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Title

"Morphological Characterization and Identification of *Olea europea L.* Olive Ecotypes in the Bordj Bou Arreridj Region, Algeria"

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بسم الله الرحمن الرحيم

الإهداء

ما أصعب أن أجمع أحبائي في سطور وما أكثرها صعوبة أن أذكر واحدا أهمل واحدا وأن أنسى التعب وقد تغفل ذاكرتي لكن لن أنسى فضلهما ما حييت.

إلى من كلل العرق جبينه ومن علمني ان النجاح لا يأتي الا بالصبر والإصرار الى النور الذي انار دربي والسراج الذي لا ينطفئ نوره بقلبي ابدا من بذل الغالي والنفيس واستمديت منه قوتي واعتزازي بذاتي والدي العزيز

الى من جعل الجنة تحت اقدامها وسهلت لي الشدائد بدعائها الى الانسانة العظيمة التي لطالما تمنت ان تقر عينها لرؤيتي في يوم كهذا الى من اعتكف ظهرها ضد مكينة الخياطة من أجلي ومن أجل هذه اللحظة الى من كان لها الفضل لتحقيق كل هذا امي الحبيبة

الى ضلع الثابت وامان ايامي الى من شددت عضدي بهم فكانوا لي ينابيع ارتوي منها الى خيرة ايامي وصفوتها الى قرة عيني الى اخواني (مصباح، السعيد)

الى أمهات الاخريات شقيقاتي حبيبات الروح الى وتيني ومهجتي هن الى من كن سندا وعونا لي في كل خطوة بشيء بسيط او كبير الى من جعلتهن الدنيا فرحتي في كل ضيقة الى من دعمنني الى هاته اللحظة (صباح، نسيمة، صبرينة)

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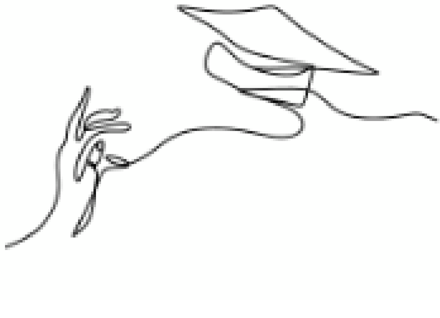

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List of abbreviations

°C: Degrees Celsius

CAOV: Catalog of Algerian Olive Varieties

DSA: Directorate of Agricultural Services

G: Grams

Ha: Hectares

Km: Kilometers

L: Liters

M: Meters

Mm: Millimeters

PCA: Principal Component Analysis

Qx: Quintal

SAU: Useful Agricultural Area

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GENERAL INTRODUCTION

Introduction

The olive tree **(*Olea europaea L.*)** is a small, slow-growing evergreen tree with a lifespan of over 1000 years. It has been cultivated for thousands of years across the entire Mediterranean region, likely derived from its wild form, the oleaster. This species is a characteristic tree of Mediterranean vegetation, well suited to dry and nutrient-poor soils, and exhibits remarkable resistance to salinity. While primarily distributed along the coastlines, olive cultivation can now be found in various Mediterranean climate zones worldwide. With over 70% of global olive oil production, this species plays a vital role in the agricultural economy of the Mediterranean region **(Maldonado *et al., 2016).***

Olive cultivation holds a significant place in the economy of Algeria. In fact, since the beginning of the millennium, there has been a growing awareness to improve the management of olive orchards and consider their expansion to lands where production intensification is possible. Algeria is ranked seventh globally in terms of olive oil production and fifth globally for table olive production, with an annual output of 220,000 tons **(Amarni, 2015).** In recent years, the olive industry has expanded into new areas in Algeria, particularly in the eastern regions, high plateaus, and southern parts of the country, with significant production. This can be attributed to the supportive policies implemented since 2000, which have sparked considerable interest in olive cultivation in previously overlooked areas. This increased interest is driven by the growing demand for olives and olive oil **(Maldonado *et al., 2016*).**

The first works on the classification and identification of olive varieties date back to the 19th century. However, it was **(Ruby, 1917)** who first used different parts of the olive tree (leaves, fruits, and stones) to characterize and classify the varieties of this species. Since then, various studies on varietal identification have been conducted in Spain, Italy, and Algeria, combining morphological, agronomic, and phenological characteristics. These studies have demonstrated the significant usefulness of the traits used in inventorying the varieties in different olive-growing regions of these countries. They have also helped resolve various cases of homonymy and synonymy **(Cantini *et al.*, 1999).**

Several studies have been undertaken on the morphological and morphological characterization of olive trees in the wilaya of Bordj Bou Arreridj. However, these previous works have encountered limitations, whether in terms of the geographical areas covered or the number of varieties studied.

According to bibliographic research, there are four major studies conducted in the wilaya of Bordj Bou Arreridj concerning olive trees. The first, carried out in the neighboring wilaya of Béjaïa, focused only on four varieties as part of a morphological study **(Rahmouni and Sidhoum, 2016).** The second study was limited to two regions of Bordj Bou Arreridj, "El-MHIR and El-ANASER", and to only two varieties, with a focus on morphological form and olive oil **(Ramadhan and Tareq, 2018).** The third study targeted a single region, Djaafra, with five different cultivars evaluated for their oil content (Mettai and Halilou, 2021). Finally, the last study sampled four olive cultivars from a single region, Toubou **(Kouchit and Meharga, 2022).**

Although contributing, these punctual studies have not fully explored the richness and diversity of the olive heritage in this wilaya. Therefore, in the context of this present work, we propose an extended prospective approach, aiming to collect and characterize the different olive ecotypes present in several reference farms. The objective is to establish a complete and representative catalog of this agro-morphological diversity, constituting a solid basis for future strategies of conservation and sustainable valorization of these local genetic resources.

The formulated research question : "To what extent does morphological characterization allow for distinguishing the olive varieties cultivated in the Bordj Bou Arreridj region of Algeria and identifying ecotypes specific to this area?", is of crucial importance for the valorization and conservation of local biodiversity. The Bordj Bou Arreridj region, with its particular climatic and edaphic conditions, may harbor unique olive varieties or adapted ecotypes. A detailed morphological study of the local olive trees, examining traits such as leaf shape, fruit size, would reveal significant differences between the varieties and identify local adaptations. Therefore, morphological characterization proves to be an indispensable tool for recognizing and promoting local agricultural richness and for gaining a thorough understanding of the intraspecific diversity of olives in this specific region of Algeria.

The objective of this study is to identify and understand certain olive varieties in the Bordj Bou Arreridj province, based on the main morphological characteristics of the different parts of the olive tree (leaves, fruits, and stones). Additionally, the study aims to examine the level of knowledge that farmers have about the olive industry. To address this topic in the Bordj Bou Arreridj province, our work is structured in six chapters as follows:

Introduction.

Chapter 1: Introduction to Olive Cultivation.

Chapter 2: Morphological Characteristics.

Chapter 3: Olive Grove Management.

Chapter 4: Presentation of the Study Region.

Chapter 5: Material and Methods.

Chapter 6: results and discussion.

Conclusion.

Chapter I

Introduction to Olive Cultivation

Chapter I: Introduction to Olive Cultivation

I-1 History

The olive tree is associated with a strong image, that of Mediterranean landscapes. This tree accompanies the founding myths of Mediterranean cultures, the Bible, the Quran, the great classical Greek texts; the tree of the gods, a symbol of strength, longevity, and peace **(Breton *et al*., 2006)**.According to the Bible, the seeds of the olive tree come from paradise, they were placed in Adam's mouth until his death. The virtues of this tree are mentioned in the Quran where it is said: "Allah is the Light of the heavens and the earth. The parable of His Light is as if there were a niche and within it a lamp, the lamp enclosed in glass, the glass as it were a brilliant star, lit from a blessed tree, an olive, neither of the east nor of the west, whose oil would almost glow forth (of itself), though no fire touched it. Light upon Light! Allah guides to His Light whom He wills." **(Surah An-Nur 35).**

The geographic origin of the olive tree is located in Southwest Asia, likely between present-day Armenia and the sources of the Indus River, where traces dating back to the Upper Paleolithic (-35,000 to -10,000 years BC) have been found. We owe a lot to the Semitic populations and the Egyptians who introduced it to the western Mediterranean Basin and continuously improved the fruits of its wild ancestor **(Schall, 2011).**

The olive tree is one of the most important fruits in the Mediterranean region. 90% of the world's olive trees are cultivated in this region, and it provides over 90% of global production. Olives and olive oil are staple foods of the Mediterranean diet and symbols of Mediterranean culture. The Phoenicians, Greeks, and Romans spread olives throughout the western Mediterranean region. Recent genetic studies support the hypothesis of the spread of the olive tree by humans from east to west across the Mediterranean basin. The diffusion of olive cultivation throughout the Mediterranean basin is due to human migration and trade exchanges. The genetic material of cultivated olives exhibits a high degree of diversity, with around 1,250 known species **(Mercati and Sunseri., 2020).**

Olive cultivation expanded outside the Mediterranean basin after the discovery of America. In the 16th century, as a consequence of the great maritime expeditions that set out from Spain and Portugal towards the New World, the olive tree was introduced to Central America, Peru, Chile, Argentina, and then in the 18th century to California. Finally, more recently, the olive tree has continued its expansion beyond the Mediterranean, establishing itself in South Africa, Australia, China, and Japan **(Viola., 1998).**

Olive cultivation in Algeria dates back to ancient times, and it has maintained great socio-economic importance until today, mainly present along the Mediterranean coast. In this area, the mountainous region of Kabylia, geographically divided into two districts by the Soummam River, Greater Kabylia in the west, and Lesser Kabylia in the east, can be considered an important reserve of local olive germplasm. The olive sector is considered strategic for the Algerian economy, and for this reason, the Algerian Ministry of Agriculture and Rural Development has recently defined a strategy for the expansion of olive cultivation in different regions **(Mercati and Sunseri., 2020).**

I-2 Botanical Classification:

The species *Olea europaea L*.Was named by Linnaeus because of its geographical area. It is the only species from the Mediterranean basin that represents the genus Olea **(Manallah, 2012).** The species *Olea europaea L*. is subdivided based on the shape of the leaves and fruits into two subspecies **(Breton *et al.*, 2006):**

- **Olea europaea sylvestris or Oleaster**, this is a wild form of olive, present spontaneously with very small fruits.

- **Olea europaea sativa**, this is the cultivated olive. It is a tree that can live for thousands of years and reaches 12 m in height. It is characterized by larger fruits than the wild olive.

According to **(Kohler, 1887)** the olive tree belongs to:

Kingdom: Plantae

Subkingdom: Tracheobionta

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Asteridae

Order: Scrophulariales

Family: Oleaceae

Genus: Olea

Species: *Oleae europaea L*.

Figure 1: Morphological diagram of different

Organs of the olive tree **(Kohler, 1887).**

I.3. Olive Cultivation

I.3.1 Olive cultivation in the world

Olive growing is one of the oldest sectors of human production and covers 10.5million hectares in the world, including 97% in the Mediterranean basin and 50% in Spain, Tunisia and Italy. World production reached 3,197,000 tons of olive oil in 2021The main importers of olive oil are the USA (36%), European Union (14%), Brazil (8%), Japan (7%) and Canada (5%), which together represent 70% imports. Olive oil production continues to show the same pattern heterogeneity in producing countries and increases in annual production between 2.5% and 5% in Spain, Italy and Portugal **(Belarmino *et al.*, 2022).**

I.3.1.1 Major Olive Varieties Cultivated Worldwide

The dominant varieties in the world are those found in Tunisia like olive oil (Chemlali and Chetoui), table olive (Marsaline). Other varieties are found in Spain such as the oil olive (Hajiblanca and Verdal) and the table olive (Manzanille and Gordal-sevillana). In Italy, we note the oil olive (Moraiolo and Leccino) and the olive of table (AscolonaTenera and Santa Caterina) **(Loussert and Brousse., 1978).**

I.3.2 Olive cultivation in the Mediterranean

The Mediterranean region is widely known for its olive oil production and is home to the largest number of olive oil producers. The Olive Tree Foundation recognizes that the Mediterranean climate, characterized by consistent temperatures, limited pollution, and suitable terrain, is highly conducive to olive oil production. However, the impact of climate change varies across different regions. While some areas may experience adverse effects on olive oil production due to extreme temperatures and other factors, it is important to consider the specific requirements and characteristics of olive oil production in Western Mediterranean countries. Additionally, it is crucial to acknowledge the interconnectedness between countries in the Eastern Mediterranean region, which contributes to the overall increase in olive oil production **(Orioles, 2022).**

Figure 2: Mediterranean Olive **(www.pinterest.es).**

I.3.3 Olive Cultivation in Algeria

Algeria is one of the Mediterranean countries that produces olive oil, and olive growing dates back several centuries. Olive growing is an important activity for families.It is a subsistence culture that is concentrated in mountainous areas in the central and eastern parts of the country. It is an important element in national agricultural development, accounting for 4 % of the agricultural land area and 40% of the total orchard area **(Saad *et al*.,2023).** The olive sector in Algeria can play a key role as a driver of development and rural empowerment, diversifying the country's economy through non-hydrocarbon exports. Olive growing is considered one of the strategic sectors and receives special attention from the government through various development programs and supportive measures. This has revitalized the olive industry by expanding olive cultivation to other areas, which have subsequently become significant olive growing hubs, Olive cultivation in Algeria has shown a remarkable rate of expansion, driven mainly by economic, social, and cultural reasons. In 1999, olive cultivation was concentrated in only 11 provinces. However, substantial progress has been made through the strategic implementation of Algerian agricultural

development policies. This development is reflected in the significant expansion of olive tree cultivation in most provinces **(Fig. 3)**. In Algeria, the olive tree occupies a huge expanse of 431,508 hectares **(Saad *et al.*,2023).**

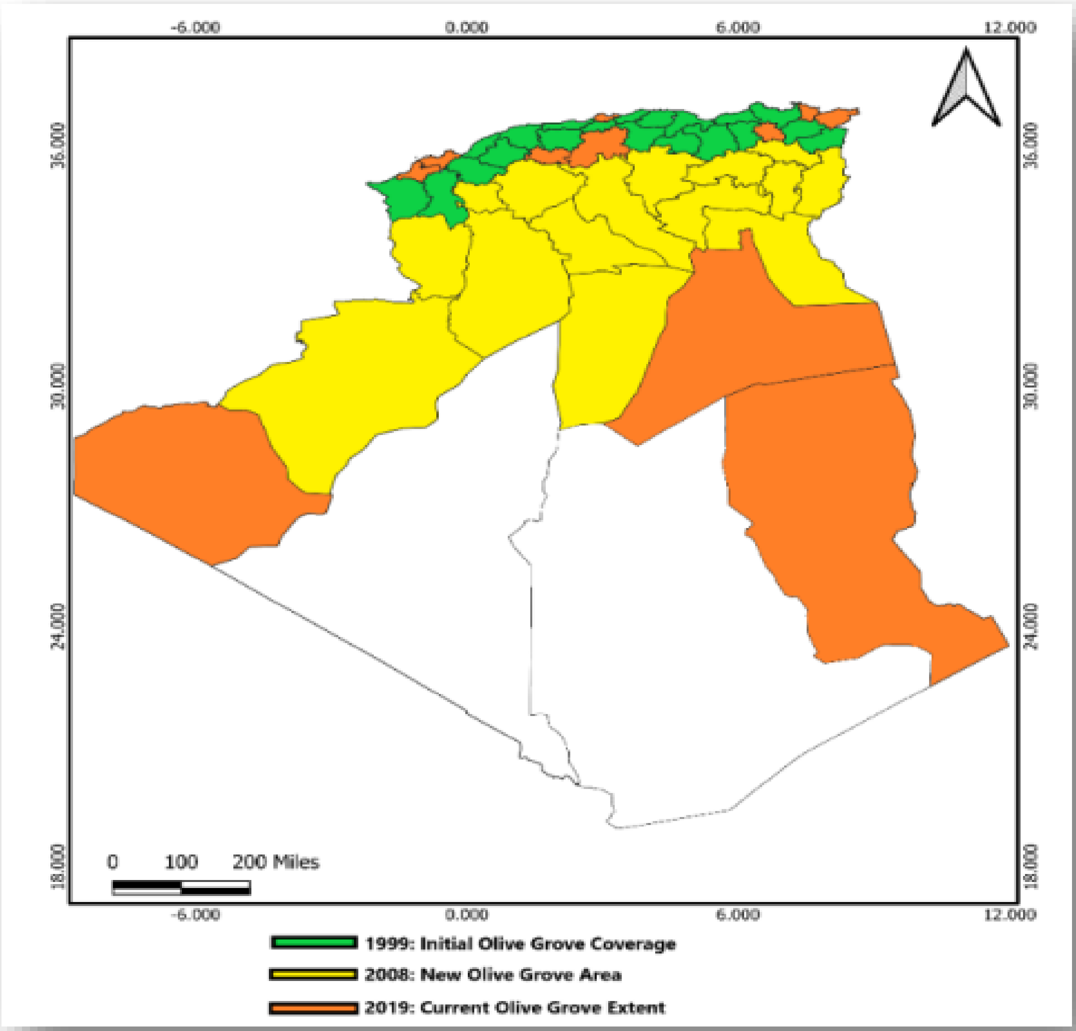


Figure 3: Expansion of Olive Cultivation in Algeria from 1999 to 2019**(Saad *et al.*,2023).**

I.3.3.1Varieties of Olive Cultivated in Algeria

In Algeria, a group of olive varieties has been identified and preserved in the experimental farm affiliated with ITAF (Technical Institute of Fruit Tree Cultivation). It consists of 174 varieties, including 36 local varieties and 138 introduced foreign varieties. **(CAOV, 2023).**

The oil olive varieties from Kabylia are Chemlal, Limli and Bouchouk **(Iguergaziz., 2012).**

I.3.4 Olive cultivation in the province of Bordj Bou Arreridj

The Bordj Bou Arreridj province ranks sixth in terms of oil production in Algeria. In 2020, olive cultivation in Bordj Bou Arreridj covered an area of 26,330.5 hectares, resulting in a production of 197,956 quintals (19,795.6 metric tons) with a yield of 15.6 liters per quintal. From 2012 to 2020, the total olive production amounted to 11,946 quintals (1,194.6 metric tons) of table olives and 186,010 quintals (18,601 metric tons) of oil olives, according to (**DSA 2021).**

The cultivated area during the period of 2012-2020 increased from 21,544 hectares to 26,385.5 hectares, reaching its peak in 2018 with 22,647.8 hectares. The olive groves are mainly located in the following communes: Djafra (9.85%), Ouled Sidi Brahim (9.09%), El Euche (8.37%), and El Main (8.16%) **(DSA, 2023).**

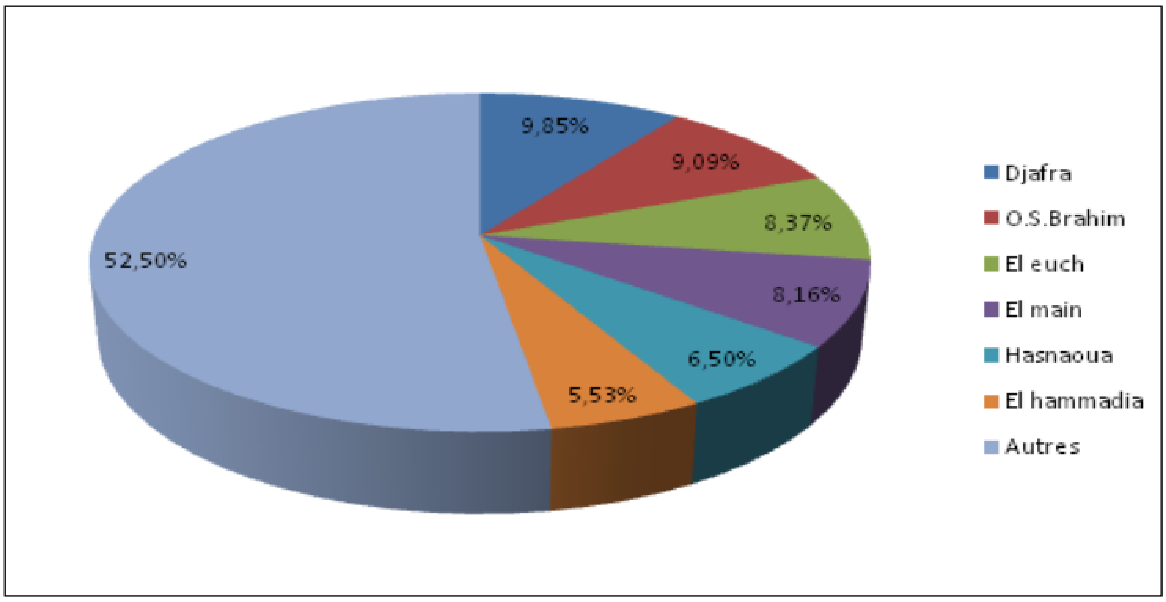


Figure 4: The distribution of the area occupied by olive cultivation in the Bordj Bou Arreridj province **(DSA, 2023).**

I.3.4.1 Olive Varieties in the Wilaya of Bordj Bou Arreridj

- Chemlal: 75%.

- Azeradj: 22.5%.
- Sigoise: 3% **(DAS, 2023)**

Chapter II

Morphological Characteristics

Chapter II: Morphological Characteristics

II.1.1. General Description

The olive tree is characterized by a short, gray-colored trunk. It is a slow-growing tree that can reach 15 to 20 meters in height in relatively warm regions with high rainfall or abundant summer irrigation. Meanwhile, in colder climates, the trees are generally smaller. In its natural state, it maintains a compact and thorny ball shape, and it is pruned between 3 and 5 m to improve productivity. It is evergreen, but its dimensions and shapes can vary greatly **(Loussert and Brousse, 1978).**

The olive tree adapts well to extreme environmental conditions such as drought and heat. Although it requires light and aerated soil for proper development, the olive tree tolerates a wide range of different soil types and is resistant to low temperatures. Its adaptation potential is due to the special anatomy of its leaves, root system, and high morphological regeneration capacity **(Maas and Hoffman, 1977).**

II.1.2. Root System

The development of the tree's root system depends on the physicochemical characteristics of the soil, its depth, texture, and structure **(Kasraoui, 2010)**. In loamy soils, the depth development can range between 15 to 150 cm, with a significant concentration around 80 cm. It should be noted that in sandy soils, roots can develop up to 6m deep. The root system is taproot if it originates from seedlings and in light soils, while it is fibrous if obtained from cuttings and in heavy soils **(Civantos, 1998)**.

II.1.3. Aerial System

The aerial part of an olive plant includes the trunk, the main branches, the foliage, and the fruiting branches **(Loussert and Brousse, 1978).**

II.1.3.1. Trunk

The trunk of an olive tree is initially smooth and greenish-gray until around the tenth year. With aging, it becomes deformed, becoming knotty, cracked, split, widened at the base, and taking on a dark gray, almost black color **(Pagnol, 1975).** Depending on the cultivation area and the pruning method adopted, some olive trees reach 8 to 10 m in height, while others hardly exceed 3 to 5 m **(Ruby, 1917).**

II.1.3.2. Bark

The bark is very thin, perceiving the slightest mechanical shock, and under impact it tears easily. The epidermis becomes thick, rough, cracked, and detaches **(Belhoucine, 2003).**

II.1.3.3. Branches

These are large ramifications intended to form the framework of the tree, they are divided into two groups:

- **The master carpenters or mother branches**

Robust, fully lignified ramifications, numbering 3 to 5 in the subject, are subject to pruning.

- **The secondary branches**

They develop on the primary branches; they form the second level of vegetation, and bear foliage-bearing branches and fruiting branches **(Loussert and Brousse, 1978).**

II.1.3.4. Stems

This is the ramification of the main stem of the tree; it is the result of the development of buds from the beginning of spring to the end of autumn. It bears a terminal bud at its tip and at the level of each node, two opposite leaves with an axillary bud in the axil of each **(Daoudi, 1994).**

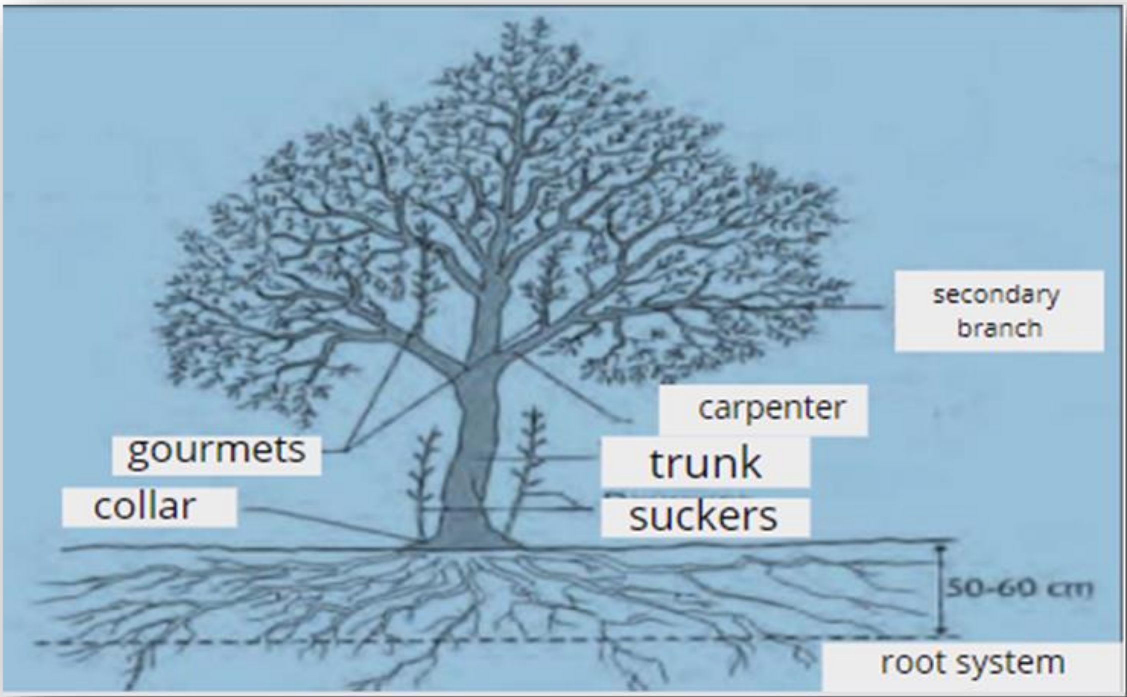


Figure 5: the main parts of an olive tree **(argensson *et al*., 1999).**

II.1.3.5. Leaves

The olive tree is evergreen, and its leaves generally live for two to four seasons, although older leaves can remain on the tree for longer. The small leaves are simple, with an elongated blade (3 to 9 cm long) and a very short petiole (about 0.5 cm). The shape of the blade varies from a slightly wider and more symmetrical elliptical shape to lanceolate, where the width is greatest at the base and the length of the blade is more than six times its width. A thick and very visible central vein divides the leaf in two along its length and extends along the underside **(Rugini *et al*., 2016).**

Figure 6: olive leaves **(original, 2024).**

II.1.3.6. Flowers

The olive flower is composed of four whorls (spirals) - calyx, corolla, androecium, and gynoecium (4 sepals, 4 petals, 2 stamens and 2 carpels). The sepals are light green, short and rounded. The corolla is gamopetalous (tubular) with four yellowish-white lobes. The androecium consists of two opposite stamens inserted on the corolla, and each stamen is composed of a filament surmounted by a large, hemispherical, introrse and longitudinally dehiscent anther. The anthers contain bicellular pollen grains, and the outer walls of the pollen grains have characteristic structures. The gynoecium is a superior ovary with two locules, formed of two carpels. Each locule contains two anatropous ovules. The style is short and robust, and ends in a well-developed, bifid, papillose, and plumose stigma. The calyx, corolla, stigma, and pollen exhibit characteristics that vary according to the cultivar **(Fabbri *et al*., 2004).**

Figure 7: Olive Flowers **(original, 2024).**

II.1.3.7. Fruit

The olive is a tree with a spherical or elliptical shape and is composed of the exocarp (skin), which contains the stomata, the mesocarp (flesh), which is the edible part of the fruit, and the stone (pit), including the seeds. The olive fruit turns a dark violet color at full maturity, but some varieties are green at maturity and some olives turn a coppery brown. The size of living fruits is variable, even on the same tree, and depends on the cultivar with long fruits, soil fertility, available water, and cultural practices **(Rugini *et al*., 2016).**

Figure 8: The Fruits of the Olive Tree **(original, 2024).**

The Epicarp

It is the skin of the olive firmly attached to the pulp. It is covered with a waxy, waterproof material (the bloom) **(Bensouna, 2014).**

During maturation, the epicarp changes color from tender green (green olive), to purple or red (turning olive) and then to blackish coloration (black olive) **(Aubanel, 1999).**

Mesocarp

It is the fruit pulp, composed of cells in which the fat droplets that will form the olive oil are stored during lipogenesis, which lasts from the end of August until veraison **(Lavée, 1997).**

Stone

Composed of a fusiform, very hard stone. Its shape and size vary depending on the variety. Thus, the morphology of the stone allows the characterization and identification of olive cultivars **(Stéphanie, 2003).** It clarifies in the summer from the end of July and contains an almond with two ovaries, one of which is generally sterile and non-functional: this seed (rarely two) produces an embryo, which will give rise to a new olive tree if the conditions are favorable **(Bensouna, 2014).**

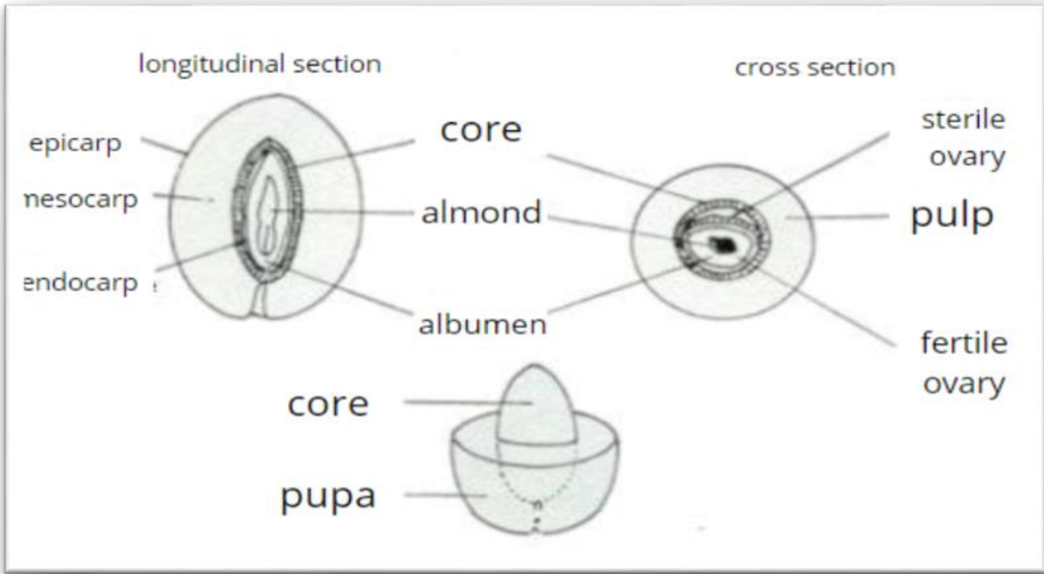


Figure 9: Cross-section of an olive **(Loussert and Brousse., 1978).**

II.2. Physiological Characteristics

II.2.1. Annual Vegetative Cycle

The biological cycle of the olive tree is characterized by the overlapping of two different physiological functions:

- The flowering and fruiting of the current year, which manifests itself on the one-year-old branches.
- The vegetative growth of the new branches that emerge on the one-year-old branches or on others of different ages. **(Bouloucha, 1995).**

The annual cycle of the vegetative development of the olive tree is closely related to the climatic conditions of its area of adaptation, characterized by the Mediterranean climate. A stage is reached when more than 50% of the vegetative organs respond to its definition **(Colbrant and Fabre., 1976).**

Stage A: winter stage; the terminal bud and the axillary buds are in vegetative rest.

Stage B: vegetative awakening; the terminal bud and the axillary buds begin to elongate.

Stage C: formation of the flower clusters; as it elongates, the cluster reveals different stages of buds.

Stage D: swelling of the flower buds; the buds, as they elongate, grow larger. They are borne on a short pedicel. The bracts located at their base are moving away from the flower stem.

Stage E: differentiation of the corollas; the separation of the calyx and the corolla is visible. The pedicels elongate, separating the flower buds from the axis of the cluster.

Stage F: beginning of flowering, the first flowers open after their corollas have turned from green to white.

Stage F1: full bloom; the majority of the flowers are open.

Stage G: fall of the petals; the petals turn brown and separate from the calyx. They can remain for a certain time within the flower cluster.

Stage H: fruit set; the young fruits appear but do not exceed much the cup formed by the calyx.

Stage I: fruit growth (1st stage); the remaining fruits grow to reach the size of a wheat grain.

Stage I1: fruit growth (2nd stage); the most developed fruits reach 8 to 10 mm in length and the beginning of lignification of the stones.

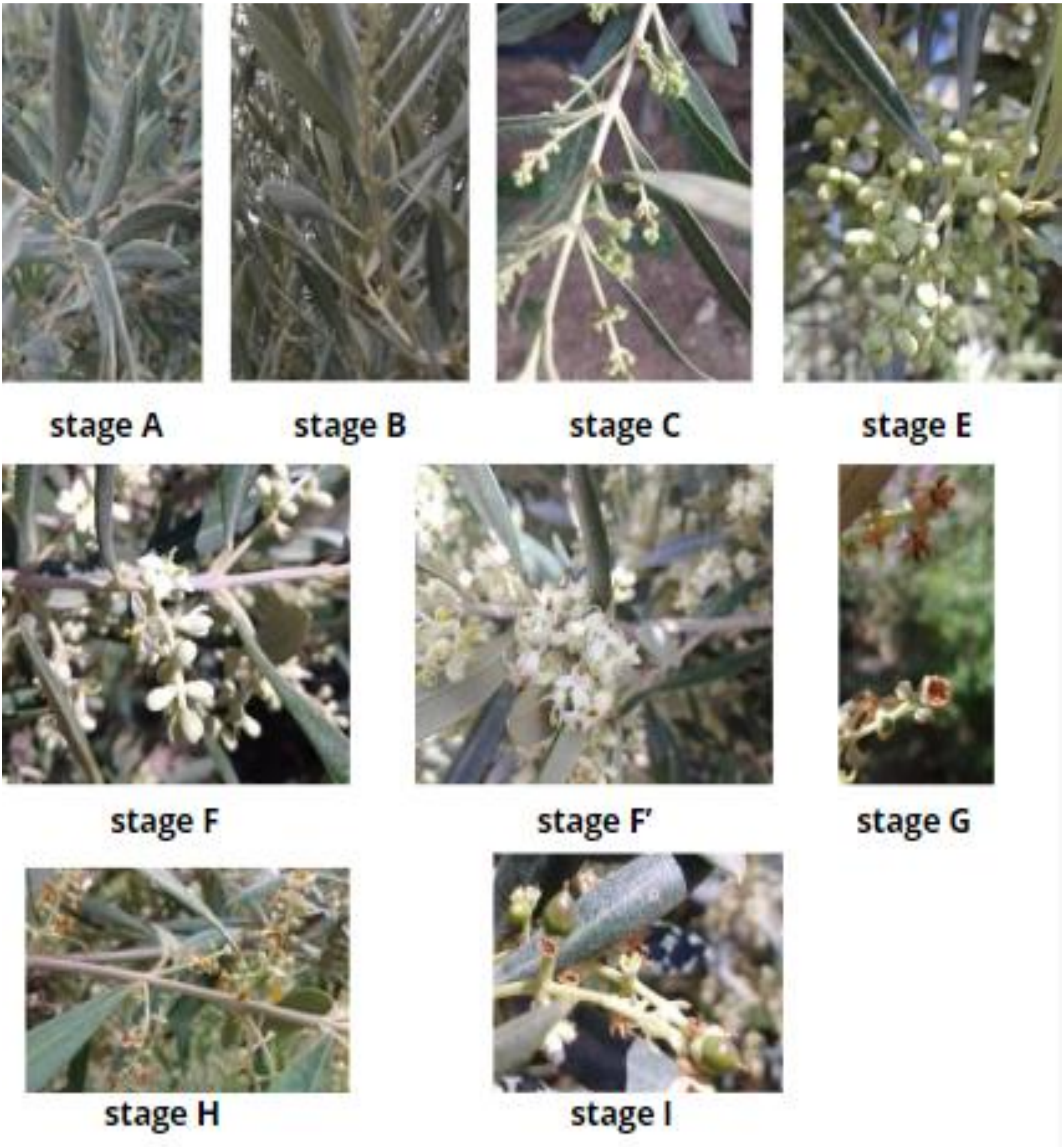


Figure 10 Phenological stages of the olive tree **(original, 2024).**

II.3. Reference Norms for Biometric Analysis of Olive Varieties

II.3.1. Leaf Characters

The leaf is evaluated based on four characteristics, with the first three being quantitative. These include length, width, and the shape determined by the ratio of length (L) to width (l). The fourth characteristic is qualitative and relates to the longitudinal curvature of the blade. By examining the longitudinal axis of the leaf, we can classify the blade into four categories: Epinastic, flat, hyponastic, helical. Table **01** and (**Figs. 10 and 11**). **(World Catalogue of Olive Varieties, 2000).**

Table 1: the different morphological characteristics of the leaf.

The characteristics of the leaf.

Quantitative characteristics	Length (L)	Reduced	<5cm
		Average	5-7cm
		High	>7cm
	Width (l)	Reduced	<1cm
		Average	1-1.5cm
		High	>1.5cm
	Shape	Elliptical	L/l <4
		Lanceolate	L/l 4-6
		Lanceolate	L/l>6
Qualitative characteristics	Longitudinal curvature of the blade	Epinastic	
		Flat	
		Hyponastic	
		Helical	

(Source: World Catalogue of Olive Varieties, 2000).

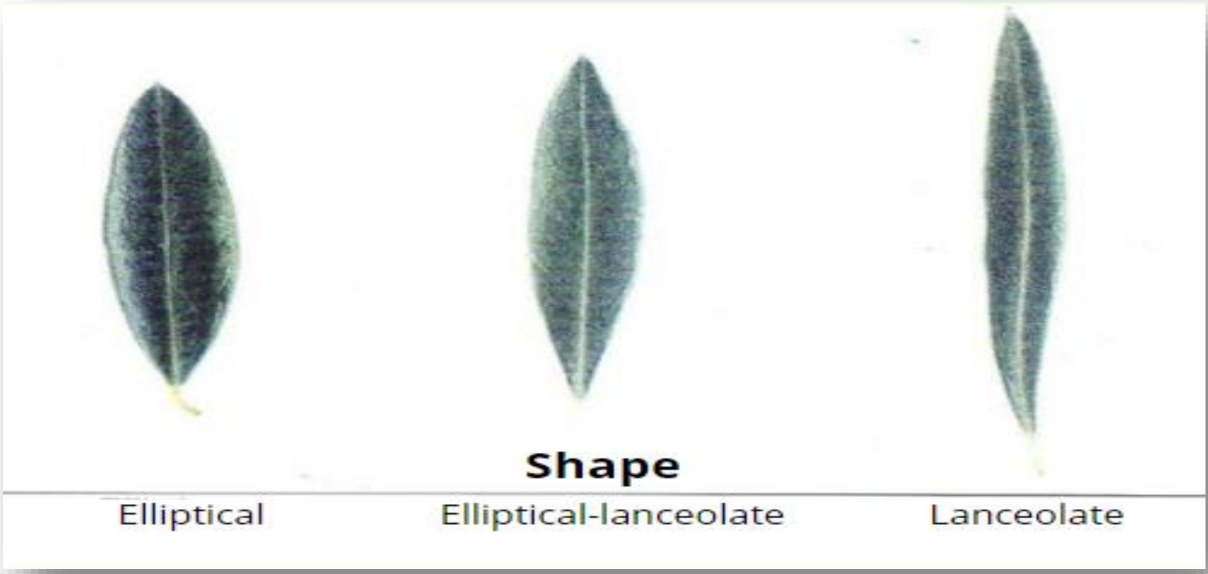


Figure 11: The different shapes of the leaf **(World Catalogue of Olive Varieties, 2000).**

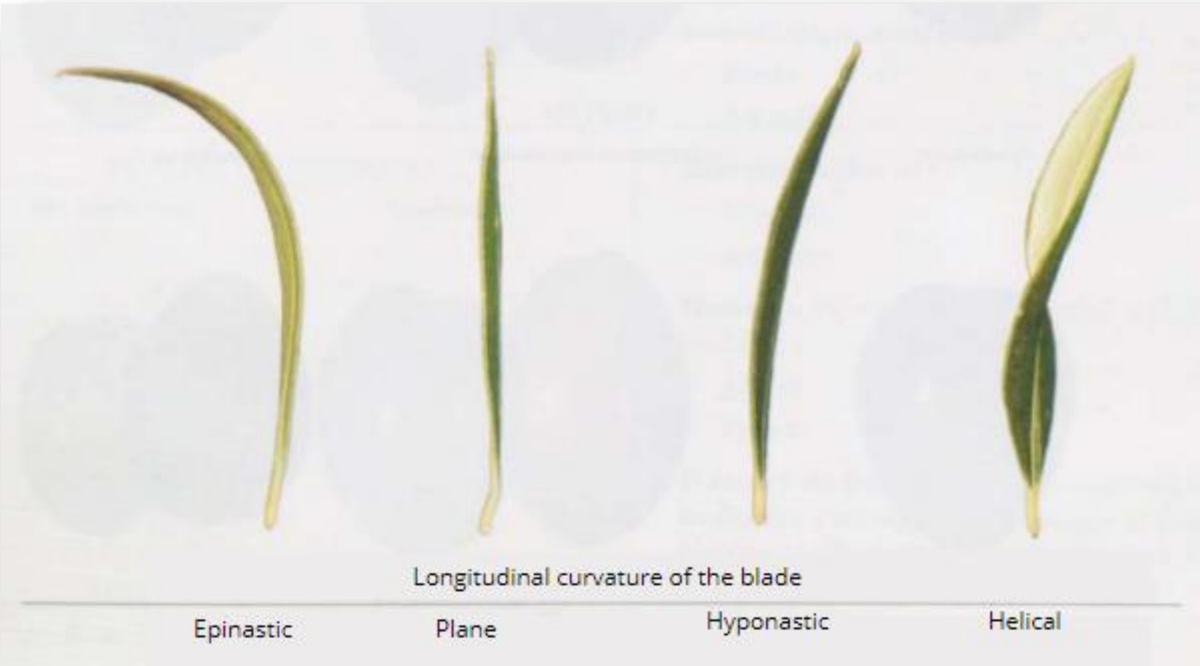


Figure 12: The different forms of the longitudinal curvature of the blade

(World Catalogue of Olive Varieties, 2000).

II.3.2. Fruit Characters

The description of the fruit is carried out at the end of veraison, for certain characteristics, two positions are mentioned: position "A" is the one where the fruit generally presents its maximum asymmetry by taking it by its two ends between the index finger and the thumb. Position "B" is the one resulting from the rotation of the fruit by 90°, in order to turn the most developed part towards the observer. The fruits generally include nine characteristics summarized in Table **02** and **(Fig 12)**. **(World Catalogue of Olive Varieties, 2000).**

Table 2: the different characteristics of the fruits.

The characteristics of the fruit		
The shape (A)	Spherical	L/l < 1.25
	Ovoid	L/l 1.25-1.45
	Elongated	L/l > 1.45
Symmetry (A)	Symmetric	-
	Slightly asymmetric	
	Asymmetric	
Position of the maximum transverse diameter (P.D.T.M) (B)	Towards the base	-
	Central	
	Towards the apex	
Apex (A)	Pointed	-
	Rounded	
Base (A)	Truncated	-
	Rounded	
Mammilla	Absent	-
	Present	
Présence de lenticelles (P.L)	Few	-
	Numerous	
Dimension of lenticels (D.L)	Small	-
	Large	
Weight	Reduced	<2g
	Medium	2-4g
	High	4-6g
	Very high	> 6g

(Source: World Catalogue of Olive Varieties, 2000).

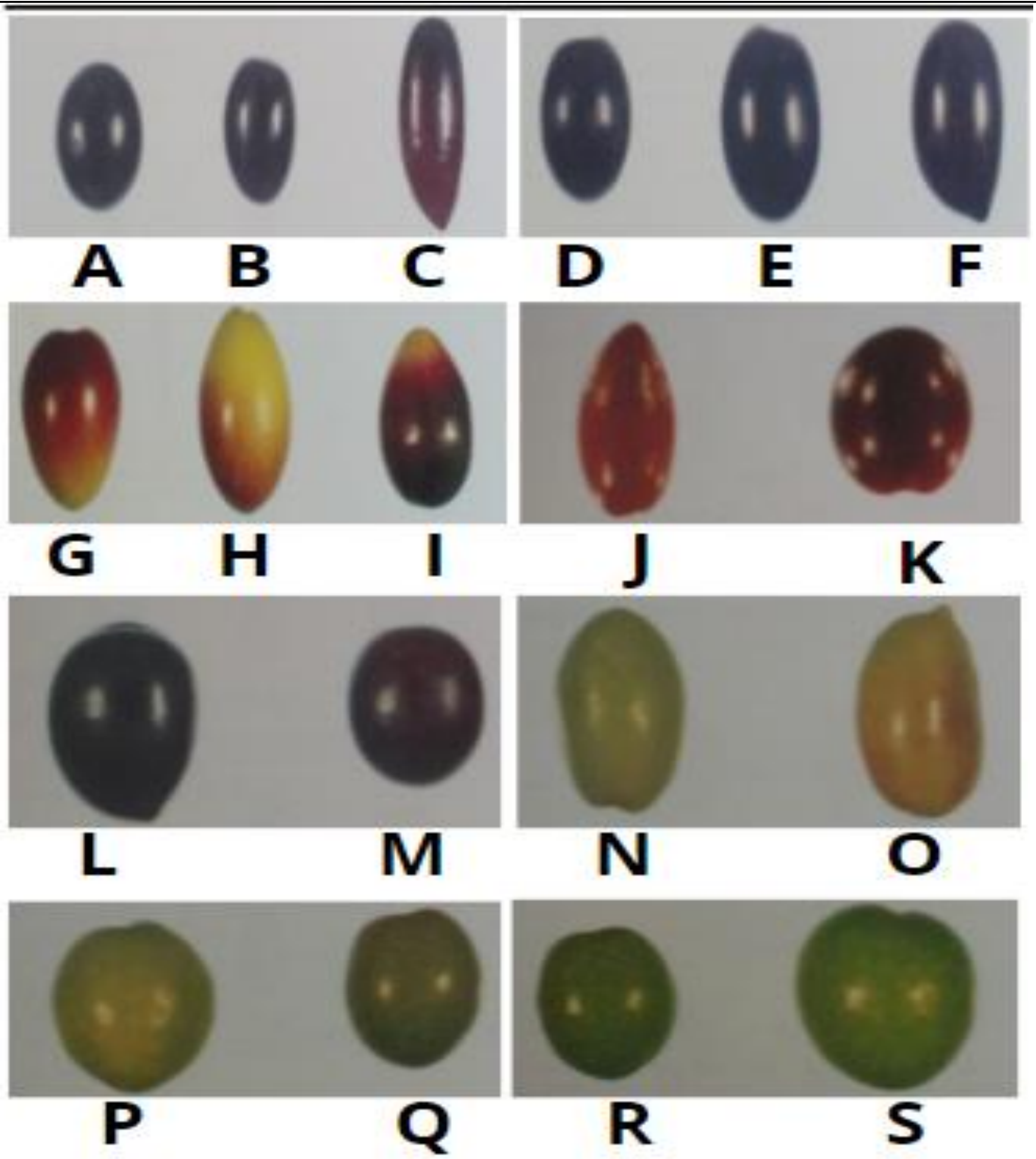


Figure 13: the different forms of the olive fruit **(World Catalogue of Olive Varieties, 2000).**

A: Spherical. **B:** Ovoid. **C:** Elongated. **D:** Symmetric. **E:** Slightly asymmetric. **F:** Asymmetric. **G:** Towards the base. **H:** Central. **I:** Towards the apex. **J:** Pointed. **K:** Rounded. **L:** Truncated. **M:** Rounded. **N:** Absent. **O:** Present. **P:** Few. **Q:** Few. **R:** Numerous. **S:** Small.

II.3.3. Stone Characters

The characteristics of the stone exhibit a very high discriminative power for the identification of the varieties presented in **Table 03** and(Figure **13**).

Table 3 :the different characteristics of the stone.

Characteristics of the stone

Weight	Reduced	< 0.3g
	Medium	0.3-0.45g
	High	> 0.45g
Shape	Spherical	L/W < 1.4
	Ovoid	L/W 1.4 < 1.8
	Elliptical	L/W 1.8-2.2
	Elongated	L/W > 2.2
Symmetry	Symmetric	-
	Slightly asymmetric	
	Asymmetric	
Position of maximum transverse diameter	Towards the base	-
	Central	
	Towards the apex	
Summit	Pointed	-
	Rounded	
Base	Truncated	-
	Pointed	
	Rounded	
Surface	Smooth	-
	Rough	
	Scabrous	
Number of fibrovascular grooves	Reduced	< 7
	Medium	7-10
	High	> 10
Apex (E.S)	Without mucro	-
	With mucro	

(Source: World Catalogue of Olive Varieties, 2000).

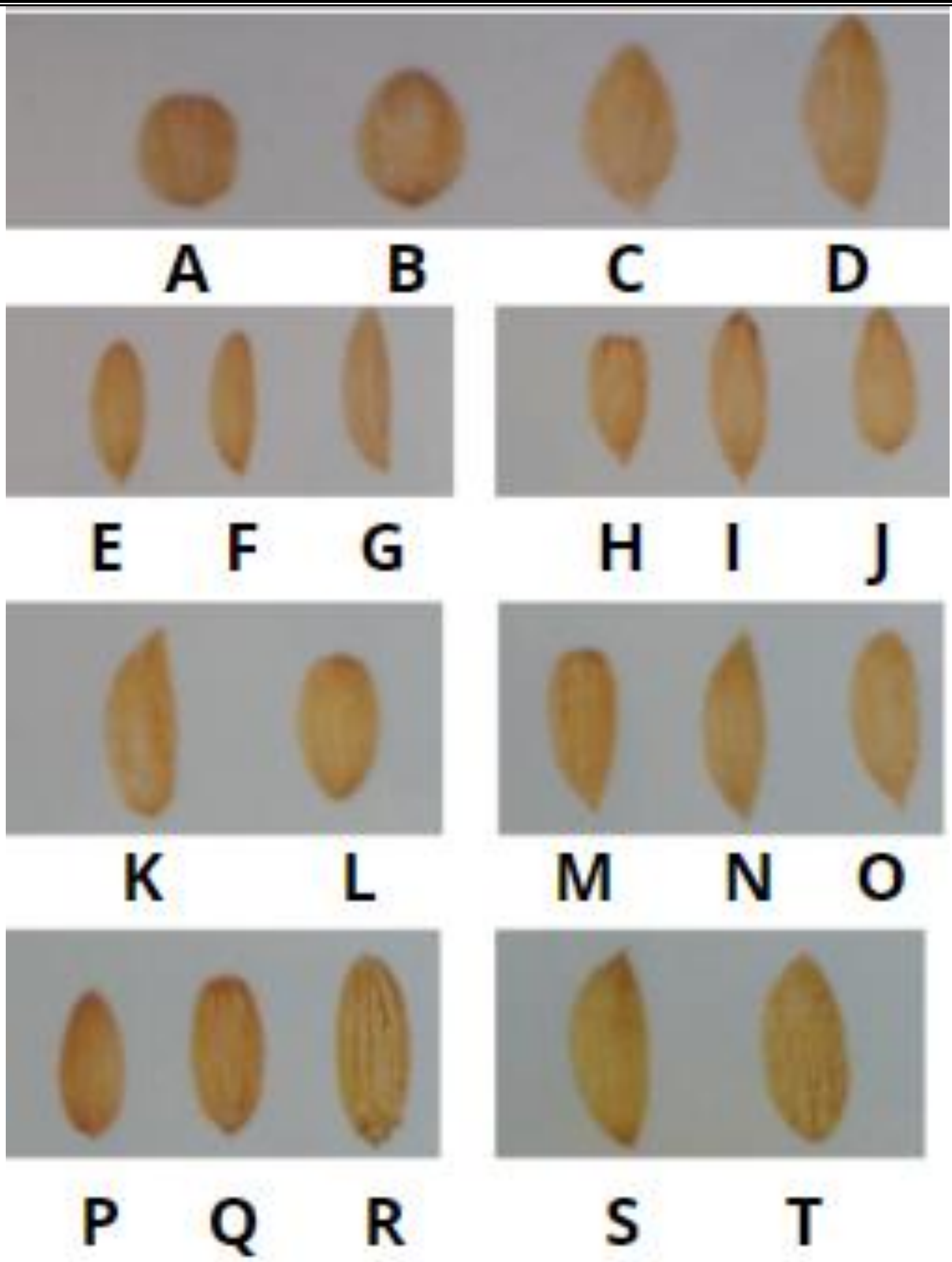


Figure 14: The different forms of the olive stone **(Source: World Catalogue of Olive Varieties, 2000)**.

A: Spherical. **B:** Ovoid. **C:** Elliptical. **D:** Elongated. **E:** Symmetric. **F:** Slightly asymmetric. **G:** Asymmetric. **H:** Towards the base. **I:** Central. **J:** Towards the apex. **K:** Pointed. **L:** Rounded. **M:** Truncated. **N:** Pointed. **O:** Rounded. **P:** Smooth. **Q:** Rough. **R:** Scabrous. **S:** Without mucro. **T:** With mucro.

Chapter III

Olive Grove Management

Chapter III :Olive Grove Management

III.1. Olive Tree Requirements

III.1.1 Climatic Requirements

The olive tree, like any living being, needs certain climatic conditions to thrive. These are described below:

- **Temperature**

The olive-growing areas have an average annual temperature of 15-20°C, with a minimum of 4°C and a maximum of 40°C. The minimum temperature should not drop below -7°C, otherwise tree damage will occur. However, this limit is only an estimate, as the tolerance of olive trees depends on various factors such as the duration of very low temperatures, atmospheric humidity, cultivar, etc. The damage also varies from one tree to another. If the temperature drop is gradual, the olive tree can withstand temperatures up to -12°C **(Therios, 2009).**

- **Wind**

The olive tree is a very resistant tree, but strong winds deform it a lot, which strongly affects its production: the effect of the Mistral wind is a good example. Its resistance is reflected in a root system that is both extensive on the surface and deep (when the soil and rainfall of the region allow it), leaves with solidly implanted petioles, and a generally rather "round" bearing...The sensitivity of its production is explained in particular by problems at the time of flowering: it is a wind-pollinated species, whose flowers can suffer from too strong winds "under and leeward". Most of the fruits are formed on the side **(Baldy, 1990).**

- **Humidity**

Additional irrigation during the summer increases fruit yields by 30 to 50%. A long, sunny, and hot summer gives a fruit with a high oil content. Olives do well with humidity ranging between 40% and 65%. Being an evergreen tree, the olive tree is sensitive to severe freezing temperatures. High humidity, above 80%, during flowering causes flowers to drop and infestation by sooty mold-producing insects. The olive tree is a long-day plant and benefits from prolonged sunshine (2,400 to 2,700 hours of sunshine per year) and a warm environment **(Mletzko, 2018).**

Rainfall

The leaves are the basic unit of photosynthesis in the olive tree. Living leaves exposed to the sun can only utilize the light that becomes partially saturated, i.e., use 30% of the sun's rays, as the leaves on the outer edge of the canopy are exposed to full sun, which is only for part of the day. Consequently, the photosynthesis of most leaves is not saturated with light for most of the day. Light within the canopy becomes more restricted. Given that the products of photosynthesis are used in the development of the fruit, managing light to maximize photosynthesis is an important element in increasing yield **(Sibbett and Ferguson, 2005).**

III.1.2 Soil Requirements

Soil

While olive trees adapt to a variety of soils, production is better where the trees can grow their roots without chemical or physical restrictions. The physical and chemical state of the soil is crucial for olive production.

The physical state of the soil describes its texture, depth, and stratification. The olive prefers unstratified soils and moderate loam, including sandy loam, loam, silt loam, and silty clay loam. These soils provide aeration for root growth, are fairly permeable, and have sufficient water-holding capacity: sandy soils lack good nutrients or water-holding capacity, and heavy clays often do not have sufficient aeration for root growth.

These soils pose challenges in terms of effective management for achieving maximum production. Olive trees have shallow root systems and do not require heavy soil in order to thrive. Soil chemistry is also a factor to consider. Olives can accumulate chemical deposits of varying quality. While olive trees can grow in or tolerate moderately acidic soils with a pH range of 5.0-7.0, alkaline soils with a pH of 8.5 are the most productive. Olive trees have a relatively high tolerance for elevated levels of boron (2 ppm) and chloride (10-15 μmol/L) in the soil **(Sibbett and Ferguson, 2005).**

III.2 Irrigation of the Olive Tree

The irrigation method applied for olive cultivation under saline conditions can have a significant influence on the accumulation and distribution of salt in the soil profile **(Paranychianaki and Chatzoulakis, 2005).** Flood irrigation is impossible in desert conditions due to the lack of water resources, and is totally unsuitable for olives. Sprinkler irrigation with saline water can cause damage due to high rates of foliar salt absorption, and the risk of injury will be much higher if such irrigation is practiced during the day when the evapotranspiration rate is high. Drip or trickle irrigation is the most and only recommended option for olive cultivation in desert conditions under saline conditions. A drip irrigation system maintains soil moisture at a consistently high level in the root zone and maintains a low level of salt concentration. Common problems associated with drip irrigation include salt accumulation on the wetting surface and clogging of emitters, however, in most cases, the use of subsurface drip irrigation and leaching can overcome these problems **(Wiesman, 2009).**

A water content below around 48% leads to better extraction, stronger tasting oils and oils with better keeping qualities. Non-deficit water conditions are very important for all olives, from flowering to pit hardening, to ensure adequate size and growth for the following year's harvest. Table olives also require non-deficient conditions from mid-August until harvest to avoid fruit sizing issues **(Vossen, 2007).**

III.3 Fertilization

Before applying a fertilization method in our olive grove, we must check the physical properties of the soil (texture, permeability, etc.) as well as the levels of available nutrients. These figures influence various other variables which in turn influence the harvest. Therefore, it is useful to know them in order to manage a lack or excess of nutrients and avoid tree stress. Two very interesting parameters are the soil pH and its calcium content because they both influence the absorption of nutrients provided by the fertilizer. The optimal pH for the olive tree is around 6.5 but the average olive tree can produce fruit on soils with a pH between 5.5 and 8. A common corrective action to restore the soil pH before planting young olive trees is to add lime to the soil **(Wikifarmer market, 2023). (Table 04).**

Table 4: olive tree fertilization program **(gazeau, 2012).**

Annual nutrient requirements in kg/ha	***Nitrogen N***	***Phosphorus P_2O_5***	***Potassium K_2O***	***Magnesium MgO***
Fairly productive orchards (2 to 3 tons of olives / ha)	30 to 50	15 to 25	50 to 60	15
Fairly productive orchards (3 to 5 tons of olives / ha)	50 to 70	20 to 30	60 to 80	20
Fairly productive orchards (5 to 6 tons of olives / ha)	70 to 90	30 to 40	80 to 100	25

III.4 Pests and Diseases of the Olive Tree

III.4.1 Diseases

- **Olive knot**

Olive knot (in Italian, Rogna, Tubercolosi) is a bacterial disease caused by Pseudomonas *savastanoi pv. savastanoi*. Its field diagnosis is simple because the infection results in tubercles, that is to say more or less globular tumors, generally between one and five centimeters in diameter in correlation with the size of the affected organ (trunk, branch, twig or leaf). The attacked trees do not die but are weakened by the disease. The pathogenic agent is present at the level of the tumors and each rainy episode is an opportunity for it to spread. Infection by the bacterium requires an entry point that is offered to it by the multiple wounds that an olive tree receives, first during pruning and suckers removal from trunks and branches, then during harvesting where leaf and branch breaks are numerous. No resistant varieties to tuberculosis are known **(Breton and Bervillé, 2012).**

Figure 15: Infected olive tree branch due to olive knot **(original, 2024).**

- **Peacock eye**

The pathogenic agent is a fungus (*Cycloconiums oleaginum*) that develops on mature leaves and forms dark brown spots with a yellow border, in concentric circles, then causes heavy leaf drop. It develops in the fall and winter in regions with dry summers and mild winters, and in the spring and early summer in regions with colder winters **(Schall, 2011).**

- **Verticillium wilt**

Verticillium wilt is caused by the fungus *Verticillium dahliae*. The disease is very common in modern orchards, particularly on young trees planted in the best possible growth conditions, which consequently rapidly extend their root system. It generally manifests in the spring and results in sudden drying out of entire branches, sometimes leading to the death of young olive trees. The symptom is explained by the invasion of the vascular bundles by V. dahliae following the infection of roots by an inoculum consisting of microsclerotia preserved in the soil, which germinate when the tree's roots reach their vicinity **(Breton and Bervillé, 2012).**

- **Sooty mold**

Sooty mold covers the branches, twigs, and leaves of the olive tree with a black, soot-like layer. This is a group of microscopic fungi that grow saprophytically on the honeydew of scale insects. Several organisms contribute to forming this black layer. The genus Fumago, which gave its name to the symptom, is rarely present. One mainly finds Alternaria, Stemphylium, Cladosporium, etc. The generally significant defoliation associated with the black layer of sooty mold is the exclusive work of the scale insects. It is these latter that need to be combated **(Breton and Bervillé, 2012).**

III.4.1 Pests

- **The olive moth**

The larva of this butterfly (*Prays oleae*) is a particularly voracious 6mm caterpillar that nibbles on the leaves, floral buds, and fruits. Furthermore, its life cycle causes two fruit drops, one in July and the other in September-October when the larva leaves the fruit. Three generations succeed one another. The first, in the spring, eats the flowers, the second, in the summer, devours the seed inside the olive pit, the third in the summer and autumn nibbles on the leaves. The presence of silk threads in the flower clusters indicates its presence. In winter, it remains discreet and resides within the leaf blade **(Schall, 2011).**

- **The Olive Fly**

It (*Bactrocera oleae*) is the most serious enemy of the olive tree, in terms of fruit production, as it is invariably present every year, at least in the plains, renders the olives unfit for consumption and considerably alters the quality of the oil. Dacus olea, *Bactocera olea* by its former name still in use, is a small fly, 4 to 5 mm in size, very lively which carries out its life cycle exclusively at the expense of the olive tree and the wild olive, its wild form. Between June and November, up to four generations can succeed each other depending on the regions. The most exposed are those with the mildest climate, the most spared are located at altitude and in the cold. As soon as the first fruits are available, the fly lays between 50 and 300 eggs, at the rate of one per olive **(Schall, 2011).**

Figure 16: the olive fly **(original, 2024).**

- **The Cotton Olive Insect**

The psylla (*Euphyllura olivina*) is an insect about 0.25 centimeters long. It has a greenish-brown color and also has wings. This insect spends the entire winter in a static state. It hibernates in the leaf buds of the tree and at the base of the leaf blades. It is active in the spring, especially with the onset of April, when temperatures rise. The heat promotes the activity of this insect and its oviposition. The burning of the cotton plant represents a great danger for the olive tree. They feed on flowers and damage them. Consequently, the olive harvest is lost **(Faharase, 2023).**

Figure 17: the cotton olive insect **(original, 2024).**

III.5 The Pruning of Olive Trees

There are different types of pruning depending on the objectives:

III.5.1Formation pruning:

Practically nothing at first. You must wait until the olive tree reaches at least 1.50 m. Just remove all the fruits, so that the tree can devote itself to its growth, and the lower young branches that have no future, to form the future trunk. Two to three years after planting, formation pruning can begin, it will last three years, and aims to form a balanced tree with an open crown, supported by a 1 m trunk **(Schall, 2011).**

III.5.2 Fruiting pruning:

A self-governed olive tree provides a large quantity of fruits. However, annual fruiting pruning makes it possible to obtain olives of regular size and to avoid the alternation of production which is always very marked in this fruit tree. Fruiting pruning is the main task in olive cultivation. For the same variety, it varies greatly from one region to another, and local practices are as numerous as the olive groves **(Schall, 2011).**

III.5.3 Regeneration pruning:

This very severe pruning is practiced in three very specific cases: the renovation of trees that have suffered from frost, the rejuvenation of an old subject whose productivity is declining, and the restoration of an olive tree left abandoned for decades. This drastic pruning, carried out with a chainsaw, aims to bring the tree back to its first level of vegetation **(Schall, 2011).**

Chapter IV

Presentation of the Study Region

Chapter IV: Presentation of the Study Region

IV. 1 Presentation of the Province

IV. 1.1 Geographical Location

Bordj Bou Arreridj Province extends over an area of 3920.42 square kilometers **(RMW, 2010).** Geographically, it is located at latitude 36°4'60" north and longitude 4°45'0 east.

Located in the eastern highlands of the country, it stretches along the Alger-Constantine axis and is bordered by the following Province **(Belhadj and Hamouche, 2020):**

- To the north, by the Province of Bejaia.
- To the east, by the Province of Sétif.
- To the west, by the Province of Bouira.
- To the south, by the Province of M'Sila.

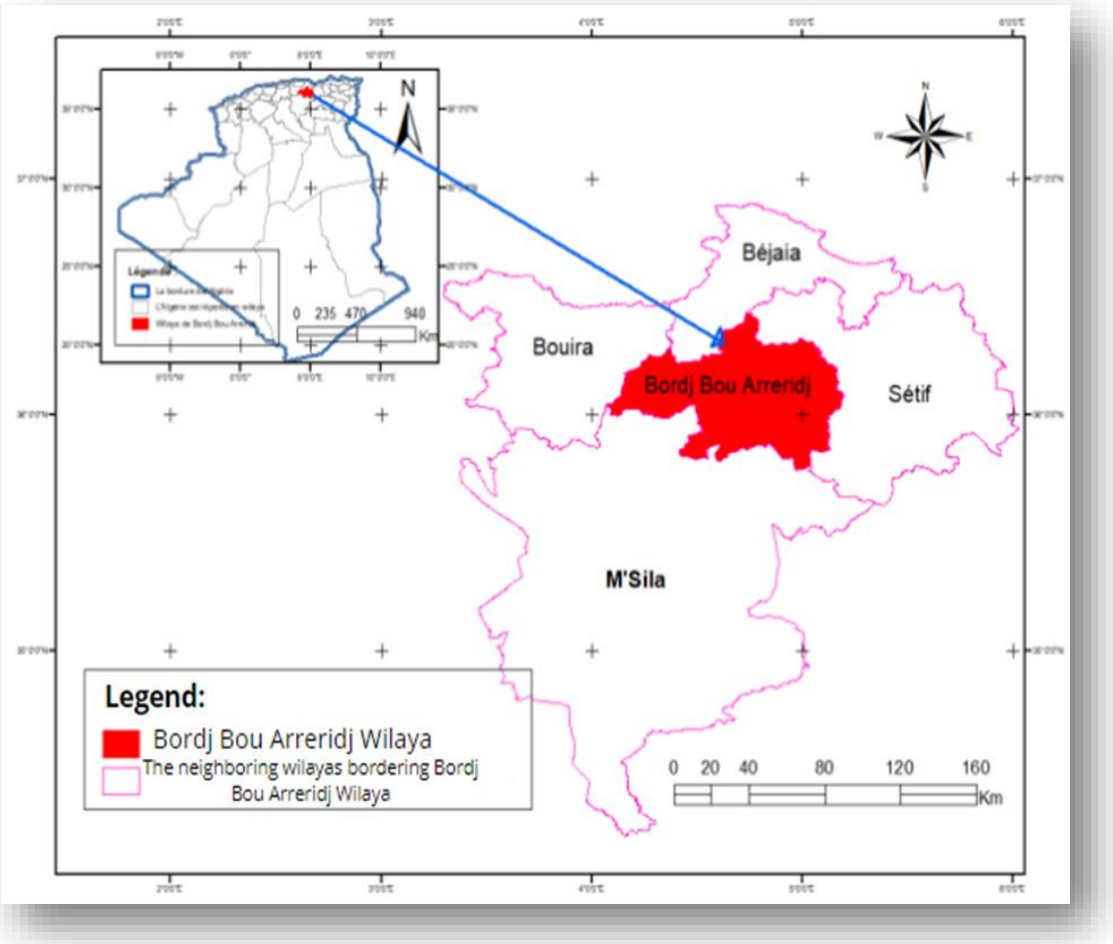


Figure 18: geographical location of bordj bou arreridj Province **(Khinouche and Meddah.,2021)**.

Therefore, bordj bou arreridj Province distinguishes itself due to its significance, as it is located northeast of Algiers at a distance of 243 km, west of Sétif at a distance of 67 km, and north of Msila at a distance of 58 km. Furthermore, it is located 175 km from Bejaïa and 100 km from Bouira to the east **(PDAU, 2021).**

The wilaya is composed of three successive geographical zones **(Tennah and Saidat, 2019):**

- A mountainous zone in the north (the Bibans mountain range).
- A high plains zone, which constitutes the majority of the Province.
- A steppe zone in the southwest, with an agropastoral vocation.

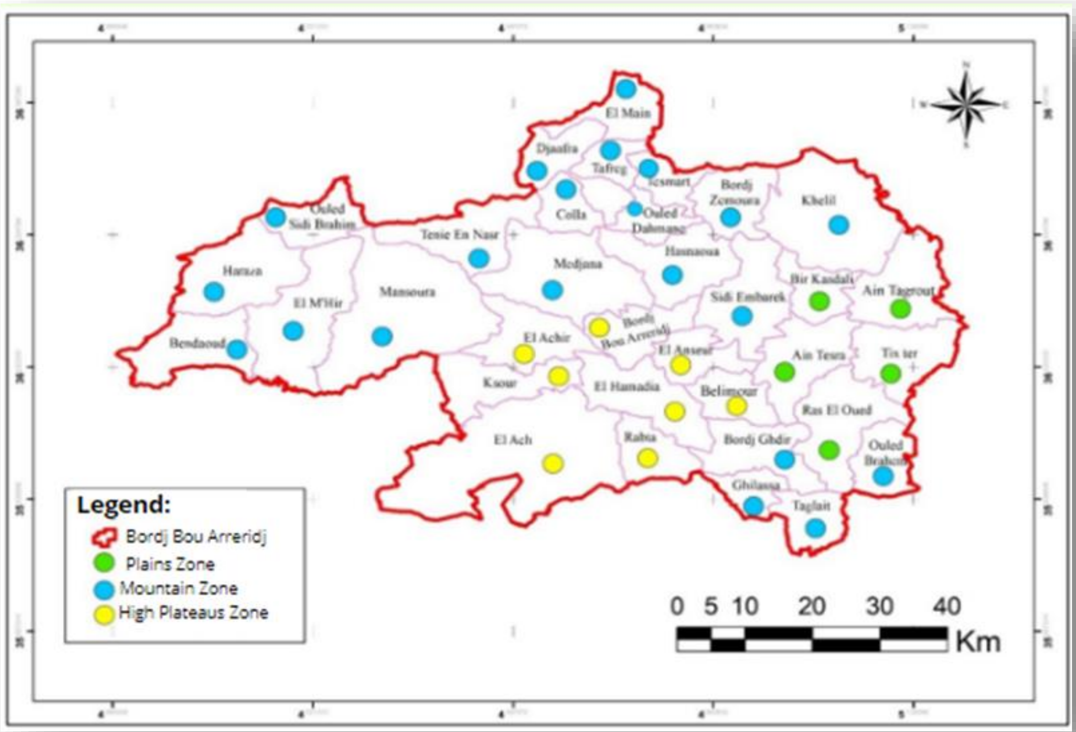


Figure 19: Map of registration zones in Bordj Bou Arreridj **(Khinouche and Meddah,2021)**.

Geographical delineation for each region:

➢ **Mountainous Zone:** The mountainous area in the northwest, which is an extension of the Medjana mountains in the form of hills and mounds. The highest point is Djebel Morissane (1499 m). It is a homogeneous mountain range that overlooks the high plains with moderate relief and valleys surrounding it with steep slopes. Its topography is asymmetrical **(Chihi *et al*., 2017).**

- **High Plains Zone:** It extends from the Bibans mountain range in the west to the Ain Zada Dam in the east. To the north, it is bordered by the heights of Teniet Ennasr and Bordj Zemoura, and to the south, by the Maadid mountains. The southern part is relatively flat with a slight slope, forming a semi-enclosed basin with an average altitude of 800 m to 900 m **(Chihi *et al*., 2017).**

- **Steppe Zone:** The northeastern part of the province is characterized by a range of hills called Draà, with altitudes ranging from 800 m to 1100 m. This range is intersected by numerous dry riverbeds and ravines, reflecting the rugged nature of the terrain **(Chihi *et al*., 2017).**

IV. 1.2 Climatology

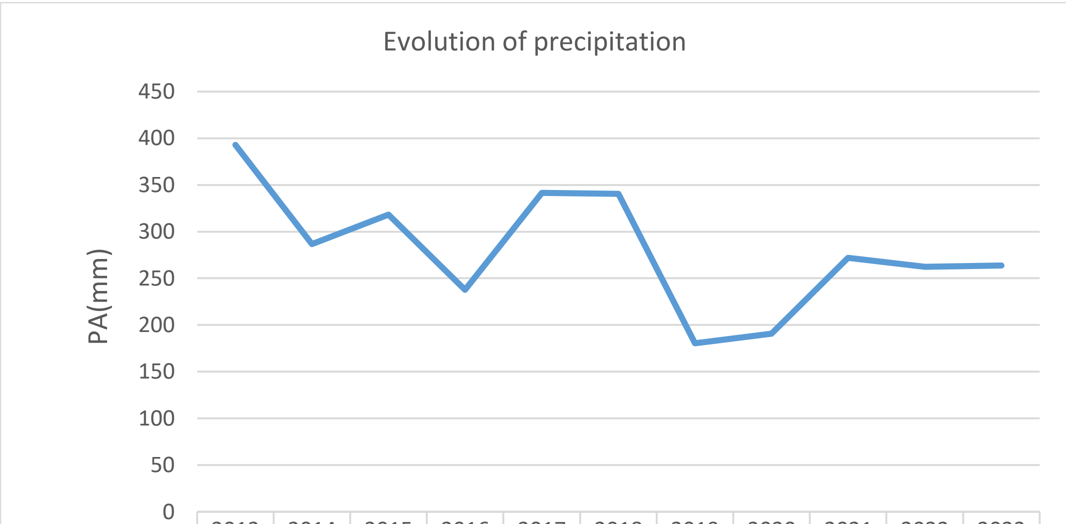
Climate is defined as the interaction of several factors, including temperature, precipitation, humidity, wind, and frost, among others.

In the Mediterranean region, climate is a determining factor due to its significance in the establishment, organization, and maintenance of ecosystems. It plays a fundamental role in the distribution and life of living beings. Climate depends on numerous factors such as temperature, precipitation, humidity, and wind. Temperature and precipitation are the most important factors in climate **(Belgoumri and Tiet, 2020).**

IV. 1.2.1 Pluviometry

Pluviometry is the total amount of water measured by a rain gauge or a pluviograph. It includes all forms of meteorological water, such as rain, hail, etc. **(Serifeg and Lessaad, 2020).**

Annual precipitation



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
PA(mm)	392,93	286,51	318,05	237,74	341,35	340,3	180,51	190,8	272	262,2	263,59

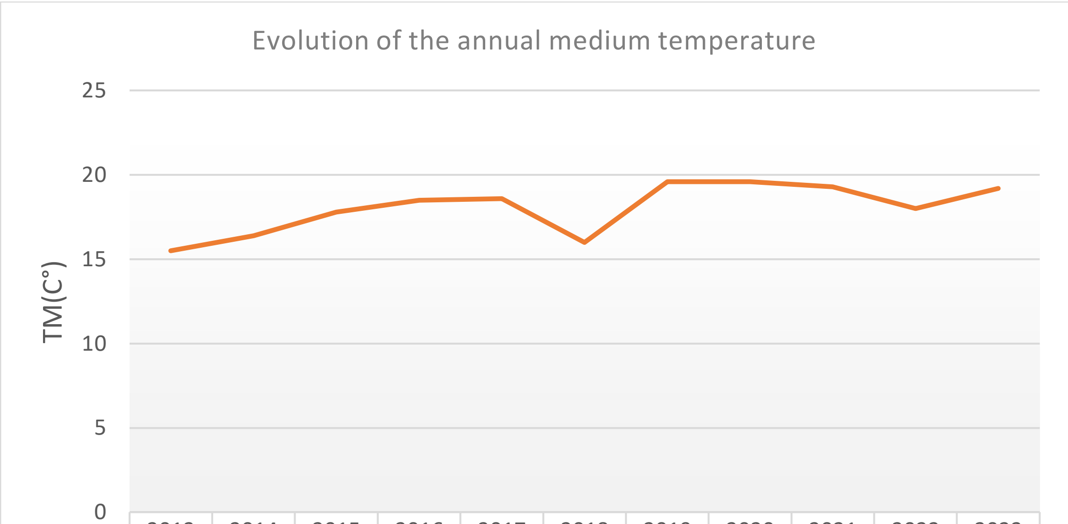
Figure 20: Evolution of precipitation during the period 2013-2023 **(Source : Tutiempo, 2024).**

The line graph depicts a dataset spanning from 2013 to 2023, illustrating the fluctuations in the values of PA (mm) over this period. The highest recorded value is approximately 400(mm) in 2017, while the lowest value is close to 150(mm) in 2020. Notably, there is a substantial decline following 2017, followed by a slight increase after 2020.

IV. 1.2.3 Temperature

Temperature is one of the most important climatic factors. It directly affects living organisms and their environment. Temperature is the most significant climatic factor as all metabolic processes depend on Each species can only survive within a certain temperature range, and there is an optimum temperature at which vital functions are performed best **(Tennah and Saidat, 2019).**

- **The annual average temperature**



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
T	15,5	16,4	17,8	18,5	18,6	16	19,6	19,6	19,3	18	19,2

Figure 21: Evolution of the annual medium temperature 2013-2023 **(Source : Tutiempo, 2024).**

The line graph illustrates the evolution of temperature over several years from 2013 to 2023. Notably, there are slight fluctuations in temperature during this period. It began at 15.5°C in 2013, reached its peak at 19.6°C in 2020, and then slightly decreased to 19.2°C in 2023.

IV. 1.2 .3Wind

Wind is the movement of air within the atmosphere. It occurs due to differences in temperature and pressure. When there is a difference in pressure between two points, air moves from the area of higher pressure (where the air is colder) to the area of lower pressure (where the air is warmer). In other words, air moves from high pressure to low pressure. The primary driver of this phenomenon is the sun **(Belgoumri and Tiet, 2020).**

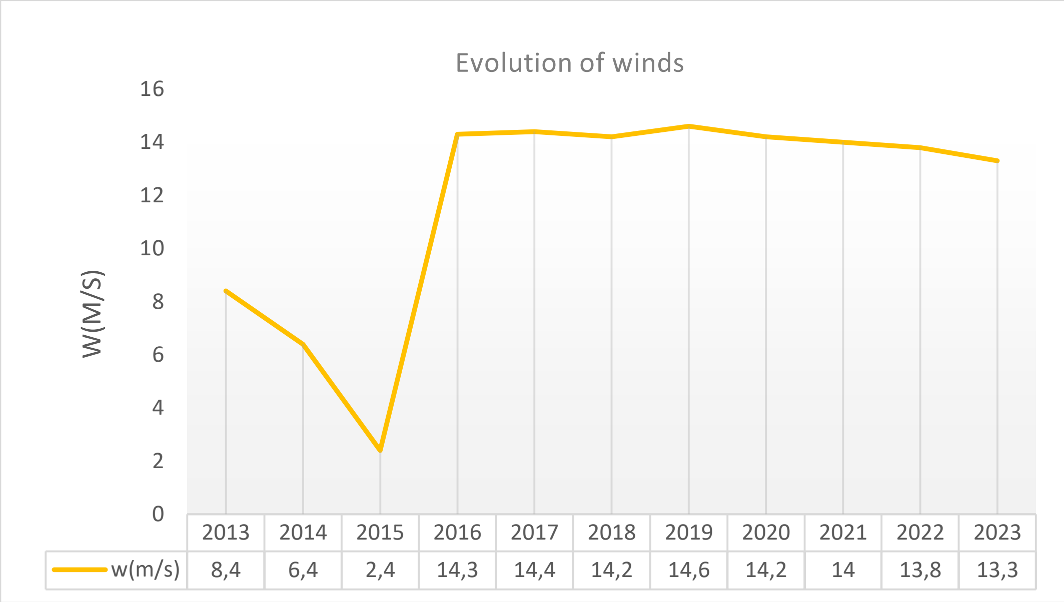


Figure 22: Evolution of winds during the period 2013-2023 **(Source: Tutiempo, 2024).**

The line graph depicts the fluctuation of values from 2013 to 2023. The value was 8.4(m/s) in 2013 and experienced a sharp decline to 2.4(m/s) in 2015. However, there was a gradual rise between 2015 and 2017, reaching around 14(m/s). This increase suggests a stable trend since that year.

IV. 1.2.4 Humidity

"Air is a sponge whose greediness increases with temperature." While the amount of water vapor in the air (from water surfaces and living organisms' transpiration) can vary greatly, it cannot exceed a certain maximum. This maximum depends on the temperature. Most often, there is less water vapor in the air than these maximum quantities. The ratio between the amount of water vapor present in the air and the maximum amount it can hold at a given temperature is called relative humidity, expressed in %. Absolute humidity is also distinguished, measured in g/m³ **(Medjelekh, 2006).**

Table 5: the monthly and annual average humidity percentages (%).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
H(%)	76,79	70,9	64,54	60,06	54,42	45,01	38,47	42,9	56,28	61,93	71,77	76,6	59,81

Source**: (ONM, 2023)**

According to the table, we can observe that the month of January has the highest humidity at 76.79%, while the lowest average monthly humidity is recorded during July with 38.47%. The annual average humidity in the study area is 59.81%.

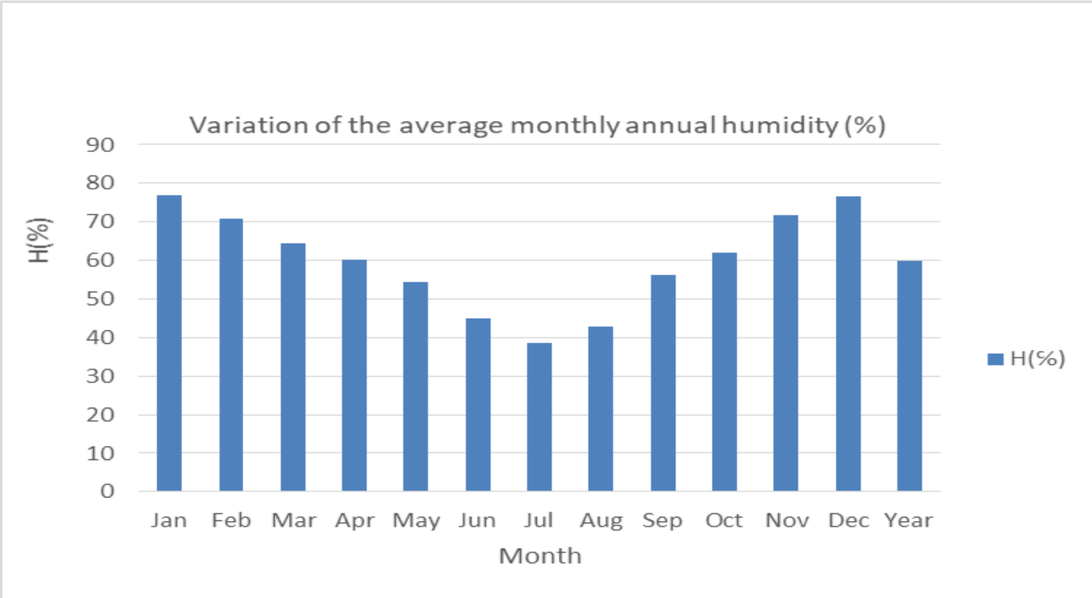


Figure 23 : Variation of the average monthly annual humidity at the Boumergued station **(ONM,2023).**

IV. 1.3 ombrothermic diagram

The ombrothermic diagram presented in Figure 24 shows the presence of a dry period (low precipitation with high temperatures) that extends from May to the end of September. This period is considered critical according to several previous studies, and its impact on vegetation and productivity parameters is severe. Hence, there is a need for irrigation, either at full capacity (100% of plant needs) or at a deficit, depending on the capabilities and objectives of olive growers **(Grini and Bendjedou.,2021).**

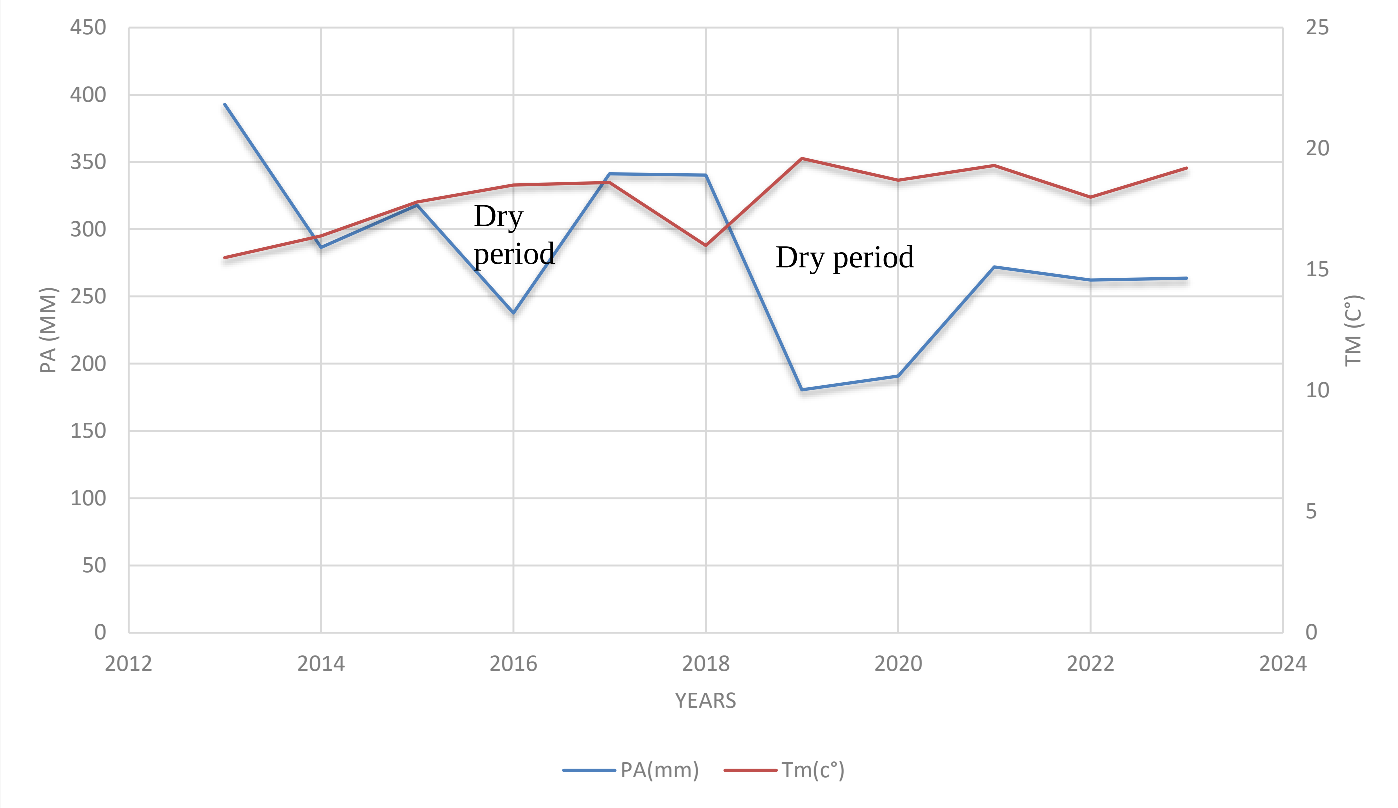


Figure 24: Ombrothermic diagram of the Bordj Bou Arréridj province (2012 - 2024) **(Grini and Bendjedou.,2021).**

IV .1.4. Pluviometric Quotient and climagram:

The work of **(Emberger; 1930, 1936, 1955)** consists in defining and classifying the Mediterranean climates from a biogeographical point of view (bioclimatic stages) according to the following formula (Pluviometric Quotient):

Q2=1000P /M+ m /2(M-m) =2000P/M²- m²

This quotient was modified by **(Stewart, 1969)** as Q2=P/ M²- m²3. 43

- Q2: Annual pluviometric Quotient (in mm).
- P: Annual rainfall (in mm).
- M: Average of the maxima of the hottest month (in °C).
- m: Average of the minima of the coldest month (in °C).

To define the bioclimatic stage of our study area, we used the pluviometric and thermal climagram of (Sauvage, 1963) which combines two climatic parameters.

The ordinate axis represents the values of the quotient (Q2) and on the abscissa axis are the values of the minimum temperature (m) of the coldest month. On this climagram we have five bioclimatic stages: Saharan, arid, semi-arid, sub-humid and humid. The latter are divided into lower, middle and upper substages, then into thermal variants depending on the value of (m):

let's recalculate using the Emberger diagram to determine the Bioclimatic Lithotope.

The available data is:

T max (°C) = 19.3

T min (°C) = 2.5

P mean (mm) = 280.54

Calculation according to the Emberger diagram:

1. Calculation of the annual average temperature (T):

T = (T max + T min) / 2

T = (19.3 + 2.5) / 2

T = 10.9°C

2. Calculation of the Emberger dryness index (P/T):

P/T = 280.54 / 10.9

P/T = 25.74

3. Using the Emberger diagram, based on the P/T value of 25.74, the Bioclimatic Lithotope is:

Bioclimatic Lithotope = Semi-arid

Therefore, according to the Emberger diagram, the Bioclimatic Lithotope of this region is Semi-arid.

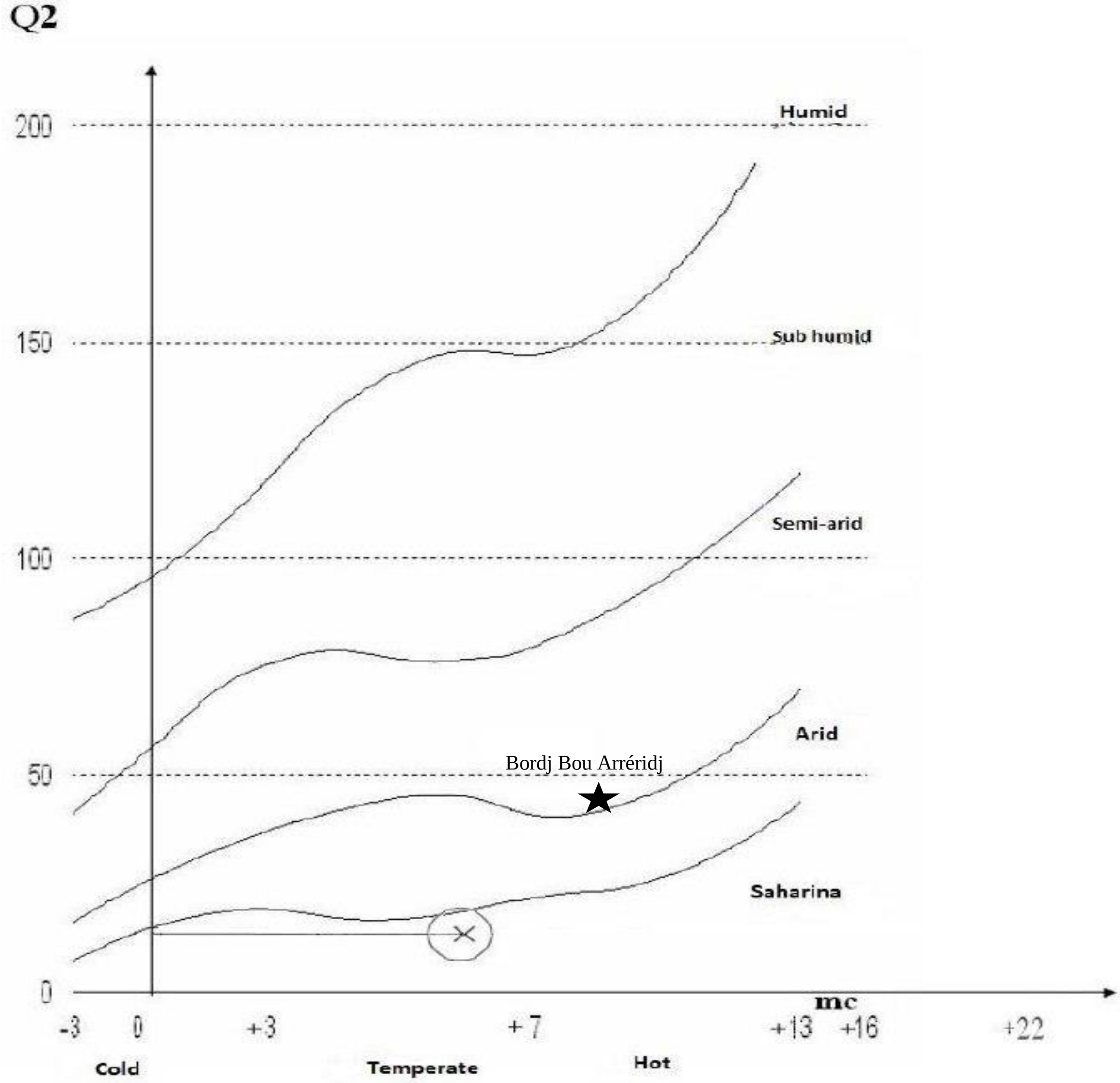


Figure 25: Climagram of Bordj Bou Arréridj region.

IV. 1.5 Farmland Agricultural Land

The total agricultural land area is approximately 392,252 hectares, while the actual utilized agricultural land area is around 245,120 hectares. As for the area specifically used for rural agriculture, it amounts to approximately 185,966 hectares. However, there are 5,197.05 hectares of irrigated land **(DSA, 2023).**

- **The legal nature of SAU**

State-owned lands	Private lands
50 294 ha (27 %)	135 672 ha (73 %)

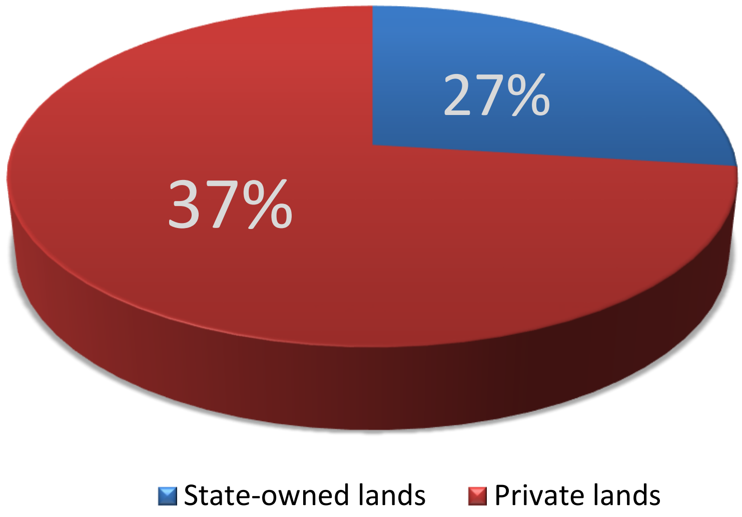


Figure 26: Distribution of SAU by Legal Nature **(DSA ,2023).**

IV. 1.6 Land use

Viticulture, olive cultivation, and tree farming: 30,702.03 ha, accounting for 16.51% of the SAU.

Field crops: 75,858 ha, accounting for 40.79% of the SAU.

Market gardening: 1,128.55 ha, accounting for 0.61% of the SAU.

Others: 78,277.42 ha, accounting for 42.09% of the SAU. **(DSA, 2023).**

IV. 1.7 Crop system:

According to data from the **DSA (2023)**, the agricultural land in the region is primarily dedicated to the cultivation of cereals, covering an area of 72,165 hectares. Forage crops occupy 3,466.5 hectares, while dry vegetables and market gardening crops account for 226.5 hectares and 1,128.55 hectares, respectively. There are no reported areas dedicated to industrial crops. Potatoes are grown on 34 hectares, and arboriculture, including 26,435.5 hectares of olive groves, covers a total of 30,702.03 hectares.

IV .1. 8Animal resources:

According to the latest data from the **DSA (2023)**, the region's livestock population consists of 20,751 heads of cattle, with 10,873 dairy cows. The sheep population is much larger, totaling 420,856 heads, including 230,351 ewes. The goat population stands at 46,246 heads, with 23,377 does. In the poultry sector, there are 9,946,300 broiler chickens and 2,199,900 layer hens. The turkey population is 55,550 subjects. These figures demonstrate the significant agricultural and livestock production capacity of the region, which relies on a diverse mix of cattle, sheep, goats, and poultry to support the local economy and food supply.

IV .1. 9 Water potential

According to the data from the **DSA (2023),** the region's water resources include a single dam used for water supply, 1,011 boreholes with very low flow, and 2,744 wells, also with very low flow. Additionally, there are 8 reservoirs, but these are not currently being exploited due to a lack of water. In terms of irrigation systems, drip irrigation is used on 1,088.55 hectares, accounting for 20.94% of the total irrigated area. Sprinkler irrigation is employed on 1,066 hectares, making up 20.61% of the irrigated land. The majority of the irrigated area, 58.55%, or 3,042.5 hectares, utilizes gravity-fed irrigation systems. These figures highlight the region's reliance on limited water resources and the need for efficient irrigation practices to support agricultural production.

IV .1. 10 Agricultural Equipment:

The region's agricultural sector is equipped with a variety of machinery and equipment. There are 2,436 tractors, 3,711 soil tillage implements, 454 combine harvesters, and 410 seeding and fertilization machines. The area also has 666 treatment units and 1,575 trailers. Additionally, 1,064 tanks are utilized for various agricultural purposes. This diverse array of machinery and equipment underscores the technological capabilities and mechanization of the region's agricultural production, which likely enhances efficiency and productivity in the sector **(DSA ,2023).**

IV .1. 11 Agricultural Structures:

The agricultural landscape of the region is supported by a diverse set of stakeholders. According to the data, there are 10,850 farmers who have been issued magnetic cards, indicating a substantial agricultural workforce. Additionally, there are 3 pilot farms that serve as demonstration and experimentation sites. The region also has 15 agricultural associations and 8 cooperatives, including 7 private ones, which likely facilitate cooperation, knowledge sharing, and collective action among farmers. Furthermore, there are 11 interprofessional councils that bring together various players in the agricultural value chain. This network of farmers, pilot farms, associations, cooperatives, and councils highlights the institutional and organizational support structure in place to foster the development and growth of the region's agricultural sector **(DSA ,2023).**

IV .1.12 Evolution of agricultural production.

IV .1.12.1Plant sectors

- **Cereals**

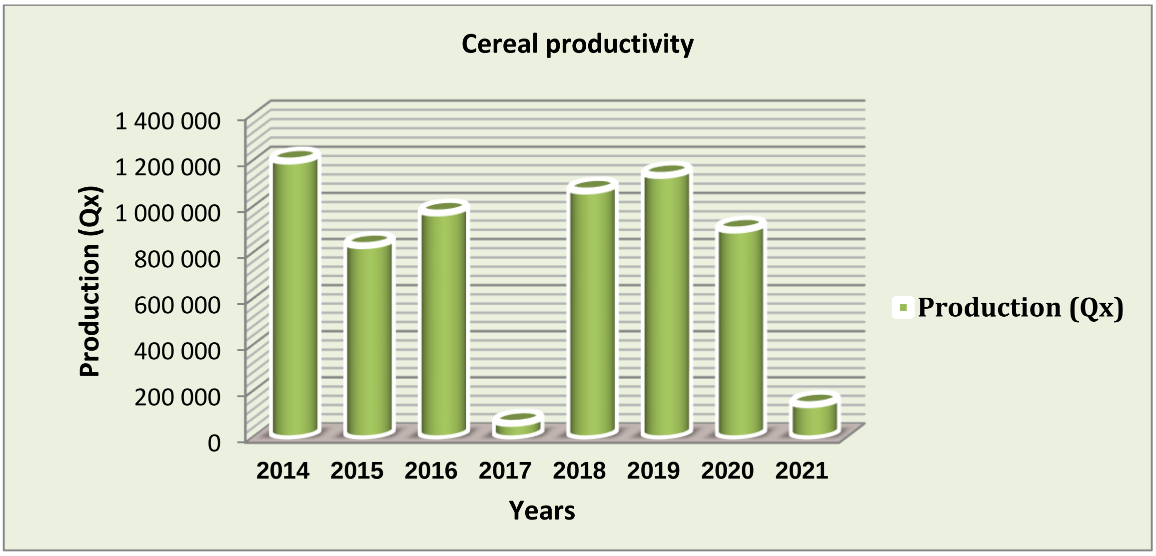


Figure 27: Evolution of cereal production from 2014 to 2021 **(DSA ,2023).**

- **Market gardening**

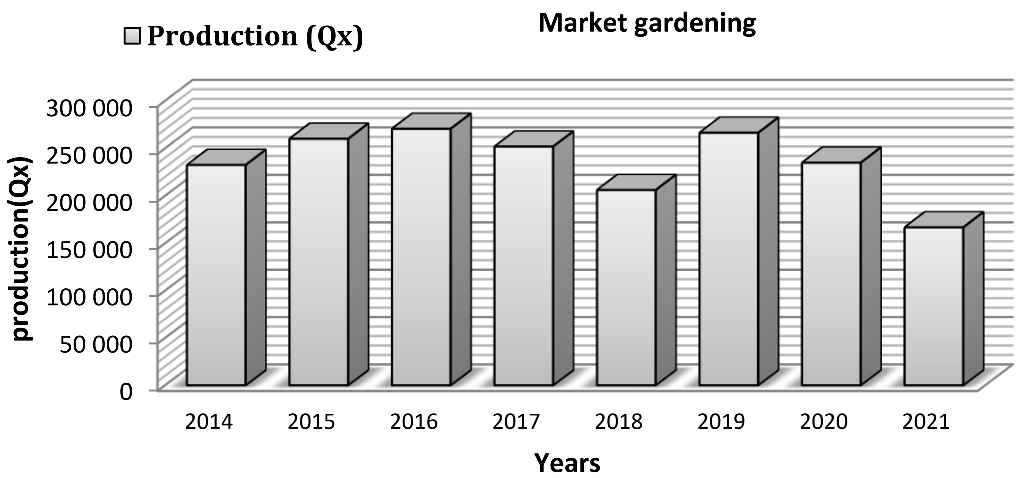


Figure 28: Evolution of vegetable production from 2014 to 2021 **(DSA,2023).**

- **Olive cultivation**

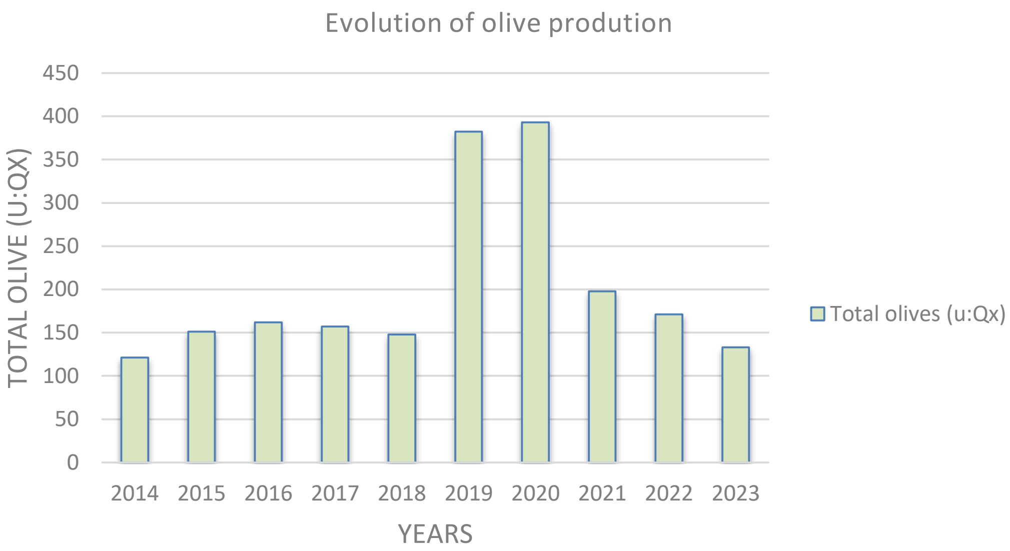
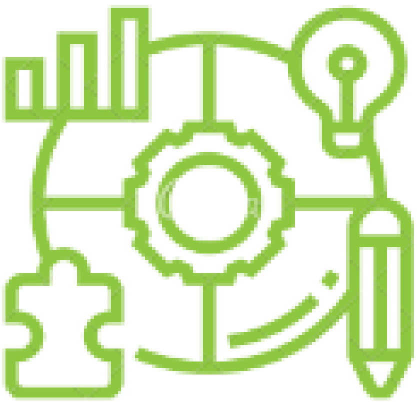


Figure 29 : Evolution of olive production from 2014 to 2023 **(DSA,2023).**

Chapter V

Material and Methods



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