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RESEARCH ARTICLE

Phenotypic Characterization of Local Date Palm Cultivars at Jericho in Palestinian Jordan Valley District

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Abstract

Background: This study aimed to evaluate the phenotypic diversity of Date Palm cultivars grown in Jericho region in Palestine, in order to identify and preserve the most economically and environmentally feasible cultivars. **Methods:** Thirty-five samples were collected from three historical Palm stations in Jericho during the harvest season in September 2018 and repeated in September 2019. Twenty-two morphological markers were analyzed separately on vegetative parts using multivariate analysis. **Findings:** The results showed high morphological variability among local Date Palm cultivars. Data analysis using principal component analysis revealed that morphological characteristics of fruits and leaves could be used for identification and description of Date Palm cultivars. The results showed a wide variation for different degrees of similarity when local cultivars were separated from introduced one. Significant variation was found among the 35 cultivars for most studied traits, and showed the superiority of the fruiting characteristics in NARC1, NARC4, NARC5, DH4 and DH5 cultivars. These local varieties have a good fruit width range from 19.2 to 20.3 mm; fruit length 47.01 mm; fruit size more than 8 cm^3; and fruit weight and flesh weight, 9.8g and 8.87g. **Novelty:** Up to our knowledge, this study is the first of its kind in Palestine where the local Date Palm cultivars in Jericho area were assisted by studying the morphological characteristics of fruits and leaves. The data obtained could help to create a phenotypic database and use the most discriminants descriptors found in this study for a large-scale phenotyping.

Keywords: Date Palm; Cultivar; Phenotypic diversity; Morphological variability; Jericho

1 Introduction

Date Palm (*Phoenix dactylifera* L., Arecaceae), is the oldest cultivated fruit tree and it has a great socio-economic importance due to its commercial, nutritional,

environmental, social, health and religious values [1]. It is broadly distributed in many regions of the world, especially in North Africa and the Middle East. These countries grow 62 million of the 105 million trees available worldwide [2]. About 5000 different Date Palm cultivars are known worldwide and date fruit production and consumption are continuously increasing [3]. The worldwide production of dates fruits is about 8.5 million mt in 2018 [4]. Jericho district in Palestine is characterized by extensive farming system where the agriculture sector is one of major sources of income for the population. Date palm is considered one of the most important fruit crops in Palestine and its plantations cover an area of 725 ha distributed in the regions of Jordan Valley (West Bank) and in the Gaza Strip in 2012. Dates constitute about 0.9% of total cultivated agricultural land of the West Bank. Jericho governorate at Jordan Valley is considered the highest producer of soft dates, constituting 99% of total production in the West Bank [5]. In recent years, a significant increase in date palm farming and production in Palestine was recorded. Palestinian Ministry of Agriculture estimated that 11000 mt were produced in Jericho governorate in 2019. In addition to that, there are approximately 217000 fruitful palm trees. Medjool cultivar constitutes about 95% of date palms followed by local varieties (e.g. Baladi) and some introduced and improved varieties, such as Barhi and Deglet Nour. The extremely high temperatures and the low relative humidity that prevail in those areas during spring and summer provide the optimal conditions for growth and development of the date palm, as well as for maturation of the fruits [6,7].

Medjool is improved, introduced cultivar and one of the finest dates produced in Palestine, regionally and globally. Because it is grown in areas below sea level, there is an increase in the proportion of oxygen available to the palm, which aids respiration and in turn adds flavor and a distinctive color to the fruits [8]. Local varieties have been grown from seeds and have been selected by farmers over the years, which are closely similar to the improved and introduced cultivars. The local varieties have been adapted to the high temperature, soil salinity and drought that characterizes the Jericho region in Palestine. In addition, the lack of information about the plant genetic resources minimizes the advantages of the potential diversity existing among cultivars. Therefore, it is urgent to implement a strategy to support cultivars preservation and to restore genetic resources of date palm as well as for commercial valorization of unknown cultivars. Hence, cultivars characterization should be the first step because it is an essential prerequisite for evaluation of date palm varieties. Several studies have adopted morphological characteristics to identify date palm varieties [9–13].

Date palm is considered one of the economically feasible crops in Palestine. For this reason, conservation of local cultivars is a priority for date palm farming. However, the introduction of improved cultivars and lack of attention to local varieties leads to their loss. The aim of this study was to describe the phenotypic diversity of Palestinian date palm cultivars, identify discriminants descriptors that can be used in the field to recognize and differentiate between cultivars, assess similarity relationship among the local date palm cultivars, and to identify the most economically and environmentally feasible cultivars in order to preserve them.

2 Materials And Methods

2.1 Study area

Jericho is a Palestinian city in the West Bank.It isthe oldest city in the world31°52′16″N, 35°26′39″E located innorth to the altitude of 273 m below sea level Figure 1C, and the humidity is 49 %.in Jericho governorate at Palestinian Jordan valley were chosen as follows: Jericho Agriculture Experiment station (NARC); Arab Development Society SHijleh station (DH)Figure 1 [14].

2.2 Sampling

Thirty-five indigenous and exotic female date palm cultivars were selected from the three identified stations, which represent the diversity of all dates cultivars in the area based on the records of the stations. There were 13 samples from NARC, 12 from ADS and 10 samples from DH station Table 2.The experiment was designed as a completely randomized design with three replications. Fruit samples at the full ripening stage were collected from the identified cultivars during the harvest season in September 2018, and repeated in September 2019. While, leaf samples were collected from the same cultivars during February 2019. In order to conduct the morphological characterization, twenty-two (22) vegetative traits of the date palm were analysed for all of the identified trees. Out of which 10 were agronomic (fruit and seed traits) (MP1-MP10) and 12 were leave traits (MP11- MP22) as described in Table 1. These characters have already been reported as a standard descriptor to characterize date palm [10,11,15–18]. Thirty fruits of each cultivar were harvested at rutab stages. The preparation of fruit samples were cleaned, packed in polyethylene film bags and immediately frozen and kept at —- 80°C according to Sakr et al., (2010) [19]. All measurements were performed in triplicate using measuring tape and different geometrical tools. The length and diameter of the fruit (mm) were measured using a micrometer caliper.

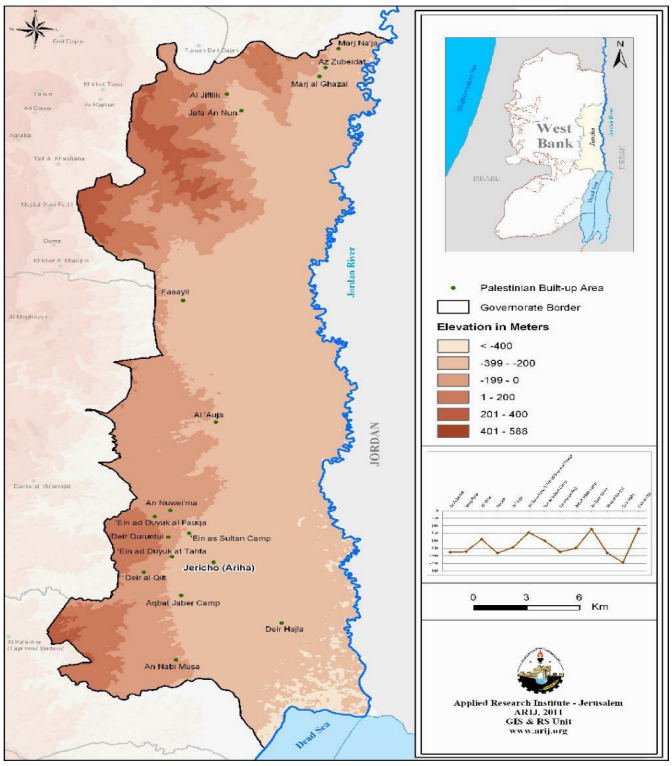

Fig 1. The geographical distribution of date palm stations in Jericho governorate in Jourdan Valley

Table 1. The studied phenotypic traits with their designations

Phenotypic Trait		Trait Code	Unit
Fruit	Colour	MP1	Scale of notation
	Texture	MP2	Scale of notation
	Length	MP3	Mm
	Width	MP4	Mm
	Volume	MP5	cm^3
	Weight of the flesh part	MP6	gr
	Weight of the fruit	MP7	Gr
Seed	Length	MP8	Mm
	Width	MP9	Mm
	Weight	MP10	Gr
Leaf	Leaf length	MP11	Cm
	Leaf width	MP12	Cm
	Middle leaflet length	MP13	Cm
	Middle leaflet width	MP14	Cm
	Middle spine length	MP15	Cm
	Middle spine width	MP16	Cm
	Spinate part length	MP17	Cm
	Leaflet number	MP18	Scale of notation
	Spine number	MP19	Scale of notation
	Colour	MP20	Scale of notation
	Curvature of the leaf	MP21	Scale of notation
	Arrangement of spines	MP22	Scale of notation

With: gr: gram; mm: millimeter; cm: centimeter.

2.3 Data analysis

Statistical analyses were performed using analysis of variance (ANOVA) to detect significant variation among the cultivars for each trait, and differences between the means were determined using Tukey's HSD test at $p < 0.01$.

Traits means values were used to perform principal component analysis (PCA) and the correlation analyses (CA) to test whether the variables are correlated in the population [12]. Cluster analysis was carried out using IBM SPSS (Ver. 20) Ward method to perform hierarchical clustering analysis [20]. This analysis will allow us to classify the studied cultivars into homogeneous and distinct groups. All analyses were performed using XLSTAT (Microsoft) version 2016.02.

3 Results And Discussion

Phenotypic characterization of the thirty-five cultivars for leaves, fruits and seeds were studied and the mean values of the measured traits (MP1-MP22) are given in Tables 2 and 3. The date palm cultivars exhibited significant differences ($p < 0.01$) among the cultivars for most of the studied traits.

Table 2 shows the resultsfor five qualitative morphological features (fruit colour, consistency, leaf colour, curvature and arrangement of spines) revealed high variability between cultivars. The fruit colour ranged from dark brown (Maijhool, Hijazi, Hayani, Baladi 3, 8, 23, 24 and 25) to golden (Barhi, Deglet Nour, Zhedi, Khadrawy, Baladi 1-2, 4-7, 10, 19, 21-22 and Baladi 26-27). Marzouk and Kassem (2010) [21] reported that fruit colour in dates is enhanced with the application of organic manures or supplementation with mineral NPK compared to mineral fertilization alone. Said et al. (2014) [18] recorded six colours in date fruits including from yellow, orange, red, brown, black and dark in a study deals with the characterization and evaluation of the morphological quality of date palm cultivars grown in Algeria. Farmers have denominated the cultivars based on shape and colour of the fruits or the presence of specific location [9]. Along with this, the date palm is selected for cultivation based on better fruit quality and post-harvest life. The obtained results showed that the date cultivars were clustered based on fruit consistency into four groups: so-soft fruit (Maijhool, Barhi and Baladi2), semi-dry fruit (Deglet Nour, Hijazi, Zhedi, Khadrawy, Baladi 3, 7, 11-12, 14, 23 and Baladi 27), dry fruit cultivar (Baladi 10) and other cultivars fruit were soft. Fruit consistency constitutes an important quality trait in dates. The classification of dates into soft, so-soft, semi-dry and dry types, mainly based on the consistency of the ripe fruit (Rutab stage), is thought to be associated with the content of particular sugars and water. According to Said, et al., (2014) [18], dates are classified based on moisture content as dry date with less than 20 percent. Dry dates are exceptionally important for the date palm culture in production areas where storage under in room temperature required.

Dry types are considerably easier to store than soft types that are consumed fresh during the production season. This is an indication of its mixed group (dry, semisoft, or soft) because of seed propagation [17,22]. Leaf colour, arrangement of spines and curvature of the leaf revealed great variability between cultivars Table 2**.** These results agreed with a study conducted by Salem, et al., (2008) [23].

Table 2. Quantitative morphological features for thirty-five date palm cultivars collected from the study area at Jericho in Palestine

Site	Cultivar #	Cultivar Code*	Fruit Colour	Fruit Texture	Leaf Colour	Curvature of the Leaf	Arrangement of the Spines
	Baladi 7	DH1	Golden	Semi-dry	Pale green	Curving	Solo
	Baladi 8	DH2	Dark brown	Soft	Bright green	Standing	Paired
	Baladi 9	DH3	Brown	Soft	Pale green	Semi-curving	Paired
Deir Hijleh Station	Baladi 10	DH4	Golden	Dry	Pale green	Semi-curving	Paired
	Baladi 11	DH5	Brown	Semi-dry	Pale green	Standing	Paired
	Baladi 12	DH6	Brown	Semi-dry	Pale green	Standing	Paired
	Baladi 13	DH7	Brown	Soft	Dark green	Semi-curving	Paired
	Maijhool 2	DH8	Dark brown	So soft	Pale green	Semi-curving	Triple
	Baladi 14	DH9	Brown	Semi-dry	Dark green	Standing	Solo
	Baladi 15	DH10	Brown	Soft	Bright green	Semi-curving	Solo
	Baladi 16	ADS1	Brown	Soft	Pale green	Semi-curving	Paired

Continued on next page

Table 2 continued

	Baladi 17	ADS2	Brown	Soft	Pale green	Semi- curving	Solo
	Baladi 18	ADS3	Brown	Soft	Dark green	Standing	Solo
	Baladi 19	ADS4	Golden	Soft	Dark green	Standing	Paired
	Baladi 20	ADS5	Brown	Soft	Pale green	Semi- curving	Solo
	Baladi 21	ADS6	Golden	Soft	Dark green	Standing	Solo
	Baladi 22	ADS7	Golden	Soft	Pale green	Curving	Solo
	Baladi 23	ADS8	Dark brown	Semi-dry	Pale green	Standing	Paired
	Baladi 24	ADS9	Dark brown	Soft	Bright green	Semi-curving	Solo
	Baladi 25	ADS10	Dark brown	Soft	Pale green	Semi-curving	Solo
	Baladi 26	ADS11	Golden	Soft	Dark green	Curving	Paired
	Baladi 27	ADS12	Golden	Semi-dry	Pale green	Standing	Paired
	Maijhool 1	NARC7	Dark brown	So soft	Pale green	Standing	Solo
	Barhi	NARC8	Golden	So soft	Pale green	Semi-curving	Solo
	Deglet Nour	NARC9	Golden	Semi-dry	Pale green	Standing	Triple
Jericho Agriculture Experiment Station	Hijazi	NARC10	Dark brown	Semi-dry	Dark green	Semi-curving	Solo
	Zhedi	NARC11	Golden	Semi-dry	Bright green	Semi-curving	Solo
	Khadrawy	NARC12	Golden	Semi-dry	Dark green	Semi-curving	Solo
	Hayani	NARC13	Dark brown	Soft	Dark green	Standing	Solo
	Baladi 1	NARC1	Golden	Soft	Pale green	Semi-curving	Solo
	Baladi 2	NARC2	Golden	So soft	Bright green	Standing	Solo
	Baladi 3	NARC3	Dark brown	Semi-dry	Bright green	Semi-curving	Solo
	Baladi 4	NARC4	Golden	Soft	Pale green	Standing	Solo
	Baladi 5	NARC5	Golden	Soft	Pale green	Semi-curving	Solo
	Baladi 6	NARC6	Golden	Soft	Pale green	Standing	Solo

Furthermore, eight quantitative fruit morphological features (fruit weight (MP7), flesh weight (MP6), fruit size (MP5), seed weight (MP10), date length (MP3), seed length (MP8), seed diameter (MP9) and date diameter (MP4) vary significantly ($p<0.01$) Table 3. The average fruit size varies between 12.16 cm^3 for the improved and introduced cultivar Maijhool to 1.17 cm^3 for the cultivar Baladi 25. The local (Baladi) cultivars: M1, M4, M5, M6, M10 and M11 had the most important fruit size (>8 cm^3). Baladi M1 had the most fruit length cultivar (47.01 mm) due to the fact that the fruit of this cultivar is of elongated shape. The length of this date is similar to the cultivar Deglet Nour whose average length is of 45 mm. For fruit width Baladi 4, 5, 11 and 23 cultivars have a good fruit width range from 19.2 to 20.3 mm, which is similar to Maijhool whose average fruit width is 23.4 mm. These results have high similarity with the findings of Nadeem et al., (2011)[24] who reported that the maximum mean value of date diameter in Aseel-Sindh and Dhakki were 2.40 and 4.56 cm, respectively. The minimum mean value for diameter and length in Desi were 1.30 and 2.08 cm, respectively.

The weight of fruits varied between 13.63g in Maijhool (improved and introduced cultivars) to 3.5 g in Baladi 25 cultivar. From local cultivars, the Baladi 11 cultivar showed the highest date weight and flesh weight, (i.e., 9.9 g, and 9.03 g) followed by cultivar Baladi 4 (9.8 g and 8.87 g). The minimum and maximum date's weight (3.04 - 8.50 and 11.60 - 28.71 g in different cultivars have been reported in other studies[17,19]. The results presented in Table 4 show that cultivars NARC9, NARC7 and DH8 had the lowest seed :fruit weight percent (W1) 7.1, 8.9 and 9.0% respectively. The maximum seed /fruit weight percent (46.3, 30.4 and 28.1 %) was recorded in cultivars NARC12, ADS10 and DH10 respectively, Table 3. According to Bedjaoui, & Benbouza, (2020); Mtaoua, et al., (2009)[12,25], the mean value of seed /fruit weight percentage varied between 11.9 to 40.33% for different date palm cultivars.

Table 3. Mean value of fruit and seed quantitative morphological features for thirty-five samples collected from the study area at Jericho.

Site	Cultivar #	Code	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	W1
Deir Hijleh Station	1.	DH1	25.73	18.9	6.07	5.2	5.73	18.6	6.83	0.63	11
	2.	DH2	25.6	17.1	6.07	6.37	7.13	17.2	8.03	0.8	11.2
	3.	DH3	31.2	18.1	7.83	8.23	8.93	20.2	7.4	0.83	9.33
	4.	DH4	41.67	18.6	8.7	7.63	8.4	22.9	7.27	0.96	11.4
	5.	DH5	36.47	19.8	9.83	9.03	9.9	23.3	8.47	1.25	12.6
	6.	DH6	25.1	18.2	6.07	5.93	7.53	22.1	6.9	0.74	9.82
	7.	DH7	35.03	15.9	6.17	6.53	7.03	21.7	7.3	0.92	13
	8.	DH8	35.93	23.4	12.2	11.9	13.6	20.7	9.5	1.21	8.85
	9.	DH9	31.23	18.3	6.07	5.53	6.1	21.3	7.57	0.93	15.3
	10.	DH10	20.77	16.3	4.07	2.8	3.57	15.2	8.9	1	28
Arab Development Society Station	11.	ADS1	23.43	18.7	4.1	5.57	7.3	16.7	8.37	1.13	15.5
	12.	ADS2	21.97	12.7	2.1	2.83	4.2	16.8	5.53	0.7	16.7
	13.	ADS3	27.93	16.5	3.1	4.83	6.63	20.7	8.5	1.27	19.1
	14.	ADS4	23.5	16.7	2.1	3.3	4.5	16.7	8.6	1.13	25.2
	15.	ADS5	28.87	15.6	3.1	4.7	5.83	19.8	7.27	0.93	16
	16.	ADS6	24.03	16.8	2.1	4.1	4.6	16.1	6.3	0.57	12.3
	17.	ADS7	25.33	17	2.07	3.7	5.5	18.2	8.3	1.17	21.2
	18.	ADS8	32.5	20.3	2.1	4.83	6	19.7	8.6	1.17	19.4
	19.	ADS9	28.67	17.4	3.07	4.23	5.33	18.5	7.83	1.07	20
	20.	ADS10	19.23	13.4	1.17	2.27	3.5	14	8.3	1.07	30.5
	21.	ADS11	21.97	14.5	2.1	2.8	3.53	14.6	6.73	0.67	18.9
	22.	ADS12	26.87	14.5	2.13	2.8	3.83	18.4	7.67	0.93	24.3
Jericho Agriculture Experiment Station	23.	NARC7	39.1	23.1	12.2	12.1	13.2	21.7	10.2	1.2	9.06
	24.	NARC8	30.3	21.2	9.5	7.47	9.43	18.2	7.97	1.1	11.7
	25.	NARC9	45.07	19.8	9.53	11	11.5	23	6.23	0.81	7.06
	26.	NARC10	33.77	19.8	8.43	7.77	7.83	22.9	8.1	0.83	10.6
	27.	NARC11	26.47	17.5	5.77	3.9	4.77	19.7	7.76	0.77	16.1
	28.	NARC12	19.97	15.2	2.83	2.9	3.57	17.3	9.64	1.6	44.9
	29.	NARC13	33.53	18.2	5.5	6.1	6.9	21.6	8.13	1.37	19.8
	30.	NARC1	47.01	7.1	8.17	7.91	8.57	29.3	7.14	1.09	12.7
	31.	NARC2	27.22	16.6	6.33	5.13	5.88	19	8.28	1.03	17.5
	32.	NARC3	29.9	16.8	4.67	4.04	4.81	20.3	8.24	0.98	20.5
	33.	NARC4	32.48	19.3	9.67	8.87	9.8	23.9	8.67	1.27	12.9
	34.	NARC5	31.5	19.2	9.37	8.73	9.63	23.2	8.1	1.21	12.5
	35.	NARC6	31.23	17	8.5	8.13	9.13	21.4	7.77	1.17	12.8

Measurement of quantitative morphological traits of Date Palm leaves Table 1 revealed significant variation between cultivars. Leaf length (MP11) and width (MP12), Middle leaflet length (MP13) and width (MP14), Middle spine length (MP15) and width (MP16), leaflets number (MP18), spines number (MP19), spinate part length (MP17), are shown in Table 5. Results indicated that Leaf length and width ranged from 395 cm and 150 cm to 230 cm and 61.2 cm respectively. Middle leaves length and width ranged from 67.2 cm and 3.87 cm to 30.5 cm and 2.4 cm. Middle spine length and width ranged from 17.8 cm and 0.75 cm to 3.83 cm and 0.23 cm. Cultivar ADS12 showed the highest leaflets number (113 leaflets), NARC9 has the highest spines number (18.7 spines) and the longest spinate part length (140.7 mm) was recorded in cultivar DH2. While the lowest leaflet and spine numbers (64.3 and 6) were recorded in cultivars NARC5 and NARC6 respectively Table 4. These results are in agreement with findings of Simozrag et al., (2016) [11], who found that leaves characteristics show higher diversity between cultivars.

Table 4. Mean value of leaf quantitative morphological features for thirty-five samples collected from the three sites of the studied area

Site	Cultivar #	Code	MP11	MP12	MP13	MP14	MP15	MP16	MP17*	MP18**	MP19
Deir Hijleh Station	1.	DH1	381.7	93.7	52	3.47	9.3	0.61	104	14	84
	2.	DH2	392.3	93.7	41	2.5	11.8	0.35	93.3	12	140.7
	3.	DH3	292.3	93.7	44.3	2.8	8.33	0.27	94.3	14.3	51
	4.	DH4	316	61.2	30.7	2.47	9.77	0.23	89.3	15.3	77.67
	5.	DH5	351.7	113	55	2.97	17.8	0.57	72.3	10.3	104.3
	6.	DH6	315	156	48.3	2.7	7.5	0.45	76.3	18.3	87
	7.	DH7	395	137	67.2	2.47	15.5	0.6	84.3	16.7	120.7
	8.	DH8	310	124	60.7	3.8	14.3	0.62	86.7	11.3	63.33
	9.	DH9	297.7	113	55	3.5	9.5	0.62	86.3	18.3	76
	10.	DH10	320.7	123	60.7	3.03	11.5	0.62	83	9.33	51
Arab Development Society Station	11.	ADS1	318.3	150	30.5	2.7	13.5	0.46	95	8	100.2
	12.	ADS2	268	105	51.7	3.03	14.2	0.78	92.3	14.3	58.17
	13.	ADS3	296.3	81.3	40.2	3.03	11.5	0.55	87	9.33	67.9
	14.	ADS4	357	96.2	46.7	3.5	8.5	0.52	86.3	13.3	124.7
	15.	ADS5	287	88	43.5	2.5	11.3	0.4	90.3	12	56.33
	16.	ADS6	303.3	86.4	41.5	3.7	6.4	0.4	72.3	9.67	86.67
	17.	ADS7	330	119	57.7	3.5	8.33	0.44	97	10.3	75.67
	18.	ADS8	325.3	83.2	40	2.7	9.5	0.45	92.3	14.3	76.33
	19.	ADS9	230	91.5	45.3	2.5	7.5	0.38	85	10	68
	20.	ADS10	387	75.3	36.3	2.4	10.5	0.44	83	13	129
	21.	ADS11	329.7	87.2	42.5	2.53	17	0.59	95	9.67	99
	22.	ADS12	341	79	38	3.77	8.5	0.75	113	13.7	109.7
Jericho Agriculture Experiment Station	23.	NARC7	316	104	51.3	3.5	14.5	0.52	67	13.7	110.7
	24.	NARC8	341	83.7	40.7	3.87	9.5	0.45	100	14.7	87.67
	25.	NARC9	353	115	57.5	3.5	16.5	0.73	65	18.7	137.3
	26.	NARC10	352.7	111	54.3	3.5	13.5	0.47	74.3	9.67	69
	27.	NARC11	352.3	104	50.7	2.67	8.5	0.32	100	17.3	69.67
	28.	NARC12	242.7	66.7	33	3.03	5.5	0.42	80.3	8.67	60.33
	29.	NARC13	277	117	57	3.17	10.5	0.32	64.3	15	62.67
	30.	NARC1	345.3	100	49.5	2.83	16.3	0.51	79	4.33	55.33
	31.	NARC2	289.3	93.3	44.8	2.52	5.83	0.3	75	6.67	73
	32.	NARC3	289.7	84.2	41.3	2.83	7.5	0.34	88.7	5.67	45.33
	33.	NARC4	308.3	114	55.5	2.5	4	0.31	84.3	5.67	61.67
	34.	NARC5	290	75.3	37.7	3.33	3.83	0.46	88.3	6	67
	35.	NARC6	256.7	96.3	46.7	3.67	3.88	0.44	88	4.67	29.83

*Leaflets number in one side. **Spines number on one side.

3.1 Principal components analysis (PCA)

To obtain a comprehensive overview of the morphological traits of date palm in correlation to cultivar, the whole data set was subjected to PCA. Results showed that the phenotypic diversity existed among 35 studied date palm varieties based on the 17 quantitative morphological characteristics (Table 5). In fact, the results of PCA showed that the first two principal components (PC1 and PC2) were associated with eigenvalues higher than one and accounted 59.5% of the total cumulative variation. The first component (35.2%) was strongly positively correlated (> 0.5) based on Date fruit weight (MP7), flesh weight (MP6), fruit size (MP5), date length (MP3), seed length (MP8) and date diameter (MP4) analysis. While, spinate part length (MP17) trait is negatively correlated. The second component (24.3% of the total variability) was positively influenced by the middle spine length (MP15), width (MP16), leaflets number (MP18), spines number (MP19) and leaf length (MP11), and negatively correlated with

Table 5. Correlationcoefficients for date palm morphological traits with respect to the twoprincipal components (PC1 and PC2)

Trait	PC1	PC2	Trait	PC1	PC2
MP3	.826	.076	MP12	.333	.426
MP4	.558	-.046	MP13	.446	.443
MP5	.919	-.039	MP14	.279	.088
MP6	.961	.009	MP15	.264	.674
MP7	.945	-.010	MP16	.003	.628
MP8	.756	-.101	MP17	-.502	.032
MP9	.279	-.523	MP18	.020	.637
MP10	.295	-.692	MP19	-.028	.646
MP11	.041	.698			

seed diameter (MP9) and seed weight (MP10) (Table 5). Our results are in agreement with the results of Elsafy et al. (2015) and Salem, et al. (2008) [22,23], who reported high morphological diversity between fruits and vegetative morphology of different Date Palm cultivars. Simozrag et al. (2016) [11], also found the same results concerning fruits and leaves.

The graphic representation of variables according to the plan axis one and two showed that these variables were positively correlated Figure 2. Two distinguished groups of variables negatively correlated in PC1. The first one, with high negative loadings was obtained by spinate part length (M17). While the second one with high positive loadings was formed by fruit size (M5), flesh weight (M6) and date fruit weight (M7). On the other hand, PC2 opposed two distinguished groups of variables negatively correlated. The first one, with high negative loadings was obtained by seed diameter (M9) and seed weight (M10). While the second one, with high positive loadings was formed by Leaf length (M11) and spines number (M19) Figure 2. Mohamed et al. (2011) [9] studied phenotypic diversity in twenty-one date palm cultivars using PCA analysis. The results showed great variations in 30 selected vegetative traits and were similar to these results.

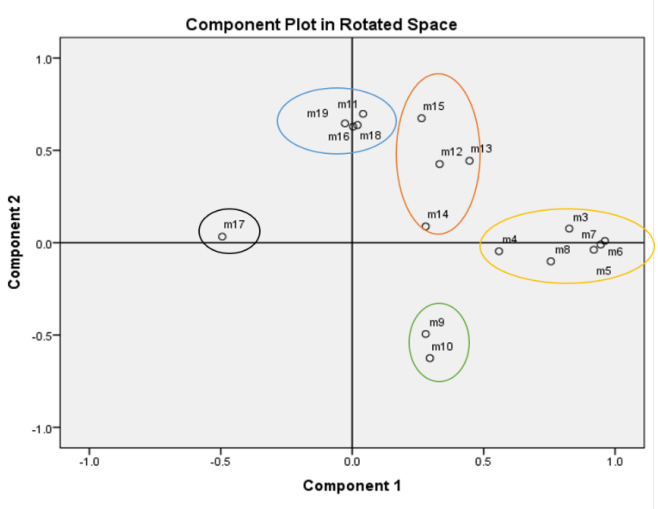

Fig 2. Graphic represented the date palm cultivars traits in relation to 1-2 axes of PCA.

3.2 Cluster analysis (CA)

The dendrogram of cluster analysis Figure 3 indicates that the dissimilarity levels are ranged from 0.82 - 1.35. According to the dendrogram, the thirty-five date palm cultivars can be assembled into two large phenotypically correlated clusters with high similarity. The first cluster is composed of six cultivars including Baladi 16, 17, 19, 21, 23 and 26. The remaining cultivars are grouped in a second large cluster, which exhibited two sub-clusters. The cultivars Baladi 6 and 22 are grouped in the first sub-cluster where cultivar Baladi 25 stands alone in this sub-cluster. The remaining cultivars composed the second sub-cluster, and a great variability was observed within this sub-cluster, which was divided, into three subgroups where the improved cultivars, such as Barhi, Zhedi, Maijhool, Khadrawi, Hayani and Deglet Nour represented together in the same subgroup. The lowest

Table 6. Correlation matrix of morphological traits of Jericho dates studied. (table 2 for traits' labels)

	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18	MP19	MP20	MP21	MP22
MP1	1																					
MP2	.040	1																				
MP3	-.155	.295	1																			
MP4	**-.49****	.030	.212	1																		
MP5	-.338*	.213	**.720****	**.543****	1																	
MP6	-.295	.246	**.788****	**.573****	**.937****	1																
MP7	-.291	.230	**.743****	**.597****	**.913****	**.986****	1															
MP8	-.003	.232	**.859****	.068	**.672****	**.680****	**.637****	1														
MP9	-.139	.009	-.020	.405*	.221	.200	.239	-.012	1													
MP10	.041	-.141	.136	.152	.158	.189	.240	.210	**.766****	1												
MP11	.023	.332	.098	-.007	.080	.061	.038	-.022	-.089	-.345*	1											
MP12	-.067	-.060	.070	.197	.208	.239	.264	.166	-.024	-.096	.171	1										
MP13	-.074	.092	.292	.159	.324	.308	.274	.292	-.031	-.091	.211	**.619****	1									
MP14	-.293	-.103	.113	.334*	.243	.261	.277	.034	.078	.059	-.027	.009	.211	1								
MP15	.056	.135	.350*	-.071	.153	.238	.229	.113	-.139	-.179	.446	.322	.339*	-.064	1							
MP16	.021	-.044	-.005	-.112	-.076	-.022	-.011	-.087	-.224	-.183	.228	.236	.361*	.439**	**.520****	1						
MP17	-.069	.072	-.380*	-.136	-.315	-.396*	-.343*	-.351*	-.136	-.223	.154	-.252	-.319	.008	-.202	.093	1					
MP18	-.196	-.032	.067	.264	-.018	.009	.013	-.094	-.294	-.368*	.331	.204	.227	.061	.247	.234	.039	1				
MP19	-.016	.101	-.012	.102	-.062	.035	.034	-.241	-.051	-.207	**.700****	.098	-.031	-.030	.401*	.279	-.065	.445	1			
MP20	.073	-.063	-.357*	.029	-.107	-.169	-.184	-.300	.190	.052	-.188	-.077	.012	.224	-.43*	-.175	-.086	-.225	-.267	1		
MP21	.133	-.064	-.001	-.236	-.036	-.076	-.125	.072	-.212	-.235	.085	-.157	.192	.110	.053	.240	-.174	.042	-.034	.094	1	
MP22	.058	-.130	-.264	-.140	.339*	.354*	.322	.273	.001	.104	.096	-.097	.046	-.106	.218	.286	.294	.248	-.008	-.183	.141	1

**Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level(2-tailed)

distance for the difference between the cultivars that fall between the trees Baladi 17 and 26 with a degree of affinity 0.87%. It is also noted that there is a similarity between the strains in the second cluster, where the difference distance between trees Baladi 6 and 22 was slight and with a degree of affinity did not end at 85%. These results indicate the presence of high phenotypic similarity in Palestinian date palm cultivars. This result agrees with other studies of morphological traits for date palm cultivars based on cluster analyses [12,23].

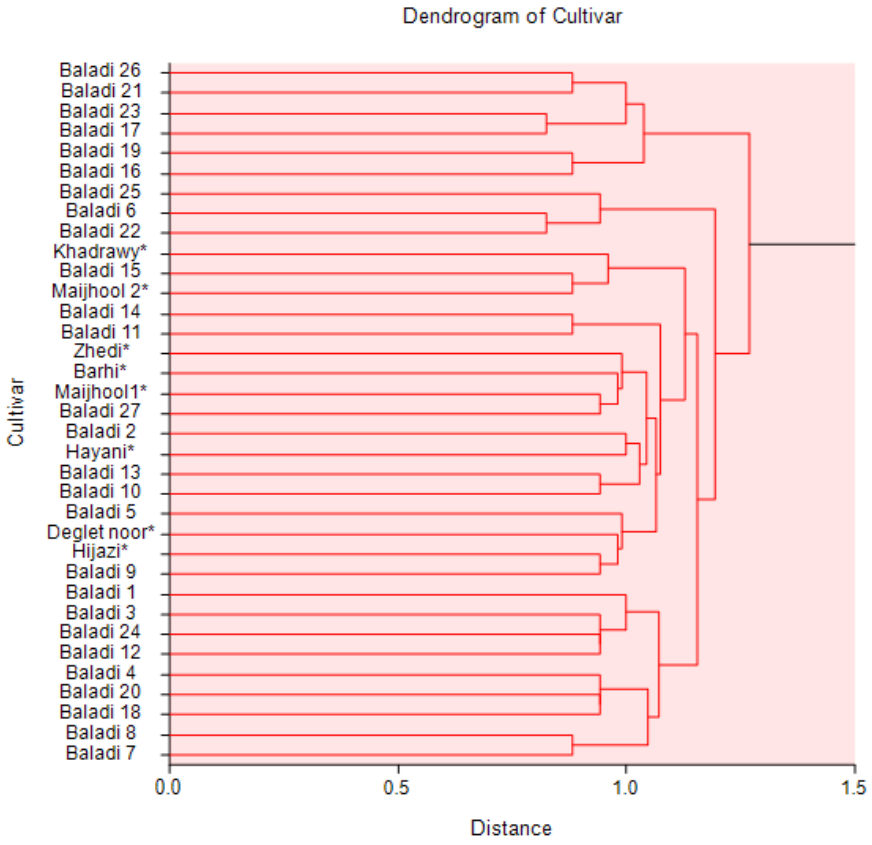

Fig 3. Dendrogram of hierarchical clustering of 35 date palm cultivars based on quantitative morphological attributes

3.3 Correlation matrix

Overall, the correlations between the studied traits showed positive correlations between most of them and many traits showed high positive correlation at 0.01-probability level. However, the following traits had a coefficient correlation more than 0.50 Table 6. It shows that trait correlations have more or less importance. In fact, the date length (MP3) correlated positively with the fruit size (MP5), flesh weight (MP6), date fruit weight (MP7) and seed length (MP8). Date diameter (MP4) was positively correlated with the fruit size (MP5), flesh weight (MP6) and date fruit weight (MP7); the fruit size (MP5) was positively correlated with the flesh weight (MP6), date fruit weight (MP7) and seed length (MP8). In addition, the flesh weight (MP6) with date fruit weight (MP7) and seed length (MP8). Seed diameter (MP9) was positively correlated with seed weight (MP10); the leaf length (MP11) with spines number (MP19), the leaf width (12) with middle leaflet length (13) and the middle spine length (MP15) with middle spine width (MP16). Whereas, a negative correlation between the date diameter (MP4) with fruit colour (MP1), and the middle spine length (MP15) with leaf colour (MP20) was observed Table 6. Thus, a study of a trait can give an idea on the other according to the antagonist or the synergy of traits. Correlation analysis was used in similar studies to demonstrate the degree of correlation between the phenotypic properties of palm trees, and they obtained similar results for this study [12,26].

4 Conclusion

The results of this study confirmed that the studied morphological traits could be a useful tool to assess the phenotypic diversity in date palm cultivars and constitute a complementary way for other characterization processes. From this study results, the best studied morphological characteristics that can be used to distinguish between the different varieties of date palm were MP 3-8, MP 11-13, MP 15-16 and MP 18-19. Morphological characterization of the main date palm fruits cultivars grown in Jericho governorate revealed significant variations from cultivar to another and within the same cultivar from region to another. We conclude from this study that some statistical methods such as CA and PCA can be used to study the degree of similarities and differences between date palm varieties.

In this study, local varieties with specifications similar to those of known improved cultivars have been determined, especially in the physical properties of fruits, and the best of these were NARC1, NARC4, NARC5, DH4 and DH5. These local varieties have grown from seeds and have been selected by farmers over the years, which closely similar to the improved and introduced varieties. These local varieties have adapted to the high temperature, soil salinity and lack of water that characterizes the Jericho region in Palestine. Therefore, we recommend to collecting and propagate these varieties in order to preserve them.

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