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Full Length Research Paper

Selection of pomegranate (*Punica granatum* L.) in south-eastern Tunisia

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Tunisia is one of the main producers and exporters of pomegranate (*Punica granatum* L.) in the world. Due to its international importance, the selection of both quantitative and qualitative most desirable varieties has become a necessity. To select new cultivars that are most appropriate for commercial use, 21 accessions were collected from different regions of south-east Tunisia. 24 morphological characters of the tree and fruit were studied for each accession. This study has revealed considerable diversity especially concerning the tree vigor, the fruit size and color and the acidity of juice. Taking into account all comments, some trees are considered particularly efficient in south-eastern Tunisia.

Key words: South-east Tunisia, *Punica granatum* L., selection, morphological characters.

INTRODUCTION

Pomegranate is one of the oldest fruit species in the world (Evreinoff, 1949). It is considered native of Persia and surrounding areas. It is well adapted to the Mediterranean climate and arid zones (Salaheddin and Kader, 1984). In Tunisia, the introduction of pomegranate date to very antique times (Evreinoff, 1949). Its cultivation spread throughout the country except areas above sea level where growers feared the frost. The main production centers are the oasis of Gabes and Gafsa, Cap Bon, the region of Bizerte and Sousse in the Sahel.

Having long been regarded as in secondary, the cultivation of pomegranate has known during the last decade a great extension. The area reserved for this species increased from 5,650 ha in 1980 to 13,000 ha in 2008 (Anonymous). The Governorate of Gabes occupies the first place in terms of area and production with 2,600 ha and 24,000 tons per year respectively (GIAF and APD, 2008). In 2009, the national production of pomegranate had reached 75,000 tons. The variety Gabsi, one of the well-known pomegranate cultivars in Tunisia with very appreciable sensory quality, and therefore with high value, representing approximately 35% of this tonnage (Emna, 2010). This variety is widely cultivated in the south of the country (coastal oasis). It is also found in the western oases in the region of Kairouan and in some orchards in the north (Zaghouan and Bizerte). Pomegranate Gabsi is a mid season variety, the fruits can be collected as from mid-September and contains several desirable traits (Dhouibi, 1982).

In the world, the production and consumption of pomegranate has been increased because it is used in various fields. Indeed, besides its use fresh, it is used for making refreshing drinks, aromas, jam and other preparations (cakes, wines, etc) (Evreinoff, 1949; Zukovskij, 1950; Melgarejo and Martinez, 1992; Tous and Ferguson, 1996; Aviram et al., 2001). To meet the requirements of the sector, some work in the exploration and collection of varieties have been undertaken to study the diversity of local plant materials. The plant genetic resources are the raw materials used in breeding and biotechnology to produce new varieties that meet the criteria of productivity, quality and tolerance to biotic and abiotic stress. The genetic improvement of crops has made significant progress including the creation of new varieties on several very interesting plants.

However, regarding pomegranate, research on genetic improvement remained very limited. The main work on accessions are based on the physico-chemical and technological issues relating to leaves, flowers and fruits (Al Kahtani, 1992; Levin, 1994; Melgarejo et al., 1995; Ben Nasr et al., 1996; Mars and Marrakchi, 1999). The

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Table 1. Accessions of *Punica granatum* L. (cv. Gabsi), their codes and their places of origin.

Accession	Code	Origin
GME1, GME2, GME3	1, 2, 3	Metouia
GO1, GO2, GO3	4, 5, 6	Ouedhref
GG1, GG2, GG3	7, 8, 9	Gabès ville
GC1, GC2, GC3, GC4, GC5	10, 11, 12, 13, 14	Chenini
GM1, GM2, GM3, GM4	15, 16, 17, 18	Mareth
GK1, GK2, GK3	19, 20, 21	Kettana

Table 2. Quantitative and qualitative variables of the fruits studied and their abbreviations.

Abbreviation	Definition	Abbreviation	Definition
Quantitative variables			
WP (g)	Weight of peel	HC (mm)	Height of Calyx
PT (mm)	Peel thickness	DC (mm)	Diameter of Calyx
%P	Percentage of peel	HC/DC	Height to diameter ratio of calyx
FW (g)	Fruit weight	WS (mg)	Weight of 100 seeds
HF (cm)	Height of fruit	%S	Percentage of seeds
DF (cm)	Diameter of fruit	VJ (%)	Volume of juice/100 g
HF/DF	Height to diameter ratio	pH	pH of juice
TSS (%)	Total soluble solids	A (%)	Acidity of juice
RI	Ripeness index		
Qualitative variables			
Abbreviation		**Definition**	
PC		Peel color	
SC		Seed color	
SH		seed hardness	

acceptability of pomegranate to the consumer and processor depends on a combination of several quality attributes that are related to the physico-chemical and mechanical properties. Fruit quality depends largely on sugar and acid content of the juice. A high quality pomegranate should also have an attractive skin, small seeds in the aril and should be free from sunburn, growth cracks, cuts, bruises, and decay (Mars, 1998; Mars and Marrakchi, 1999; Onur et al., 1999). Large fruit, thin and red colored skin, soft seed and abundant juice are considered among the desirable traits that could be considered in pomegranate breeding programs for selection of superior cultivars (Onur et al., 1999; Zamani et al., 2010). In this preliminary study, we describe the first results for the research of mother plants to select the major accessions able to obtain new varieties that meet the criteria of productivity and quality.

MATERIALS AND METHODS

Plant material

The first phase of work has concerned to the search of mother plants. For the pomegranate, selection is done directly without passing through the test of rootstock selection (Simmonds, 1989). This selection aims to identify the best performing clones for desired traits in the population. A survey has been conducted to identify the plants studied. 21 pomegranate accessions cv. Gabsi were collected from mature trees in two successive seasons (2009 to 2010) in 6 oases in the region of Gabes in the south-east of Tunisia, which is characterized by an arid bioclimate of Mediterranean type with a mild winter (Table 1).

Characterization of the selected plants

On each tree, the following morphological characters were determined: (1) plant vigor, (2) intensity of branching, (3) density of foliage and (4) plant health. For the characterization of fruit, a sample of 10 fruits per plant were harvested in full maturity to determine the variables presented in Table 2 that were previously reported to be important in pomegranate evaluation (Zamani, 1990; Mars et al., 1997; Sarkhosh et al., 2005; Vinson et al., 2001).

The titrable acidity (A) was calculated as the percentage of citric acid by titrating 10 ml pomegranate juice with a solution of NaOH (0.1 N) until pH 8.1 was reached. The ripeness index (RI) was measured using the TSS/A ratio, to classify the pomegranate accessions according to Melgarejo (1993) as sweet (RI = 31 to 98), sour (RI = 17 to 24) and sweet-sour (RI = 5 to 7). Qualitative traits were coded as following: peel color (1: yellow; 2: green; 3: pink; 4:

Table 3. Characteristics of selected accessions.

Accession	Vigor	Intensity of branching	Density of foliage	Plant health
GME1	High	Average	Very dense	More desirable
GME2	Average	Average	Average	More desirable
GME3	High	High	Dense	Desirable
GO1	High	Average	Dense	More desirable
GO2	High	High	Average	Less desirable
GO3	High	Average	Very dense	More desirable
GG1	High	Average	Dense	Less desirable
GG2	Average	Weak	Weak	Desirable
GG3	High	Very high	Dense	Less desirable
GC1	High	High	Dense	Less desirable
GC2	Average	Weak	Weak	Desirable
GC3	Average	Weak	Weak	Desirable
GC4	High	High	Dense	Less desirable
GC5	High	Very high	Very dense	Less desirable
GM1	High	High	Average	Less desirable
GM2	Average	Weak	Average	More desirable
GM3	Average	Weak	Dense	More desirable
GM4	Average	Average	clear	Less desirable
GK1	High	Very high	Very dense	Desirable
GK2	Average	Weak	Clear	Desirable
GK3	High	Very high	Very dense	Desirable

red), seed color (1: white; 2: pink; 3: red; 4: red-purple), seed hardness: (1: hard; 2: semi-soft; 3: soft).

Statistical analysis

A variance analysis (ANOVA) was done for the quantitative morphological characters. Results were significant when $p < 0.05$. Whereas the qualitative morphological character variations were evaluated using the contingency tables of the chi-square test with a confidence level of 95%. Mean values recorded for each parameter were used to perform factor analysis and clustering of genotypes into similarity groups using Ward's method. Correlations between the morphological and chemical parameters were established using the test of Pearson. Data processing was performed using SPSS software (version 18.0).

RESULTS

Qualitative traits

The first observations relating to 21 selected plants show a wide diversity. Tree vigor and plant health are generally satisfying. Branching and dense foliage are generally balanced (Table 3). The variation of qualitative morphological characters is shown in Figure 1. For the character seed color, 10 genotypes have pink seeds, 5 are white, 4 are red and 2 are red-purple. The majority of fruits, 8, have a pink peel, 6 are red, 5 are green and 2 yellow. Regarding the hardness of seeds, 9 are semi-hard, 7 are soft and 5 are hard. The variation of the qualitative traits is independent among cultivars ($P = 1 > 0.05$).

Quantitative traits

Minimum and maximum values, means, standard deviations and coefficients of variation of different parameters are reported in Table 4. Some parameters show relatively low coefficients of variation such as HF (9.31%), DF (8.41%), HF/d (5.58%), % S (9.33%) and VJ (7.88%). However, A, RI, WF, WP, WS and % P were the most variable characteristics of accessions (56.12, 52.46, 25.07, 31.66, 25.08 and 22.82%). The rest of the studied parameters have middle coefficients of variation. Table 5 shows the averages of the different quantitative parameters of two seasons. The results of analysis of variance showed a highly significant effect recorded for all variables studied ($P < 0.001$) except HF/d ($P = 0.39 > 0.05$). The fruit weight ranged from 222.50 g (GME3) to 537.83 g (GC5) with an average of 378.34 g. GO3 has the highest HF (8.90 cm) and DF (10.13 cm), the lowest values were registered for GG3 (6.43 and 7.73 cm respectively). The weight of the peel varies from 52.50 g for GG3 to 185.33 g for GO3. The calyx height values were 13.97 mm (GO2) and 24.22 mm (GO1). The PT and the % P vary respectively from 2.93 mm for GC2 to 5.12 mm for GME1 and from 19.12% for GM3 to 41.22% for GO1. The weight of 100-seed is ranged between 11.30 g for GO2 to 27.53 g for GC2. GO1 has the lowest

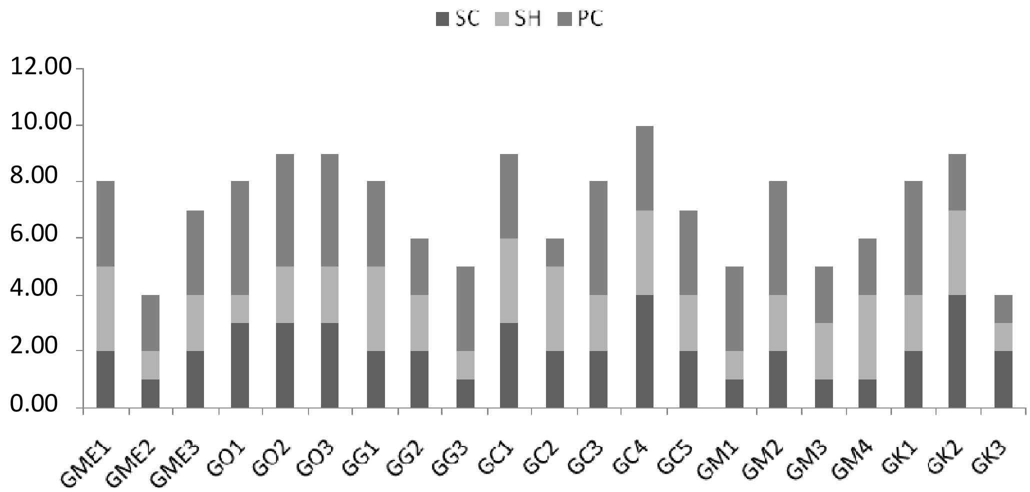

Figure 1. Qualitative descriptors of the studied accessions (SC: seed color; SH: seed hardness; PC: peel color).

Table 4. Minimum and maximum values, averages, standard deviations and coefficient of variation of measured parameters.

Parameter	Minimum	Mean	Maximum	Standard deviation	CV %
WF	194.00	387.34	639.5	97.11	25.07
HF	6.10	7.93	9.30	0.74	9.31
DF	7.10	9.15	11.20	0.77	8.41
HF/d	0.77	0.87	1.00	0.05	5.58
HC	11.39	19.82	26.2	3.28	16.56
DC	10.99	18.38	26.03	3.44	18.69
HC/d	0.88	1.09	1.72	0.14	13.01
WP	36.50	109.54	201.00	34.68	31.66
TP	2.87	3.79	5.26	0.63	16.52
% P	17.81	28.46	43.92	6.5	22.82
WS	10.59	20.32	29.3	5.1	25.08
% S	56.08	69.50	81.60	6.48	9.33
VJ	63.00	76.91	87.5	6.06	7.88
PH	2.80	3.65	4.72	0.50	13.84
TSS	11.60	14.86	18.71	1.58	10.65
A	0.15	0.37	1.21	0.21	56.12
RI	11.09	51.27	107.25	26.90	52.46

CV, coefficient of variation = (standard deviation/mean) x 100.

percentage of seeds (57.72%) while GM3 has the highest percentage (78.90%).

The results for pH, volume of juice, total soluble solids, acidity and ripeness index of the pomegranate from the different accessions (mean of two seasons) are given in Table 5. Variations in the physico-chemical characters were significant ($P < 0.001$). As shown in Table 5, GK2 gives the less juicy fruits (64.67%), whereas GC2 gives the juiciest one (85.50%). The mean titrable acidity and the pH were 3.65±0.5 and 0.37±0.21% respectively. The lowest pH and the highest acidity was obtained for GG3 (3.03 and 1.14% respectively). GM1 has the highest pH and the lowest acidity, which are respectively 4.60 and 0.16%. The TSS varies between 12.2% for GO2 to 17.7% for GC5. For the ripeness index, 16 accessions present good taste evaluation (RI > 31) and they are classified among sweet varieties, four are sweet-sour and only one accession is sour.

Variability according to morphological and chemical characterization

Grouping of accessions based on the combination of fruit

Table 5. Means of two seasons and standards deviations of measured morphological traits in studied pomegranate accessions.

Variable	WF	HF	DF	HF/d	HC	DC	HC/d	WP
GME1	283.67±14.89	7.87±0.81	8.67±0.64	0.91±0.03	23.89±1.67	15.39±1.53	1.56±0.14	98.00±12.56
GME2	326.17±131.51	7.30±0.30	8.53±0.12	0.86±0.04	15.14±3.62	14.65±3.66	1.03±0.02	96.33±36.07
GME3	222.50±38.37	7.10±0.40	8.30±0.30	0.86±0.02	19.01±2.14	17.35±4.04	1.12±0.14	85.17±15.25
GO1	377.00±10.44	8.40±0.36	9.50±0.70	0.89±0.04	24.22±1.73	21.70±2.14	1.12±0.08	155.43±5.17
GO2	442.67±27.45	8.87±0.51	9.63±0.47	0.92±0.03	13.97±0.89	13.10±1.38	1.07±0.04	155.00±13.23
GO3	499.67±64.90	8.90±0.44	10.13±0.72	0.88±0.02	19.73±2.66	18.92±2.33	1.04±0.02	185.33±18.45
GG1	363.33±34.66	8.17±0.29	8.97±1.00	0.92±0.08	19.91±1.12	20.23±1.08	0.98±0.01	105.50±14.50
GG2	479.17±162.28	8.70±0.66	10.07±1.10	0.87±0.10	20.15±1.49	19.24±1.42	1.05±0.02	127.67±42.15
GG3	245.00±38.19	6.43±0.42	7.73±0.57	0.83±0.06	22.57±1.29	18.87±1.64	1.20±0.04	52.50±16.26
GC1	348.83±21.78	7.23±0.31	8.80±0.35	0.82±0.02	18.48±2.26	15.84±1.74	1.17±0.17	94.83±12.91
GC2	472.83±44.04	8.60±0.44	9.73±0.38	0.88±0.03	18.60±0.63	16.12±1.12	1.16±0.05	125.00±23.40
GC3	429.00±81.21	8.03±0.45	8.90±0.61	0.90±0.03	18.39±1.61	18.63±1.23	0.99±0.04	103.67±19.90
GC4	419.17±55.72	7.80±0.40	9.20±0.00	0.85±0.04	21.93±1.90	23.65±1.53	0.93±0.04	122.67±28.02
GC5	537.83±67.54	8.17±0.65	9.90±0.79	0.83±0.02	20.36±1.19	20.74±0.12	0.98±0.05	128.00±2.65
GM1	428.33±38.94	8.17±0.06	9.80±0.44	0.83±0.04	16.51±2.40	15.73±2.92	1.06±0.05	116.67±14.94
GM2	401.17±28.02	7.80±0.26	8.97±0.15	0.87±0.04	21.37±2.48	19.54±2.19	1.09±0.03	93.33±10.40
GM3	410.50±69.58	8.07±0.29	9.17±0.40	0.88±0.02	18.52±1.65	16.68±0.47	1.11±0.12	78.50±14.73
GM4	349.00±10.04	7.53±0.49	8.70±0.26	0.87±0.08	21.49±0.46	20.34±1.25	1.06±0.05	77.83±23.56
GK1	328.83±103.75	7.50±0.98	8.67±0.57	0.86±0.06	15.51±1.63	14.70±2.27	1.06±0.05	74.17±20.43
GK2	350.67±71.17	7.67±0.68	9.10±0.62	0.84±0.04	22.52±1.71	20.54±3.98	1.11±0.13	108.67±20.77
GK3	418.83±61.16	8.17±0.65	9.60±0.17	0.85±0.07	23.87±2.82	24.11±2.02	0.99±0.07	116.00±21.40

Values are mean ± standard deviation.

traits and chemical characters divided them into 3 main clusters (Figure 2). The first cluster was consisted of 5 individuals, characterized by the largest fruit with an average WF of 457.43 g, the thinner peel (3.43 mm), the highest percentage of seed (71.65%), volume of juice (80.2%), pH (4.42), total soluble solids (16.93%). The accessions of this group are classified among sweet varieties with an average RI of 91.1. The seeds are semi-soft and soft, they have pink and red-purple color (except GM1 which is characterized by white seeds) with an average seed weight of 25.63 g. Their peels are pink and red (except GC2). The second group holds the accessions of Ouedhref characterized by the lowest RI with an average of 32.28. Morphologically, this group has a red peel, the highest WP which is higher than 155 g and a PT varies between 3.35 and 4.44 mm. The VJ ranges from 76.50 to 80.27%. The pH and the TSS vary respectively from 3.34 to 3.45 and from 12.20 to 15.20%. A weight of fruit varies between 377 and 499.67 g. They have the smaller seed (<11.30 g), red colored and semi soft (except GO1). The third group comprises the majority of the accessions (13). This group has the smaller fruit with an average size of 348.28 g for WF, 7.66 mm for HF and 8.87 mm for DF, the lowest WP (an average of 92.96 g) and the highest PT (an average of 3.91 mm). They have white and pink seeds with an average WS of 19.98 g except GK2 which is red purple.

Concerning the seed hardness and the color of peel, it is variable between the accessions. With an average RI around 40.36, these accessions would be classified among the sweet-sour varieties. The plot of PCA identified three principal components that explained 89% of the total variance. A specific meaning could be variables

Table 5 contd.

var	PT	%P	WS	%S	VJ	PH	TSS	A	RI
GME1	5.12±0.14	34.45±2.71	18.49±0.45	62.77±1.97	71.00±2.65	3.73±0.19	14.60±0.53	0,20±0.009	71.59±1.30
GME2	3.23±0.29	29.77±0.96	17.25±0.47	67.04±6.14	76.13±1.06	3.51±0.11	15.00±0.60	0.35±0.005	42.73±1.700
GME3	3.23±0.11	38.30±2.92	17.31±0.84	59.04±1.09	77.00±2.00	3.45±0.65	13.80±1.97	0.43±0.045	32.36±6.27
GO1	4.44±0.44	41.27±2.46	13.60±0.79	57.73±1.55	77.47±4.39	3.46±0.43	15.20±2.09	0.42±0.013	36.03±5.88
GO2	3.35±0.13	35.03±2.21	11.30±0.89	62.97±1.99	80.27±1.10	3.34±0.08	12.20±0.20	0.42±0.006	28.77±0.44
GO3	3.83±0.28	37.22±1.97	13.90±0.10	61.45±0.65	76.50±3.12	3.45±0.35	13.80±0.36	0.43±0.007	32.02±1.15
GG1	3.69±0.17	29.04±3.03	14.70±0.12	68.96±3.95	74.93±1.11	3.23±0.15	14.20±0.44	0.49±0.009	28.62±0.44
GG2	4.23±0.21	26.67±2.55	21.87±1.31	71.33±3.12	82.77±4.13	3.23±0.25	14.83±0.11	0.51±0.026	28.93±1.29
GG3	5.07±0.15	21.14±3.94	21.71±0.34	77.19±2.99	80.00±1.73	3.03±0.16	13.77±1.36	1.14±0.060	12.07±0.86
GC1	3.13±0.11	27.10±2.12	26.93±3.04	70.57±2.46	82.73±0.64	3.27±0.25	14.93±0.38	0.44±0.062	34.34±4.46
GC2	2.93±0.07	26.29±2.44	27.53±1.33	71.38±2.76	85.50±1.80	4.34±0.11	17.47±1.13	0.19±0.004	89.53±3.90
GC3	3.55±0.10	24.16±0.20	22.93±3.93	73.84±1.59	83.13±1.03	4.44±0.21	16.10±0.90	0.19±0.001	84.76±5.40
GC4	4.07±0.18	30.08±9.79	27.10±1.01	67.92±6.63	85.33±0.58	4.22±0.29	16.80±0.69	0.19±0.002	84.40±2.40
GC5	3.35±0.15	24.02±2.66	26.67±1.66	73.98±1.37	77.03±1.00	4.49±0.09	17.70±0.95	0.18±0.002	97.27±5.51
GM1	3.26±0.29	27.22±2.05	23.93±2.76	71.11±2.88	70.00±1.00	4.60±0.14	16.57±1.36	0.16±0.013	99.38±7.53
GM2	3.79±0.11	23.26±2.02	24.83±3.84	75.07±1.56	71.03±0.96	3.63±0.19	15.27±0.81	0.22±0.007	69.20±5.56
GM3	3.85±0.09	19.10±1.48	18.47±1.37	78.90±2.53	65.00±2.00	3.56±0.14	13.73±0.98	0.21±0.038	66.11±16.15
GM4	4.00±0.04	22.26±6.45	17.15±2.66	75.74±5.66	80.33±0.42	3.26±0.10	13.60±0.87	0.44±0.008	30.47±1.41
GK1	3.75±0.05	22.73±1.10	22.27±1.62	75.61±2.14	76.43±1.24	3.41±0.27	14.03±0.15	0.42±0.006	33.25±0.76
GK2	3.24±0.22	31.04±0.37	20.75±0.96	66.63±3.68	64.67±1.53	3.47±0.16	14.53±0.51	0.42±0.002	34.42±1.07
GK3	4.55±0.34	27.62±1.47	18.03±5.46	70.38±2.16	77.80±2.99	3.53±0.10	13.97±0.38	0.34±0.006	40.51±1.71

Values are mean ± standard deviation.
WF, Weight of fruit; HF, height of fruit; DF, diameter of fruit; HF/D, height to diameter ratio; HC, height of Calyx; DC, diameter of Calyx ; HC/D, height to diameter ratio of calyx; WP, Weight of peel.

(Figure 3) as follows: the first axis, can be interpreted as an expression of fruit size, it accounted for 34% of total variation, the second axis, explained 22% of total variance and is related to the percentage of seed and peel, the weight of seed and the HF/d ratio, the third component explained 10% of total variance dominated by the height and the diameter of calyx and the peel thickness. Highest positive correlation coefficients were observed between pH and RI (0.95), HF and DF (0.91), WF and DF (0.90), WF and HF (0.81) and TSS and RI (0.81). The weight of peel was significantly correlated with the HF and DF (0.83). A significant correlation was also noticed between pH and TSS (0.83) and between the seed hardness and the volume of juice (0.66). The highest negative correlations were observed between % P and % S (-0.97). The plots obtained were according to axes 1 to 2 (55% of total inertia) and 1 to 3 (42% of total inertia) confirmed the clustering that was obtained by the hierarchical classification analysis (Figure 3).

DISCUSSION

The study of genetic diversity constitutes a first approach for any breeding program and genetic conservation of species. Morphological and

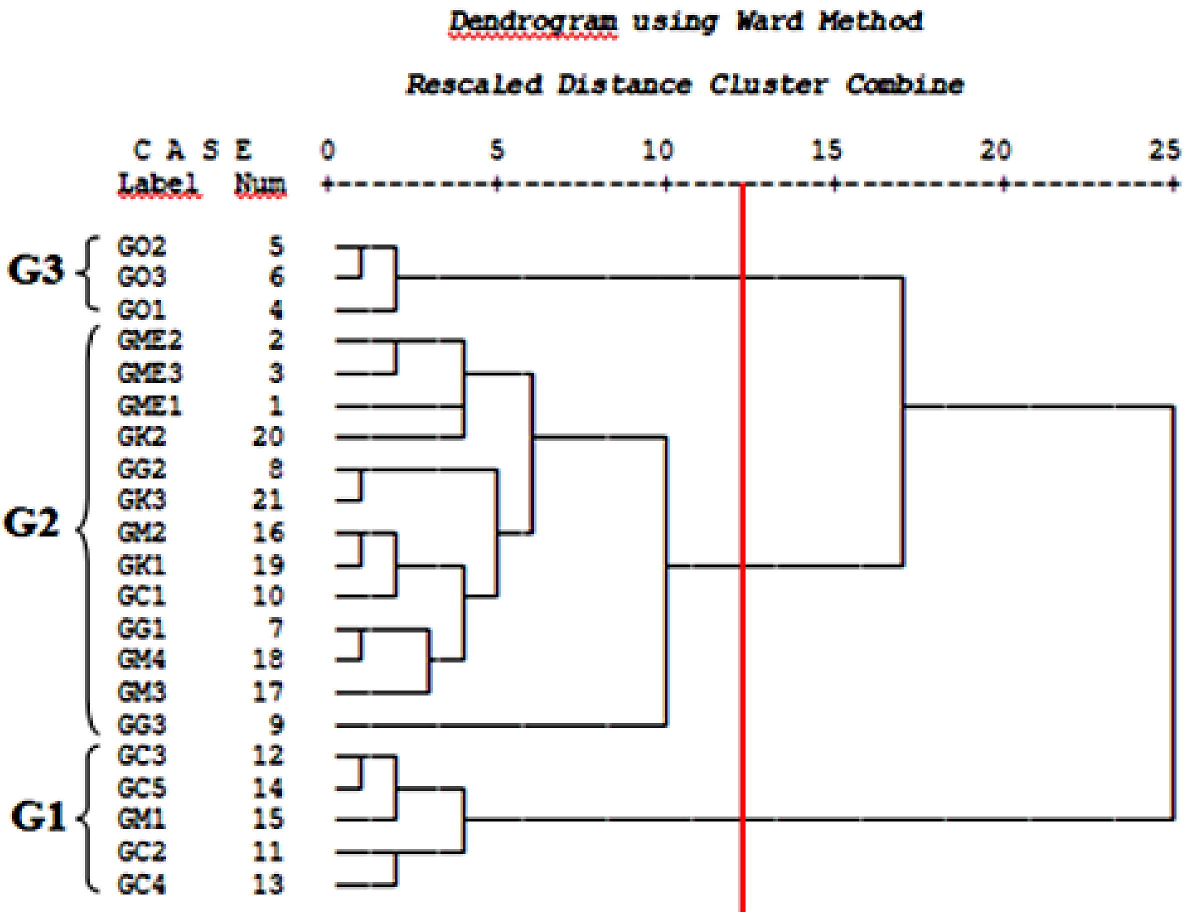

Figure 2. Cluster analysis of studied accessions according to the morphological traits and chemical characters G1: group 1, G2: group 2 and G3: group 3.

chemical characters are important and have been traditionally used for the identification of pomegranate varieties (Mars and Sayadi, 1992; Ercan et al., 1992; Mars and Gaaliche, 1993; Polat et al., 1999; Mars and Marrackhi, 1999; Al-Maiman and Ahmad, 2002; Yildiz et al., 2003; Özkan, 2005; Gundogdu, 2006; Muradoglu et al., 2006) and other species like Bergamot (Statti et al., 2004), rice (Bajracharya et al., 2006), carob (Naghmouchi et al., 2009), quinoa (Bhargava et al., 2007) and *Satureja hortensis* L. (Hadian et al., 2010). The studied morphological and chemical characteristics showed considerable variations between accessions for all of the characters. Among the 17 analyzed parameters, 9 have coefficients of variation (CV) above 15%. Indeed, Audergon (1987) considers that the values between 15 and 20% are medium and those above 20% are significant and indicate a wide variability related to the studied trait. The acidity, the ripeness index, the percentage of peel and the weight of fruit, of peel and of seed were characteristics with higher variation (CV= 56.12, 52.46, 22.82, 25.07, 31.66 and 25.08% respectively), so they are the most discriminant parameters. The results of analysis of variance showed a highly significant effect recorded for all variables. Most accessions had an average weight of fruit higher than 400 g, an average weight of peel lower than 97 g, percentage of seeds higher than 70, a peel thickness below 3.5 mm, a higher soluble solids content (TSS = 14.5%) and a pH higher than 3.5. Yildiz et al. (2003), Özkan (2005), Gundogdu (2006), Mars and Marrackhi (1999), Polat et al. (1999) and Al-Maiman and Ahmad (2002) working on pomegranate from Turkish, Mediterranean region and Tunisia found that promising pomegranates must have 192.0 to 806.6 g fruit weight, 12.1 to 70.2 mm fruit width, 58.0 to 101.5 mm fruit length, 1.5 to 4.4 mm peel thickness, 12.4 to 21.7 mm calyx length, 18.5 to 33.1 mm calyx diameter 48.4 to 76.6% seed percentage, 11.7 to 18.9% soluble solids content, and 2.9 to 4.6 pH. Consequently, pomegranate genotypes identified in this study was comparable and even better than those obtained by the aforementioned authors. Softness or absence of seeds is a desirable economic trait that improves the consumptive qualities of fruits, but for pomegranate only soft-seedness is possible (Levin, 1994).

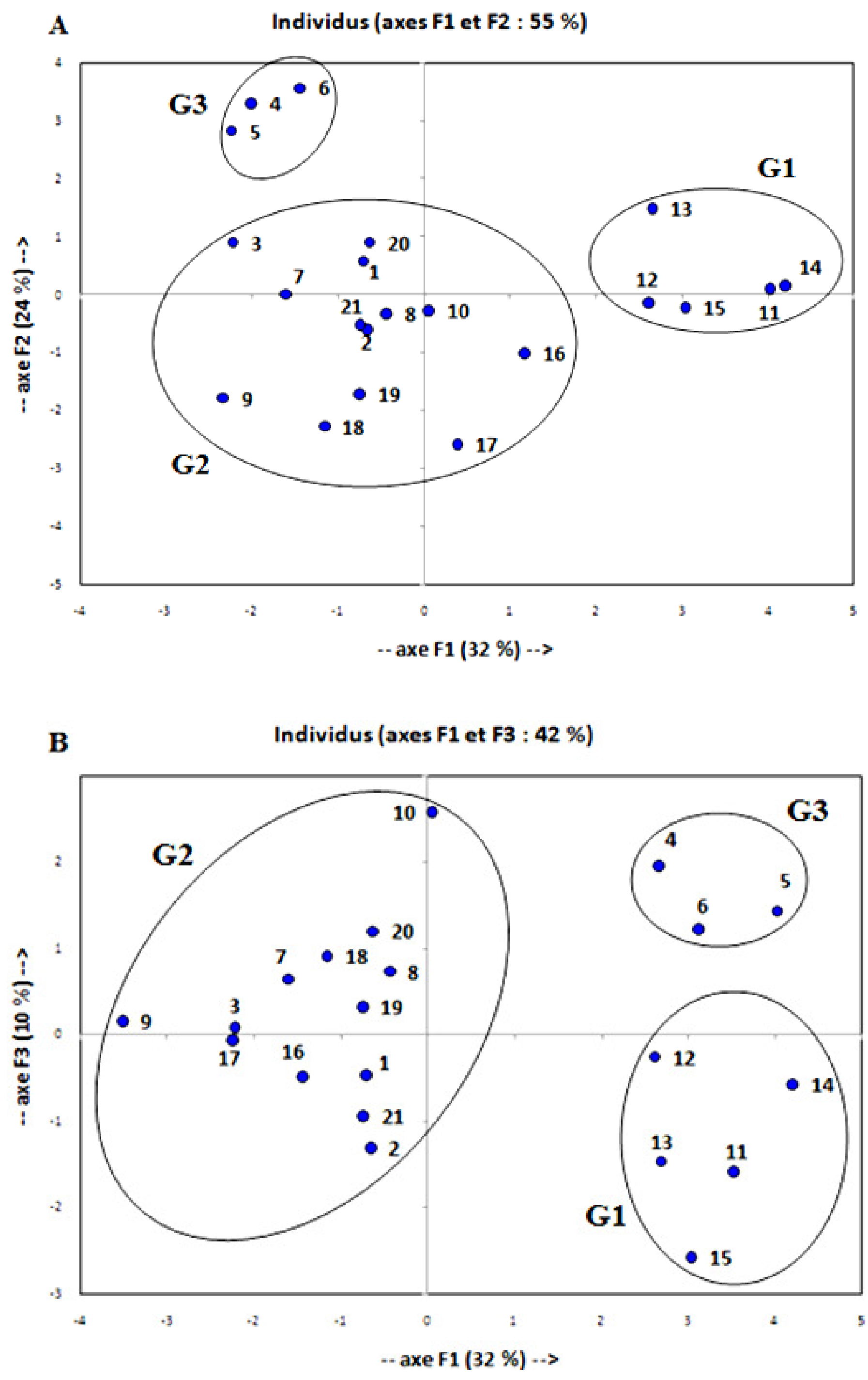

Figure 3. Plot of the accessions on the first, second and third components. (A) Pomegranate accessions according to axis 1-2, (B) pomegranate accessions according to axis 1-3. G1: group 1, G2: group 2 and G3: group 3.

Among the studied accessions, 7 are soft and 10 have pink seeds. Initial aril color intensity is an important factor affecting color degradation and kinetics during the production of juice concentrate by heating methods (Maskan, 2006; Vardin and Fenercioglu, 2003). Fruit peel color varied widely among the accessions and 8 of them have pink peel. According to Cristosto et al. (2000), Hess-Pierce and Kader (2003), Elyatem and Kader (1984) and Kader et al. (1984), skin color is an important quality attribute in pomegranate marketing and fruit with red coloration tend to have greater consumer appeal. High juice content is a desirable attribute in pomegranate production and other fruits and it is the most important parameter from an industrial point of view (Cassano et al., 2004; Maestre et al., 2000). In the studied varieties, this varies from 64.67 to 85.50%, which corroborates with those noted by Agrawal and Chandra (1991) which indicates that the percentage of juice in the cultivar Muscat varied between 60 and 84%. This result is better than that obtained by other authors who found percentages ranging from 44.96 to 68.55% in Indian and Spanish varieties (Viswanath et al., 1999; Martinez et al,. 2006). The mean titrable acidity is 0.375±0.211%. If this result is used to compare a variety well known throughout the world (example, Wonderful), this cultivar, with an acidity content of around 1.8% (Chace et al., 1981), would be considered bitter-sweet or bitter if judged on the same scale.

A significant positive correlation was reported between the seed hardness (SH) and juice content (VJ) of pomegranate, then accessions which have lower seed hardness contained more juice per unit mass of aril. This information could be useful in the early screening particularly for juice production (Mars, 2000; Maestre et al., 2000; Xian et al., 1997). Referring to the parameters studied in this work, outlines of valorization can be advanced. The analysis of results allows to distinguish some genotypes. The accessions of Chenini are characterized by their seeds which have pink, red and red-purple color, their biggest fruit and seed, their thickness skin, their highest pH, total soluble solids, ripeness index and percentage of seed and of juice. The accessions of Oudhref are characterized by their color of seed and peel.

In conclusion, the studied accessions present an interesting source of genetic diversity. For most of the analysed characters, the observed values can be considered comparable, and sometimes superior, to those presented by other well-known cultivars from other countries. They have an attractive appearance, a low acidity content and a high soluble solids. These results support the improvement and the selection and have identified some genotypes as parents for the traits. To clarify the genetic relationships within the plant material to study, our research should move towards the development of chemical, biochemical and molecular markers. They confirm the observed variability and to better assist the work of breeding and selection.

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