture of the olive farmers. Natives of the arid environment have a comprehensive understanding of various agricultural methods and techniques, particularly in terms of irrigation and adaptation to the dry desert climate. On the other hand, farmers from the northern regions have extensive knowledge of olive cultivation, pruning techniques, and

harvesting. Therefore, Hernández-Morcillo et al. (2018) and Stutzman et al. (2019), recommend to address the issue of a lack of skills in planning and managing an olive growing system, guidelines, training programs, and possibilities for knowledge exchange between farmers and advisers have been developed. Farmers require ongoing training to deal with the demands of their industry (Hernández-Morcillo et al. (2018); Landini et al.(2017); Stutzman et al.(2019)). A more practical and less theoretical education/training technique has been suggested by (Landini et al., 2017). Thus, we encourage further research to be carried out to better understand the motivation of advisors to engage in training programs fostering the exchange of ideas between these two groups of farmers and engaging with various agricultural authorities to organize study and training days to promote and develop the olive sector in arid regions.

The majority of orchards surveyed are young, approximately 37% of farmers reported that the ages of their orchards ranged from 16 to 20 years; this means that their orchards were planted in the period from 2000 to 2004. This is primarily due to the National Agricultural Development Plan (PNDA), through this program, olive cultivation areas expanded across the entire Algerian territory by distributing olive trees to most farmers nationwide.

Among these farmers are those from the Biskra region, known for date production and date palm cultivation, as a result of the agricultural nature of our study area, many farmers in this region allocated small spaces to live cultivation. Despite having extensive areas, about 53.7% of farmers stated that their orchards covered an area ranging from 1 to 5 hectares our results are the similar of Ater M., Barbara and H., Kassout . (2016),(Baldini, 1992)with a planting density falling within the intensive planting system; Regarding those kinds of planting density, most farmers focused on the intended planting system to maximize the number of trees in a small area. This leading to cost savings in irrigation equipment and labor, as well as higher yields per hectare compared to the traditional isolated tree cultivation. Most farmers relied on a density of 200 to 299 trees per hectare (42.5%) as a traditional system planting, followed by a thickness of 300 to 400 trees per hectare (31.5%), and 13 % by more than 400trees per hectare. Within these typologies fall olive orchards with intensive plantings characterized by planting densities of 300–1000 trees/ha, (Scaramuzzi, 2007).

As for the third unit of the survey,it included information about the plant materials used. Most farmers used certified plant material. This is essential for successfully cultivation, as it ensures knowledge of the characteristics of the planted variety in terms of quantity and quality of production and adaptation. Moreover, about the olive varieties, Chemlal and Sigoise are the most commonly used in the region by farmers these are the two most commonly used local

varieties in the country (Boukhari, 2014). These two varieties are the most prevalent in the northern part of the country, where they have been extensively planted. Primarily, they were distributed to farmers free of charge by the National Olive Germplasm Repository (ITAFV) The remaining percentage of farmers either owned old orchards purchased from other individuals or relied on planting trees with unknown sources bought from the general market without precise criteria.

Some farmers also mentioned having a local variety specific to the Biskra region, known as 'Biskria' (35.2%). It is essential to verify and genetically and morphologically classify this variety for potential propagation, as it is a successful local variety. Olive cultivars native to dry locations are more adapted to drought circumstances than cultivars from other regions.

For foreign varieties we found just one farm in Ain Naga area that includes an orchard with a high density Arbequina. This variety is considered one of the most adaptabale varieties in arid climate, withe high production yeild (Bacelar et al., 2009; Greven et al., 2009), especially in areas with a more temperate climate.

Michalopoulos et al. (2020), also mentioned that proper pruning techniques that improve within canopy light distribution, foliage aeration, and the development of bearing shoots could help to reduce the "alternate bearing" phenomenon (high/low yield year) and achieve stable yearly crop yield. Furthermore, the same study suggests that shredding pruning wastes rather than burning them enhances soil organic matter, creating a mulching layer as well as improved soil water retention capacity.

Regarding tree pruning, (28%) of farmers engage in the practice of pruning fruits and mo. This practice is essential for achieving improved fruit production. Engaging in this practice is essential for achieving equilibrium in vegetative growth (Baldini, 1992). The growth of fruit production can have a significant impact on light efficiency, which in turn affects the quality of production. This has been demonstrated in studies by Proietti et al. (2011), Reale et al. (2019), and Servili et al. (2013) . Additionally, the sensitivity of plants to plant diseases is influenced by the balance between vegetative and reproductive activities, which is affected by fruit production. This relationship has been observed by (Viruega et al., 2011),88.9% of farmers primarily use organic fertilizers due to the high cost of mineral fertilizers. Only 11% of farmers utilize mineral fertilizers in their orchards, indicating a widespread scarcity of fertilizer usage. The results of our study are consistent with those of (Therios, 2009) , indicating that this factor plays a critical role in affecting both the quantity and quality of fruit production (Rufat et al., 2014; Sallam et al., 2014). All the olive orchards

in the region are among the crops that are irrigated throughout the year. The only difference that exists is in the source of the water used for irrigation. 68.5 of the farmers' source of water is Drilling, Biskra is a Saharan region where agricultural strategies have resulted in extraordinary agricultural success. Drilling techniques became more common in the 1980s, and their costs fell dramatically, resulting in a phenomenal increase in the number of individual boreholes, which served as the foundation for the development of a new type of Saharan agriculture outside the oases that was intensive and completely market-oriented(Mubarak, 1998). More than 100,000 hectares of land in the region are irrigated, but the precise number of boreholes in use is unknown. The local branch of the Southern River Basin Agency estimates that there are 17 thousand boreholes in the region, only 8 thousand of which have been sunk with the permission of the necessary authorities.(Daoudi et al., 2017) due to the process of support from the state through loans to farmers, which made drilling wells easier. It is within the reach of most farmers and has contributed to the development of the confiscation of irrigation water in the region, and the rest is between traditional wells and irrigation from the valleys. The most widely used irrigation system is the local irrigation system, 75.9 percent, and it is widely relied upon in the region because its equipment is available at reasonable prices compared to other systems and does not consume energy.

Large electric, regulating watering periods for olive orchards is necessary and necessary for the success of agriculture. Most farmers irrigate every five days 46.3%, and 27.8% of farmers irrigated every 15 days, which means that irrigation frequencies and periods differ among farmers and are irregular in quantities that are not precisely organized, whether in quantities that is more or less than the trees' need for water. However ,a survey of the recent literature shows that deficit irrigation allows to maintain oil yield above 80% of that of fullyirrigated trees while water saving ranges from about 15 to 50% of the volume applied(Caruso et al., 2013; Gispert et al., 2013; Gómez-del-Campo, 2013; Iniesta et al., 2009).

Since olive cultivation is a perennial agriculture and irrigation water is mostly salty, farmers must install a drainage system to avoid the formation of resulting secondary salinity. The accumulation of salts from repeated watering with salty water, will lead in the future to a problem that will harm and perhaps destroy the trees of the olive groves or affect the yield and quality of the product, whether oil or table olives. Therefore, efficient evaluation of drainage system is essential for sustainable agricultural water management, crop production, soil salinization prevention, and salinized land reclamation(Blann et al., 2009; Khand et al., 2017; Singh, 2019), especially in arid regions with severe water scarcity and intense evapotranspiration.

All farmers mentioned a significant challenge during the harvesting season due to a shortage of labour, which is attributed to the overlap between the region's olive harvest season and the date palm harvesting season. Because date palm farming offers a considerably higher daily income compared to olive picking, many young individuals favour engaging in date palm cultivation. The daily wage for date palm harvesting is approximately twice that of olive picking, creating a substantial income gap that strongly incentivizes young people to choose date palm harvesting over olive picking. Consequently, working in date palm orchards is increasingly viewed as a practical option for enhancing income and saving time. These factors collectively contribute to the scarcity of available labour for olive harvesting, as the younger workforce is drawn to the financial benefits associated with date palm harvesting, making it a more attractive choice for them.

Olive harvesting is mainly manual methods using hands, long poles, or sticks. However, Hand harvesting accounts for up to 80% of table olive labor input and 60% of production expenditures (Cicek, 2011). Mechanical harvesting is the only solution(Homayouni et al., 2022). We also noticed a misconception among farmers, 87% of them believe that fully ripe olives with a black and wrinkled appearance have a higher oil content, which is completely untrue. Harvesting olives at this stage deteriorates the quality of the oil and reduces its nutritional value, and as the fruit becomes more ripe the oil content increases, although the quality of the oil deteriorates correspondingly (Salvador et al., 2001; Sönmez et al., 2018). Moreover, many farmers pick olives and leave them in boxes for two weeks or more, believing that this reduces the water content, a procedure that saves the costs of transportation and pressing. There is a scarcity of oil processing facilities and there are only four processing centers in the entire Biskra region (DSA 2021). It is far from olive groves, as 60% of the farmers surveyed mentioned this problem.

As for the benefit from the harvested olives, 61.1% is directed to the production of table olives, while 20.4% is used to produce olive oil. This is completely consistent with the statistics of the Biskra province (DSA) Agricultural Statistics Directorate. The main reason for the decline in olive oil production is due to the prevailing dietary habits in the region, where olive oil consumption is lower compared to the northern regions of the country.

Many residents of the region consume table olives in large quantities, to the point that every family prepares them at home. In addition, farmers are considering selling olives immediately after harvest, without the cost of turning them into oil, as a quick and cost-effective way to make a profit.

To evaluate tree productivity, we proposed 15 liters of oil per quintal and the same amount in kilograms of olives per tree, based on the age of the orchard obtained from statisticians at the Biskra Agricultural Chamber. Most farmers estimate their production at about 15 liters of oil per quintal and about 20 kilograms of olives per tree. This is normal because most orchards are still in the early stages of production due to their young age.

6. Conclusion

Our comprehensive field study in the Biskra region has provided valuable insights into the multifaceted aspects of olive farming in an arid climate. The findings underscore the pivotal role of education in shaping farmers' attitudes toward innovation and modern agricultural practices. The diversity among farmers, whether native to Biskra or investors from northern regions, presents an opportunity for a rich exchange of agricultural knowledge and practices.

Our recommendations emphasize the need for ongoing training programs, collaborative initiatives, and practical education to bridge skill gaps and foster sustainable agricultural practices. The prevalence of young orchards, the choice of planting systems, and the utilization of local olive varieties highlight the intricate balance between tradition and innovation in olive cultivation.

Moreover, the selection of appropriate olive varieties is paramount for the sustainable development of olive cultivation in the Biskra region. It is crucial to focus on choosing adaptable and productive varieties that can thrive in arid climates. Introducing new varieties from other regions, specifically tailored for arid conditions, could bring about innovation and resilience in the face of climate challenges. A concerted effort should be made to conduct indepth research on local olive varieties in the Biskra region, with special attention given to unique varieties such as 'Biskria.' This research should include genetic and morphological classification to ensure a thorough understanding of these local varieties. Recognizing the inherent advantages of native cultivars in dry regions, especially their ability to acclimate to drought conditions, will inform future decisions on propagation and cultivation practices. This approach aligns with the broader goal of promoting sustainable and climate-resilient olive farming in the desert climate of Biskra.

Agricultural practices such as pruning, fertilization, and irrigation emerged as key determinants of olive production, with a particular emphasis on water-efficient strategies in arid regions. Additionally, addressing misconceptions among farmers, enhancing processing

infrastructure, and promoting olive oil consumption are crucial steps toward fostering a thriving olive sector.

The challenges identified, including the scarcity of processing facilities, suboptimal harvesting practices, and regional dietary preferences impacting olive oil consumption, call for a holistic approach involving education, infrastructure development.

In arid regions also emphasizes the importance of multiplying outreach campaigns for producers. Actively supporting scientific research, with a particular focus on combating olive tree diseases, is recommended. Additionally, promoting the establishment of cooperatives and specialized units in quality control, packaging, processing, marketing, and export of olive products is advised.

In essence, our study not only contributes valuable insights to the specific context of Biskra but also serves as a broader reference for regions facing similar challenges in the cultivation of olives in arid environments. The integration of education, collaboration, and sustainable practices emerges as the cornerstone for the continued growth and success of the olive sector in arid climate.

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