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Morphometrics and morphological comparative study of three natural populations of *Zizyphus Lotus.*

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ABSTRACT

A study of three natural populations of *Zizyphus lotus* was made in Morocco; the purpose is to find the morphological variability within and between its populations. The concerned areas in these investigations are Ain Chifa (sub wet floor), Fez (semi arid) and Guercif (arid zone). The three *Zizyphus lotus* ecotypes are hereinafter referred to, respectively, A, B and C. This study includes the leaves and fruits biometric part complemented by a descriptive macro- and micro- morphological study. To estimate the morphological variability, several characters have been used namely: size and color of the leaf, number of rib, number of long and short spines of the branch, as well as the shape, size, caliber, color and weight of the fruit. The variance's analysis and comparison of means of the studied morphological characters noted diversity between the three sources, this diversity corresponds to different bioclimates, and this morphological variability could be due to environmental conditions.

Keywords: *Zizyphus Lotus*, morphology, leaf, fruit, variability, population

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INTRODUCTION

Jujube (*Zizyphus lotus L.*) commonly known in Morocco as "Sedra" sprouts in all the southern shores of the Mediterranean and extends to Afghanistan. It is an aromatic and medicinal plant widely used in traditional medicine. It has several advantages in terms of nutrition, cosmetics and medicine. Its anti-inflammatory, analgesic and antispasmodic activities were extensively highlighted [1]. In addition to its pharmacological properties, *Zizyphus lotus L.* is very appreciated by many animals for being pastrol and fruit specie (Sheep, cattle, camels and goats) [2]. Meanwhile, it has an important role to fixe mobile substrates by issuing its branches outside the soil [3]. It is also considered as a shelter for some animals such as rodents, insects and reptiles. The *Zizyphus lotus* fruits are rich in alkaloids, flavonoids, sterols, tannins and saponins triterpenoids [4 ; 5]. These features make *Zizyphus lotus L as* a plant of universal value colonizing arid ecological surfaces and semi-arid. However this species experiencing a further deterioration due to the impact of human factors that continues to increase (overgrazing, uprooting farmers for land clearing, etc.). This looting may endanger the survival of this specie. However, no work has been done to study the morphological characterization of the jujube tree in Morocco. It is in this context that our work aims to evaluate the morphological variability of three ecotypes of *Zizyphus lotus L.* located in different climate zones, in order to ensure sustainable production and better utilization of this plant in Morocco.

MATERIAL AND METHODS

Studied stations

The studied populations of *Zizyphus lotus* L. are harvested in three different bioclimatic zones: Ain Chifa (A), Fez (B) and Guercif (C) (figure 1), including climate data are summarized in Table 1.

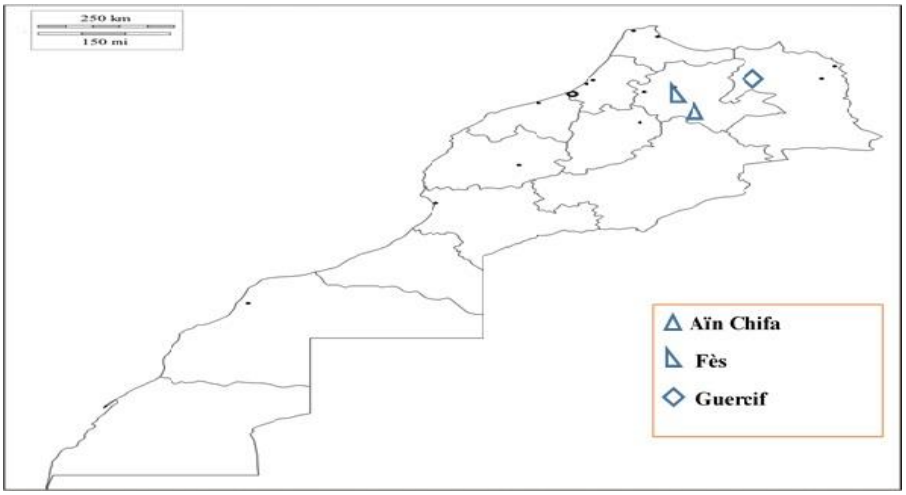

Figure1: Location of sampling stations

Table 1: Main studied stations climate data

Station	Latitude	Longitude	Altitude(m)	*m* (°C)	Pluviometry mm/year	Bioclimatic floor
Aïn chifa (A)	33°47'8 N	5°1'45 W	1084	1,6	460	Sub-Humide
Saïs (B)	34°02'13N	4°59'59 W	403	4	375	Semi-Arid
Guercif (C)	34°13'32'' N	3°21'12'' W	367	9,5	220	Arid

Note : *m* : mean minimum of the coldest month; N: North ; W: West

In each station, we have selected 30 trees randomly and from each of them 10 branches, 20 leaves and 10 fruits were collected from a total of 300 branches, 600 sheets and 300 fruits, were sampled for each study site. Branches, leaves and fruits dried in the open air, were kept in the laboratory. For morphological

measurements, we have used the method described by [6] and in the database of the International Plant Genetic Resources Institute [7].

Morphological measurements characters (Table 2)

Table2: Quantitative and qualitative variables used to measure the three populations of *Z. Lotus*.

Quantitative characters	Qualitative characters
Leaf's length (cm)	Leaf's texture
Leaf's width (cm)	Leaf's odor
Number of main veins	Leaf's color
Branch's length(cm)	Fruit's shape
Number of short spines	Fruit's color
Number of long spines	Fruit's odor
Weight of the branch with leaves (mg)	
Weight of the branch without leaves (mg)	
Fruit's size (mm)	
Fruit's weight (mg)	
Core's weight (mg)	
Pulp's weight (mg)	

Statistics analysis

The data obtained were subjected to statistical analysis (averaging, analysis of variance ANOVA, and standard deviation) in order to search the existing variability between different stations. The data were processed using the software "SYSTAT 12". A comparison of means test was done each time there was a significant effect of factor shown by ANOVA. Thereafter the Pearson correlation test was applied for quantitative variables.

RESULTS

Quantitative characters

Leaves

The results of various quantitative parameters obtained in leaves of *Ziziphus lotus L.* are shown in Table 3.Leaf size varies depending on the harvesting site. Thus they are smaller for the population coming from the region of Guercif, and longer from the region of Fez. The average length is about 1,65 , 2,014 and 2,017 ± 0.5 cm respectively for populations C, A and B.As for the width of the leaves, it varies between 1,26 cm ± 0,22 and 0,23 ± between 1,33cm. Similarly the number of main veins varies from one population to another, it is 3.07, and 3.33 respectively for populations 3,88cm A, B and C. The length / width ratio, ranges from 1,30 to 1,57 cm indicating variability in the leaf shape.

Fruits

The results obtained on *Z. lotus* fruits are reported in table 4. Fruit size is 11 mm and 11,70 respectively for the two varieties A and C. Fruit weight varies from one population to another, they are 646,16 and 559,4mg respectively for populations A and C. The weight of pulp ranges from 207,64 to 362,45 mg respectively for both populations A and C. Otherwise the core weight is of 367,6 mg (population A) and 287,15mg (population C). The pulp / core ratio increased to 0,56% (population A) 1,26% (population C).

Branches

Measured characteristics for the *Z Lotus* branches are shown in Table 5. The length of the branches of *Z. lotus* per station varies between 7,37cm (Guercif) and 8,96cm (AïnChifae).The number of thorns (short and long) varies from one population to another; it is of the order 9,96 , 10,07 and 10,34 respectively for the three

populations A, B and C. For the weight of the branch with the presence of leaves, it varies from 438,13 mg (Guercif) and 490,62mg. Nevertheless, the weight of the branch in the absence of the leaves vary between 70,51mg (AïnChifae) and 87,42mg (Guercif) averaging 74,42mg.

The variation expressed by the coefficients of variation (CV) for quantitative variables is high (> 20%) within each station at the leaf length, length / width ratio of the leaves, main leaf veins, fruit weight and weight of the branch without leaves. In the other hand, variability expressed in terms of other variables is more or less important , it varies between 5.46% and 19,26% (Tables 4, 5 and 6).The analysis of variance for most quantitative variables indicates the presence of highly significant differences between the three stations of study (Tables 3, 4 and 5).

Table 3: Quantitative characters measured for the leaves of *Z. lotus*

Characters		Ain Chifa(A)	Fez (B)	Guercif (C)
Leaf's length (cm)	*Avg*	*2,014*** ± 0,5*	*2,017*** ±0,29*	*1,65*** ± 0,24*
	Min-Max	*1,3-2,3*	*1,1-2,5*	*1,3-2,3*
	CV(%)	***25,90***	***14,377***	***13,714***
Leaf's width (cm)	*Avg*	*1,277*** ±0,13*	*1,33*** ± 0,23*	*1,26*** ± 0 ,22*
	Min-Max	*0,85- 1,5*	*0,7-1,7*	*0,4-1,7*
	CV(%)	***10,56***	***17,29***	***17,46***
The length / width ratio	*Avg*	*1,577bc*** ±0,14*	*1,517***±0,15*	*1,309***±0,36*
	Min-Max	1,13-1,88	1,15-1,91	0,75-1,91
	CV(%)	**9,95**	**10,18**	**25,75**
Number of main veins	*Avg*	*3.07***± 0,27*	*3,33***± 0,6*	*3,38***± 0,81*
	Min-Max	*3-5*	*3-5*	*3-5*
	CV(%)	***8,977***	***18,01***	***20,876***

Note: Average ± standard deviation; *** p < 0,001 ; * p ≤ 0,05 ; CV= Value of the coefficient of variation (%)
Values marked with the same letter are not significantly different.

Table 4: Quantitative characters measured for fruit *Z. lotus*

Characters		Ain Chifa(A)	Fez (B)	Guercif (C)
Fruit size (mm)	*Avg*	*11,7**± 1,044*	-	*11**± 1,15*
	Min-Max	10,22-15,08	-	10,22-15,08
	CV(%)	***8,86***	-	***9,65***
Fruit weight (mg)	*Avg*	*712,62***±* 172,46	-	*649,6***±135,47*
	Min-Max	391,2-1061	-	380-1085
	CV(%)	**26,689**	-	***19,07***
Core weight (mg)	*Avg*	*454.98***±28,06*	-	*287,15***±15,7*
	Min-Max	335-478	-	271,2-302,6
	CV(%)	***7,63***	-	***5,46***
Pulp weight (mg)	*Avg*	*257.64***±16,76*	-	*362,45***±14,12*
	Min-Max	214,1-270,2	-	322,9-440,4
	CV(%)	***8,07***	-	***18,63***
The core / pulp ratio	*Avg*	*1.76***±0,08*	-	*1,262***±0,17*
	Min-Max	0,49-0,87	-	1,12-1,19
	CV(%)	**14,68**	-	**13,84**

Note:Average ± standard deviation; *** p <0,001; * p ≤ 0, 05; CV= Value of the coefficient of variation (%)
Values marked with the same letter are not significantly different.

Table 5: Quantitative characters measured for the branches of the *Z.lotus*

Characters		Ain Chifa(A)	Fez (B)	Guercif (C)
Length of the branch (cm)	*Avg*	*8,967***±0,69*	*7,63***±1,21*	*7,371***±0,91*
	Min-Max	*5,1-7,8*	4,55-9,4	7-9,7
	CV(%)	***7,69***	**15,85**	***12,34***
Number of short spines	*Avg*	*9,967***±0,85*	*10,072***±1,61*	*10,34***±1,11*
	Min-Max	*6-9*	*7-12*	*7-11*

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	CV(%)	***10,67***	***16,01***	***13,77***
Number of long spines	*Avg*	*9,967***±0,85*	*10,072***±1,61*	*10,34***±1,11*
	Min-Max	*6-9*	*7-12*	*7-11*
	CV(%)	**10,67**	**16,01**	**13,77**
Weight of the branch without leaves (mg)	*Avg*	*70,516±17,09*	*65,33±12,08*	*87,42±22,77*
	Min-Max	45,6-109,4	47-124	44-143
	CV(%)	***24,23***	***12,08***	***23,37***
Weight of the branch with leaves (mg)	*Avg*	*490,62***±56,56*	*480,6***±92,6*	*438,13***±67,51*
	Min-Max	243,3-457,5	291-667	232-511
	CV(%)	***11,58***	***19,26***	***15,40***

Note : Average ± standard deviation ; *** p < 0,001 ; * p ≤ 0,05 ; CV= Value of the coefficient of variation (%)
Values marked with the same letter are not significantly different.

Table 6: Correlations between quantitative variables measured for leaves, branches and fruit *Z. lotus*

	Long F	Width F	R Long /Width	Rib P	Nbr Thr C	Nbr Thr L	Long B	Long B With L	Long B Out L	Caliber Fr
Long L	1	0,092	0,238**	-0,037	-0,015	-0,015	-0,029	0,0089	-0,021	0,0615
Width L	0,0924	1	-0,474**	0,254**	-0,004	-0,0043	-0,009	0,184**	-0,03	-0,0813
R Long/Larg	0,238**	-0,474**	1	-0,20**	0,016	0,016	-0,069	0,0363	-0,085	-0,019
Rib P	-0,037	0,254**	-0,204**	1	-0,01	-0,0107	0,0627	0,075	0,114*	-0,0334
Nbr Th C	-0,015	-0,004	0,016	-0,01	1	1**	0,197**	0,132*	0,112*	0,054
Nbr Th L	-0,015	-0,004	0,016	-0,01	1**	1	0,197**	0,13*	0,112*	0,054
Long B	-0,0294	-0,009	-0,069	0,062	0,197**	0,197**	1	0,161**	0,34**	0,005
Long B With F	0,008	0,184	0,036	0,075	0,132*	0,132*	0,161**	1	0,27**	-0,123*
Long B out F	-0,021	-0,03	-0,085	0,114*	0,112*	0,112*	0,34**	0,27**	1	0,026
Caliber Fr	0,061	-0,081	-0,019	-0,033	0,054	0,054	0,005	-0,123*	0,026	1

Note:*, significant a` p < 0,05 ; **, significant a` p < 0,01. ; L, Leaves ; B : Branch ; Fr : Fruits ; P : Principale ; L : Long ; S :Short ; R : Ratio ; With L : With Leaves ; out L : Without Leaves

Several characters are correlated (Table 6). Nevertheless, these correlations are highly significant between the ratio long / wide leaf and the leaf length (r = 0,238) between the width of the sheets and the number of main ribs (r = 0,254) and between the length of the branch and the number of short and long spines (r = 0,197). However, the width of the sheet is negatively correlated and significantly with the report of its long / wide (r = -0,474). Regarding fruit size, correlations are significant with the length of the branch (r = -0.123).

Qualitative characteristics

The results presented in Table 7 correspond to the quality criteria for the three populations of *Z. lotus* A, B and C.

Leaves

The leaves of *Z. Lotus* in the three populations A, B and C are of "Thick" texture. This was recorded for 99% of leaves. The leaves were generally green to dark green. Station A has the darker color of leaves (79%), compared to the stations B (54%) and C (20%). Furthermore, the leaves odor of the stations A, B and C was weak (Table 7).

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Fruits

The fruits are brown to dark brown. At the station A, they are of a lighter color (75%) by contributing to the station C (62%). The whole fruits are oval with a strong odor for the three populations of *Z. Lotus* (Table 7).

Table7: Qualitative characteristics measured for the leaves and fruits of *Z. Lotus*

Characters	Ain Chifa (A)	Fez (B)	Guercif (C)
Leaf texture	99%	99%	99%
Leaf odor	Weak	Weak	Weak
Leaf color	Dark Green : 79% Green : 21%	Dark Green : 46% Green : 54%	Dark Green : 20% green : 80%
Fruit color	Light:75% Dark:25%	-	Light : 58% Dark : 42%
Fruit odor	Strong	-	Strong
Fruit shape	Oval	-	Oval

DISCUSSION

According to this study, the different morphological traits studied for *Z. lotus* show a high variability between the three populations studied. This difference can be explained by many factors including the ecology of living populations environments [8]. Our results are in agreement with [9] who showed that the dimensions and the morphology of the leaves are affected by the environment resulting in variations within the same species (foliar polymorphism). Also the color of the leaf and the fruit can vary under the influence of some geo-physiological phenomena related to the chlorophyll pigments. On other hand, the contents of chlorophyll tend to vary depending on the availability of water, because water stress can causes oxidation of chlorophyll pigments inducing light green leaves. [10] report the same phenomenon in *P. mutica* (*sensu P. atlantica var. latifolia*) et *P. khinjuk* Stocks. On the other hand, in altitude, the content of anthocyanins increased protecting chlorophyll from photo-oxidation caused by UV radiation. [11] made a similar mechanism for eucalyptus. This could explain the dark color in the resorts of High Plains (Guercif) wherein the contents of chlorophylls are more important. The altitude and temperature may play an important role in their distribution and density on leaves; this has been demonstrated in a further study by [12]. Similarly, the dryness and the gradient winter temperatures can affect the texture of the paper. It has been shown that the leaves with thicker texture such as Guercif's population are more abundant with increasing temperature [13].In our study, the leaves had the same texture at all stations. The plants prefer different functional features to minimize the impact of drought [13].In arid environments, xenomorphic plants often wear leaves covered with trichomes and wax. The reduction in leaf size is correlated with the reduction of perspiration; the more aridity increases the more the size of the leaves decreases [14]. According to [13], small leaves tend to be more abundant in the highlands and other cold places. Indeed in our study, the smaller leaves were recorded in the population C. The interaction of climatic factors with the most discriminating variables is obvious. According to [15], altitude has a leading role in the length of the dry season, it could decrease with altitude.

CONCLUSION

A study of morphological variability of three populations of Z. lotus was conducted to assess the qualitative and quantitative characteristics of this plant. The dimensions of the leaf, branch and fruit, the number of rib, short thorns and long spines, the smell of the leaf and fruit, and finally the color and shape of fruit and leaves are the most discriminating characteristics. The determination of different morphological parameters among the three populations of *Ziziphus lotus L*. from different regions contributes to a better knowledge of the species and allows highlighting the behavioral study populations towards climate change. *Zizyphus lotus L*. demonstrates the ability to change some of its biological characteristics to cope with climate conditions in their living environment. This may explain the extent of the geographic range of this species. Nevertheless, the existence of genetic variability is not excluded, and the search for such variability will be a next phase for these species.

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