ASSESSMENT OF PHENOTYPIC DIVERSITY OF BISKRA DATE PALM (PHOENIX DACTYLIFERA L.) CULTIVARS

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RESUME

Date palm is an important fruit crop for Algeria due to its economic importance. More date palm is considered as a staple food for many regions in Algeria. Biskra is the first biggest region for dates production, mainly for the commercial cultivar Deglet Noor. The present study aimed at phenotypic diversity charaterization among fifteen Algerian date palm cultivars grown in Biskra using fifteen descriptors measured on vegetative part. The results, using multivariate analysis, indicated high morphological variability among cultivars. Globally, correlation matrix showed relatively high positive and negative correlations between some vegetative characters. Principal component analysis (PCA) defined the most discriminants characters responsible of the observed variability. In fact, among the fifteen vegetative traits analyzed in this study, five related to the different descriptors of the leaf, leaflet and spines allowed effective differentiation among the studied cultivars. The data obtained here constitute a contribution to help to create a phenotypic database and also to highlight the importance of neglected cultivars.

MOTS CLES: Date palm, cultivars, phenotypic, Biskra, diversity.

1 INTRODUCTION

The date palm is an important fruit crop in Algeria mainly in Biskra, because of many socio-economic activities depends on it. The date palm is often propagated clonally by offshoots because cross-pollination results in new cultivars out-of-type with unknown characteristics (Al-Khayri, 2005; Rhouma *et al.*, 2010). Furthermore, About 50% of the seedlings are male although they cannot be recognized until trees begin to bloom after 4 to 5 years (Chao and Krueger, 2007) except when using male-specific DNA markers (Cherif *et al.*, 2013).

About 940 cultivars were recorded in Algeria (Hannachi *et al.*, 1998). However, the most trade-marketable date cultivar is the famous Algerian “Deglet Noor”. Yet, this practice of monovarietal culture constitutes a genetic erosion on the diversity of date palm in Biskra oases. In addition, the lack of information about the plant genetic resources and other important cultivars contribute largely to the promotion of monoculture practices in Biskra. Thus, cultivars characterization should be undertaken to evaluate date palm diversity. Many studies using morphological traits to identify cultivars have been reported (Ould Mohamed Salem *et al.*, 2008; Ould Mohamed Ahmed *et al.*, 2011; Simozrag *et al.*, 2016). Genetic diversity is also explored by using different molecular markers (Bennaceur, *et al.*, 1991; Ould Mohamed Salem *et al.*, 2001, El-Assar *et al.*, 2005; Zehdi *et al.*, 2004 ; Elshibli and Korpelainen, 2008; Racchi *et al.*, 2013).

The objectives of the present study was to a) characterize the quantitative phenotypic diversity by IPGRI descriptors and b) to find out the genetic relationships among the date palm cultivars.

2 MATERIALS AND METHODS

2.1 Plant material and measurement

In all, fifteen date palm cultivars (Table 1) collected from different sites in the region were evaluated at the morphological level in this study. Fifteen variables (Table2) were analyzed, describing vegetative part (leaves, leaflets and spines) based on International standard descriptors of the date palm (IPGRI: International Plant Genetic Resources Institute 2005, now BIOVERSITY INTERNATIONAL).
For each cultivar; five trees were selected and five leaves per tree were sampled to evaluate the vegetative parameters.

In the following, a set of spines grouped together will be labeled n-spines, i.e. a twin of spines is labeled 2-spines, and a 1-spine is simply single spine. Likewise, the leaflets number will be labeled n-leaflet.

Table 01: Name, label and collection site of date palm cultivars

Accessions	Labels	Locations
Arechti	ART	Sidi Okba
Degla Baidha	DGB	Sidi Okba
Deglet Noor	DGN	Leghrouss
Ghars	GHS	Tolga
Halwa	HAL	Leghrouss
Hamraya	HAM	Chetma
Horra	HRR	Leghrouss
Itima	ITM	Foughala
Kseba	KSB	Leghrouss
Mech Degla	MDG	Chetma
Safraya	SAF	Chetma
Sbaa Laroussa	SBL	Chetma
Tantboucht	TNT	Chetma
Thawri	THW	Tolga
Tinicine	TNC	Chetma

2.1 Data analysis

Parameters means values were used to perform principal component analyses (PCA) as well as the correlation analyses to test whether the variables are correlated in the population (Taylor 1990; Jolliffe 2002). The PCA goal is to extract the most important information from the data table and compress its size by keeping only this important information to express it as a set of new orthogonal variables called principal components (Abdi *et al*., 2010). Thus, it analyzes the structure of both observations and variables. This analysis will allow us to classify the studied cultivars into homogeneous and distinct groups. All analyses were performed using XLSTAT software version 2014.02.

Table 02: Measured vegetative and reproductive characters in date palm cultivars

Vegetative Characters	Unit	Codes
Trunk circumference at 1m from the soil	cm	V1
Leaf length	cm	V2
Leaf width	cm	V3
Spined part length	cm	V4
Spines number		V5
Spine width at the middle	mm	V6
Spine length at the middle	mm	V7
Leaflets number		V8
1-Leaflet number (single leaflet number)		V9
2-Leaflets number		V10
3-Leaflets number		V11
4- Leaflets number		V12
5- Leaflets number		V13
Leaf length at the middle	cm	V14
Leaf width at the middle	cm	V15

3 RESULTS

3.1 Correlation matrix

Mean values of morphometric vegetative characters were analyzed and reported in Table 3. They revealed a high variability between the date palm cultivars for the evaluated traits. The correlation matrix showed mostly positive correlations between measured parameters. However, only some correlation showed high positive correlation (at 0.05 probability level). Yet, the following parameters had a coefficient correlation more than 0.5 (Table 4). In fact, the palm length (V2) was correlated with spined part length (V4), spines number (V5), spine width at the middle (V6), leaflets number (V8) and leaf length at the middle (V14).

Also, spined part length (V4) and spines number (V5) were intercorrelated. This latest parameter had a high positive correlation with spine width at the middle (V6), spine length at the middle (V7) and leaf length at the middle (V14). The middle spines dimensions width (V6) and length (V7) were highly intercorrelated. Correlation matrix also revealed a significant intercorrelation between the 2-Leaflets number (V10) and both leaflets number (V8) and single leaflets number (V9).

The variables 4- leaflets number (V12) and 5- leaflets number (V13) showed a positive correlation. It is of interest to point out that only negative correlation observed in this study was between 4- leaflets number (V12) and leaf width at the middle (V15).

Table 03: Means values of vegetative parameters (Abbreviations as in Tables 1 and 2)

Cv	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
ART	183,5	447,4	79,6	53,76	16,4	4,66	7,2	227,6	33,2	63	17,6	3,4	0,4	54,26	2,42
DGB	208,4	387,8	44,74	62,52	32,6	4,8	11,54	225,8	29	47,4	22,6	6,8	1,4	55,02	2,76
DGN	187,7	399,3	92,33	34,72	55	6,57	13,78	166,3	20	35	21	3,33	0	67,33	3,28
GHS	193,3	489,5	66,5	87,83	39,33	5	11,63	198,7	25	47,67	21,33	2,33	1	52,23	3,77
HAL	99,17	325,3	62,06	56,12	25,4	3,35	10,04	158,4	20	35,8	13	5,2	1,4	40,7	2,76
HAM	126	443	44,7	120,3	47,33	7,33	16,83	168,7	15,33	40,33	19,33	3,67	0	49,17	1,73
HRR	182,6	332,1	59,24	78,28	37,6	3,72	9,3	187,2	14,6	50,8	14,4	6,2	0,6	36,98	3,18
ITM	127	448,8	56,84	111,9	57	5,1	7,9	214,4	42	51,4	13	2,8	0,6	73,62	2,6
KSB	181,6	373,5	66,9	69,4	35,2	5,38	10,06	167,6	17,6	44,4	11,6	5,6	0,8	54,92	2,94
MDG	146,7	356	39,33	50	20,67	3	7,43	144,3	9,67	41,6	14,33	1,67	0,33	49,33	3,13
SAF	151,7	423,5	64,88	96,35	30,5	3,5	8,21	162,2	4,25	41,25	12,25	7,5	1,75	59,63	0,88
SBL	99,33	304	29,23	51	21	3,67	7,17	159,7	7,67	35,67	20,67	4,67	0	38,2	1,2
THW	156,7	333,2	66,58	47,18	19,6	3	8,58	120,6	28	34,4	6,8	0,6	0	46,03	3,75
TNC	167	382,6	78,1	87,74	31	3	8,52	180,6	8,2	34,2	18,8	7,4	3,6	55,02	1,58
TNT	164,8	364,5	93,8	59,64	23	3,49	5,74	168,4	37,8	52,6	5,8	2	0	59,98	2,66

CV: Cultivar. V: vegetative parameters.

Table 04: Pearson's correlation matrix between the different Vegetative characters (Abbreviations as in Table 2).

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
V2	0,34													
V3	0,45	0,23												
V4	-0,16	**0,57**	-0,20											
V5	0,11	0,48	0,09	**0,51**										
V6	0,18	**0,57**	0,04	0,32	**0,73**									
V7	0,13	0,35	-0,10	0,29	**0,62**	**0,80**								
V8	0,43	**0,57**	0,06	0,30	0,28	0,33	0,04							
V9	0,22	0,32	0,36	-0,03	0,15	0,19	-0,14	0,46						
V10	0,40	0,44	0,19	0,15	-0,05	0,12	-0,29	**0,72**	**0,60**					
V11	0,19	0,33	-0,30	0,07	0,31	0,46	**0,52**	0,48	-0,26	-0,08				
V12	0,10	-0,10	-0,11	0,26	0,07	-0,08	0,08	0,28	-0,50	-0,12	0,32			
V13	0,14	0,08	0,13	0,29	-0,05	-0,36	-0,09	0,18	-0,33	-0,23	0,17	**0,68**		
V14	0,28	**0,61**	0,47	0,23	**0,54**	0,38	0,02	0,35	0,46	0,23	-0,04	-0,11	0,06	
V15	0,45	0,00	0,24	-0,38	0,10	0,06	0,12	-0,04	0,47	0,15	-0,17	**-0,57**	-0,33	-0,01

Correlation is significant at the 0.05 probability level

3.2 Principal component analysis

The principal component analysis results showed the phenotypic diversity existing among the fifteen studied date palm accessions based on fifteen vegetative traits. The first three principal components (PC1, PC2 and PC3) accounted for 28.24%, 21% and 14.76%, respectively of the total cumulative variation.

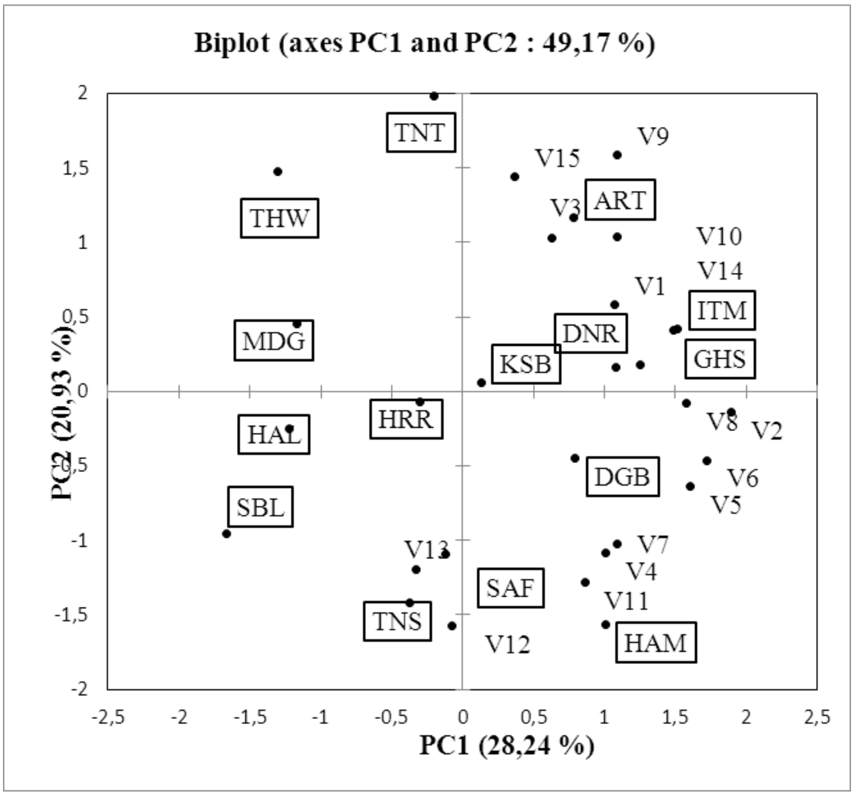
3.2.1 Variables representation

The most important variables, with positive loadings, contributing to the first principal component were palm length (V2), spines number (V5), spine width at the middle (V6), leaflets number (V8), 2-Leaflets number (V10) and leaf length at the middle (V14). The graphic representation of variables according to the plan

Table 05: Eigenvalues, proportion of variation and eigenvectors explained for the three PCs

Axe	**1**	**2**	**3**
Eigenvalues variance	4,236	3.139	2.218
Individual (%)	28.24	21	14.76
Cumulative (%)	28.24	49.116	63.951
Eigenvectors of vegetative parameters	V2 (0.415) V5 (0.351) V6 (0.377) V8 (0.345) V10 (0.238) V14 (0.325)	V9 (0.404) V11 (-0.326) V12 (-0.401) V15(0.367)	V7 (-0.404) V13(0.446)

[1]Only variables showing high loading in different principal components were considered.



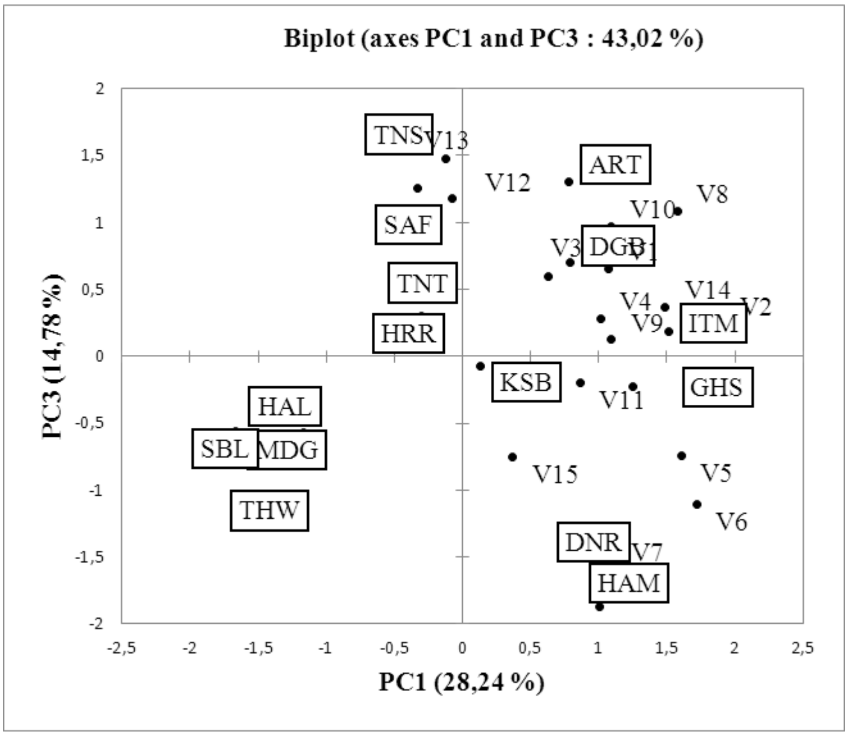


Figure 01: Graphic representation of cultivars and the vegetative parameters on planes 1–2 and 1-3 of principal component analysis (Abbreviations as in Tables 1 and 2)

axis (1 and 2) showed that these variables were positively correlated and formed a homogenous group (Figure1).

The PC2 opposed two distinguished groups of variables inversly correlated. The first one, with high positive loadings was formed by single leaflets number (V9) and leaf width at the middle (V15). While the second one, with high negative loadings was formed by also by two variable: 3- leaflets number (V11) 4- leaflets number (V12). The third PC distinguished mainly two opposed variables, the 5-leaflets number (V13) and the spine length at the middle

(V7).

3.2.2 Cultivars projections

The graphic representation of cultivars on the plan axes (1–2) and (1–3) is presented in Figure 1. The projection of the cultivars on the first plan axis showed a significant opposition between two groups of cultivars, the first one composed of GHARS (GHS) and ITIMA (ITM) and the second one HALWA (HAL), SBAA LAROUSSA (SBL), MECH DEGLA (MDG) and THAWRI (THW) according to the following traits: palm (V2) and middle leaf lengths (V14), spines number (V5), spine width at the middle (V6), leaflets (V8) and 2-leaflets number (V10).
The second axis opposed ARECHTI (ART) and TANTBOUCHT (TNT) characterized by a high single leaflets number (V9) and an important leaf width at the middle (V15) to SAFRAYA (SAF) cultivar with a dense leaflets part where the number of 3- leaflets (V11) and 4-leaflets (V12) was very important. Concerning the third axis, on its positive extremity, Tinicine (TNC) cultivar leaflets were distinguished by the high number of 5- leaflets grouping (V13) when, on the other extremity DEGLET NOOR (DGN) and HAMRAYA (HAM) middle spines (V7) were the longest among all the cultivars.

4 DISCUSSION

Fifteen vegetative traits were used to assess the status of phenotypic diversity and differentiate date palm cultivars. The study of the morphological diversity of 15 date palm cultivars revealed a relatively rich local diversity in Biskra. Previous similar studies were conducted using qualitative and quantitative morphological markers (Mason, 1915; Elhoumaizi *et al.*, 2002; Rizk *et al.*, 2007; Ould Mohamed Salem *et al.*, 2008; Ould Mohamed Ahmed *et al.*, 2011; Simozrag *et al.*, 2016).
The relatively high morphological diversity observed among the studied cultivars could result from a genotypic diversity and from the environmental conditions.
Relatively high correlation was revealed by our results between some characters expressing the well organization of the palm. Indeed, the leaf length that was defined by a long spined part, which contains a high number of leaflets and spines, carried. As the leaflets, spines number was closely correlated to their dimensions. Indeed, the presence of a high number of spines is associated to strong ones. In addition, when the leaflets number increased, the first three groups of leaflets (single, grouping by 2 and by 3) were the most frequent. Accordingly, the high densities of leaflets make the leaf less wide at the middle (V15).
Principal Component analysis results showed that among the 15 vegetative traits used in this study, five were the most discriminant in regards to their Eigen values: palm length (V2), single leaflets number (V9), 4- leaflets number (V12), the spine length at the middle (V7) and the 5-leaflets number (V13).
Similar findings have been reported in genetic diversity studies of Moroccan and Mauritanian germplasm collection (Elhoumaizi *et al.* 2002; Ould Mohamed Salem *et al.*, 2008; Ould Mohamed Ahmed *et al.*, 2011).
Some characters used by the farmers to identify known cultivars were found in this studyas useful. For example, DEGLET NOOR (DGN) cultivar which is commonly distinguished by its long spine has, according the PCA results a very long spines like HAMRAYA (HAM) cultivar which is well known by the farmers for being resistant to dryness. However, further investigation must be undertaken to identify vegetative descriptors that might be used, out of fruiting period, to distinguish between cultivars.

5 CONCLUSION

The results of this study indicate that vegetative traits could be a practical tool to assess phenotypic diversity to start assessment of local diversity when means to use other assessment methods are not available. However, other descriptors should be included for the phenotypic characterization of the date palm cultivars. More, future investigation with increased number of cultivars should be undertaken to assess the state of the local diversity of palm date in Biskra that is threatened by several factors mainly, the commercial one. Other markers could be also used to elucidate relationships between local cultivars. The setup of *in situ* collections is extremely recommended to preserve local biodiversity.

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REFERENCES

[1] Posey, C. J., Hsing, P. S. (1938). Hydraulic jump in trapezoidal channel, Engineering News Record. pp. 797-798.

[2] Açourene S., Belguedj M., Tama M. and Taleb B., 2001 :Caractérisation, évaluation de la qualité de la datte et identification des cultivars rares de palmier dattier de la région des Ziban. Recherche agronomique, Institut national de la recherche agronomique d'Algérie 8:19-39.

[3] Al-Khayri J.M., 2005:Date palm Phoenix dactylifera L. In: Jain SM, Gupta PK (eds.). Protocols for Somatic Embryogenesis in Woody Plants. Springer Berlin, 309-320.

[4] aaziz M., and Saaidi M., 1988 : Preliminary identification of date palm cultivars by esterases isoenzymes and peroxidase activities. Can J Bot 66:89–93.

[5] Belguedj M., 2002 : Les ressources génétiques du palmier dattier, caractéristiques des cultivars de dattiers dans les palmeraies du Sud-Est Algérien. Institut National de la Recherche Agronomique d'Algérie.

[6] Bennaceur M., Lanaud C., Chevalier M.H. and Bounaga N., 1991 : Genetic diversity of the date palm (Phoenix dactylifera L.) from Algeria revealed by enzyme markers. Plant Breed 107:56–69.

[7] Boyang R., Cao B.R. and Chao C.T., 2002: Identification of date cultivars in California using AFLP markers. Hort Sci 37 (6):966–968.

[8] Chao C.C.T,. and Krueger R., 2007: The Date Palm (Phoenix dactylifera L.): Overview of Biology, Uses, and Cultivation. Hort Sci 42(5):1077-1082.

[9] Hannachi S., 2012 : Ressources génétiques du palmier dattier (Phoenix dactylifera L.): Analyse de la variabilité inter et intra des principaux cultivars dans les palmeraies algériennes. These magister. Ecole Nationale Supérieure Agronomique EL-HARRACH. pp 120.

[10] IPGRI, 2005 : Descripteur du palmier dattier (Phoenix dactylifera L.). International Plant Genetic Ressources Institute, Rome, Italy.

[11] Jolliffe I.T., 2002: Principal Component Analysis. 2nd ed. Springer.

[12] MADR, 2015. Statistiques agricoles, série B. Ministère de l'Agriculture et du Développement Rurale, Algérie.

[13] Mason S.C., 1915: Botanical characters of the leaves of date-palm used in distin-guishing cultivated varieties. United States Department of Agriculture. Bulletin 223.

[14] Nixon R.W., 1950: Imported cultivars of dates in the United States U.S. Department of Agriculture Circular no. 834, U.S. Department of Agriculture, Washington, 144 pp.

[15] Ould Mohamed Ahmed M.V.O., Bouna Z.E., Mohamed Lemine F.M., Djeh T.K.O., Mokhtar T. and Mohamed Salem A.O., 2011: Use of multivariate analysis to assess phenotypic diversity of date palm (Phoenix dactylifera L.) cultivars. Sci Hort 127:367–371.

[16] Ould Mohamed Salem A., Trifi M., Sakka H., Rhouma A. and Marrakchi M., 2001: Genetic inheritance analysis of four enzymes in date palm (Phoenix dactylifera L.). Genet Resour Crop Evol 48:361–368.

[17] Ould Mohamed Salem A., Rhouma S., Zehdi S., Marrakchi M. and Trifi M., 2008: Morphological variability of Mauritanian date-palm (Phoenix dactylifera L.) cultivars as revealed by vegetative traits. Acta Bot Croat 67(1):81–90.

[18] Rencher A.C., 2002. Methods of Multivariate Analysis, 2nd ed. Wiley.

[19] Rizk R.M. and El Sharabasy S.F., 2007: Descriptors for Date palm (Phoenix dactylifera L.): characterization and evaluation in genebanks. Plant Genet Resour News 150:42-44.

[20] Simozrag A., Chala A., Djerouni A. and Bentchikou M.E., 2016: Phenotypic diversity of date palm cultivars (Phoenix dactylifera L.) from Algeria. Gayana Bot 73(1):42-53.

[21] Saracli S., Dogan N. and Dogan I., 2013: Comparison of Hierarchical Cluster Analysis Methods by Cophenetic Correlation. Journal of Inequalities and Applications, Vol. 203,1-8.

[22] https://journalofinequalitiesandapplications.springeropen.com/articles/10.1186/1029-242X-2013-203

[23] Taylor R., 1990: Interpretation of the Correlation Coefficient: A Basic Review. J of Diagnostic Medical Sonography. 6(1):35-39.

[24] Zehdi S., Trifi M., Billotte N., Marrakchi M. and Pintaud J.C., 2004: Genetic diversity of Tunisian date palms (Phoenix dactylifera L.) revealed by nuclear microsatellite polymorphism. Heredity 141:278–287.