Phenotypic diversity of date palm cultivars (*Phoenix dactylifera* L.) from Algeria

Diversidad fenotípica de cultivares de palmera datilera (*Phoenix dactylifera* L.) de Argelia

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ABSTRACT

The aim of this work is to evaluate the phenotypic diversity of date palm (*Phoenix dactylifera* L.). This study shows that Biskra region has an interesting biodiversity. This latest was conducted during the growing palm groves since 3 years (2010, 2011 and 2012) in Biskra, on 89 date palm varieties, to identify their distinctive phenotypic characteristics. Seventeen physical parameters have been examined, including 4 relative to vegetative growth, and 13 to the fruits at the date parameters stage. The main components analysis was used to identify the differences and similarities between the parameters studied. The principal component analysis showed that morphological characters for fruits should be used for identifications and descriptions of date palm cultivars. The results revealed a wide variation for different degrees of significance between the 89 cultivars for most studied traits, and showed the superiority of the fruiting characteristics over the vegetative, the former included: Fruit weight 0.851 and length 0.746, flesh weight 0.865, the coefficient of fruit length/width 0.754 and the weight coefficient flesh/seed 0.675. These features had significant representation, as they helped significantly in finding 18 well identified varieties. The results analysis showed three homogeneous groups varieties sharing some traits, the convergence rate is different from one class to another within the same group. This study allowed us to highlight the most discriminating characters that can be used for further studies of diversity.

Keywords: Cultivars, date palm, identification, Algeria, phenotypic.

RESUMEN

El objetivo de este trabajo es evaluar la diversidad fenotípica de la palmera datilera (*Phoenix dactylifera* L.). Nuestro estudio muestra que la región de Biskra cuenta con una interesante biodiversidad. Este estudio se llevó a cabo durante 3 años de crecimiento (2010, 2011 y 2012) en Biskra, para 89 variedades de palmera datilera, para identificar sus características fenotípicas distintivas. Se analizaron 17 parámetros físicos, 4 de ellos relacionados al crecimiento vegetativo y 13 durante la etapa de fruto. Se utilizó el análisis de componentes principales para identificar las diferencias y similitudes entre los parámetros estudiados. El análisis de componentes principales mostró que los caracteres morfológicos de las frutas deben ser utilizados para identificaciones y descripciones de variedades de palmera datilera. Los resultados revelaron una amplia variación para diferentes grados de importancia entre los 89 cultivares para los rasgos más estudiados, y mostraron la superioridad de las características de fructificación frente a los de vegetación para distinguir las variedades. Estos resultados incluían: peso del fruto 0,851, longitud del fruto 0,746, peso de la pulpa del fruto 0,865, coeficiente longitud/ancho del fruto 0,754 y coeficiente peso pulpa/semilla 0,675. tienen representación significativa para diferenciar 18 variedades. Los resultados del análisis estadístico mostraron que hay tres grupos homogéneos de variedades que presentan similitudes en algunas de las características estudiadas, y la tasa de convergencia era diferente de una clase a otra dentro del mismo grupo. Este estudio nos ha permitido poner de relieve los caracteres discriminantes que pueden ser utilizados para otros estudios de diversidad.

Palabras clave: Cultivares, palmera datilera, identificación, Argelia, fenotípica.

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is the most important fruit tree grown in Algeria and the Arab world due to its commercial and economic usefulness, where Algeria is among the leading countries in the cultivation and production of palms dates. Recent statistics indicate that the number of palm trees planted globally grown accounts for about 18 millions (Anonyme 2011).

Date palms confined in Algerian oases exceed 900 cultivars, including soft, dry and semi-dry varieties. The greater part of them is classified within the bad range in terms of quality, which is often not economically rentable and affects their plentiful and spread. Each region has its own cultivars. Some of them have been transplanted to other areas with the same or new names. Cultivars having more than one name. Or common names calling for two or more cultivars (Barrett 1975).

In date palms, most of the female cultivars are recognized by their fruit characteristics such as size, shape, colour and taste. Morphologic characters of the tree are also taken into consideration for cultivar identification. For the male trees, cultivar identification is a cumbersome process because they mostly are seed-borne and are hardly identical to any female cultivar. However, farmers dealing with date palms can identify some male cultivars from their experience. Several workers attempted to describe and enlist the date palm cultivare grown in their countryof interest. Rhouma (1994) enlisted 250 cultivars of date palm grown in Tunisia, Dowson (1923) indentified 370 cultivars in Iraq, while 26 cultivars were recorded by Brown (1924) from Egypt, and Nixon (1950) enlisted 196 date verieties imported in the USA. In Morocco, Saaidi (1979) identified 244 cultivars; in 1996, Bashah provided fruit description for 30 cultivars grown in Saudi Arabia. Zaid & Wet (1999) provided an elaborative description of two cultivars, viz Mejdool and Barhee covering vegetative and reproductive characters, which can be used as amodel for detailed description of other cultivars. In Algeria, Hannachi *et al.* (1998) presented a study on 160 cultivars and Belguedj (2002) on 120 cultivars as well as Belguedj & Tirichine (2011) on 75 cultivars included the phenotypic characteristics of the leaves and fruit.

Date palm varieties are very similar; however, studies have shown that there are clear differences based on the vegetative characteristics and Spath (Djerouni *et al*. 2015). Since the palm leave constituents look very different, the measurements which were taken from leaf palm like thorns length, pinna number and leaf palm length have shown the similarities and the differences between the palms (Saker *et al*. 2010, Hider *et al*. 2015). The measurements taken from the fruits can be considered as the best proof of the differences of varieties of date palm (Mohamed *et al*. 2014). Thus, to differenciate between the trees and plants that belong to the same family through vegetative characteristics.

Since the lack of studies on the phenotypic characterization of different cultivars in Algeria, and publication of the references values of the International Plant Genetic Research Institute (IPGRI), determining the criterions that can be relied upon to distinguish palms and identify the differences and similarities between cultivars, a study on date cultivars cultivated in Biskra (Algeria) have conducted to identify the distinctive phenotypic characteristics and determine the existing extent of variation.

The first objective is to contribute to the morphological characterization of 89 cultivars date palm and enrich the existing germplasm in Biskra. The study is based on a detailed morphological characterization of the vegetative part and the fruit of 89 cultivars. The second objective is the exploitation of the statistical analysis results in order to study the phenotypic diversity among cultivars in the Biskra region. This is done for the assessment of the polymorphism degree between studied and the importance of the most discriminating characters in order to have a classification of homogeneous groups and cultivars which can be used for the classification of date palm.

MATERIAL AND METHODS

The 89 varieties are shown Appendix A of the date palm that have been selected were cultivated in the oases of the Biskra region, in the south-eastern Algeria (see Fig. 1), that lies at an altitude of 124 m above sea level, between latitudes 35°15'- 33°30' north and longitudes 04°15'- 06°45', They have been estimated to cover 21,617 km^2 (Anonyme 2003).

The vegetative activity of date palm largely linked with the climatic condition of region. The average of maximum and minimum temperature respectively 28.43 °C and 17.01 °C witch appropriate for the optimal species needs that vary between 32 °C and 38 °C and the tolerance limits that range between 7-45 ºC (Khadhi *et al*. 1995). The Saharan rains are ineffective for irrigation (10,96 mm). However, they can affect flowering and maturing where abundant rainfall in spring and autumn can launch the development of diseases and parasite attacks (Belguedj *et al.* 2008). The ecological optimum of relatively average humidity (H) is 40% (Belguedj *et al.* 2008), the latter is almost adequate with the value of humidity in the study area (42.2%), allowing them to keep textures in relation to their varietal characteristics (Belguedj *et al.* 2008). Finally, the wind are frequent in the Spring but generally calm (4.44 m/s) (Table I).

Three repetitions of each cultivar have been chosen as identical in force of their growth, the similar size of each class of age (15 years), and because all the palm trees have been treated as the practice with each other in terms of irrigation, pruning, pollination and other agricultural operations.

Quantitative parameters for each variety have been also studied, including (Table II): 4 parameters for leaves and 13 for fruits (natural qualities), where 3 leaves and 20 fruits in the phase of dates were taken from each varieties (Anonyme 2005). The Figure (2) shows the description of some essential parameters of leaf and fruit of date palm.

Data analyses

Principal Component Analysis (PCA) was used (Johnston 1978, Mainley 1994). In order to identify groups of inter-correlated variables for *P. dactylifera*. Data analyses were performed using XLSTAT program (2009.3.02) which allowed us to make the intra-cultivar variance analysis. The stable selected descriptor measurements of the cultivars were subjected to a components analysis to determine the characteristics with greater contributions to the total variability.

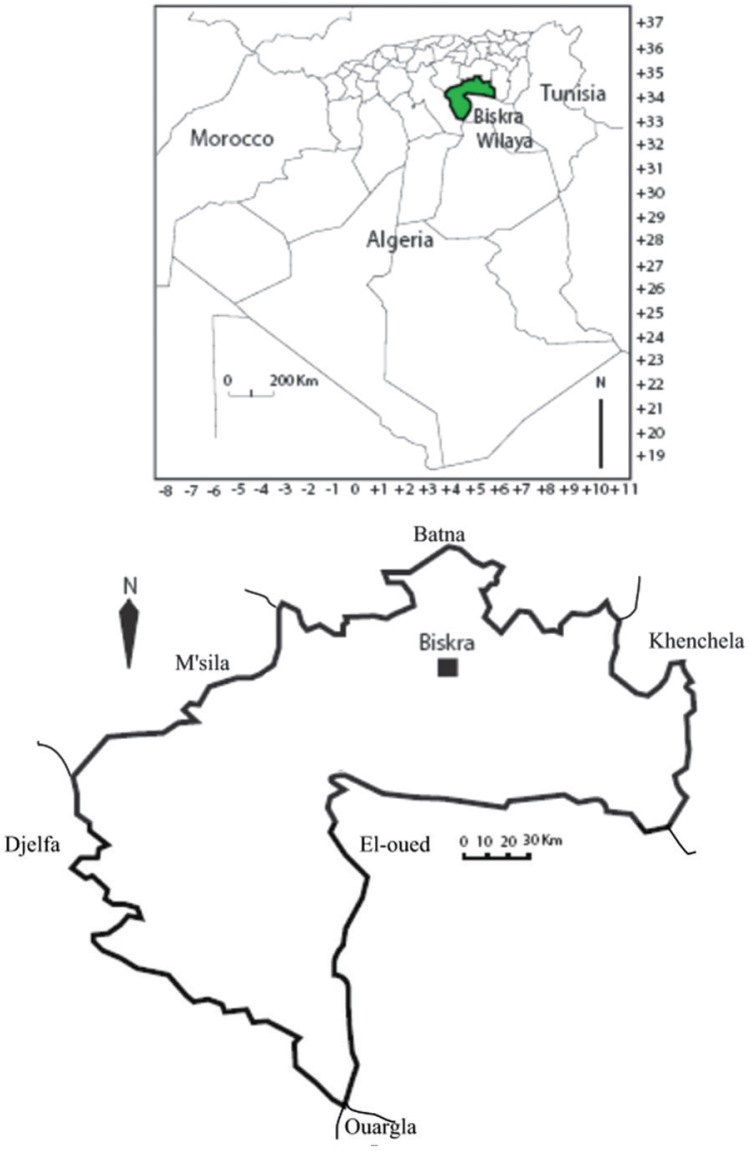

Figure 1. Map of Biskra.

Figura 1. Mapa de Biskra.

Table I. Climate data from the Biskra region for the period 2002-2012.

Tabla I. Los datos climáticos de la región de Biskra para el período 2002-2012.

Month	T (°C)		Tm (°C)		TM (°C)		P (mm)	V (m/s)	H (%)
	moy	e-type	moy	e-type	moy	e-type			
J	6.27	11.25	1.08	1.24	16.91	1.36	26.42	4.18	59.00
F	7.82	13.12	1.41	1.17	19.11	1.95	6.02	4.4	48.64
M	11.76	17.61	1.36	1.04	23.87	1.50	12.20	5.05	41.45
A	15.39	21.25	1.28	0.74	27.52	1.27	11.85	5.88	37.45
M	20.59	26.90	1.60	1.38	31.99	2.82	11.45	5.61	32.73
J	25.00	31.93	1.17	0.96	38.11	1.23	1.39	4.37	27.27
J	28.01	34.89	1.08	1.12	41.20	1.13	0.85	4.00	25.82
A	27.78	34.22	0.82	0.97	39.80	1.30	2.47	3.76	28.36
S	23.19	28.78	0.93	0.91	34.01	1.47	15.90	4.07	41.18
O	18.66	23.94	1.29	1.20	29.65	1.69	12.00	3.65	47.45
N	11.78	16.02	1.76	0.79	21.79	0.79	15.07	4.15	54.27
D	7.90	12.17	1.00	0.94	17.21	1.21	15.85	4.20	62.73
Avg/year	17.01	22.67	1.23	1.04	28.43	1.48	10.96	4.44	42.2

T: Average Temperature (°C); Tm: Minimum Temperature (°C); TM: Maximum temperature (°C); P: Total rainfall (mm); V: Average wind speed (m/s); H: Average relative humidity (%). / T: Temperatura media (°C); Tm: Temperatura mínima (°C); TM: Temperatura máxima (°C); P: Precipitación total de lluvia (mm); V: Velocidad media del viento (m/s); H: Humedad relativa media (%).

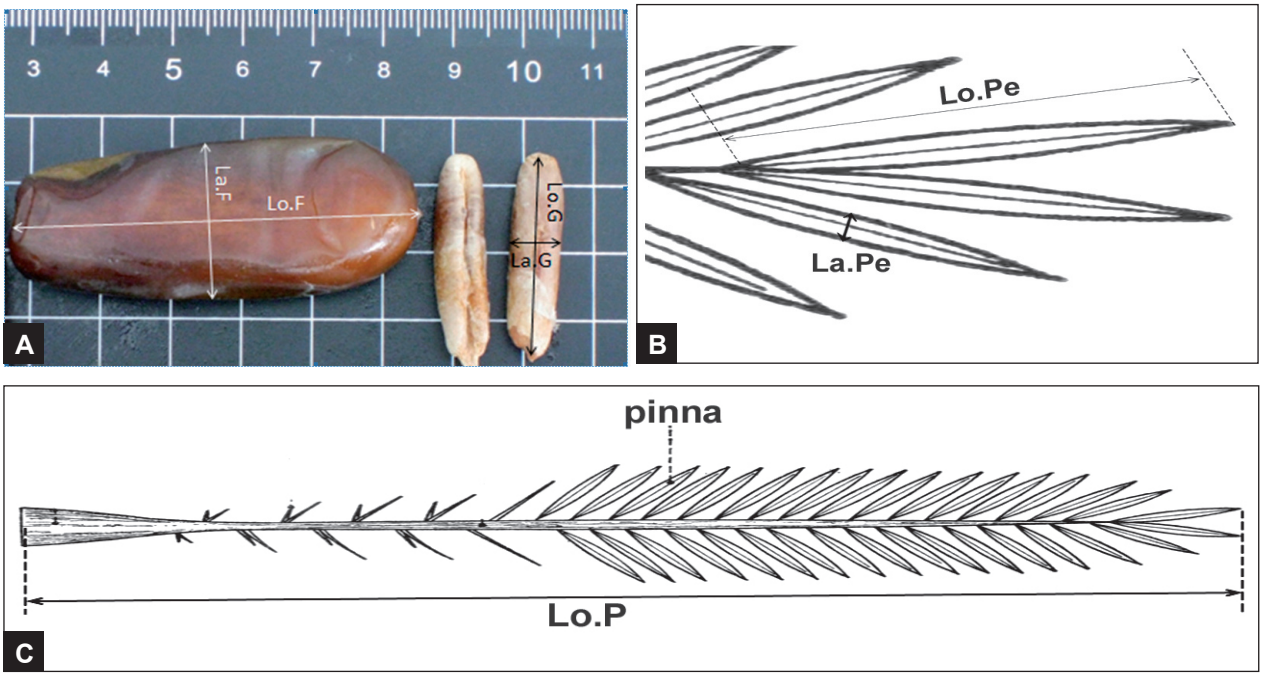

Figure 2. A. The fruit and seeds. B. The pinna. C. The leaf. Descriptors in Table II.

Figura 2. A. El fruto y semillas. B. La pinna. C. La hoja. Descriptores en Tabla II.

Table II. Mean values of phenotypic characters of date palm cultivars.

Tabla II. Los valores medios de los caracteres fenotípicos de cultivares datileras.

VARIETIES	Lo.P (m)	No.Pe	Lo.Pe (cm)	La.Pe (cm)	Hu (%)	Ms (%)	P.F (g)	Lo.F (mm)	La.F (mm)	Lo/La.F	P.G (g)	Lo.G (mm)	La.G (mm)	Lo/La.G	P.Pu (g)	P.Pu/P.G	Lo.G/Lo,F
V1	2.64	116.44	50.00	3.77	20.93	79.07	12.04	37.41	22.38	1.67	1.39	23.97	8.15	2.94	10.66	7.67	0.64
V2	2.75	139.00	48.89	2.61	17.27	82.73	5.92	28.27	18.68	1.51	0.71	22.68	6.93	3.27	5.22	7.39	0.80
V3	3.37	130.89	35.44	2.29	14.20	85.80	7.57	35.88	18.15	1.98	0.68	17.60	7.08	2.49	6.90	10.19	0.49
V4	2.73	147.33	47.00	2.72	16.27	83.73	5.50	33.97	15.84	2.15	0.98	22.95	7.24	3.17	4.51	4.60	0.68
V5	5.16	192.44	53.33	4.44	14.40	85.60	4.17	30.36	16.71	1.82	0.96	19.98	8.11	2.46	3.21	3.36	0.66
V6	4.08	208.44	53.78	2.86	22.37	77.63	7.80	35.53	17.64	2.01	0.67	23.73	7.48	3.17	7.13	10.60	0.67
V7	2.99	115.78	46.89	3.77	20.47	79.53	13.73	41.93	22.54	1.86	1.23	24.96	8.04	3.10	12.50	10.13	0.60
V8	4.19	271.33	46.11	4.06	20.90	79.10	16.19	49.22	18.03	2.73	0.77	18.75	7.34	2.55	15.42	20.02	0.38
V9	3.67	173.67	42.11	3.67	15.27	84.73	5.01	32.69	26.01	1.26	1.00	22.90	7.34	3.12	4.01	4.01	0.70
V10	2.90	140.33	44.89	2.42	22.47	77.53	6.24	37.76	19.13	1.97	1.07	22.98	7.66	3.00	5.17	4.84	0.61
V11	3.75	199.89	55.22	3.24	25.00	75.00	9.43	36.81	23.47	1.57	0.83	22.82	6.55	3.48	8.60	10.43	0.62
V12	4.06	176.89	52.67	3.66	32.20	67.80	12.84	39.61	17.03	2.33	1.20	24.89	7.75	3.21	11.63	9.66	0.63
V13	3.89	200.89	60.33	3.28	11.50	88.70	5.81	38.45	17.17	2.24	1.10	25.11	6.21	4.04	4.71	4.28	0.65
V14	3.72	193.67	41.89	3.43	12.05	87.95	8.41	38.20	20.09	1.90	1.01	24.56	7.27	3.38	7.40	7.30	0.64
V15	2.13	123.00	44.56	3.36	15.97	84.03	7.39	34.63	20.70	1.67	0.91	22.87	7.61	3.01	6.48	7.14	0.66
V16	3.64	174.00	58.22	3.64	37.31	62.69	15.22	48.22	16.25	2.97	1.08	24.88	6.93	3.59	14.14	13.07	0.52
V17	3.36	173.44	69.11	2.69	17.03	82.97	6.45	36.54	17.17	2.13	0.95	23.47	7.43	3.16	5.50	5.79	0.64
V18	4.12	217.67	53.67	2.97	14.67	85.33	5.40	29.87	20.89	1.43	1.16	23.27	6.84	3.40	4.24	3.64	0.78
V19	2.58	137.00	41.89	2.22	16.87	83.13	7.44	34.22	19.11	1.79	1.32	22.61	8.51	2.66	6.12	4.62	0.66
V20	2.54	130.00	38.89	3.08	25.53	74.47	9.49	44.16	14.83	2.98	0.85	24.41	5.84	4.18	8.65	10.20	0.55
V21	4.31	134.22	40.89	2.57	9.90	90.10	5.24	33.87	15.34	2.21	0.99	22.50	6.93	3.25	4.26	4.31	0.66
V22	3.63	185.89	46.00	2.30	14.90	85.10	3.82	27.72	15.64	1.77	0.91	20.19	7.90	2.55	2.91	3.21	0.73
V23	3.60	136.11	46.56	2.84	25.07	74.60	5.74	30.05	19.23	1.56	0.85	21.96	8.01	2.74	4.89	5.77	0.73
V24	3.59	216.67	56.11	2.83	10.10	89.90	7.40	58.76	17.92	3.28	1.38	28.75	8.48	3.39	6.02	4.36	0.49
V25	3.93	178.56	60.44	3.28	15.20	84.80	3.88	31.71	16.67	1.90	1.12	22.55	7.65	2.95	2.76	2.47	0.71
V26	3.24	123.67	48.67	3.89	19.77	80.23	9.21	41.86	18.81	2.22	0.94	25.82	7.08	3.64	8.26	8.77	0.62
V27	3.02	125.11	55.33	3.40	20.30	79.70	7.97	32.79	18.76	1.75	0.92	21.21	7.88	2.69	7.06	7.71	0.65
V28	3.00	115.78	56.00	3.20	20.23	79.77	12.91	41.77	19.81	2.11	0.92	24.24	7.61	3.19	11.99	12.99	0.58
V29	2.25	157.33	32.33	3.71	19.33	80.67	6.74	31.22	19.23	1.62	1.09	21.30	8.13	2.62	5.64	5.16	0.68
V30	3.69	125.78	41.67	4.17	19.47	80.53	9.89	36.60	18.03	2.03	1.03	21.64	8.16	2.65	8.86	8.58	0.59
V31	4.10	190.11	43.78	3.44	18.64	81.36	5.17	43.44	16.68	2.61	1.01	26.59	8.52	3.12	4.16	4.11	0.61
V32	3.47	184.44	60.78	2.66	11.27	91.73	6.18	34.46	17.10	2.02	0.79	22.33	6.96	3.21	5.39	6.82	0.65

VARIETIES	Lo.P (m)	No.Pe	Lo.Pe (cm)	La.Pe (cm)	Hu (%)	Ms (%)	P.F (g)	Lo.F (mm)	La.F (mm)	Lo/La.F	P.G (g)	Lo.G (mm)	La.G (mm)	Lo/La.G	P.Pu (g)	P.Pu/P.G	Lo.G/Lo,F
V33	4.04	170.00	46.33	3.43	21.17	78.83	7.42	34.94	19.65	1.78	1.13	21.74	8.36	2.60	6.29	5.56	0.62
V34	3.63	87.11	52.44	3.60	16.10	83.90	10.72	39.43	20.53	1.92	1.15	21.99	9.05	2.43	9.57	8.32	0.56
V35	3.20	157.00	45.56	3.36	39.37	60.63	11.82	38.95	24.13	1.61	0.82	21.05	6.63	3.18	11.00	13.45	0.54
V36	3.03	175.00	39.11	2.79	16.73	83.27	8.62	39.56	18.64	2.12	1.05	24.78	7.93	3.13	7.56	7.17	0.63
V37	3.03	173.67	38.33	2.79	21.17	78.83	5.66	29.33	19.06	1.54	1.23	20.33	8.05	2.53	4.43	3.60	0.69
V38	3.74	204.33	49.67	4.53	19.13	80.87	6.71	36.05	16.64	2.17	1.06	23.51	8.14	2.89	5.65	5.34	0.65
V39	3.32	138.00	50.44	2.44	18.93	81.07	6.44	37.78	16.18	2.34	1.00	25.29	7.00	3.61	5.43	5.43	0.67
V40	3.46	134.44	53.78	2.80	27.23	72.77	5.98	31.50	21.07	1.50	0.77	21.38	7.82	2.73	5.21	6.74	0.68
V41	3.22	105.56	45.33	2.29	23.03	76.97	14.62	35.53	21.49	1.65	1.16	22.77	8.24	2.77	13.46	11.59	0.64
V42	3.04	166.56	46.11	2.59	18.23	81.77	9.45	35.23	17.31	2.03	1.12	19.82	8.25	2.40	8.33	7.43	0.56
V43	3.41	228.89	52.33	5.19	21.03	78.97	10.87	30.09	20.67	1.46	1.36	22.81	8.78	2.60	9.51	7.00	0.76
V44	3.06	132.78	41.33	2.47	15.83	84.17	8.88	37.05	21.74	1.70	1.10	20.97	7.63	2.75	7.78	7.04	0.57
V45	3.70	166.22	33.33	3.30	20.47	79.53	7.35	34.58	14.13	2.45	0.74	21.96	5.37	4.09	6.62	9.00	0.64
V46	4.42	211.56	73.22	4.14	49.17	50.83	11.63	51.71	24.54	2.11	1.10	23.28	7.02	3.31	10.53	9.58	0.45
V47	2.56	127.33	33.89	3.63	21.07	78.93	8.00	42.20	20.67	2.04	0.88	22.93	7.73	2.97	7.12	8.09	0.54
V48	4.44	203.78	53.11	4.24	24.60	75.40	3.92	29.20	19.53	1.49	0.83	23.71	6.93	3.42	3.09	3.70	0.81
V49	2.39	163.78	46.89	2.37	20.47	79.53	9.05	34.05	19.68	1.73	1.24	22.72	9.13	2.49	7.81	6.28	0.67
V50	3.69	179.78	43.33	3.38	17.70	82.30	5.82	32.64	16.84	1.94	0.82	22.20	7.34	3.03	5.00	6.10	0.68
V51	4.20	182.33	48.56	3.14	20.30	79.70	9.54	45.85	17.00	2.70	1.07	23.89	7.19	3.32	8.47	7.90	0.52
V52	3.73	181.44	61.44	3.32	16.63	83.37	8.69	38.37	18.53	2.07	1.62	25.63	8.82	2.91	7.06	4.35	0.67
V53	3.59	199.78	60.00	4.06	14.43	85.57	7.20	38.81	17.51	2.22	1.01	23.25	8.01	2.90	6.19	6.10	0.60
V54	3.23	111.89	49.22	2.73	16.50	83.50	7.99	39.06	15.96	2.45	0.75	22.85	6.84	3.34	7.24	9.60	0.59
V55	2.52	140.89	35.44	3.86	27.57	72.43	13.02	33.96	21.83	1.56	1.25	23.96	7.24	3.31	11.77	9.44	0.71
V56	3.11	162.78	48.89	3.39	13.10	86.90	5.05	32.96	14.71	2.24	0.57	19.24	6.35	3.03	4.48	7.79	0.58
V57	3.08	115.22	63.11	2.44	20.57	79.43	8.56	37.69	19.08	1.98	1.32	22.51	7.47	3.01	7.22	5.48	0.60
V58	3.83	132.33	53.89	4.22	16.00	84.00	7.34	39.98	17.50	2.28	1.33	20.94	9.20	2.28	6.02	4.54	0.52
V59	4.40	104.78	53.44	3.39	20.97	79.03	4.65	34.64	15.15	2.29	1.67	22.77	7.36	3.09	2.97	1.78	0.66
V60	2.60	131.33	43.22	2.67	19.90	80.10	9.20	36.25	18.97	1.91	1.14	24.11	7.20	3.35	8.06	7.06	0.66
V61	2.53	119.33	38.67	2.72	12.87	87.13	6.67	36.46	18.66	1.95	1.15	22.08	8.39	2.63	5.52	4.79	0.61
V62	3.05	161.78	44.89	2.53	15.80	84.20	9.82	44.91	18.27	2.46	1.31	25.52	7.41	3.44	8.51	6.48	0.57
V63	2.52	141.89	42.11	3.18	29.10	70.90	11.37	35.37	15.39	2.30	1.62	23.16	8.62	2.69	9.75	6.01	0.65
V64	4.16	199.56	53.33	4.37	16.37	83.63	9.77	41.40	18.95	2.19	1.06	26.27	6.65	3.95	8.71	8.19	0.63
V65	3.43	169.56	50.89	3.33	22.50	77.50	8.35	40.58	16.99	2.39	0.84	24.90	7.16	3.48	7.51	8.94	0.61
V66	3.14	111.11	53.78	2.66	20.63	79.37	7.20	31.80	20.58	1.54	1.30	23.95	6.29	3.81	5.90	4.54	0.75
V67	4.00	185.33	52.11	2.53	10.80	89.20	5.89	34.52	16.70	2.07	1.04	23.64	7.53	3.14	4.85	4.66	0.68

VARIETIES	Lo.P (m)	No.Pe	Lo.Pe (cm)	La.Pe (cm)	Hu (%)	Ms (%)	P.F (g)	Lo.F (mm)	La.F (mm)	Lo/La.F	P.G (g)	Lo.G (mm)	La.G (mm)	Lo/La.G	P.Pu (g)	P.Pu/P.G	Lo.G/Lo,F
V68	2.35	137.00	44.67	2.78	19.11	80.89	7.67	26.35	18.78	1.40	1.00	18.55	10.25	1.81	6.67	6.68	0.70
V69	3.18	137.11	49.56	2.77	14.80	85.20	3.26	24.54	15.58	1.57	1.01	18.29	8.03	2.28	2.25	2.22	0.75
V70	2.55	101.00	36.22	2.71	12.97	87.03	9.87	42.39	16.83	2.52	1.51	26.93	7.42	3.63	8.36	5.53	0.64
V71	3.28	157.00	54.11	2.39	22.07	77.93	10.09	28.29	23.27	1.22	1.17	18.58	8.68	2.14	8.93	7.64	0.66
V72	3.72	149.78	50.00	2.96	17.00	83.00	4.17	35.59	23.96	1.49	1.03	19.75	8.70	2.27	3.13	3.03	0.55
V73	3.44	163.11	50.89	3.58	17.67	82.33	9.50	40.47	18.31	2.21	1.17	25.64	7.94	3.23	8.33	7.14	0.63
V74	2.95	162.11	51.11	2.91	11.23	88.77	6.03	32.39	19.58	1.65	0.80	20.31	7.48	2.72	5.23	6.54	0.63
V75	3.86	199.89	43.56	2.94	17.40	82.60	5.96	36.24	18.55	1.95	0.86	23.71	7.25	3.27	5.10	5.93	0.65
V76	4.08	153.44	53.56	2.34	16.57	83.43	6.55	44.48	16.87	2.64	0.91	25.88	7.07	3.66	5.63	6.16	0.58
V77	3.17	183.44	45.44	3.04	11.98	86.69	7.94	38.63	21.20	1.82	0.73	20.40	6.68	3.05	7.21	9.88	0.53
V78	3.86	215.11	47.11	2.92	13.20	86.80	5.71	33.43	16.02	2.09	0.84	21.86	7.25	3.01	4.88	5.82	0.65
V79	3.70	147.89	50.22	2.13	21.87	78.13	9.01	36.27	23.09	1.57	1.05	22.18	8.00	2.77	7.97	7.60	0.61
V80	3.68	193.89	47.44	3.04	17.03	82.97	6.42	36.11	19.23	1.88	1.27	21.70	9.10	2.39	5.15	4.07	0.60
V81	3.11	131.33	36.89	3.66	12.90	87.10	5.78	38.53	16.07	2.40	1.37	28.50	7.71	3.69	4.41	3.23	0.74
V82	2.93	124.78	50.44	4.03	32.77	67.23	11.26	40.94	20.28	2.02	1.39	27.93	6.33	4.41	9.87	7.11	0.68
V83	3.34	142.78	47.78	2.79	15.23	84.77	8.21	37.46	19.90	1.88	1.14	22.68	8.34	2.72	7.07	6.19	0.61
V84	4.08	126.11	48.00	2.82	16.97	83.03	7.36	37.45	17.40	2.15	1.01	25.20	7.04	3.58	6.35	6.28	0.67
V85	3.48	125.56	54.22	2.80	27.70	72.30	7.19	34.33	17.77	1.93	0.72	21.85	5.57	3.92	6.47	8.98	0.64
V86	2.63	160.44	53.11	2.61	18.97	81.03	8.40	35.84	19.82	1.81	1.09	23.57	8.09	2.91	7.31	6.72	0.66
V87	3.00	173.11	42.56	3.70	27.70	72.30	5.92	32.85	17.92	1.83	1.02	20.66	7.92	2.61	4.90	4.82	0.63
V88	3.30	133.00	54.78	2.83	22.60	77.40	7.07	32.70	21.49	1.52	1.37	26.08	7.60	3.43	5.70	4.15	0.80
V89	3.40	131.44	47.89	3.53	24.73	75.27	4.75	28.92	15.92	1.82	1.29	21.85	6.13	3.56	3.46	2.68	0.76

Leaf length (Lo.P), pinna number (No.Pe), pinna length (Lo.Pe), pinna width (La.Pe), humidity (Hu), dry matter (Ms), fruit weight (P.F), fruit length (Lo.F), fruit width (La.F), length / width of fruit (Lo/La.F), seed weight (P.G), seed length (Lo.G), seed width (La.G), length / width of seed (Lo/La.G), weight of pulp (P.Pu), weight of pulp / weight of seed (P.Pu/P.G) and length of seed / length of fruit (Lo.G/Lo.F).

Longitud de la hoja (Lo.P), número de pinnas (No.Pe) longitud de la pinna (Lo.Pe), ancho de la pinna (La.Pe), humedad (Hu), materia seca(Ms), peso del fruto (P.F), longitud del fruto (Lo.F), ancho del fruto (La.F), longitud / ancho del fruto (Lo/La.F), peso de la semilla (P.G), longitud de la semilla (Lo.G), ancho de semilla (La.G), longitud / ancho de la semilla (Lo/La.G), peso de la pulpa (P.Pu), peso de la pulpa / peso de la semilla (P.Pu/P.G) y longitud de la semilla/ longitud del fruto (Lo.G/Lo.F).

RESULTS

Mean values of morphometric characters studied are reported in Table III. Data show large variability between cultivars.

The overall differences in morphological variables between cultivars were examined by principal component analysis. The first component accounted for about 27% of the total variability, while the cumulative variance explained by the first two and the three components were about 44% and 55%, respectively (Table III).

We found also their positions with respect to the fruits and the leaf (see Fig. 2), and especially of the quantities values studied, that 12 parameters (variables) have a good representation among the 17 parameters which deliberated.

This results was obtained by using the theory of the parameters square cosinus.

The abbreviations names are found in Fig. 3, and their square cosinus values were taken in two axis, the most important values are the sum of square cosinus of the first and second axis. it's very important to take the values of the sum square cosinus bigger than 0.70 as well repported,to have an excelent representation.

The values obtained were the following: pulp weight (0,865), which is the highest value; fruit weight (0,851), fruit length/fruit width (0,754), fruit length (0,746), weight of pulp seed (0,675), the coefficient seed length/width (0,576), dry matter (0,516), humidity (0,513), fruit width (0,449), seed length (0,426), seed width (0,305), and the seed length/fruit length (0,393).

The results show that there are only 18 varieties, and by using this theory of square cosinus of the variables, shows that:

Class Bezoul El Khadem (V16) has been taken the value of square cosine of the category of the varieties equal to 0.890, Haloua (V69) 0.785, Tantebouchet (V71) 0.771, Guelb Echa (V67) 0.764, Ghazi (V65) 0.755, Bedai (V13) 0.745, Tichtat (V37) 0.712, Rotebet Abdelah (V35) 0.690, Daglet Azzi (V25) 0.684, Guelb Echa (V68) 0.681, Rebib El Ghars (V51) 0.656, Sbaa Laroussa (V76) 0.655, Halouat Saada (V22) 0.652, Arechti (V7) 0.638, Deglet Nour (V28) 0.635, Baydh Lahmam (V41) 0.634, Baydh Ghoul (V12) 0.620 and Bouzerou (V21) the square cosinus of the category equal to 0.603.

By observing the correlation circle in Figure 3, the traits have shown a convergence, between the variables which are: Humidity (Hu) was in creasing relationship with weight of pulp (P.Pu), fruit weight (P.F), coefficients of the weight/seed (P.Pu/P.G), fruit width (La.F), and with decreasing relationship by (Ms), as the first group.

The second group: fruit width (Lo.F), coefficient length of fruit/width (Lo/La.F), the coefficient seed length/width (Lo/La.G) and seed length (Lo.G), these above traits have a common effect with themselves, but it remains the representation of this group average compared to the first set of variables.

Axis 1 (F1): The traits that have a good representation are: the weight of pulp (0.763), fruit weight (0.747), the coefficient weight of pulp/seed (0.631), the fruit length (0.582), and to a lesser extent a proportion of humidity (0.390) was find, the proportion of dry matter (0.390), the coefficient the length of the seed/fruit length (0.391), and the coefficient the length of fruit/width (0.225).

Axis 2 (F2): The parameters which have the middle representation are the parameters length/width (0.529), the coefficient length of seed/width (0.444), the fruit width (0.412), the seed length (0.310) and the seed width (0.252).

To verify the overlap of the traits, the correlation coefficient was studied, as described in Figure 3: results show the existence of liaisons and the counter liaisons between certain traits.

From the vegetative parameters: leaf length (Lo.P) increases with the pinnae number (No.Pe). In the traits fruiting: humidity (Hu) has increased with the fruit weight, counter productive with the proportion of dry matter (Ms), finally it has an inverse relationship with the pulp weight (P.Pu). Fruit weight (P.F) has increasing relationship with each of the fruit length (Lo.F), the pulp weight (P.Pu), coefficient weight of flesh/seed (P.Pu/P.G), and counterproductive with the coefficient length of the seed/length of the fruit (Lo.G/Lo.F). However the fruit length (Lo.F) has an increasing relationship with each of the coefficient length/width of fruit (Lo/La.F), the seed length (Lo.G), the pulp weight (P.Pu), but counterproductive with the coefficient of length of seed/length of the fruit (Lo.G/Lo.F). On the other side, the fruit width has an inverse relationship with the coefficient of length/width of fruit (Lo/La.F).

Beside of that the coefficient of length/width of fruit (Lo/La.F) has an inverse relationship with the coefficient of seed length/fruit length (Lo.G/Lo.F). The seed length (Lo.G) has a growing relationship with the coefficient of length/width of the seed (Lo/La.G). And (Lo/La.G) has an inverse relationship with seed width (La.F), pulp Weight (P.Pu) has increasing relationship with the coefficient pulp weight of the seed (P.Pu/P.G), and counterproductive with the coefficient of the seed length/fruit length (Lo.G/Lo.F), and (Lo.G/Lo.F) it has an inverse relationship with coefficient pulp weight on the seed (P.Pu/P.G).

According to the kinship which has been described in Figures 4 and 5, there are 3 homogeneous groups, and this heterogeneity has been caused by the most important variables in the plan consisting of two axes (F1 and F2), and this division with respect to the Pearson coefficient = 0.982, where each group will be composed of the following:

Group 1: the largest groups containing 48 varieties (components), and these varieties are similar with each other in this set of the variables: the seed width (La.G), fruit

Table IV. Value of variations accumulated for the compounds F1, F2 and F3 resulting from the analysis.

Tabla IV. Valor de las variaciones acumuladas del F1, F2 y F3 compuestos resultantes del análisis.

Axes	Eigenvalues	Variability (%)	Accumulated (%)
F1	4,580	26,941	26,941
F2	2,892	17,012	**43,953**
F3	2,000	11,762	55,715

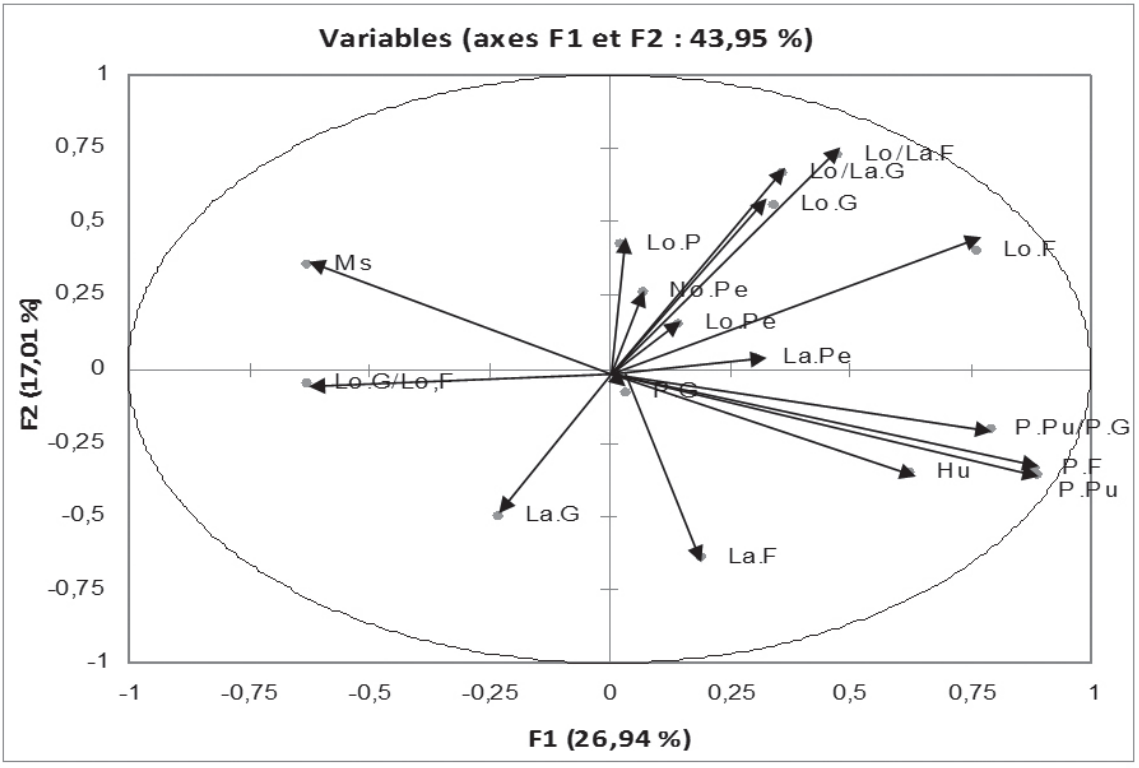

Figure 3. Correlation circle shows the relationship of the parameters and factorial axis

Figura 3. Circulo de correlación mostrando la relación entre los parámetros y los ejes factoriales

width (La.F), humidity (Hu), coefficient of weight of flesh/seed (P.Pu/P.G), the coefficient seed length/fruit length (Lo.G/Lo.F), fruit weight (P.F), and the pulp weight (P.Pu).

Group 2: composed by 34 varieties, which have the similarity in the following set of variables: the fruit length (Lo.F), the seed length (Lo.G), the proportion of dry matter (Ms), the coefficient of length/width of seed (Lo/La.G), and the coefficient length/width of fruit (Lo/La.F).

Group 3: Is composed of 3 varieties.

With regard to eigenvalue equal 43.95%, this value will be considered acceptable made it possible to find 58% of the first group down the coordinate's axis, and 67% above the coordinate's axis.

DISCUSSION

The results obtained show differences between the varieties, especially fruiting characteristics, while vegetative traits are not representative of the varieties.

Overall analysis selected leaves characteristics shows a high diversity of cultivars. Certainly this phenotypic variability reflects a genetic diversity while the environment effect was eliminated. This diversity is due to genetic recombination during the sexual reproduction, given that each cultivar derives from a unique seed, cloned thereafter by vegetative multiplication (Elhoumaizi *et al*. 2002).

The morphological studies of date palm have always

been considered difficult to undertake because they require a large set of phenotypic data and because they are varied due to the environment effect (Munier 1973). The present study has sifted morphological characters that are not controlled by edaphic or climatic factors. Several previously published data have indicated some morphological characters but the major has an adaptive response to the environment (Nixon 1950).

The geographic origin was not a determinant criterion for cultivars aggregation, because the names of cultivars change frequently from one oasis to the other because synonyms and homonyms may be encountered.

The majority of the phenotypic studies on date palm aimed at studying the spectrum of the genetic variation but they cannot allow definitive discrimination between cultivars, fruit quality and plant behavior. However, the study of Saaidi (1979) and Elhoumaizi *et al.* (2002) highlighted a strong morphological resemblance between some date palm cultivar known for their resistance to Bayoud disease.

Date palm selection by peasants is often based on fruit characteristics. Hence, this study highlighted the relationship between vegetative and fruit characteristics which may be genetically related. Vegetative tools are so important in genotype evolution process; they are decisive in date palm cultivar selection and adaptation (Hamza *et al.* 2009).

Previous studies have looked at biochemical and molecular markers of cultivars. The use of isozymes permit discrimination of some cultivars but these methods are not in routine use (Baaziz & Saaidi 1998, Bennaceur *et al*. 1991). In addition, these methods gave contradicting results when applied to date-palm trees and other plants (Chevreau 1990, Elhoumaizi *et al*. 1993).

Research in molecular markers is taking the lead in this context (Aitchitt *et al*. 1995, Corniquel & Mercier 1997, Lewis *et al*. 2000). However, these methods are at a preliminary stage with regard to date-palm research, and they have been tested on a limited number of cultivars (Benabdellah *et al*. 2000, Trifi *et al.* 2000). Despite the large number of cultivars evaluated by Sedra *et al*. (1998) (43 cultivars using RAPD markers), the study could not identify a significant discriminating criteria between different cultivars. In addition, this study overlooked some important cultivar like 'Mekt', 'Oumnhel', 'Racelahmar'and 'Mestali'. The currently existing biochemical and molecular data do not allow definitive discrimination between cultivars, fruit quality and resistance to Bayoud disease.

Morphological, isozyme and molecular data of date palm cultivars gave different results (Elhoumaizi *et al.* 1993, Bendiab *et al*. 1993, Sedra *et al.* 1998).

Vegetative characteristics can be considered as a principle to know the differences between the date palm varieties (Djerouni *et al*. 2015). Moreover, Mohamed Lemine *et al*. (2014) affirmed in their study of 28 Mauritanian date palm varieties that there are differences in the physical characteristics of the fruits. As Haider *et al.* (2015) concluded in their study on the sixteen Pakistani palm dates varieties from different origins in terms of vegetative characteristics that the pinna number, length and width and the Leaf palm length are characteristics that help to differentiate between the types of date palm. According to Saker *et al*. (2010), the anatomical study of date palm fruits is a scientific measure that helps to find the similarities between the female varieties. Hamadi *et al*. (2009) have confirmed in their study of some Tunisian date palm varieties that the vegetative characteristics like thorns length, the length of thorns area and the leaf palm length are appropriate characteristics that show the similarities and the differences between the female palms. Since the vegetative characteristics are only the expression of genes, the molecular analysis proved the phenotypic differences between palm date varieties (Ahmed *et al*. 2006, Zhao *et al*. 2013).

The same situation was observed in other plants, because a short distance calculated with RFLP markers always corresponds to a short morphological distance; however, a long distance calculated with the molecular markers can correspond to a long or a short morphological distance. This relation could be explained with the fact that a morphological character can be resulted of various combinations of genes (Grivet & Noyer 1999). The morphological study is indispensable as far as programs of selection and improvement of date palm are concerned.

This method of taxonomy cannot resolve definitively the cultivar identification problem. In fact, many different populations may have the same aspect in spite of their different genotypes.

Future studies should consider the possible relations of other important phenotypic markers related to the tolerance towards oases stress. This should be backed up by others studies such as molecular ones to provide reliable tools for measuring genetic divergence.

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Appendix A. Names and abbreviations of cultivars of *Phoenix dactylifera* used in this study.

Apéndice A. Los nombres y las abreviaturas de los cultivares *Phoenix dactylifera* usados en este estudio.

Code	Cultivar	Code	Cultivar	Code	Cultivar
V1	Abdelazaz	V31	Derjini	V61	Fliachia
V2	Ain El Fés	V32	D'For El Gat	V62	Garn Ghazel
V3	Saout Bghal	V33	D'Guel Arechti	V63	Lokzi
V4	Alig	V34	Adjina	V64	Ghars
V5	Amari	V35	Rotebet Abdelah	V65	Ghazi
V6	Arar	V36	D'Guel Boujadi	V66	Tati Bent Nouh
V7	Arechti	V37	Tichtat	V67	Kantichi
V8	Khnafre	V38	D'Guel Bouzouaid	V68	Guelb Echa
V9	D'Guel Eljayh	V39	D'Guel Daim	V69	Haloua
V10	Assala	V40	D'Guel Debdab	V70	Halouat Loulache
V11	Baar El Djeaach	V41	Baydh Lahmam	V71	Tantebouchet
V12	Baydh Ghoul	V42	D'Guel El Bar	V72	Noyet Rass El Thaour
V13	Bedai	V43	Takarmoust	V73	Tafezuine
V14	Bent Merague	V44	D'Guel Hamlaoui	V74	Hamrayet El Ghareb
V15	Besbassi	V45	Khaira D'Guel	V75	Noyet Deglet Nour
V16	Bezoul El Khadem	V46	Zogar Mogar	V76	Sbaa Laroussa
V17	Bouarous	V47	Zemachi	V77	Horra
V18	Ech Chouaib	V48	D'Guel Maroufi	V78	Mech Degla
V19	Boulantate	V49	Rass El Thaour	V79	Itima
V20	Bouzenzen	V50	Mezith	V80	Jaouzia
V21	Bouzerou	V51	Rebib El Ghars	V81	Sokria
V22	Halouat Saada	V52	Dalgla touila	V82	Sokriet Hassanine
V23	Dahbia	V53	Tinicine	V83	Khdraye
V24	Degla Baidha	V54	D'Guel Souareg	V84	Safraye
V25	Daglet Azzi	V55	Oudane	V85	Rotbet Cheikh Amar
V26	Khdraya	V56	D'Guel Trik	V86	Khoudri
V27	Daglet Med Tahar	V57	Timdjouhart	V87	Kseba
V28	Deglet Nour	V58	Thouri	V88	Laoun Litima
V29	Daglet Ziane	V59	Ech El Oued	V89	Menakher
V30	Daldala	V60	Tebet Nouh		

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