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Study of Dendrometric and Morphological Variability of *Celtis Australis* Located in Northern Tunisia

Youssef AMMARI[1]; Refka ZOUAOUI[1*]; Majda ABBASI[1] ; Sana JEBALI[2] and Sameh HAMDI[3]
[1] Laboratory of Forest Ecology, National Research Institute of Rural engineering, Water and Forests (INRGREF)
[2] Higher Institute of Biotechnolog, Beja (ISBB)
[3] Higher Institute of Heritage Skills, Tunis (ISMPT)
Corresponding author*: panicumrefka@yahoo.fr

***Abstract* – This study evaluated the morphological variability of forest species "*Celtis australis*" in the subject to determine the existing forms at their ranges throughout Tunisia, based on some qualitative and quantitative morphological descriptors. *Celtis australis* is a vigorous tree of the family Ulamacées. Its height is 30 m and its growth is very slow, but it can reach a very old age. It thrives especially in light, rich and fresh but not wet (Brush, 2000).Cold-resistant, drought and wind (Singht *et al.*, 2004). This species has many interests in particularly medicinal. The results of this study showed a significant morphological variability that affected leaf, seed and fruit of *Celtis australis*. Indeed, quantitative characters (LONG, WIDTH, PERI, ..) of the leaves and cores enabled to distinguish between individuals with long and small leaves. The larger leaves are represented in the Ain Drahem (9,27 cm) while from Kesra represents the smallest leaves (4,54 cm). For characters of fruits and seeds, the provenances of Ain Drahem and Ain bousaadiya show the highest values for all parameters. The analyzed characterization parameters can also be the basis of descriptors to differentiate the provenance of the various regions and select the most vigorous.**

***Keywords* – *Celtisautralis*, Leaves Morphology, Morphological, Variability.**

I. INTRODUCTION

Tunisia is characterized by flora and ecological diversity. This results from the climate variability that extends from humid to Saharien. In addition, it is characterized by its contrasting geomorphology and Pedology. This natural context falling under different habitats favored the development of a rich and diverse natural vegetation (Pottier Alapettite, 1981; Noumi, 2010, Zouaoui, 2014). Generally, the variability of plant species is expressed in the characteristics of the vegetative and / or reproductive system from the plant. For Dosba *et al.* (1999), varietal characterization must involve individuals who are adapted to specific ecological conditions. According Sounigo *et al.* (1997) and Zhang (2002), the description is necessary for all breeding and varietal selection plant operations because it can target interesting morphological descriptors and know those related to environmental factors. For this reason, we have chosen a species of the patrimony plant of Tunisia: *Celtis australis*. This is a medicinal species with leaves and fruits used in the treatment of amenorrhea, heavy menstrualisation and blood and colonic intermenstrualisation (Mazzocchi, 1999). The immature fruit is often considered very effective in medicine (Demir *et al*, 2002). Despite the specific interest in this species, there is an absence of any study of their morphological variability, genetic and chemical characterization and agronomic. Moreover, it should be noted that this species is experiencing a degradation in their natural environment. For this reason, the interest of variability arises. Like all species of Tunisian forests, *Celtis australis* is menaced by ecological upheavals caused by deforestation, overgrazing, agricultural mechanization and urbanization. This situation creates a serious malfunction resulting a loss of biodiversity with genetic erosion and trivialisation of flora (Barbero *et al.*, 1990) and consequent a workforce reduction of this species at the level natural distribution area. The need to slow this process of degradation by protection and appropriate recovery measures is necessary. In this context, it integrates this study that contributes to assessment of biological diversity of "*Celtis australis*" based on the study of inter and intra-specific diversity of provenances in their natural distribution area.

II. MATERIEL AND METHODS

II.1.Materials plant: The plant material used is essentially composed of trees, leaves and seeds of *Celtis australis*.
II.2.Study area: We selected sex provenances to cover the main range of climatic conditions of provenances of *Celtis australis* distribution in Tunisia (Fig. 1 and Table I).
II. 3. Dendrometric study: The measurements were carried out on adult individuals spontaneous in the various stations of study. The study is appreciated by dimensions measures (quantitative characters) of the tree: Chest height diameter (DHP) to 1.30 m; Total height (HT); Height of the first ramification (HP); Crown height (HH) and diameter of the crown (DH); Circumference of crown and Biovolume. The biovolume is determined according to the mathematical formula:
V = ((4/3) * Π * R3) / 2 With: V= hemispherical tree volume (in m^3) ; Π = 3,14 ; R = mean radius of the tree (m)
II.4. Study of the morphological variability
II.4.1.Measurement of structural parameters of the foliage: Sampling leaves of *Celtis australis* has been accomplished on the six areas of study including 20 leaves per tree. The determined parameters are: form the leaf blade; Teeth on the edge blade; Depth lobes; Position of the lobes; Length of main vein and petiole; leaf area; length; width ; thickness, perimeter and ratio (length / width). Leaf area is measured with a digital planimeter.
II.4.2. Morphological characteristics of seeds: The sample was performed at random manner, 30 fruits from each tree. Quantitative variables were determined of kernels: length;

width; thickness; weight kernel, and the ratio width / length. The aspect ratio character of the seed was calculated.

II.5. Statistical analysis: The results were submitted to analysis of variance (ANOVA) by a factor Fisher's F test to check for equality of means of assumption of the risk level of 5% using the SPSS software (version 24). It is complemented by multiple comparisons of means testing by Newman Keuls, Pearson correlation and dendrogram. Then the results were presented as histograms reaching average values framed by their origins.

III. Results and Discussion

III.1.Dendrometric study: The results of figure 2 showed that the total height of *Celtis australis* shaft has a very highly significant ($p = 0.000 < 0.05$; $F = 13.457$) between different provenances studied. It moves from one low height from Henchir naam (2.78 ± 0.43 m) at high height from Kesra (14.82 ± 3.97 m). Similarly, from Kesra shows the dimensions of the highest tree with a diameter at chest height (73.90 ± 26.05 cm); crown height (11.87 ± 3.66 m) and crown diameter (7.03 ± 2.37 m). The ANOVA single factor showed very highly significant variations for different morphological descriptors studied. These results indicate a wide diversity of provenances.

In addition, the highest values were observed in the high altitude area (995 m) in Kesra (Fig.3.a, b, c and d). While the lowest values were encountered at low altitude of Henchir naam (435 m).

The figure 3 shows the variation of tree growth characters of *Celtis australis* in different provenances. These are different from the precipitation, temperature and also relief. In fact, the circumference of the trees passes to (23.57 ± 7.73 m) in Henchir naam at (232.26 ± 81.88 m) in Kesra. Similarly for biovolume, the highest average is recorded in Kesra (90.80 ± 3.49) while the lowest is that in Henchir naam (1.38 ± 0.02). The height of the first ramification is the average of (3.29 ± 0.86 m) in Ain Drahem.

III.2. Analysis of correlations between morphological variables of *Celtis australis*

-Hierarchical clustering (CAH): The hierarchical ascending classification of provenance taken together has gaven a dendrogram (Fig. 4). According a similarity index at 0.998, we distinguished four clusters : C1: Ain Drahem and Ain Bousadia; C 2: Ain soltan and Feija; C 3: Henchir naam and C4: Kessra.

-Correlations between morphological variables of *Celtis australis*: The correlation matrix of Pearson (n) indicates that there are a negative correlations and other positive between variables taken two by two (Table II). Some correlations were negatively high between morphological characteristics of trees of different provenances:

-The Total height of the tree shows strong negative correlations between crown height (r = -0.747) and the diameter of the crown (-0.508).

-The diameter at chest height shows a strong negative correlation with the circumference (r = -1.000).

- The height of the crown expresses a strong negative correlation with the crown diameter (r = -0.538).

- The diameter of the crown shows a strong negative correlation with biovolume (r = -0.906).

III.3.Morphological variability of *Celtis australis* leaves

-Analysis of variance: The analysis of variance and comparison of means were performed at all provenances character by character. The region of AD showed the best morphological descriptors of the sheet of *Celtis australis*. The results of figure 5 show a highly significant effect from ($F = 66.310$, $P = 0.000$) for the leaf surface. Of which the highest value is recorded in Ain darahem (AD) (30.83 ± 11,61cm2) while the lowest value in Kesra (K) (9.76 ± 4.49 cm2) (fig 5a).

Similarly, the leaves of AD (9.27 ± 2.24 cm) are the longest compared to that of K (4.54 ± 1.57 cm) that are shorter (Fig.6b). The analysis of variance showed a very highly significant difference in perimeter of the sheets ($F = 59.946$; $P = 0.000$) from under the effect.

The perimeter leaf from AD (27.48 ± 7.12 cm) is the highest compared with that of K (14.28 ± 3.91 cm) (Fig 5d). Similarly to length of the main leaf vein with (10.35 ± 1.95 cm) in AD compared to (5.90 ± 1.34 cm) K (Fig 6b).

While for the quantitative character (leaf width), the ANOVA with one factor presented a very highly significant ($F = 23.263$, $P = 0.000$) in the provenance effect. The highest value was observed in AB (5.15 ± 2 cm), while the lowest was obtained from the provenance of K (3.26 ± 0.84 cm). The provenance of AB showed the best length of leaf petiole with (1.43 ± 0.45 cm).

-Analysis of correlations between variables of *Celtis australis* leaves: The correlation matrix of Pearson (n) indicates the existence of negative correlations and other positive between variables taken two by two (Table III).

Some correlation coefficients are positively high between the morphological characteristics of leaves of different provenances:

-The leaf surface shows strong positive correlations between leaf length (r = 0.904 **); width (r = 0.584 **) and the perimeter (r = 0.943 **).

-The leaf length shows a strong positive correlation with the perimeter leaf (r = 0.904 **) and the main vein length (r = 0.733 **).

- The leaf width expressed a strong positive correlation with the perimeter leaf (r = 0.555 **) and the midrib of sheet length (r = -0.551 **).

-The perimeter leaf shows a strong positive correlation with length of the main leaf vein (r = 0.807 **).

-Ascending hierarchical classification (CAH): The hierarchical ascending classification of provenances taken together has given a dendrogram (Fig.7). According a similarity index with 0.998, there are three clusters: C1: Ain sultan, El feyja and Henchir naam ; C2: Kessra and C3: Ain Bousadia and Ain Drahem.

III.4. Morphological variability of *Celtis australis* fruit and seed

- Analysis of variance: The variance analysis for each variable (Table IV) revealed a very highly significant difference (P = 0.000) between provenances for all characteristics of fruit and seeds. For the fruits of *Celtis*

australis, comparing the means for the fruit fresh weight character has distinguished (2) homogeneous groups. The average fresh weight is the order of 0.38 ± 0.07 g.
It varies from 1.15 ± 5.41 g to 0.49 ± 0.09 g for the respective provenances of AS and AB.

For the dry weight of fruit, the comparison of the mean has allowed to distinguish (3) homogeneous groups. The mean value is of the order of 0.12 ± 0.14 g reported in AS. It varies from 0.12 ± .14 to 0.24 ± 0.06 g for the respective provenances AS and AD.

Concerning the mean length of fruit, the highest value recorded at AB (176.58 ± 37.78 mm), while the lowest value is encountered in HN (19.34 ± 2.30 mm). The mean length of *Celtis australis* fruit is of the order of 10.41 ± 1.40 mm. While the average width is of the order of 8.47 ± 0.44 mm. The highest width is encountered in AD (9.36 ± 0.60) mm, while the lowest is at AS with 8.19 ± 1.15 mm.
The provenance of AD has a longest peduncle (26.29 ± 5.19 mm) compared to other, especially AS shows the length of the shorter peduncle (8.19 ± 1,15mm). While AB shows the biggest petiole diameter (0.66 ± 0.11 mm)and HN is the smaller (0.49 ± 0.08 mm).

Concerning seeds *Celtis australis*, the seed length shows a significant difference between the sources (F = 2.145; P = 0.059). The comparison of means has allowed to distinguish (2) homogeneous groups. The mean value is on the order of 6.31 ± 0.44 mm with a maximum for the provenance AS (31.35 ± 159.12 mm and a minimum in HN (0.85 ± 0.41).

While the highest seed width is encountered in AD (5.97 ± 0.56 mm) and lowest among in HN (5.28 ± 0.34 mm).The ANOVA test showed a very highly significant difference in the effect provenance (F = 42.835, P = 0.000) for this character. The comparison of means has discriminated (4) homogeneous groups (Table IV).

-Analysis of correlations between variables of *Celtis australis* fruits and seeds*:* The correlation matrix of Pearson (n) indicates the existence of negative correlations and other positive between different variables taken two by two (Table V). Some correlation coefficients are positively high between morphological characters of fruits and seeds for different provenances:

-The Dry weight of fruit shows a strong positive correlation between fruit width (r = 0.454**) and seed width (r = 0.260**).

- The width of fruit shows a strong positive correlation with the length of peduncle (r = 0.263 **) and seed width (r = 0.335**).

- The peduncle length expresses a strong positive correlation with peduncle diameter (r = 0.297**) and seed width (r = 0.332**).

-Ascending hierarchical classification (CAH): The figure 8 shows the hierarchical clustering of provenances combined. According a similarity index with 0.998, there are four clusters: C 1 : Henchir naam, El feyja and Kesra ; C2 2 : Ain Bousadia ; C 3 : Ain Soltan and C 4 : Ain Drahem.

IV. DISCUSSION

The observation of these graphs shows the direct influence of environmental conditions on the growth and productivity of trees *Celtis australis* both at the level structural parameters of foliage than at dendrometric parameters.

The differences between provenances are probably related to climatic, edaphic or genetic conditions that differ between collection sites. Several studies on other species studied the effect of climatic conditions on the morphological characterization of the plants showed that the differences of morphological characters of a given species can be also caused by variation in age between individuals or ecological factors in different geographical areas.

Concerning the morphology of the species, this study highlights a high intra-specific variability and inter-species of *Celtis Australis* for all measurements. The results of this study showed a high variability of the characteristics of the total tree height (14.82 m) and crown (11.87 m) in provenance Kesra.

Indeed, the large variations of the total height; diameter at breast height; height of the crown; circumference and biovolume essences obtained for the entire study area (6 provenances), testify the existence of heterogeneity of *Celtis australis* trees for these characters. This very highly significant variability can be linked to genotypic factors. This principal factor is added other secondary factors including the micro-variations of soil characteristics (Heller, 1996 ; Jongschaap *et al.*, 2007). In fact, Kesra provenance holds a first place for the various parameters studied and is clearly distinguishable from other provenances. It is followed by the provenance of Ain Drahem. While Henchir naam shows the lower values compared with other provenances. Concerning *Celtis australis* leaves, the variability of leaves parameters is generally higher among individuals. This differentiation inside provenance may be related to genotypic factors. Note also, there is a high variability observed for morphological descriptors of fruits and seeds. It is greater in individuals with the exception of weight. This variability of fruit and seeds weight is probably caused by effects of the environment (Kouyaté, 2005 ; Roach et Wulff, 1987 cited by Diallo, 2001). Indeed, seeds and fruits of small size may be justified by the drier climatic conditions of their original localities (Gómez, 2004).

In this parameters, the provenance effect is clearly marked in Ain bousaidiya (highest fruit length (37.78 mm), Ain soltan (highest seed length (31.35 mm) and Ain Drahem (highest peduncle length (26.29 mm)). This situation presents a strong argument to prove the morphological polymorphism noted previously in the provenance and even organs (fruits and leaves). This variability has been obtained for the cork oak acorns (*Quercus suber* L.) of some northern populations of Tunisia (Tlili *et al*,. 2015). In addition, similar results were observed in fruits and seeds cacao of wild Cacao Populations from the Brazilian Amazon (Luiz Antônio D. S.D *et al*., 2003). In general, forest trees such as *Celtis*

australis show a phenological variability as well as morphology, as shown by several provenance tests (Nardini *et al*, 1999; Gandour *et al*, 2007). The variability observed between populations can depend on two factors: the intra-populational variability and the inter-populational variability related both to the effect of the environment and to the genetic structure of the population (Vitasse, 2005).

V. Conclusion

This study aims to determine the dendrometric and morphological characteristics of celtis australis trees, leaves, fruits and seeds. Since there is a range of variation between provenances and in the same origin. The results of this study should serve as guidelines for selection of the best celtis australis ecotypes throughout its range. In addition, We must preserve this plant patrimony in state disparition.In this study, the both provenances (Ain Drahem and Ain bousaadiya) are the best compared to Kesra. In the near future, it will be important to increase the long-term studies on natural provenances in order to understand species response to environmental factors fluctuations.

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Table I. Origin and geographic position of *Celtis australis* provenances

Species	Provenance	Site name (Governorate)	Bioclimat	Geographic coordinates
Celtis australis	Kesra	Siliana	Semi-arid	32S0532999 UTM 3963156 995 m
	Henchir El naam	Siliana	Semi-arid	32S0515529 UTM 4008384 435 m
	Parc national feija	Jendouba	Sub wet	32S0437776 UTM 4038359 775 m
	Ain bousadia	Siliana	Semi-arid	32S0557715 UTM 3989690 527 m
	Ain soltan	Siliana	Semi-Arid with mild winter	32S0440326 UTM 4044906 945 m
	Ain drahem	Jendouba	Sub wet	32S0471575 UTM4070071 709

Table II. Correlation matrix between morphological variables: total height tree (HT); diameter at chest height (DHP); Crown height (HH); Crown diameter (DH); Height of the first ramification (HR); Circumference (C) and Biovolume (B) measured of *Celtis australis* trees

	HT	DHP	HH	DH	HR	C	B
HT	1						
DHP	-0,368	1					
HH	-0,747**	-0,392	1				
DH	-0,508**	0,151	-0,538**	1			
HR	0,225	0,166	0,201	0,145	1		
C	-0,368	-1,000	-0,392	0,151	0,166	1	
B	-0,423	0,212	-0,497	-0,906	0,093	0,212	1

Table III. Correlation matrix between different variables (SFL: leaf area; LONG: length; LARG: width; PER: perimeter ; RAT: length / width; FACT: factor ; LNP: length of the main leaf vein ; LP: petiole length) measured on leaves of *Celtis australis*.

	SFL	LONG	LARG	PER	RAT	FAC	LNP	LP
SFL	1							
LON	0,904**	1						
LAR	0,584**	0,442**	1					
PER	0,943**	0,904**	0,555**	1				
RAT	0,023	0,134*	-0,115*	0,047	1			
FAC	0,056	0,053	0,036	0,057	-0,004	1		
LNP	0,812**	0,733**	0,551**	0,807**	0,001	0,033	1	
LP	0,402**	0,329**	0,277**	0,394**	-0,046	0,037	0,429**	1

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Table IV. Averages of characters (PER: fresh fruit weight, PSC: dry weight of fruit; LOF: fruit length ; LAF: fruit width ; LOP : peduncle length ; DIP: peduncle diameter ; LOG: seed length ; LAG : seed width) kernels of *Celtis australis*

Provenances	PFR (g)	PSC (g)	LOF (mm)	LAF (mm)
HN	0,33±0,04 c	0,15±0,04 b	10,56±0,61 b	7,98±0,44 d
K	0,36±0,05 c	0,15±0,04 b	9,80±9,92 b	8,47±0,44 b
AB	0,49±0,09 ab	0,23±0,07 a	11,01±1,98 b	9,29±0,58 a
AD	0,47±0,08 ab	0,24±0,06 a	37,78±176,58 a	9,36±0,60 a
EF	0.38±0,07 c	0,17±0,05 b	10,92±0,76 b	8,67±0,57 b
AS	1,15±5,41 a	0,12±0,14 c	10,41±1,40 b	8,19±1,15 c
Provenances	**LOP (mm)**	**DIP (mm)**	**LONG (mm)**	**LARG (mm)**
HN	19,34±2,30 c	0,49±0,08 b	0,85±0,41 b	5,28±0,34 d
K	20,91±3,47 c	0,53±0,08 b	5,55±0,40 b	5,32±0,33 d
AB	26,29±5,19 a	5,94±11,47 a	6,31±0,44 b	5,70±0,38 b
AD	23,93±3,79 b	0,49±0,10 b	6,71±0,81 b	5,92±0,50 a
EF	19,84±3,24 c	0,50±0,06 b	6,06±0,63 b	5,49±0,41 c
AS	23,73±8,57 a	0,58±0,07 b	31,35±159,12 a	5,97±0,56 a

Table V. Correlation matrix between the different measured variables (PER: fresh fruit weight ; PSC: dry weight of fruit ; LOF: fruit length; LAF: fruit width; LOP : peduncle length; DIP: peduncle diameter ; LONG: seed length; LARG: seed width) on fruits and seeds of *Celtis australis.*

	PFR	PSC	LOF	LAF	LOP	DIP	LONG	LARG
PFR	1							
PSC	-0,051	1						
LOF	-0,001	0,022	1					
LAF	0,039	0,454**	0,074	1				
LOP	0,045	0,108*	0,096*	0,263**	1			
DIP	-0,002	0,097*	-0,014	0,153**	0,297**	1		
LOG	-0,008	-0,04	-0,005	-0,094*	0,051	-0,013	1	
LAG	0,007	0,260**	0,041	0,335**	0,332**	-0,004	0,138**	1

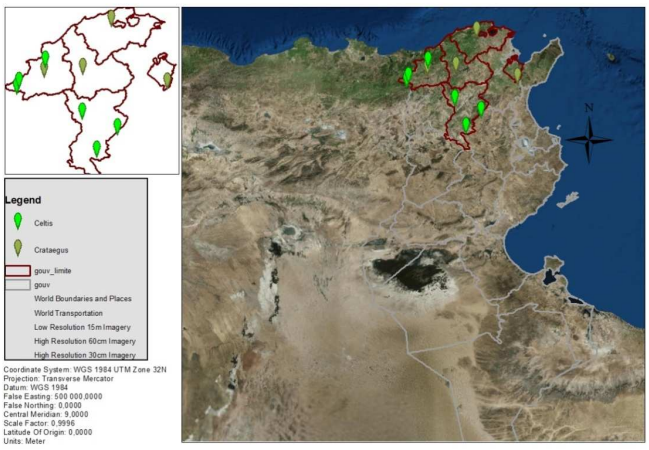

Fig. 1. Map showing the locations of collection sites of *Celtis australis* in Tunisia

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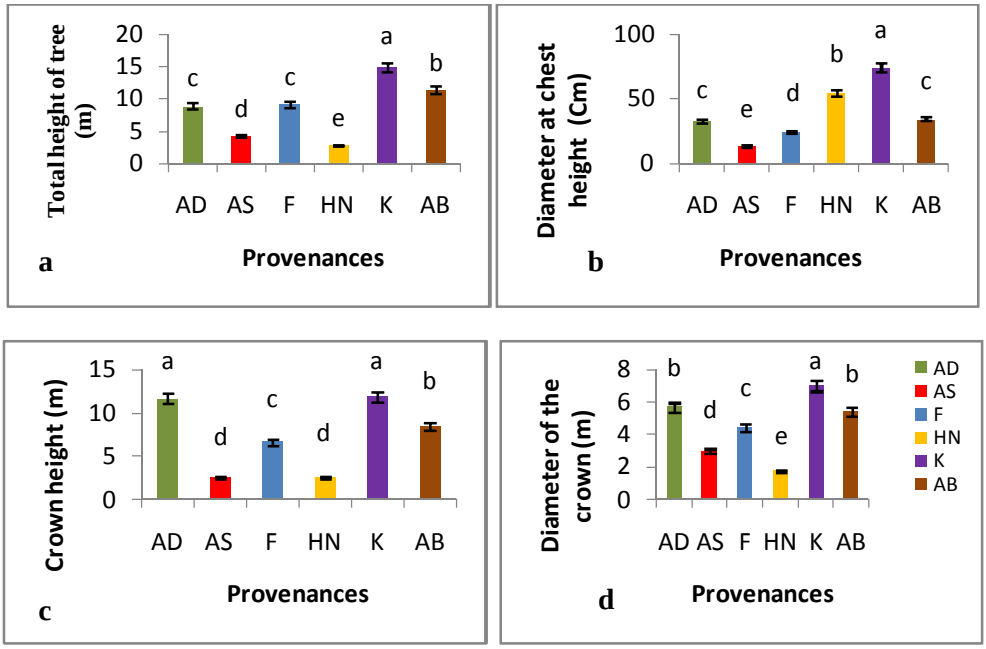

Fig. 2. Variation of morphological parameters of *Celtis australis*: Total height of tree (a); Diameter at chest height (b); Crown height (c) and Diameter of the crown (d) of different provenances studied: Ain Drahem (AD), Ain Soltan (AS), Feija (F), Henchir Naam (HN), Kesra (K), Ain Bousadia (AB). The values represent the average of 6 individual measurements trees. Security intervals are calculated at 5% level.

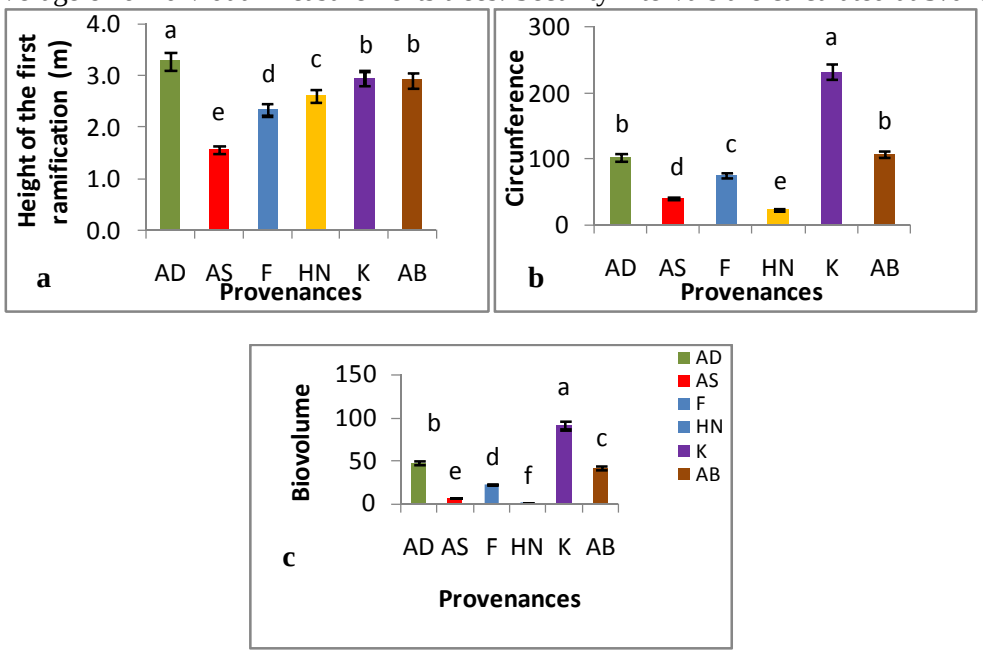

Fig. 3. Variation of morphological parameters of *Celtis australis*: Height of the first ramification (a) ; Circumference (b) and Biovolume (c) of the different provenances studied: Ain Drahem (AD), Ain Soltan (AS), Feija (F), Henchir Naam (HN), Kesra (K) and Ain Bousadia (AB). The values represent the average of 10 individual measurements trees. Security intervals are calculated at 5% level.

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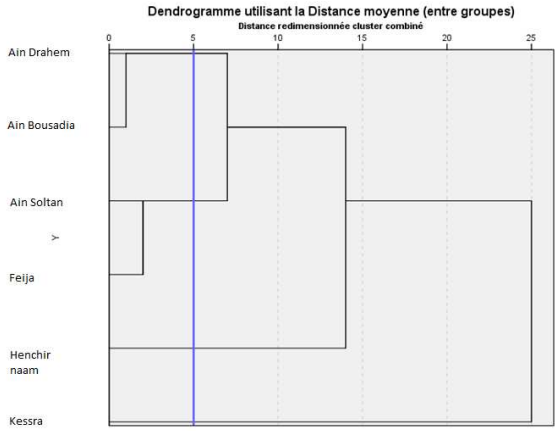

Fig. 4. Dendrogram according to morphological parameters of *Celtis australis* provenances clustered base on dissimilarity of Pearson Method

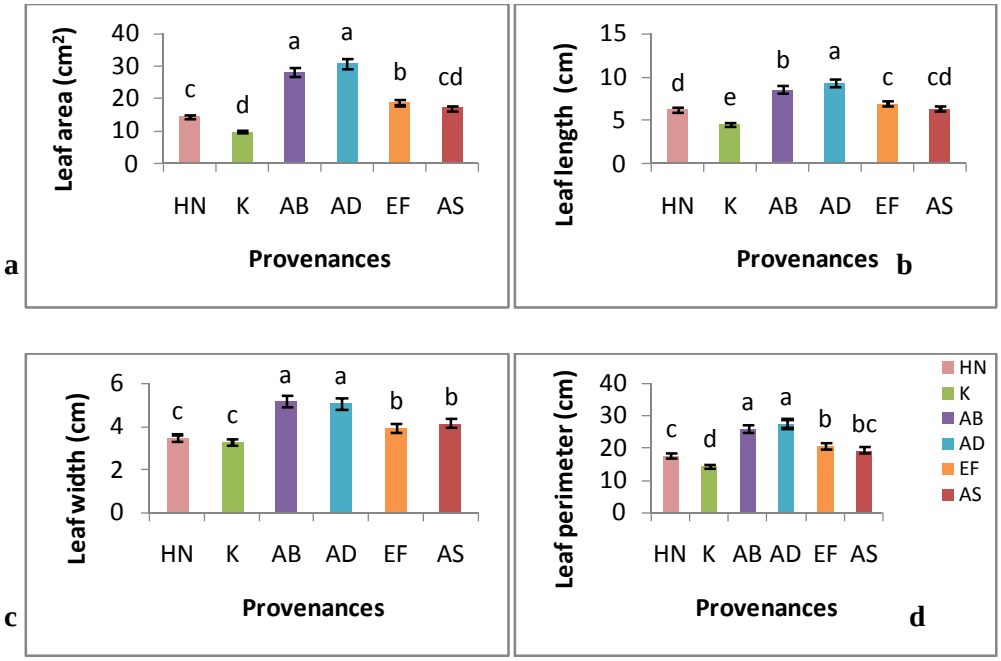

Fig.5. Variation of leaf parameters of *Celtis australis* : Leaf area (a) ; Leaf length (b) ; Leaf width (c) ; Leaf perimeter (d) of different provenances studied: Ain Drahem (AD), Ain Soltan (AS), Feija (F), Henchir Naam (HN), Kesra (K), Ain Bousadia (AB). The values represent the average of 180 individual measurements. Security intervals are calculated at 5% level

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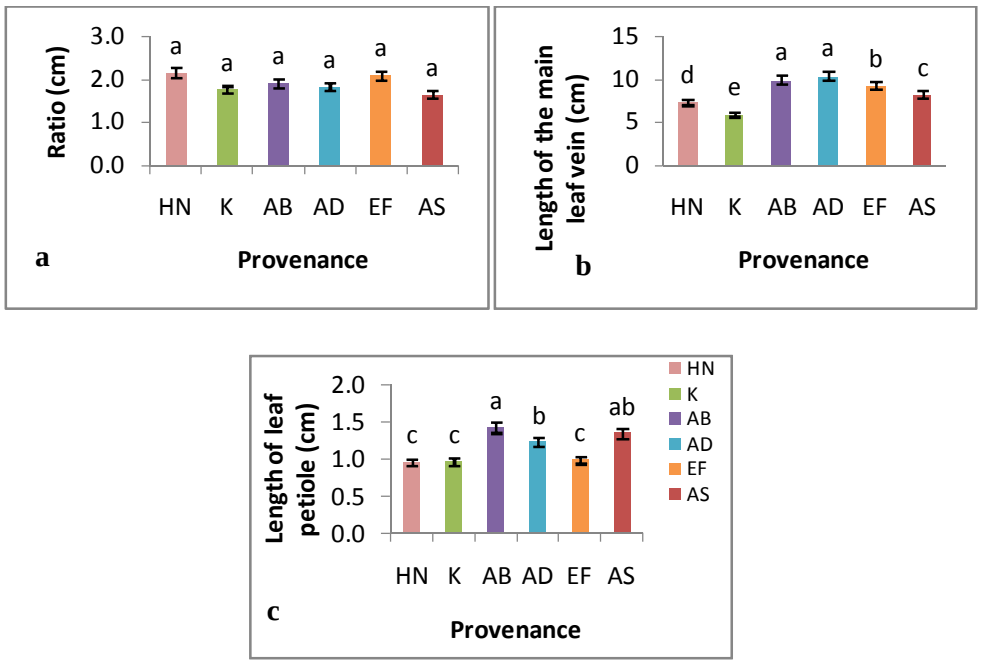

Fig.6. Variation of leaf parameters of *Celtis australis* : Shape index leaf (a) ; length of the main leaf vein (b) ; Length of leaf petiole (c) of different provenances studied: Ain Drahem (AD), Ain Soltan (AS), Feija (F), Henchir Naam (HN), Kesra (K), Ain Bousadia (AB). The values represent the average of 180 individual measurements. Security intervals are calculated at 5% level

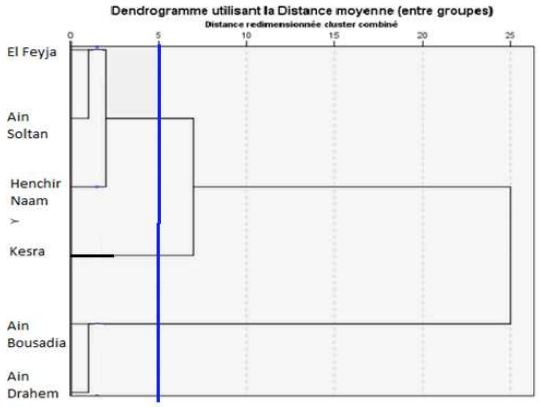

Fig.7. Dendrogram according to leaf parameters of *Celtis australis* provenances clustered base on dissimilarity of Pearson Method

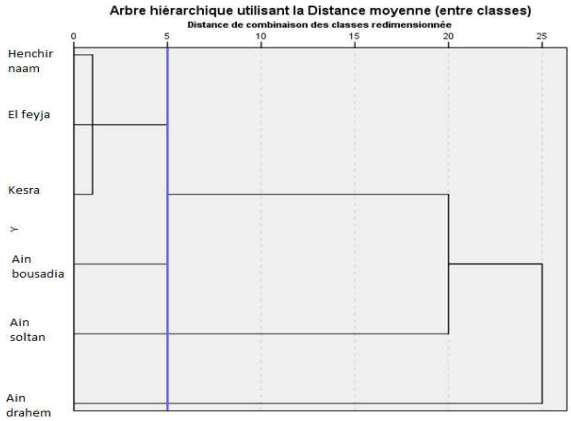

Fig. 8. Relationship between the provenances of *Celtis australis* according to fruits and seeds variables