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Use of multivariate analysis to assess phenotypic diversity of date palm (*Phoenix dactylifera* L.) cultivars

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ABSTRACT

Twenty one date palm (*Phoenix dactylifera* L.) accessions originated from different date palm groves were studied to assess the overall degree of polymorphism, detect similarities between genotypes and assess important agronomic traits. Thirty vegetative and reproductive variables were scored and subjected to multivariate analysis. Results showed a considerable phenotypic diversity among local date palm germplasm. Principal component analysis (PCA) revealed that characters related to leaflets length and spine, fruit and seed sizes accounted for a large proportion of the observed variability. Cluster analysis (CA) showed a typically continuous phenotypic diversity among date palm accessions and little associations between accessions from same geographic origin. Also, some heterogeneity within accessions that received the same denomination was evidenced.

1. Introduction

The date palm (*Phoenix dactylifera* L.; $2n = 36$), a dioecious perennial monocotyledonous tree, is a crop of economic importance in Mauritania and all of North Africa. It presents a source of income to oases inhabitants, provides protection to under-crops from the harshness of the climate and reduces the damage from sand storms and wind erosion. Well-adapted ecotypes empirically selected by farmers for their attractive fruit qualities are cultivated. Each cultivar derives from a unique descendant individual seed. For instance, there are about 250 cultivars in Tunisia (Rhouma, 2005), 800 in Algeria (Benkhalifa, 1996), 244 in Morocco (Toutain et al., 1971) and 400 in Soudan (Osman, 1984). In Mauritania, date palm culture is concentrated in the Adrar, Tagant and Assaba regions between latitude 16.5° and 21°, although some isolated date palm groves exist in oases areas in the south-eastern regions of the country. The total harvested areas are estimated to 5000 ha amounting to 1.9 million palm trees (Anonymous, 1995). The annual production is about 23,000 tons representing a source of income for 500,000 oasis dwellers (Ould Mohamed Salem et al., 2008). Local date palm varieties are numerous and well adapted to agroecological conditions. Their denominations are strictly local and originating, most often, from the place of cultivation, the color or the shape of the fruits. There are 3 main types of date palm varieties based on fruit moisture content, i.e., soft, semi-dry, and dry cultivars. Despite its importance, little is known about date palm genetic diversity in the country. Data available are limited to an earlier work by Munier (1955) suggesting the existence of 350 cultivars. However, due to land and human pressures, pests, diseases and plant nutritional problems certain date palm cultivars have become rare or completely disappeared. Multivariate analysis is one of the most important statistical tools for estimating total variations in different samples of individuals (Chatfield and Collins, 1986). It has been successfully utilised in different crop species such as Wheat (Shoran and Tandom, 1995), coconut palm (Zizumbo-Villarreal and Piñero, 1998), fig (Saddoud et al., 2008), carob (Sidina et al., 2009) and date palm (Elhoumaizi et al., 2002; Ould Mohamed Salem et al., 2008). This paper describes genetic diversity of the most common date palm cultivars in Mauritania. The main goals of this study were the use of vegetative and reproductive characters (i) to detect genetic relationships among cultivars, (ii) to determine the overall degree of polymorphism of studied characters and (iii) to assess important agronomic traits for date palm classification. Understanding of the genetic variability and proper cultivar identification in date palm constitute indispensable steps with regard to the development of breeding strategies.

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Table 1
Name, label and origin of date palm accessions.

Accession	Label	Location
Ahmar	AHA	Atar
Ahmar	AHC	Chinguitti
Ahmar	AHO	Ouadane
Amsakhsi	AMS	Atar
Tamchkrert	TAM	Atar
Bouseker	BSK	Atar
Tiguidert	TGD	Atar
Lemdina ghailania	LMG	Atar
Tijib	TIJ	Atar
Adaghd	ADG	Atar
Sembahra	SMB	Chinguitti
Sel medina	SLD	Chinguitti
Boudjeire	BDJ	Chinguitti
Sijoumen	SIJ	Chinguitti
Sembahmoud	SBM	Chinguitti
Enzer	ENZ	Chinguitti
Athmenmej	ATH	Ouadane
Tenwazidi	TNW	Ouadane
Sekanni	SKN	Ouadane
Temazad	TMZ	Ouadane
Tenterguel el kahla	TNT	Ouadane
Tadeghdit el hadi	TDH	Ouadane
Lemdina	LMD	Ouadane

2. Materials and methods

2.1. Plant material and measurements

The study included 23 date palm accessions originated from different locations in Adrar region. These accessions represent 21 denominations (Table 1). For each accession, a sample of three individuals was randomly selected to perform morphometric analysis. The study was based on 30 characters describing vegetative (15 traits) and reproductive (15 traits) organs of date palm namely leaf, leaflets, spines, spathes, spadices and fruits (Table 2). These are reported as part of standard descriptors in the date-palm (IPGRI, 2005). Parameters related to the fruit were measured at harvest stage. Measurements were performed in triplicate. All measurements were performed using digital calliper, precision weighing balance and digital measuring tape.

2.2. Data analysis

Standardised traits mean values were used to perform principal component (PCA) and hierarchical cluster (CA) analyses using XLSTAT software version 3.06. The goal of PCA is to decompose a data table with correlated measurements into a new set of uncorrelated variables. The results of the analysis are presented with graphs plotting the projections of the units onto the components, and the loadings of the variables. Correlation between variables was evaluated using Pearson's correlation coefficient (Snedecor and Cochran, 1968). Cluster analysis, based on Euclidean distances as similarity measures and the unweighted pair-group method with arithmetic averages (UPGMA) were used to analyse the genetic relationships among accessions.

3. Results

Mean values of vegetative and reproductive characters studied are reported in Table 3. Data show large variability between genotypes for all traits.

3.1. Principal component analysis

Table 4 summarizes the results of principal component analysis. The first three principal components accounted for 22.25%, 15.03% and 12.74%, respectively of the total variations among date palm accessions based on the thirty vegetative and reproductive traits. Spineted part length (P1), terminal leaflet length (P10) and leaflet length at the middle (P15) had high positive loadings, while fruit and pulp weights (P18, P19) had high negative loadings in the first principal component. In the second component, spines width and length at the middle (P8, P9) were the traits with high negative loadings whereas, fruit and seed lengths (P16, P20) and seed/fruit weight ratio (P24) showed high positive loadings. The most important variables contributing to the third principal components were: leaf length (P3), spine number (P7), seed width (P21) and weight (P22) with strong positive loadings and spadice thickness at the middle (P27) with high negative loading. The graphic representation of cultivars on the plan axes (1–2) and (1–3) presented in Figs. 1 and 2 showed a significant opposition of Tiguidert (TGD) to Tenwazidi (TNW) according to the first principal component. TGD is characterized by a long leaflet at top and middle of the leaf, while TNW has a large fruit size. The second axis opposes Adaghd (ADG) with very long fruits and seeds and a great fruit/seed weight to Sekanni (SKN) and TGD characterized by large and long spines. The third axis shows the opposition of Lemdina ghailania (LGH) distinguished by a thick spadice to cultivars Athmenmej (ATH) and Ahmar from Ouadane (AHO) characterized by long leaves, many spines and large and sized seeds.

Table 2
Measured vegetative and reproductive characters in date palm accessions.

Character	Unit	Codes
Leaf		
Spineted part length	cm	P1
Petiole width at the bottom	cm	P2
Leaf length	cm	P3
Leaf width	cm	P4
Rachis thickness between the last Spine and the first leaflet	cm	P5
Leafleted part length	cm	P6
Spines		
Spines number		P7
Spine width at the middle	mm	P8
Spine length at the middle	cm	P9
Leaflets		
Terminal leaflet length	cm	P10
Leaflets number		P11
Spacing index		P12
Terminal leaflet width	mm	P13
Leaflet width at the middle	mm	P14
Leaflet length at the middle	mm	P15
Fruit		
Fruit length	mm	P16
Fruit width	mm	P17
Fruit weight	gr	P18
Pulp weight	gr	P19
Seed length	mm	P20
Seed width	mm	P21
Seed weight	gr	P22
Seed/fruit length ratio		P23
Seed/fruit weight ratio		P24
Spadice		
Spadice length	cm	P25
Sapdice width at the middle	mm	P26
Spadice thickness at the middle	mm	P27
Spadice length at the ramified part	cm	P28
Spathe		
Spathe length	cm	P29
Spathe width	cm	P30