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A Geobotanical and Phenological Study of *Zizyphus lotus* in the Naama Region (South-Western of Algeria)

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ABSTRACT

Zizyphus lotus is a perennial specie showing adaptation to arid climatic conditions. In order to value this specie in the restoration of degraded areas, a geobotanical and phenological study was carried out in the region of Naama (Southern Algeria) over a period of 5 years (2012-2016).
The results obtained allow us to map the geobotanic distribution of this specie, its vegetative and phenological developmental cycle (foliage, flowering, fruit maturation and leaf fall). Those data confirm the interesting place this specie should occupy in the ecological restoration of degraded steppe areas.
KEYWORDS: Jujube - Plant Phenology - Geobotany - Naama - Climatic Influence.

INTRODUCTION

The degradation of the steppe ecosystem under the combined effect of drought and overgrazing induced by a real average pastoral charge estimated at more than 5 sheep-equivalents per hectare whereas the possibilities are only 0.5 according to Nedjraoui (2004) and Benabdeli (2008). The pastoral charge and the cultivation have become much superior to the possibilities of the environments. Once degraded, the ecosystem is often slow or unfit to rebuild; its resilience is low or nought, a threshold of ecological irreversibility has been crossed (Moulay et al., 2011).
The steppe ecosystem can be rescued by rehabilitating *Zizyphus lotus* through a mapping of its distribution and a geobotanical study supported by an approach of its vegetative and phenological developmental cycle (foliage, flowering, fruit maturation and leaf fall). Those elements have to confirm the importance of this specie in the ecological restoration of degraded steppe areas.
According to Schnelle (1955), Plant phenology is the scientific study of seasonal variations, growth and development of plants, taking into account the dates at which certain natural phenomena of species reproduce each year.
The vegetal species can adapt to a certain extent to their environment and its modifications, hence the need to take an interest in this specie, which show a remarkable characteristics of resilience which can play a decisive role in the revegetation of degraded steppe areas.

1. Ecological characterization of the studied area

The studied area is located in the South-western part of Algeria in the high plateaus as shown in figure 01.

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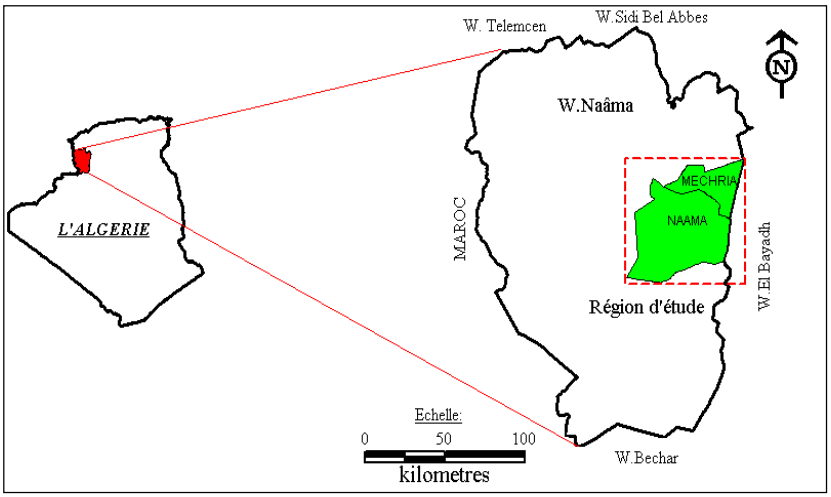

Figure 01: Geographical location of the province of Naama and the studied area (AMARA, 2014).

In this region, the steppe occupies 74% and characterized by the predominance of pastoral activity. The pre-Saharan zone extends to the South of the steppe area and covers 14%. These two areas occupy more than 88% and they are threatened by desertification.

1.1. Bioclimatic frame

The climate of the region is the Mediterranean arid type characterized by a long dry and warm season of about 8 months per year and a cold and rainy season of a short duration (the rest of the year).
The climatic data of three meteorological stations located in the region: Naâma, Mécheria and Ain Sefra are summarized in Table 01.
The seasonal distribution of rainfall is marked by the predominance of the autumn rains followed by those of spring and winter, so the rainfall pattern is of APHE type.

Table 01: climat and bioclimatic data of the region de Naama

Parameters	Mécheria	Naama	Ain Sefra
Annual precipitation (mm)	225,7	231,8	108,9
Summer Precipitation (mm)	34,8	35,2	20,4
Fall Precipitation (mm)	67,9	86,3	34,6
Winter Precipitation (mm)	57,4	49,5	24,3
Spring Precipitation (mm)	65,6	60,8	29,6
Mean temperature (°C)	16,29	15,18	15,80
Maximum temperature (°C)	36,7	28,02	36
Low temperature (°C)	2,2	1,0	1,1
Emberger's quotient	28,02	1,0	10,51
Aridity Index	8,58	9,03	4,22
Summer Index	1,20	1,26	0,72

Annual average precipitation is very low (between 100 and 300 mm), often stormy and exhibiting a great inter-monthly and inter-annual variability.
The annual mean temperatures for the three stations are of 16.29° C at Mecheria, 15.18° C for Naama and 15.80° C in Ain Sefra.
The calculation of De Martonne's aridity index (1923) and Emberger's summer drought index (1955) ranks the region between the values of 4.22 and 9.03, respectively, in the types of hyper-arid to steppe climate of 0.72 to 1.26.
From a bioclimatic point of view, the region belongs to the lower arid bioclimatic stage with a fresh variant.

1.2- Edaphic Aspects

Soils in the area are deep sandy well drained soils with a neutral or slightly alkaline pH belonging to the class of steppe soils. The dominant soils in the area are the calcimagnesic soils with the rendzines and calcium brown soils that occupy the glacis.
Raw mineral soils are represented by the erosion mineral soils, alluvial raw mineral soils and crude mineral wind input sols.

2- Ecological overview of *Zizyphus lotus*

The genus Zizyphus belongs to the Rhamnaceae family and is represented by deciduous shrubs and trees totaling between 135 and 170 species generally armed with unequal stipular spines (Bhansali 1975; Liu and Cheng, 1994). It is common throughout North Africa, Sahara and West Africa and its forms vary with soil and climate (Chevallier, 1947; Paris and Dillemann, 1960).

According to (Paroda et al., 1989; Maydell, 1990), it is known for its drought tolerance and high heat resistance with temperatures between 20 and 35° C (Vashishtha, 1997). It can be found in desert areas with very low precipitation (Jawanda et al., 1978). Kim and al (1989) reported that 42% of explants can grow in alluvial plains, 23% in mountains, 22% in valleys and 13% in hills.

The specie can develop in areas with marked climatic differences (between 150 and 1000 mm of rainfall) and can withstand temporary flooding (Maydel, 1990). It supports all types of soils but prefers deep well-drained sandy soils with neutral or slightly alkaline pH (FAO, 1992).

2.1- Description and botanical classification

The *Zizyphus lotus* (jujube tree) is a fruitful thorny shrub, belonging to the Rhamnaceae family (Rsaissi and Bouchache, 2002). Commonly called in North Africa "Sedra" (Borgi et al., 2007). It forms tufts of a few meters in diameter, up to 2 to 3 meters in high.

Photo 01: Morphology of the jujube tree (leaves and flowers, AMARA, 2015)

The fruits are drupes with welded cores, the size of a pea or an olive, the mucilaginous endocarp called "Nbeg". From a classification point of view, it belongs to the branch of the Spermatophytes, the sub-branch of the Angiosperms, the Dicotyledon subclass, the Celastral order, the Rhamnaceae family, the genus Zizyphus and the lotus specie (Quézel and Santa, 1962). Five varieties of Zizyphus are listed: *Zizyphus lotus (L.) Lam, Zizyphus spina-christi (L.) Wild, Zizyphus mauritiana Lam and Zizyphus saharae (Batt.)*

Photo 02 : *Zizyphus lotus* fruits (AMARA, 2016).

According to Quézel and Santa (1962), the leaves are deciduous, glabrous, coriaceous, shortly petiolate and with entire margins. They are alternately oval in shape and small in size (15 x 10 mm, 1.5 to 2 times longer than wide), accompanied at its base by two stipules transformed into uneven and vulnerable spines.
The flowers are polygamous, yellow and have a rotated calyx, pentameters and grouped in inflorescence tops. The sepals are welded at their base and the stamens are arranged in a cycle of 5 and composed of a long thread terminated by a bilobed anther.
Zizyphus lotus, is spontaneous in southern Spain and Portugal, Sicily, Greece (Bross, 2000), Mauritania and Northern Africa (Aubreville, 1950). In Algeria, according to Quézel and Santa (1963), he frequents the arid, steppe and arid pastures, except the Algiers-Constantine Tell.

2.2- Ecological and economic importance of the specie
It's specie whose origin is always controversial. Some authors believe the specie is native to Africa (Chevalier, 1947); others say it comes from Central Asia (Morton, 1987).

2.2.1- Ecological Importance
It is found in very low rainfall stations (100 mm) and supports high temperatures (20 to 35 ° C) and long dry periods (sometimes 6 to 12 months) (Chevalier, 1952, Depommier, 1988).
Its ecological plasticity gives it increased interest especially in arid areas in a context of desertification and decline in agricultural production (FAO, 1992). The jujube tree is autochthonous, rustic species of great ecological plasticity (Laamouri, 2005). They survive well in arid environments thanks to their physiological and morphological adaptation mechanisms (Reich, 1991, Ardnt et al., 2001).
They play a very important role in soil conservation thanks to their deep and vigorous root systems that stabilize the substrates and protect them from erosion. Tufts of jujube grow on all types of soils and can withstand temporary flooding (Maydel, 1990).
They constitute a place of sand accumulation and alluvial deposits forming a biotope for reptiles, hedgehogs, foxes, rodents (hares, jerboas, jirds, rats ...) and even arachnids (scorpions and spiders) . In the event of a fire, Grice (1997) showed that the jujube trees are relatively resistant to bush fires and generally resume their vigor 4 months after the passage of fire with only 10% of young sprouts who do not survive.
All these ecological and botanical elements militate in favor of the rehabilitation of *Zizyphus lotus* on degraded areas in the arid steppe zone; this is what has been undertaken through a mapping of its presence in the Naama region and the study of its development cycle to better understand it.

3- MATERIAL AND METHODS

After locating *Zizyphus lotus* zones in the Naama region, plots have been delimited and observation sheets providing information on the parameters determining the cycle of its development are given monthly.
These will include bud break, foliage, flowering, fruit set and maturation, the harvest and defoliation. The control of these elements makes it possible to justify the rehabilitation of this specie in a process of ecological restoration since they give information on the ecological and economic interest of this specie.

3.1- Behavioral of *Zizyphus lotus* in the region of Naama
The preservation of vegetation cover in the steppe and pre-Saharan zones is problematic under the effect of anthropozoic pressures and only a restoration of these areas with a resistant species to human and climatic pressures can yield results. Benabdeli (1996; 2015), by classifying the resistivity of species to pressures, highlights the interest of this species in the preservation of areas threatened by desertification.
Zizyphus lotus is a nanophanerophytic plant with a long longevity with abundant sprouts and a possibility to multiply by burst of the strains as well as by the germination of the seeds after their passage in the digestive tubes of the goats and the birds. When steppe lands are developed and turned into cereals, the Zizyphus develops and regains its space.
The jujube tree has a highly developed root system with two distinct morphologies: a structural root system with a surface area of no more than 25 cm and another with a depth of up to 150 cm allowing it to prospect the soil.

3.2- Phenology of the specie and choice of sites of observations
The term phenology was used in 1735 by Réaumur. "Plant phenology is the scientific study of seasonal variations, growth and development of plants" (Schnelle, 1955). It consists in observing what are called phenological phases, or phenophases, such as foliage, flowering, maturation of fruits and leaf fall.
The presence and dominance of the specie through stands has been selected to localize the plots of observations for 5 years between 2012 and 2016. The presence in pure stand of Zizyphus in the Naama region was identified in four zones (Table 02) namely Ain Ben Khélil, Djebel Bourezg, Naama and El Biodh. These areas are fairly well covered by meteorological stations whose data have been summarized above (Figure 02).

Table 02: Biogeographic situation of *Zizyphus lotus* in the Naama region.

Town	Site	Lat (N)		Long (W)		Alt (M)	Sup (ha)
A .B.Khelil	Mesdouria	*33°15'58''*	*33°18'09''*	*0°49'18''*	*0°51'22''*	1160	1095
D.Bourezg	Maader	32°26'11''	32°27'28''	0°44'47''	0°45'98''	1048	158
Naama	*B.Twaref*	*33°06'45''*	*33°07'35''*	*0°16'24''*	*0°17'49''*	1196	137
El-Biodh	Laaguer	*33°29'52''*	*33°30'51''*	*0°25'56''*	*0°26'38''*	1104	54

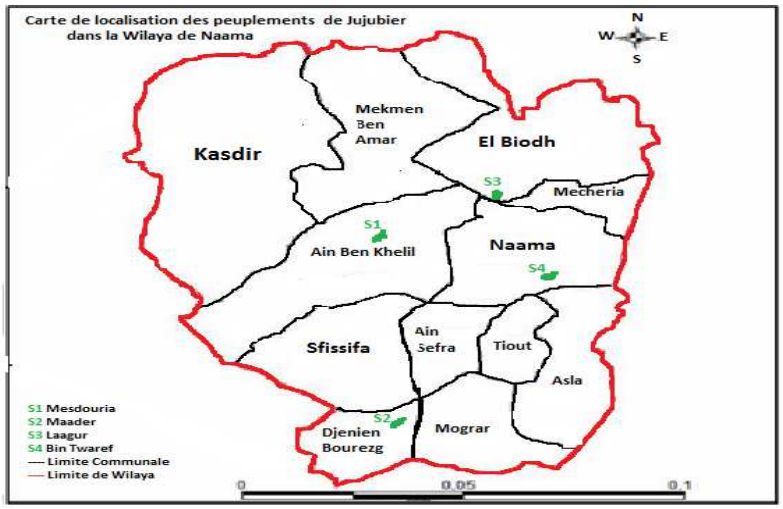

Figure 02: localization of the pure stand of Zizyphus in the Naama region (AMARA, 2015)

With an area of more than 1444 ha, jujube is distributed throughout the territory of the Naama region. Its presence is remarkable in the form of pure stands in the dayas of the areas mentioned. It is also present in the wadis in association of other species like the *Pistacia atlantica* and the *Nerium oleander* (Photo 03).

Photo 03: jujube with the *Pistacia atlantica* and the ***Nerium oleander*** in Djebel Founassa (AMARA, 2016).

4- RESULTS OBTAINED

Observing the development cycle of *Zizyphus lotus* has highlighted some qualities that make it possible to preserve and especially to use this specie in the context of restoring the threatened and degraded ecosystems.

4.1- Phenology of the specie in the four stations

Using the observations made on the phenology of *Zizyphus lotus* throughout the studied region, the following facts are established and summarized in the table 03:

- The bud break is generally on an average of 30 to 35 days concentrated on the month of March
- The foliage spreads on the first week of May and lasts an average of 35 days
- Flowering has an average duration of 30 days and extends throughout the month of May and part of June
- Fruit setting and maturation is fairly long as it extends from May 25 to September 15

• Fruit harvest usually begins at the end of August.
• Defoliation begins with the fall of temperature in the winter from the end of November and lasts until December.

Table 03: Phenological phases of the specie

	Ain Ben Khellil	Djenien Bourezg	El-Biodh	Naama
Budding	5 to 20 March	01 to 20 March	15 to 30 March	10 to 30 March
Foliation	25 March to 28 April	10 March to 15 April	20 March to 10 May	1 avril to 5 May
Flowering	01 mai to 30 May	20 April to 20 May	15 May to 15 Juin	5 May to 5 Juin
Nouaison	25 May to 30 July	15 mai to 30 Juin	01 Juin to 30 July	25 May to 15 July
Maturation	Du 15 August to 15 Septembre	25 July to 5 August	25 August to 15 Septembre	10 August to 5 Septembre
Defoliation	25 November to 30 December	01 to 30 December	01 to 30 December	01 to 30 December

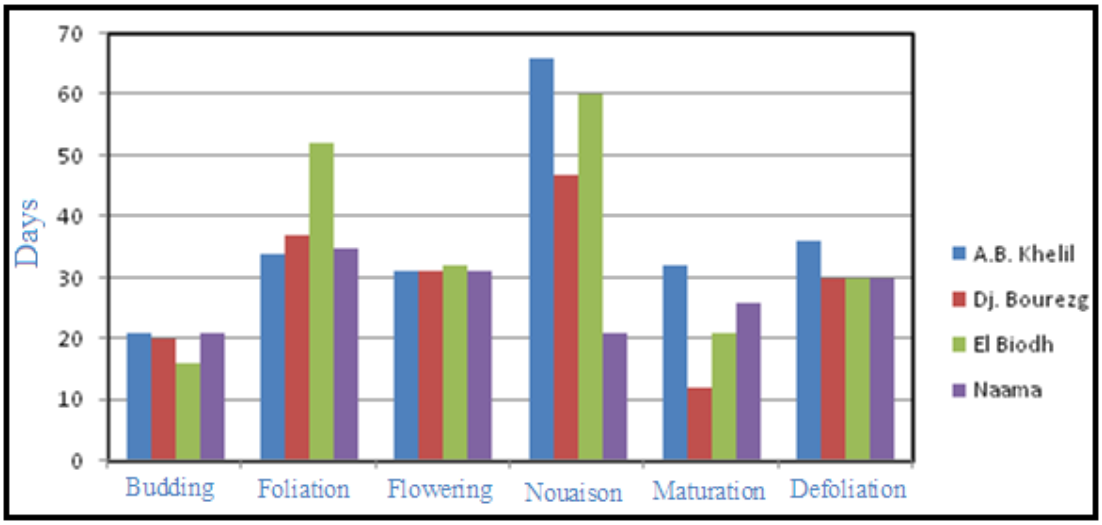

Figure 03: Phenological phases of the specie in the studied stations

4.2- Usefulness of the specie

Field observations have shown that insects that visit jujube flowers play a large role in the transport of pollen. The catches in trees showed that Hymenoptera (bees, wasps) are the main pollen carriers, particularly those belonging to the genus *Apis* and *Cyphonomyx*. In addition, there are many beetles of the genus Lycus and Mylabris: *Milabris nubica* (Beetle), *Apis mellifica* (Hymenoptera), *Lycus semiaplexus* (Coleoptera), *Cyphonomyx croceicornus* (Hymenoptera), *Ammophila cyanipennis* (Sphecidae), *Saropogon melampygus* (Asilidae).

In addition, the only element of attraction of the insects in the jujubiers is the yellow color of the fresh flowers which preferentially attracts the Diptera. For its part, Renner (1990), notes that odor emanation plays an important role in early plant / pollinator relationships. Indeed, according to Willner (1983) and Corbet (1990), bees prefer concentrated nectar rich in sugars. The importance of bees in pollination of flowers was also reported by Berhardt (1989).

4.3-Socio-economic Importance

The preservation of ecosystems and plant formations can contribute to meeting the food and energy needs of populations, especially local populations. Indeed, rural populations have always taken part of their food, building materials, pharmaceutical or energy needs from their immediate natural environment (Bergeret and Ribot, 1990). According to the FAO (1992), the forest contributes significantly to the food security of populations whose tufts of jujube are generally cut and used for the making of enclosures around habitats, cultivated plots and livestock parks and as sources of heating.

The jujube timber is very resistant to termites, serves as stakes, tool handles, kitchen utensils and charcoal or firewood (Roussel, 1995). Fruits are marketed for human consumption and for their medicinal properties. In dayas and areas with jujube potential, beekeepers practice their honey production activities.

However, on agricultural land and infested sites, tufts of jujube Make thousands of hectares uncultivated and hamper the carrying out of agricultural work (plowing, sowing and harvesting of produce), especially in grain crops. They also constitute a refuge for several natural enemies, particularly rodents, insects, spiders, and certain birds that are harmful to agriculture.

Current research on the various pharmacological activities of Jujube has revealed several effects of great importance for modern medicine. The different species of Zizyphus are widely used in the treatment of certain diseases such as digestive disorders, weakness, liver diseases, obesity, urinary disorders, diabetes, skin infections, fever, diarrhea and Insomnia (Abdel-Zaher et al., 2005; Suksamrarn et al., 2005).

The fruits of *Zizyphus lotus*, by its richness in vitamins A and C, phosphorus and protein (Maydel, 1990), are described as softening, and enter into throat treatment and bronchopulmonary irritations, and dry leaf powder and fruit powder are applied in the treatment of furuncle (Borgi et al., 2007).

They have also shown that the leaves and bark of the roots of *Zizyphus lotus* possess significant anti-ulcerogenic activity attributed to the presence of tannins and flavonoids known by their gastro-protective effects. The root bark of the *Zizyphus lotus* is used in traditional medicine in the treatment of diabetes. All these activities confirm the traditional use of this plant in certain inflammatory and painful diseases (Borgi et al., 2007, Ghedira et al., 1995).

Conclusion

The jujube in its various varieties, is an autochthonous specie, rustic and of great ecological plasticity. It develops and produces an appreciable edible fruits in arid environments thanks to their physiological and morphological adaptation mechanisms.

In the study area, the jujube occupies an area of 1444 ha in pure stands in depressions and mixed with Atlas pistachio, laurel and even with Retama retam in sandy areas.

The study of its phenology highlights an adaptation to the conditions of the environment, in particular the precipitations resulting in phenophases of its rather large development cycle. These elements militate in favor of the use of this specie in the context of a restoration of degraded steppe ecosystems in the arid and sub-Saharan zones.

This study can contribute to the creation of a database of phenological observations of jujubier linked to climatic influences and to develop models of the functioning of vegetation and agricultural crops according to its ecological, socio-economic and phytopharmacetic importance in the region .

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