Typology and varietal biodiversity of date palm farms in the North-East of Algerian Sahara

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ABSTRACT
In Algerian desert, oases are characterized by the presence of date palm (Phoenix dactylifera L.) as a dominant species. This plant gives fruit but also creates a favourable microclimate for other crops. The date palm is essential for the oasis agro-ecosystem equilibrium, the latter being a group of small family farms, has been the subject of serious damages in recent years, it’s blossoming. Two cultivars are dominated regarding to their economic importance in local market with 96% (Ghars and Deglet Nour). Recently, a clear degradation of oases was noticed due to the lack of interest from growers to replace old and dead palms. These palm grove have aged palm, high height and a fragile stamina which limiting the cultural operations and affecting grimly the production. Actually, the old palm groves in the North-east of Algerian Sahara are divided into types: “Bour” and “Old palm groves”.

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1. Introduction

The date palm cultivation (Phoenix dactylifera L.) is the keystone of Saharan agriculture. It remains largely the main source of population income within the dispersed oases of Algerian Sahara [1].

An oasis is composed essentially of date palms, in addition to some botanical families [2].

In an oasis, date palms have several benefits by enhancing the quality of soil with organic matter and minimize soil drying, create a favourable microclimate which helps populations to support difficult climatic conditions of desert. In arid regions, water resources are extremely limited. The contribution of groundwater to satisfy date palm water requirements can be very high [3]. However, the rise of water table threatens constantly this plant.

Oasis agroecosystem has faced major problems in recent years and many growers have chosen to leave their exploitation [4]. A socio-economic study by Faci et al. [5] showed an increasingly tendance amongst young growers to look for job opportunities away from oases.

In fact, oasis agroecosystem is experiencing an accelerated degradation due to socio-economic (such as the aging workforce and the lack of supply, means and production), environmental (among others, the sanitation problem, wastewater discharges and invasion of palm groves by concrete) and technical impacts (caused essentially by poor farming practices and lack of maintenance according to Faci et al. [6]).

In this study, we aimed to identify the different types of date palm groves. In a second step, we speculate on the future agro-biodiversity of the date palm varieties.

2. Material and methods

2.1. Geographic location

Our study was carried out in Ouargla region one of the largest oases in the Algerian Sahara. The oasis occupies the centre of an endorheic basin called “Ouargla basin” and it is located in the valley “Oued M’ya” bed, from Sedrata and Gara Krimes in the south to Hassi El-Khefif in the north. The average altitude is 137 m [7].

Ouargla palm groves are located at the North-East of Algerian Sahara (Figure 1) and are among the highest producing regions in Algeria [4].

2.2. Climate

The climate of Ouargla is typical of Saharan desert, with a mild winter which is characterized by low precipitation, whereas the summer is characterized by intense evaporation, high temperatures and luminosity [8].

The average annual temperature is 23.34°C. The warmest and the coldest months are respectively July with an average temperature of 34.81°C and January with an average temperature of 11.65°C.

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Evaporation reaches very high values due to the high temperatures and strong evaporation of air and desiccating winds in particular in July. It reaches 494.73 mm which corresponds to 16 mm per day for an annual total of 3380.64 mm, with a minimum of 103.55 mm in December.

Most precipitation in this region occurs during the winter, although some winters are practically dry. Total annual precipitation is 32.87 mm, November is the rainiest month (7.98 mm) and June is the driest (0.02 mm).

Moisture in Ouargla is low, generally below 50% from March to October, ranging from 24.64% in July to 61.27% in December.

2.3. Topography

The relief of the study area is characterized by low slopes (slightly less than 1‰).

In the Ouargla region, there are three levels of slope:

- The slopes of 2‰ are located from the mountain “Djabel Abbay” to the marsh “Sebkha” (Ouargla).
- The slopes of 1.8‰, are located from the northern of Sebkha to the N’gouça palm grove.

The topography becomes practically flat from N’gouça to the Sebkha of Safioune, with a slope of 0.6‰ [7].

2.4. Geology

According to the National Agency for Hydraulic Resources (ANRH) [7], this region is a part of Lower Sahara, which is a synclinal basin and is characterized by more or less circular sedimentary filling with a diameter of 600 km.

The Lower Sahara is divided into two parts:

- The western basin of Tademait.
- The eastern basin of Tihert.

It is limited to:

- North by Atlas South.
- To the East by the Cretaceous outcrops of the Dahra.
- South by the Tihert cliff.
- To the west by the M’zab ridge.

2.5. Hydrogeology

The Northern Sahara basin constitutes a large hydrological basin of 780,000 km² which extends in Tunisia and Libya, with a thickness of about 4000–5000 m [7]. Two hydrogeological basins have been individualized:

- Western sub-basin of 280,000 km², drained to the south and partly covering the Grand Erg occidental.
- Eastern sub-basin, the largest one with 500,000 km² drained to the Northeast (depression of the big Chotts), and largely occupied by the Grand Erg oriental.

Three aquifers exist in the basement of this region, from bottom to top:

- Sandy clays and clays of C.I (Continental Intermediate) with the so-called “Albienne” tablecloth.
Limestones with the “Senono-Eocene Carbonate” tablecloth.

The detrital (sand and clay) complex of the continental formations with the "Mio-Pliocene” water table.

2.6. Pedology

In the Sahara, the soil cover is very heterogeneous and consists of the following classes:

- Raw mineral soils.
- Poorly developed soils.
- Halomorphic soils.
- Hydromorphic soils.

The mineral fraction consists almost entirely of sand. The organic fraction is very low (less than 1%) and does not allow good aggregation. These soils are very poor, water retention is very low, it is about (8%) in volume of available water [9]. Soils are saline, for the most part, at alkaline pH [10].

Ouargla soils have often calcareous or gypsum crusts, most of them are salty and may be subject to erosion and secondary salinization [11].

Soil typology of the region was classified by Halilat [12] as follows:

- Salsic soils;
- Hydromorphic soils;
- Raw mineral soils.

2.7. Natural vegetation and animal populations

The Directorate of Planning and Spatial Planning (DPAT) [13] mentioned that the identification of plant and animal population in the region of Ouargla is related to the climatic history. The present species are either relic in more humid periods and have managed to maintain themselves, or Mediterranean or tropical species which are adapted to the desert thanks to the appearance of new physiological and / or morphological characters.

Flora, can survive in the desert as scattered species with particular characteristics: far deep roots to trap soil moisture, reduced leaves, to prevent water losses.

Few species of trees are concentrated in the Oasis and in the Oued beds.

In general, the type of vegetation varies according to the physical structure of the zone:

- The Ergs are populated mainly by grasses such as Hadd, Cramcram, Drinn and small bushes of Genets, Jujubiers and Ettels.
- Hamadas can have very sparse vegetation on the plateau and a denser stand on the slopes. There are usually bushes in cliffs and beds of the Oued.

In fact, most of the region’s vegetation, with the exception of the Oasis, which is concentrated in the Oued beds, Dayas and Sebkhas. Grasses and shrubs, such as Tamarisk or Acacia, may have a notable extension in the region.

The natural vegetation is rather due to the nature of soils and their structure as well as the climate.

As far as the fauna and as much as the flora, are rare. The mammals that can be found in the region are insectivores such as the rat with or the Hedgehog of the desert, carnivores such as the Fennec.

Some birds species are properly Saharan: the brown crow, the ganga partridge.

Reptiles often live near the vegetation whereas arthropods are the best species adapted to the Saharan ecological conditions.

Each region, in terms of agriculture, has its specific characteristics in the chain of decision-making of the date farmer and his family in a set of constraints and assets, with a view to achieving their own objectives and governing the production processes on the farm [14].

In order to achieve the study purpose, we used an approach taking into account the specificity of the region, area and the agricultural exploitation as well as the socio-economic and cultural life of the date farmers [15].

A methodology was adopted to grasp the current situation of old palm plantations in this region which preserves the oldest and largest palm groves in Algeria (Figure 2). However, this vulnerable agro-ecosystem is experiencing an alarming situation hence leading to an advanced degradation, due to several factors (sociological, economic and environmental).

The five targeted palm groves are:

- **Ksar (mansion) of Ouargla**: located on the outskirts of Ouargla ksar, composed of three palm groves, namely Beni Ouagguine, Beni Brahim and Beni Sissine. It covers an area of 623 ha;
- **Ngouca**: located twenty-three kilometres north of the palm grove in the Ouargla ksar, occupies an area of more than 300 ha;
- **Chott**: a few kilometres east of the Ouargla palm grove. It is limited to the south by An Beda palm grove;
- **Adjadja**: is located just at north of the chott palm grove;
- **Sidi Khouiled**: located fifteen kilometres east of the Ouargla palm grove. It occupies 22.5 ha.

The tool applied is the semi-structured interview, which affected (120) farms across the five areas under stress (Table 1).

We have approached 21 technical-administrative and scientific structures in the study area.
2.8. Data processing

Analysis and discussion of the parameters that influence negatively or positively the varietal biodiversity of the date palm in the ancient oasis of Ouargla were done. For the purpose of this analytical study, the option for the Multiple Correspondence Factor Analysis (AFCm) was chosen by using the computer tool.

3. Results and discussion

3.1. Agro system characteristics

In Ouargla region, agro systems are composed for the most part of date palms, which represent the upper stratum of the palm grove. Trees and shrubs form the second stratum. The lower stratum is composed of the underlying crops (condimental crops, fodder crops, market gardens, etc.).

75% of surveyed date farmers are practicing a subsistence animal breeding outside palm groves (goats, sheep, poultry, donkeys, horses, rabbits, and ducks.).

Moreover, fodder, vegetable and some fruit trees are the main crops grown in oases (Figure 3).
Also, 10% of farmers are practicing the underlying crops in 55.83% of the farms irrigated area, whereas 34.17% is left uncultivated.

Obtained results revealed that 23% of farms do not have access to water. The majority of the farms are irrigated from the boreholes (94.80%), while irrigation of more than 5% is guaranteed equally through wells and drinking water from the houses.

In 69% of irrigated farms, the irrigation network is moderately good, due to the presence of some leaks, while 9% of the other farms, the pipeline is in poor condition. Only 22% of the irrigation network is in good condition, it is the canals that bring water back to the farms adjacent to the boreholes.

The majority of farmers who irrigated their farms (71%) were satisfied with the volume of irrigation water. However, 29% had expressed their dissatisfaction especially during the summer, when the situation worsened further.

The frequency of irrigation varies from one farm to another, depending on the size and density of the plantation and on the other hand it depends on the financial capacity of each farmer. As a result, they irrigate their farms once a fortnight and up to twice a week. The monthly volume varies between one hour and 36 h.

3.2. Characteristics of agricultural labour in the region of Ouargla

The socio-economic environment directly affects the development of agriculture because of the interrelated relationships between the different factors that makes agriculture socially acceptable and economically profitable.

Indeed, the socio-economic factors in the region of Ouargla affect the development of the old palm plantations and consequently the maintenance of the current situation becomes even more disturbing.

Thus, after this analysis, the variable labour and the limiting factor on the farm were characterized by:

- Aging: approximately half of the farmers (46%) are over 60 years old while those under 40 years old represent only 13%, a real ultimatum for the next generation.

- Low level of education: only 12% of farmers have a university degree and / or secondary level, a criterion which limits the practice of new cropping techniques, the use of plant protection products and even contact with the various management structures and support.

- The lack of operators in farms: 73% of the respondents have other ancillary activities or are retired. Accordingly, they do not count on farm income as financial source.

- The disappearance of social assistance “Touiza”: mutual social assistance between farmers is going to disappear. Less than 13% of the interrogated farmers use barely this type of help.

This is limited to the scale of the family for carrying out some tasks, such as the installation of windbreaks and irrigation networks resulting the degradation of the surrounding environment, such as agricultural roads and drains, as operators are still awaiting the intervention of state structures to carry out and maintain them.

3.3. Date palm in the region of Ouargla

Ministry of Agriculture and Rural Development (MADR) [16] stated that 2/3 of the agricultural areas in the Ouargla department are occupied by the date palm, while this fraction reaches 3/4 in this region. In the majority of communes, the area exceeds the average rate of the region, where it is close to 100% in the commune of Ouargla.

Our surveys showed clearly that the majority of farms (61%) have area less than 1/2 hectare (ha), while farms with plots between 1/2 and 1 ha are around 19%. For areas exceeding one hectare, they represent 20% in the identified farms. The small area at the farms is the main characteristic of the old palm plantations.

The highest number of holdings is less than 0.5 ha in the Ksar palm grove (73%), which is characterized by fragmentation. The percentage of farms with an area of more than one hectare is (12%).

3.4. Date palm varietal distribution

In Ouargla, 64.48% of date palms are Ghars cultivar, 33.02% are Deglet Nour and a insignificant rate of Degla Beida [16].

It is noted that the Ghars and Deglet Nour varieties are dominant in this region. The difference between the total and related numbers is very high for Deglet Nour variety, as the majority of farmers use Deglet Nour plantation at the development perimeters for that market value. The difference in the Ghars variety is small compared to Deglet Nour. On the other hand, it is very low for the other varieties, which means the low planting rate of the latter.

3.5. Date palm age

Most palms in studied farms are over 30 years old. 54% of the farms contain palm trees that are over 80 years
old and 33% are between 30 and 80 years old. For those with palms less than 30 years old, they represent 13% of the total studied farms, often located in the palm groves of N’gouça, Chott and Adjadja.

We note that the most advanced age palm trees are recorded in Sidi Khouiled (73%) and the Ksar (67%). We do not find farms in Chott and Adjadja which are less than 30 years old due to the presence of Chott and Sebkha constraining the exploitation of new land.

3.6. Varietal structure

We have listed 31 varieties during our survey unlike Benkhalifa et al. [17] who had identified 58 varieties in Ouargla. This regression may be due to the erosion of a few varieties such as: Bayadir, Bidh The hmeme, Deghel Bakhtou, El Khammara, Kenta, Mizzite, Sbaâ Loucif, Taouddente, ... etc. (Appendix 1). As a result, almost all the farms (96.67%) are composed of several varieties of the date-tree, where the predominance of Ghars variety is found in 56.67% and Deglet Nour about 36.67%; whereas 3.33% of farms are characterized by the co-dominance of two varieties.

A small percentage of Ghars variety is registered in the N’gouça palm grove (49%), and Deglet Nour is registered in the ksar palm grove (30%) (Table 2).

In addition to these two varieties, the varieties of Ali Ourached, Ittime, Mizzite, Tafezouine, Takermouste and Tamesrite are present in all the palm groves of the region. Bent Khbala is present in all study areas, except in Sidi Khouiled area which is characterized by the predominance of the Ghars and Deglet Nour varieties.

The percentage of monovarietal farms in the region is 01.66% for both Ghars and Deglet Nour. They are located in the N’gouça palm grove, are new farms or renewed farms (Table 3).

3.7. Areas occupied by the date palm

The plots are totally occupied by the date palm (83%) and extension is not possible, while for the remaining 17% areas are devoted to date palms partially which are located in the extension zones, in the vicinity of the old palm groves.

We noted that the holdings are partially occupied by the N’gouça date palm with 29%, they represent the extension areas of the palm plantation. In Adjadja, all farms are entirely planted.

3.8. Planting methods

Two types of plantations in the old palm groves of Ouargla exist. The classic irrigated plantation (49%), characterized by high density and non-respect of the space between the palm trees and the improved planting, which respects the space and represents 51% of the studied farms.

Unlike other palm groves in the region, we found improved planting in the Chott (69%) and Adjadja (64%) palm groves.

3.9. Presence of Dokkar

The Dokkar, male of date palm, is present in 3/4 of the farms. These palms vary between 1 and 10, depending on the area and density of plantation. For holdings without Dokkar (25%). Only 29% of farmers don’t have the Dokkar and use the purchase of male spathes; 71% of the farmers obtain the pollen from a donation, close relatives and / or neighbours.

3.10. Production date

Date production often oscillates between 30 and 70 kg/tree. However, there are 27% of farms of which the production is less than 30 kg/tree or more than 70 kg/tree.

3.11. Rejuvenation of farms

Farmers who have planted offshoots in the last ten years since the late 1990s account for 52% of the respondents, the number of planted palms ranges from 3 to 30, the rest of the farmers have not planted any rejections during this period.
**Table 5.** Specific characteristics of the former palm groves of the Ouargla.

| Type of palm plantation | Sub-class     | Specific features                                                                 |
|-------------------------|---------------|-----------------------------------------------------------------------------------|
| Bour                    | Non-irrigated (classic) | - Invaded by sand dunes.               |
|                         |                | - Not maintained.                   |
|                         |                | - Absence of organic fertilization.       |
|                         |                | - Low production.                    |
|                         |                | - Close to development perimeters.     |
|                         |                | - Irrigated from boreholes or wells.   |
|                         |                | - Presence of the underlying crops.    |
|                         |                | - Pollination and regular harvesting.  |
|                         |                | - Predominance of Ghars, Deglet Nour or both.                                      |
|                         |                | - Failure to respect the space between the palm trees.                              |
|                         |                | - High density.                      |
| Traditional             | Classic polyvarietal | - Predominance of the Ghars or Deglet Nour variety.                                |
|                         |                | - Respecting the space between the palm trees.                                     |
|                         | Improved polyvarietal | - Existence of the Ghars or Deglet Nour variety.                                   |
|                         |                | - Respecting the space between palms.                                              |
|                         | Improved monovarietal |                                                                                   |

The Ksar palm grove is distinguished from other palm groves in the region by the low rate of rejuvenation (37%).

It is reported that 23% of farmers have lost date varieties without replacing them. Indeed, genetic erosion is the result of the loss of low-value varieties such as Deghel Bakhtou and El Khammara.

This loss is observed remarkably in the N’gouca palm grove (49%) because of the increased interest of farmers in the commercial varieties (Deglet Nour and Ghars).

### 3.12. Typology of holdings

We can split the palm groves of the ancient oasis at Ouargla into three distinct types:

- “Bour” palm groves, located in the areas of N’gouça and Sidi Khouiled.
- Irrigated palm groves of “Bour” origin, are located to the East of the N’gouça palm grove.
- Ancient palm groves, known as traditional (irrigated palm groves), which could divided into three subclasses: polyvarietal classics, improved polyvarietals, and improved monovarietals, the latter we found them in the N’gouça zone.

Each of these three types has its own characteristics and specificities. Table 4 gives the general palm grove characteristics.

Table 5 presents the specificities of traditional and “Bour” palm groves.

### 4. Conclusions

Ouargla palm groves are characterized by the constant erosion of low commercial value. Unfortunately, farmers didn’t give importance to the regenartation of their palms, and when it comes to plant new Djebbars (offshoots), they usually choose varieties of high commercial value. More importantly, the majority of palm groves (96%) are composed mainly of Ghars and / or Deglet Nour varieties.

This situation does not rule out the existence of a few “typical” farms across the different study areas, as in the case of Beni Brahim in the Ksar palm grove, where farms are well maintained with the presence of windbreaks, the practice of organic fertilization (not frequently) and the presence of underlying crops and some fruit trees. Rejuvenation is a priority for these operators; they plant new palms of different local varieties with respect for the space between palms. The specificity of these holdings is their large (non-fragmented) areas. The owners of these farms are older (more than 70 years old), which leaves us wondering about their future.

The old palm groves consist of aged palms, high height and a fragile resistance which limiting the cultural operations and affecting severely the production which has already regressed with the advancement of the age.

We can split the palm groves of the ancient oasis of Ouargla into two types: “Bour” palm groves (irrigated and non-irrigated) and ancient palm groves, known as traditional (irrigated palm groves); the latter are divided into three subclasses: poly varieties, improved polyvarietal and monovarietal.

This study clearly shows that the varietal biodiversity of the date palm is threatened in Ouargla.

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Appendix

Table 1. Date palm varieties identified on the farms visited

| Varieties            | Ouargla | N’gouça | Chott | Adjadja | Sidi Khouiled |
|----------------------|---------|---------|-------|---------|---------------|
| Abd Laâzaze          | −       | −       | +     | +       | −             |
| Ali Ourached         | +       | +       | +     | +       | −             |
| Ammari               | −       | −       | +     | −       | −             |
| Bent Khbala          | +       | +       | +     | −       | −             |
| Bent Nouh            | −       | −       | +     | −       | −             |
| Bent Zeghache        | −       | +       | +     | −       | −             |
| Bôd L’Imennene       | +       | +       | +     | −       | −             |
| Degla Beda           | +       | +       | +     | −       | −             |
| Degla Hamra          | −       | −       | +     | −       | −             |
| Deglet El Ghourghage  | −       | −       | +     | −       | −             |
| Deglet Nouh          | −       | −       | +     | −       | −             |
| Deglet Sour          | +       | +       | +     | +       | −             |
| Deglet Sba Aghrass   | +       | −       | +     | −       | −             |
| Gars                 | +       | +       | +     | +       | −             |
| Hammraia             | −       | +       | +     | −       | −             |
| Harechaia            | −       | +       | +     | −       | −             |
| Ittine               | +       | +       | +     | +       | −             |
| Kenta                | −       | +       | +     | −       | −             |
| K’la Bakhtou         | −       | +       | +     | −       | −             |
| Mizabe               | +       | +       | +     | −       | −             |
| Mizitte              | +       | +       | +     | +       | −             |
| Sebaa Oua Drai       | +       | −       | +     | −       | −             |
| Tarcherouite         | −       | +       | +     | −       | −             |
| Tadabboute           | −       | +       | +     | −       | −             |
| Tafezouine           | +       | +       | +     | +       | −             |
| Takermoustte         | +       | +       | +     | +       | −             |
| Tamesritte           | +       | +       | +     | +       | −             |
| Taouddente           | −       | +       | +     | −       | −             |
| Tati Oua Tnouh       | −       | +       | +     | −       | −             |
| Timjouherte          | −       | +       | +     | −       | −             |
| Timnakkour           | −       | +       | +     | −       | −             |
| Total                | 13      | 20      | 19    | 15      | 09            |

|                      | 31      |