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Impact of water and soil interaction on date quality of Deglet-Noor

Kaouther Debabeche[1, 2, 3]*, Mahmoud Debabeche[2], Ziane Laiadi[4]
[1]*University of Mohamed Khider, Biskra, Faculty of Exact Sciences, Natural Sciences and Life Sciences, Department of Agricultural Sciences, Biskra, Algeria*
[2]*University of Mohamed Khider, Biskra, Laboratory of Civil Engineering and Hydraulics Sustainable Development and Environment, Biskra, Algeria*
[3]*Centre for Scientific and Technical Research on Arid Regions, University Campus Mohamed Khider University, Biskra, Algeria*
[4]*University of Mohamed Khider, Biskra, Laboratory of Genetic, Biotechnology and Valorization of Bio-resources, Biskra, Algeria*

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The vast area cultivated which includes a variety of environment, climate, and agricultural maintenance, can affect the quality of the crop also the literature about the export of dates shows that those produced in the municipality of Tolga offering an opportunity for a strong export. Therefore, the objective of this study is to show the impact of the physicochemical interaction of water and soil on the intraspecific variability of Deglet-Noor. So, we will try to study the quality of Deglet-Noor dates under three axes: phenotypic, physicochemical, and biochemical in five municipalities among which Tolga. Principal Component Analysis showed a wide spectrum of variation between water and soil conditions affecting date quality. Application of fertilizer in a very salty, moderately calcareous gypseous soil allowed to produce dates considered as a good whose phenotypical and physicochemical characteristics are ranked among the best (yield with 264 kg palm^{-1} including size 4.47 cm and weight of dates 13.69 g, and moisture content 25.99% and a good consistency 2.15); the application of fertilizer in a very salty highly calcareous, moderately gypseous soil enhanced fruit phenotypical and physicochemical characteristics (yield with 252 kg palm^{-1}); the application of fertilizer in a very salty soil highly calcareous, loam type, of Sidi Okba make possible to present dates with improvements in physicochemical and biochemical characteristics (total soluble solids 70.95%, total sugars 71.68% including sucrose 41.44% levels); salinity in a moderately gypsum and calcareous of Ouled Djellel gave more or less a good biochemical level of dates (reducing sugars 30.62%).

Keywords: characteristics, dates, *Phoenix dactylifera*, soil, water

1 Introduction

The date palm is an important component of oasis farming systems because it tolerates extreme environmental conditions: high temperatures, drought, and salinity more than many other fruit plant species. Also, its cultivation contributes to ensuring socio-economic purposes. It is considered amongst woody plants that belong to the family Arecaceae, genus Phoenix (Al-Khalifah et al., 2013). *Phoenix dactylifera* is the only Phoenix species cultivated for its fruit from one dozen species of palms (Robinson et al., 2012). It is propagated in more than 40 countries (Jaradat and Zaid, 2004). FAOSTAT (2019) estimated world production of dates more than 8 million tons for the agricultural campaign 2016/2017 whose Algeria calls for a strong productive and commercial dynamic in a total of more than 20 million palm trees (MADRP, 2018). It ranks fourth in the list of dates producer countries, has a significant phoenicicultural potential whose production 1 million ton for the same year (FAOSTAT, 2019) in which the wilaya of Biskra, from all fifteen dates producing wilayas, contributes significantly to supplying national and international markets with dates. It ensures the operations of production for 25% of the total cultivated area in date palm on a national level, in areas

***Corresponding Author:** Kaouther Debabeche, University of Mohamed Khider, Biskra, Laboratory of Civil Engineering and Hydraulics Sustainable Development and Environment, BP 145 RP, 07000, Biskra, Algeria. e-mail: kaoutherdebabeche@gmail.com ORCID: https://orcid.org/ 0000-0002-3619-0059

of 43,105 hectares. The variety of Deglet-Noor occupies two-thirds of these areas for the agricultural campaign 2016/2017. The mean yield of date production varies between 40 and 290 kg of dates per date palm in the wilaya of Biskra (MADRP, 2018).

The fruit of the date palm is composed of a fleshy pericarp and one seed. It is considered a good source of energy as long as it is rich in carbohydrates. Concerning the food importance, the flesh date fruit, numerous studies in the world have been reported on dates in terms of fruit quality (Meligi et al., 1982; Mohammed et al., 1983; Estanove, 1990; Jaradat and Zaid, 2004).

Besides, many studies on Algerian dates dealing with the effect of cultivation techniques (pollination, fruit thinning, bunch removal, bunch bagging) have been reported to identify date quality (Acourène and Tama, 2002). Other studies touched soil and water proprieties on the date fruit in the Wargla basin (Bouhoun et al., 2011).

However, there are no interesting studies in this way in Ziban (Biskra), despite the reputation of the oases of Biskra in Algeria. Especially, these large areas, combine a diversity of the environment, climate, and agricultural maintenance, which can influence the date quality, on one side (Munier, 1973; Carr, 2013). On the other side, the literature about the export of Deglet-Noor dates shows that those produced in the municipality of Tolga offering an opportunity for a strong export. Therefore, the objective of this study is to show the impact of physicochemical interaction of water and soil on the intraspecific variability of Deglet-Noor dates in different areas among which palm grove of Tolga. The study focuses on the quality of dates of Deglet-Noor, under three axes: phenotypic, physicochemical and biochemical.

2 Material and methods

2.1 Plant material and experimental conditions

The study was carried out in areas under date palm cultivation, on the Algerian cultivar of "Deglet-Noor", distributed on five municipalities in the wilaya of Biskra (Table 1). The selection of study municipalities is based on the diversity of hydro-edaphic conditions. They present different production levels: more productive for Tolga, moderately productive for Sidi Okba and Ouled Djellel, and less productive for El Outaya (MADRP, 2018). It took place during the agricultural campaign 2017/2018. The choice of the orchards required us to seek that they share the same physical behaviour: age group that is adult, obtain the same water requirements and their female palms pollinated the same type, a bunch average limitation of 14 and fruit thinning. The irrigation system is localized for Tolga, Doucen and El Outaya orchards and those of Sidi Okba and Ouled Djellel use flood irrigation.

The main differences are related to irrigation water quality and soil fertilization. The irrigation water of Tolga and Ouled Djellel orchards is captured by drilling at a depth of 200 m, Sidi Okba at 150 m and Doucen at 120 m. But the water of El Outaya is brought by the fountain of the gazelles dam. The palms of Tolga and Doucen receive annually mineral manure composed of 1.5 kg of urea per palm and a biannual intake of 100 kg of organic manure per palm (first year of input for Tolga and second year of input for Doucen). The palms of Ouled Djellel and Sidi Okba obtain only organic manure every three years (first year of input for Sidi Okba and second year of input for Ouled Djellel). However, El Outaya palms do not benefit from any fertilization.

Table 1 Geographical coordinates of the study sites

Orchards	Latitude (N)	Longitude (E)
Tolga	34 ° 44,289′	5° 21,856′
Doucen	34° 35,906′	5° 5,187′
Ouled Djellel	34° 27,275′	5° 6,020′
Sidi Okba	34° 43,746′	5° 57,753′
El Outaya	34° 55,739′	5° 38,942′

2.2 Climatological features

The collected climatic data were obtained from the National Office of Meteorology (ONM) for the experimental year 2016. Generally, the climate in the wilaya of Biskra is arid, characterized by low annual precipitation with 156 mm and a high sum of evaporation with 2,746 mm. This makes the use of irrigation compulsory. The hot period in the wilaya is quite long. The monthly temperatures recorded are between 13.2 °C and 34.6 °C, of which the thermal index necessary from flowering to dates ripening is estimated at 2,821 °C, that is above 1,800 °C, the thermal limit standard to produce dates (Munier, 1973). Air humidity is relatively low throughout the year, the average is estimated at 45%, the maximum is recorded at 67% in December, excluding the sensitive time of the palm tree. The average wind speed is estimated to be between 26 m s^{-1} and 61 m s^{-1}. This is not considered to be harmful enough, as long as it is recorded in March, the time of emission of spathes.

2.3 Water sampling and analysis

For each orchard, water and soil samples were collected at the time of date harvest. The potential of Hydrogen pH is determined by pH-meter (Multi 3430 WTW) and the electrical conductivity EC by an electrical conductivity meter (HI 2315 Conductivity Meter HANNA) at a temperature of 25 °C. The total hardness of the samples is determined by titration with ethylenediaminetetraacetic acid (EDTA) which quantitatively complex many metals, including calcium (Ca^{+2}) and magnesium (Mg^{+2}) (NF T 90 003, 1984 and NF T 90 016, 1984). The measurement of alkalinity is based on the neutralization of a certain volume of the sample by sulphuric acid (N/50), in the presence of phenolphtalein. Sodium (Na^{+}) and potassium (K^{+}) are measured by a flame photometer (Jenway PFP-7) (NF T 90 019, 1984). Sulphates (SO_4^{-2}) and nitrates (NO_3^{-}) by reading the absorbance using a UV VIS spectrophotometer (HACH DR 6000) and the chlorides (Cl^{-}) are determined by titration with silver nitrate (NF ISO 9297, 2000).

2.4 Soil sampling and analysis

The soil samples were taken around a meter of a date palm up to the depth of 0.5 m. These samples are distributed in the form of a zigzag in the field with a number of five per date palm orchard (Figures 1–5). They were dried in the oven (Memmert UN30) at a temperature of 105 °C for 24 hours and passed through a 2 mm sieve. The Physicochemical analysis represented by soil texture was analyzed using the Robinson pipette method (NF X31 107, 2003), potential of hydrogen pH was determined by using a pH meter with a soil/water ratio: 1/2.5 (NF ISO 10390, 2005). Soil solutions with a soil/water ratio: 1/5 were prepared to determine the electrical conductivity EC (NF ISO 11265, 1995and Baize, 2000). They were measured using a conductivity meter. To obtain information on the balance sheet of the main elements in the soil, we have determined sodium (Na^{+}) and potassium (K^{+}) by using a flame photometer, calcium (Ca^{+2}) and magnesium (Mg^{+2}) by titration with ethylenediaminetetraacetic acid EDTA, sulphates (SO_4^{-2}) and nitrates (NO_3^{-}) by reading the absorbance with a UV VIS spectrophotometer and the chlorides Cl^{-} employing of Mohr method. Soil organic matter was determined by ISO 14235 method (1998). Meaning is the titration of samples containing potassium dichromate ($K_2Cr_2O_7$) and sulphuric acid (H_2SO_4) and reading the absorbance using a UV VIS spectrophotometer. The sodium adsorption ratio (SAR) was calculated, and calcium carbonate ($CaCO_3$) was determined by using the calcimeter Bernard method. $CaCO_3$ was calculated according to following formula (1):

$$CaCO_{3\,total}\,\% = \frac{V \times 0.3}{V' \times P} \times 100 \qquad (1)$$

where:

V – volume of carbon dioxide released (ml); 0.3 – weight of calcium carbonates (control) (g); *V′* – volume of carbon dioxide released (control) (ml); *P* – weight of the sampled soil (g)

Figure 1 Location of the study date palm orchard of Tolga

Figure 2 Location of the study date palm orchard of Doucen

Figure 3 Location of the study date palm orchard of Ouled Djellel

Figure 4 Location of the study date palm orchard of Sidi Okba

Figure 5 Location of the study date palm orchard of El Outaya (control)

2.5 Dates sampling and analysis

Date samples are only collected at the fully mature stage, with 10 dates per date palm and five feet per study area whose a number of 20 dates was analysed phenotypically and the physicobiochemical analysis was carried out in triplicate.

2.5.1 Phenotypic characteristics

The phenotypic analysis has been performed based on the discriminating biometric characteristics of the descriptor of date palm (IPGRI, 2005); which include the following criteria:

- date and seed sizes;
- date, pulp and seed weights;
- ratios of length and weight of the seed on their date;
- yield of crop obtained by a survey with the farmers.

2.5.2 Physicochemical characteristics

Moisture content was determined by drying 5 g of dates in an oven at 105 °C for 24 hours to a constant weight (Audigie et al., 1978). The potential of hydrogen was determined by using a pH meter. The total soluble solids were determined from a direct reading using a refractometer (DRB 0-45 nD). The total ash content was taken after incineration of the pulp in a muffle furnace (Nabertherm) at a temperature of 500 °C for five to six hours until the appearance of a white or gray coloration (Linden, 1981). The determination of the main mineral elements was determined by atomic absorption spectrophotometer (PerkinElmer PinAAcle 900Z) and by flame photometer (Jenway PFP-7). Dates consistency is felt by measuring the ratio (2):

$$r = (total\ sugars)/(water\ content) \qquad (2)$$

where:

r – ratio; *total sugars content* (%); *water content* (%)

The ratio *r* must be close to 2 to detect that the date has a semi-soft consistency. Beyond 2, the date is too dry, on this side, it is too wet (Munier, 1973).

2.5.3 Biochemical characteristics

To measure the total sugars, the refractometer was used. The dosage of reducing sugars requires the action of an excess of cuproalkaline liquor under well-defined conditions, and the cuprous oxide is separated off and treated with a sulfuric sulphurous solution of ferric sulphate (Navarre, 1974). The content of non-reducing sugars (mainly sucrose) was determined by the subtraction between the total sugar contents and the reducing sugars.

2.6 Statistical analysis

The principal component analysis (PCA) is determined in order to have a representation, on the factorial level, of the orchards compared to groups of variables that are close to them in reality. We considered the treatment of 39 variables (characteristics) in five study date palm orchards (10 for water, 12 for soil and 17 for date fruit). It was performed by using XLSTAT software version 2020.2.3, and the graphic representations were conducted by Microsoft Office Excel 2007.

3 Results and discussion

3.1 Irrigation water quality

Data presented in Table 2 summarized the average values of the chemical composition of different irrigation water qualities. It appears that all water samples are within the normal pH range, between 6.98 and 7.71 (Ayers and Westcot, 1985). Irrigation water from the Sidi Okba orchard is found in a state of excessive salinity with an electrical conductivity (EC) of 5.47 dS m^{-1}. The water of Tolga and Doucen presents very high salinization (Daoud and Halitim, 1994) with respective values of electrical conductivity (EC) of 3.51 and 3.18 dS m^{-1}. Moreover, the ionic balance of irrigation water expressed that of Doucen is rich in calcium (Ca^{+2}) with 617.33 mg l^{-1} and magnesium (Mg^{+2}) with 239.20 mg l^{-1} cations and sulphate anions (SO_4^{-2}) with 2,152.72 mg l^{-1}. Sulphates and Magnesium are the main components of the terminal complex in Doucen. With these high dissolved solids, it can make up a slight problem of clogging in localized irrigation systems. The water of Sidi Okba is characterized by the significant presence of nitrates (NO_3^-) with 36.66 mg l^{-1} and chlorides (Cl^-) anions with 1,122.58 mg l^{-1} compared to other orchards. The first one is an indicator of severe toxicity so that it is greater than 30 mg l^{-1} as a result of the flood irrigation (Ayers and Westcot, 1985). Tolga tends to be richer than other water types in sodium (Na^+) with 476.45 mg l^{-1} and Ouled Djellel in potassium (K^+) with 10 mg l^{-1}.

However, these high degrees of salinity do not pose any problem of infiltration of water into the soil, for Sidi Okba and Doucen, as long as they present the SAR with 25.74 and 15.21 respectively and a slight alkalisation risk could be had in Tolga and Ouled Djellel orchards with 25.08 and 32.90. In contrast, the irrigation water of El Outaya, which is characterized by a low salinity of 1.07 dS m^{-1}, experienced a problem of severe alkalization because of SAR with an estimated value of 19.26 (Ayers and Westcot, 1985).

Table 2 Chemical characteristics of irrigation water for five study orchards (means and standard deviations)

Water	pH	EC	SAR	Na^+	K^+
Tolga	7.56 ±0.05	3.51 ±0.02	25.08 ±0.03	476.45±1.11	9.99 ±0.43
Doucen	6.98 ±0.05	3.18 ±0.02	15.21 ±0.00	314.81 ±0.89	8.95 ±0.70
Ouled Djellel	7.68 ±4.43	3.22 ±0.28	32.90 ±0.00	472 ±25.24	10 ±6.00
Sidi Okba	7.18 ±0.00	5.47 ±0.00	25.74 ±0.07	444.12 ±2.37	4.28 ±1.01
El Outaya	7.71 ±0.02	1.0 7 ±0.02	19.26 ±0.06	190.95 ±0.30	8.37 ±0.36

Water	Ca^{+2}	Mg^{+2}	SO_4^{-2}	NO_3^-	Cl^-
Tolga	516 ±6.35	205.60 ±5.13	1534.54 ±3.65	8.74 ±0.90	122.90 ±0.82
Doucen	617.33 ±1.22	239.20 ±1.00	2152.72 ±7.19	8.37 ±2.04	77.99 ±1.05
Ouled Djellel	185.33 ±50.20	226.33 ±24.54	1,333.90 ±152.83	23 ±3.46	627 ±124.53
Sidi Okba	386.67 ±5.03	208.8 ±5.50	1040 ±4.51	36.66 ±2.20	1,122.58 ±73.79
El Outaya	161.33 ±2.81	35.20 ±1.69	276.36 ±1.50	7.57 ±0.87	42.54 ±1.00

EC (dS m^{-1}); mineral elements (mg l^{-1})

3.2 Identification of soil types

Triangle of soil textures showed that the soils of Tolga, Doucen and El Outaya are silty clay loam type and those of Ouled Djellel and Sidi okba are loam type (Table 3).

The soil of Tolga is loaded in gypsum ($CaSO_4 \cdot 2\,H_2O$) with 71.70%, justifying an availability of sulphates (SO_4^{-2}) and calcium (Ca^{+2}) in high levels 616.73 mg l^{-1} and 1,453 mg l^{-1} respectively (Table 4). Van Alphen and De los Ríos Romero (1971) explained this to the evaporation of high levels of sulphates from groundwater which helps in its formation. Depending on Lee et al. (2004), gypsum works on reduction soil pH slightly which can reach 7.86, also that elevation soil electrical conductivity (EC), make it very salty, with 2.99 dS m^{-1}. The high presence of sulphates (SO_4^{-2}) in the soil, allows improving the efficient use of the nitrogen fertilizer in the calcareous soil (Kassem, 2012). The calcium (Ca^{+2}), it can explain its origin also from limestone ($CaCO_3$) as long as the Tolga soil is estimated to be moderately calcareous. This state does not prevent Tolga soil appearing to be richer in organic matter, 7.02%. By the way, the soil organic matter amendment in this orchard can be very successful in preventing the soil from high salinization (Mlih et al., 2015).

The soil of Ouled Djellel is, also, moderately calcareous as long as it is less than 25% (Baize, 2000) and it is salty represented by an EC value of 2.3 dS m^{-1}, medium rich in organic matter, less than 3% (Hazelton and Murphy, 2007), with 2.91%. The cations of Na^+ and Mg^{+2} are highly presented respectively with 242.10 mg l^{-1} and 236.50 mg l^{-1} (Table 3), explained essentially by the nature of dolomitic soils ($CaMg(CO_3)_2$).

The soils of Doucen and Sidi Okba are strongly calcareous, introduced total limestone values with 34.23% and 26.57%. The first one is salty with 1.73 dS m^{-1}, acquired mostly by the solubility of calcium sulphate $CaSO_4$ and magnesium sulphate $MgSO_4$ from underground water (Bakalowicz, 1976) and it is in a rich state in organic matter with 4.86% and the second one is characterised by very high salinity, more than 2.4 dS m^{-1} (Aubert, 1978), 3.39 dS m^{-1} with the significant presence of Cl^- (460.38 mg l^{-1}), K^+ (14.56 mg l^{-1}) and NO_3^- (38.90 mg l^{-1}). The last one is related to the richness in organic matter 6.25% (Table 3), an indicator of the good reception of fertilization and flood irrigation (Bakalowicz, 1994).

Table 3 Physicochemical characteristics of soil of five study orchards (means and standard deviations)

Soil	Clay	Silt	Sand	Gypsum	Total limestone	Organic matter	pH	EC
Tolga	33.33 ±2.89	57.27 ±1.50	9.40 ±1.39	71.7 ±0.50	17.01 ±2.72	7.02 ±0.64	7.86 ±0.06	2.99 ±0.11
Doucen	30 ±0.00	52.83 ±2.00	17.17 ±2.00	14,1 ±6.23	34.23 ±2.22	4.86 ±0.46	7.97 ±0.10	1.73 ±0.79
Ouled Djellel	19.80 ±3.29	34.13 ±2.29	46.07 ±1.29	12.2 ±1.01	23.15 ±2.15	2.91 ±0.50	7.94 ±0.00	2.30 ±0.05
Sidi Okba	23.96 ±3.34	34.20 ±8.75	41.84 ±5.72	2.16 ±0.01	26.57 ±2.10	6.25 ±0.03	7.97 ±0.18	3.39 ±0.15
El Outaya	32.57 ±1.21	58.40 ±1.45	9.03 ±0.55	2.3 ±2.11	50.60 ±3.51	2.44 ±0.90	8.10 ±0.01	0.50 ±0.00

granulometric contents, gypsum, total limestone, organic matter (%); EC (dS m^{-1})

Table 4 Ionic balance of soil of five study orchards (means and standard deviations)

Soil	Na^+	K^+	Ca^{+2}	Mg^{+2}	SO_4^{-2}	NO_3^-	Cl^-
Tolga	66.76 ±6.90	5.76 ±3.07	616.73 ±16.40	67.31 ±17.02	1453 ±392.58	11.16 ±3.60	139.65 ±23.18
Doucen	40.05 ±5.68	12.98 ±2.86	345.48 ±177.20	49.47 ±18.86	887.41 ±495.81	9.26 ±3.39	122.11 ±20.16
Ouled Djellel	242.10 ±90.23	7.00 ±5.25	30 ±4.06	236.50 ±98.7	1,005.78 ±101.2	24.50 ±6.20	222.11 ±19.57
Sidi Okba	220.42 ±127.96	14.56 ±8.67	479.67 ±171.79	76.08 ±43.61	1,154.06 ±426.15	38.90 ±4.14	460.38 ±127.63
El Outaya	46.80 ±5.90	9.99 ±3.01	41.33 ±0.46	14 ±0.14	83.64 ±11.97	9.92 ±2.89	248.15 ±21.20

mineral elements (mg l^{-1})

Besides, salinity is almost non-existent in the soil of El Outaya as long as the EC value is less than 0.6 dS m^{-1} (Aubert, 1978) 0.5 dS m^{-1} and average availability of organic matter is marked (Hazelton and Murphy, 2007) with 2.44%. The soil of El Outaya is rich in limestone in a very strong way with 50.60%. It makes it of very basic character with a pH value well distinguishable 8.10 (Sarkar and Haldar, 2005) (Table 3).

3.3 Effect of irrigation water and soil on fruit of Deglet-Noor

The principal component analysis (PCA) indicated that the graphic representation of the information is based on two axes (1 and 2) which explain 76.04% (Table 5) of the total variability of the physicochemical characteristics of the water and the soil with the main phenotypic, physicochemical and biochemical characteristics of the dates.

This analysis showed a wide spectrum of variation between water and soil conditions which affect date quality where the dates of the study orchards stand out one from the other in three groups. The graphic representation exhibited the first axis whose the orchards of Tolga and Doucen, located in the positive direction, (4.672 and 2.550) opposes the orchards of El Outaya and Ouled Djellel (-6.708 and -2.913), having opposite characteristics, in the negative direction. In the second axis, the orchard of Sidi Okba is located (5.377), wherein the orchards of El Outaya, Sidi Okba and Tolga had strong loadings (Figure 6).

In fact, PCA, the positive direction in the axis 1, showed that more the soil of Tolga orchard is rich in organic matter more we find an improvement in the yield 264 kg $palm^{-1}$ (Table 6). According to Van Alphen and De los Ríos Romero (1971), as long as the calcium and the magnesium in the gypsum soil are found in high levels with Ca/Mg ratio greater than 1, this eliminates any likelihood of reducing the yield. Rhoades (1982) cited in Ayers and Westcot (1985) clarified that calcium absorbed by the crop should be greater than 40 mg l^{-1} and since the salinity does not reach 4 dS m^{-1} or even 4.29 dS m^{-1}, the crop of the date palm cannot suffer from any drop (Bouhoun et al., 2011; Carr, 2013).

In a specific way, the application of organic matter has led to improvements in the size and the weight characteristics of the dates: length 4.47 cm, and weight 13.69 g (Tables 6 and 7). According to the standards published by Meligi et al. (1982) and Mohammed et al. (1983), these dates

Table 5 Eigen-values and proportion of the variance explained for two principal components

Eigen values of PCA	Principal Component 1	Principal Component 2
Eigen value	17.516	12.139
Variance (%)	44.912	31.125
% cumulative	44.912	76.037

Table 6 Weight characteristics of Deglet-Noor dates for five study orchards (means and standard deviations)

Orchards	Yield (kg palm $tree^{-1}$)	Date weight (g)	Seed weight (g)	Weight (seed $date^{-1}$)
Tolga	264 ±7.10	13.69 ±2.11	0.90 ±0.15	0.07 ±0.01
Doucen	258 ±9.96	12.30 ±1.14	0.94 ±0.11	0.08 ±0.01
Ouled Djellel	150 ±20.00	8.05 ±0.98	0.73 ±0.08	0.09 ±0.02
Sidi Okba	200 ±26.46	11.35 ±0.81	1.03 ±0.11	0.09 ±0.01
El Outaya	140 ±21.12	7.73 ±0.43	0.75 ±0.02	0.10 ±0.00

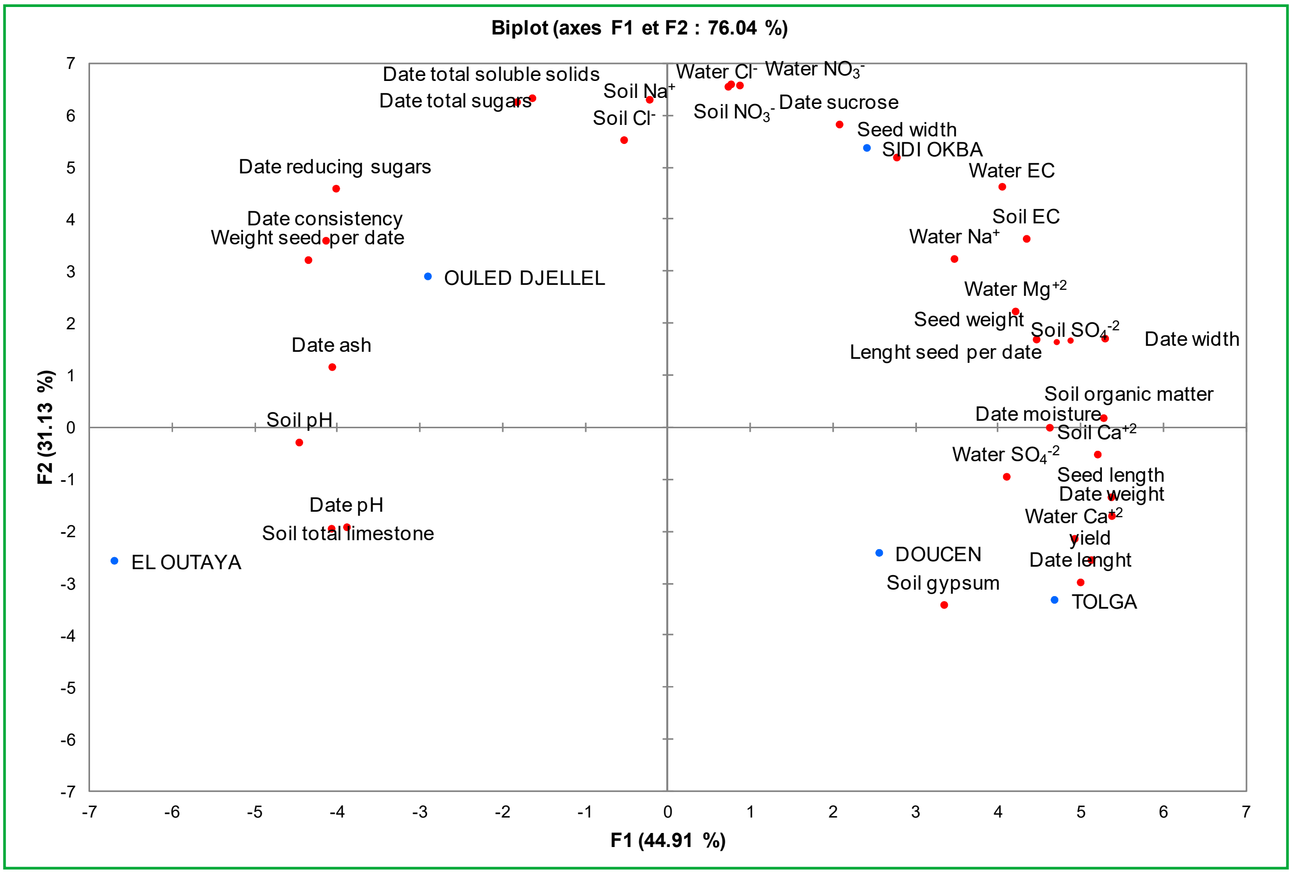

Figure 6 Representation of dates characteristics in relation to the characteristics of water and soil of date palm orchards on the plane 1–2 of principal component analysis

appear good dates as long as its length exceeds 4 cm and characterized by a high weight more than 8 g. The dates of this orchard deserve to be marketable because ratio of weight seed on fruit does not exceed 10%: 0.07 (Munier, 1973). These dates are recorded high values of moisture 25.99% followed by those of Doucen and Sidi Okba (Figure 7) and that are acceptable for conservation (Meligi et al., 1982; Mohammed et al., 1983; Estanove, 1990) and this could be meet export criteria.

Generally, the orchard of Doucen allowed to product dates similar to those of Tolga, with a good yield 252 kg palm-1 (Figure 6). The presence of 14.10% of gypsum in the soil has little or no effect on crop as long as it does not exceed 25% (Van Alphen and De los Ríos Romero, 1971).On the other direction of axis 1, the strong presence of limestone in the soil of El Outaya affected the quality of the dates which makes them small in size: they are short (3 to 4 cm), medium in width (1 to 2 cm) (IPGRI, 2005) and medium weight (6 to 8 g) (Meligi et al., 1982; Mohammed et al., 1983). Generally, they are considered unacceptable for marketing because weight seed on fruit was recorded a value exceeds 10%: 0.12 (Table 6) (Munier, 1973). Also, this character is responsible to raise more at least the pH of dates 6.91 by increasing the ash content to 2.42% (Meligi et al., 1982; Mohammed et al., 1983) (Figure 7).

In the same direction, the orchard of Ouled Djellel is located, including closer characteristics of consistency, and reducing sugars. Ismail et al. (2006) reported that the physical and chemical characteristics of fruits can

Table 7 Biometric characteristics of Deglet-Noor dates for five study orchards (means and standard deviations)

Orchards	Date length (cm)	Date width (cm)	Seed length (cm)	Seed width (cm)	Length (seed date^{-1})
Tolga	4.47 ±0.33	2.12 ±0.20	2.64 ±0.21	0.80 ±0.04	0.59 ±0.01
Doucen	4.36 ±0.17	2.06 ±0.17	2.63 ±0.14	0.79 ±0.06	0.61 ±0.01
Ouled Djellel	3.89 ±0.23	1.88 ±0.04	2.24 ±0.15	0.79 ±0.07	0.58 ±0.03
Sidi Okba	4.14 ±0.26	2.18 ±0.13	2.52 ±0.18	0.84 ±0.03	0.61 ±0.02
El Outaya	3.92 ±0.06	1.77 ±0.08	2.20 ±0.09	0.78 ±0.03	0.56 ±0.02

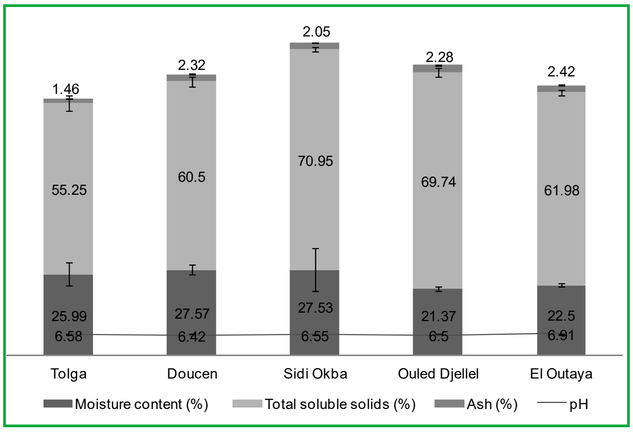

Figure 7 Physico-chemical characteristics of Deglet-Noor dates for five study orchards

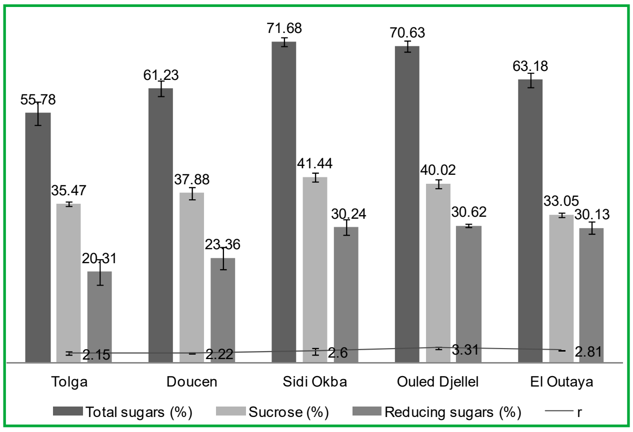

Figure 8 Biochemical characteristics of Deglet-Noor dates for five study orchards

influence their rheological and mechanical properties, which determines their firmness. They are strongly correlated with carbohydrates (El Hadrami and Al-Khayri, 2012) what reports the dates of Ouled Djellel are characterized by hard consistency seen the ratio of the total sugar: water content is greater than 2, especially that they contain a high rate of reducing sugars compared to other dates 30.62% (Figure 8). These characteristics do not comply with export requirements.

On the other axis, the orchard of Sidi Okba, it turns out that the salt concentration of the irrigation water in the positive side of this axis influences the accumulation of salts (Cl^- and NO_3^-) in the water consequently in the soil which affect negatively phenotypic characteristics represented by high seed width value. The contribution of the organic matter produced in the loam soil of Sidi Okba gave dates with high total soluble solids 70.95%, total sugars 71.68% and rich in sucrose 41.44%.

The dates of the orchards of Sidi Okba and Ouled Djellel are classified among the fruits graded first choice, considering its contents in reducing sugars which is between 20 and 40%, sucrose which are between 40 and 65% and moisture between 15 and 25% (Estanove, 1990). By there and in connection with moisture contents, we can deduct that the dates of Tolga and Doucen demonstrate stability and have a semi-soft consistency because they are close to 2 (Figure 8). Kassem (2012) mentioned that sulphur fertilization was able to enhance the physicochemical characteristics of the fruit.

4 Conclusions

As a result of the present study, a trend of relationship among water and soil characteristics had discriminating effects on most phenotypic, physicochemical, and biochemical characteristics of Deglet-Noor dates; as well it is clear that the production of dates in different areas does not detract from its nutritional value but some of them can meet export standards. Application of fertilizer in a very salty gypsum soil and moderately calcareous of Tolga was capable to produce a good yield with dates with best phenotypic characteristics (yield including size and weight) and physicochemical through its richness in moisture and have a stability in the consistency.

Application of fertilizer in a highly calcareous and moderately gypsum soil of Doucen allowed to produce dates with phenotypic characteristic important in relation to the others).

Application of fertilizer in a very salty soil highly calcareous, loam type, of Sidi Okba make possible to present dates with improvements in physicochemical and biochemical characteristics (total soluble solids, total sugars including sucrose levels).

Salinity in a moderately gypsum and calcareous of Ouled Djellel gave a good biochemical level of dates (reducing sugars).

The control: low salinity in very strongly calcareous soil, and moderately fertile of El Outaya could present dates of good physicochemical characteristics (ash and potential of hydrogen).

Based on these results, it can be recommended that date producers should ensure the relationship between salinity and the input of organic fertilizer to achieve phenotypic improvements in production. Furthermore, make adjustments for the ionic balance of the soil: Ca^{+2}-Mg^{+2} appeared necessary to ensure the best phenotypic quality of the fruit and others employing limit limestone and gypsum contents to have physicochemical and biochemical improvements.

However, the current research was limited to one year of field study in a limited number of palm orchards, so it is suggested that further multi-location field studies be performed to validate these findings.

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