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GENOTYPE SELECTION FOR PHYSICO-CHEMICAL FRUIT TRAITS IN POMEGRANATE (*Punica granatum* L.) IN TURKEY

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Abstract. Pomegranate is one of the most important ancient fruit in Turkey where planting of pomegranate has increased rapidly in recent years. This study described desirable pomological and chemical traits of seventeen pomegranate genotypes selected from Narlidere district (Bitlis) in between 2010–2011 years. We found considerable variation on fruit weight, aril weight, fruit length and fruit width that important for pomegranate breeding ranged from 99.77 (N-15) to 515.97 g (N-05), 14.16 (N-01) to 41.92 g (N-10), 51.03 (N-15) to 90.99 mm (N-05) and 58.99 (N-03) to 103.11 mm (N-05) among genotypes, respectively. Chemical parameters are also considerable varied among genotypes and Soluble solid content (SSC), titratable acidity (TA), pH and juice yield of genotypes varied between 5.96 (N-02) to 9.13% (N-03), 0.12 (N-12) to 0.91% (N-14), 2.51 (N-14) to 4.52 (N-10) and 48.58 (N-06) to72.07% (N-01), respectively. Many genotypes were found to be promising both fresh consumption and processing. Promising genotypes indicate it's importance as genetic resources and they have potential for future use in pomegranate breeding activities.

Key words: Pomegranate, genetic resources, fruit characteristics, content

INTRODUCTION

Pomegranate belongs to Punicaceae family and it contains only two species, *Punica granatum* L. and *Punica protopunica* Balf. f. 1882. *Punica protopunica* is endemic to the Socotra Island (Yemen) and is the only congeneric relative of *P. granatum* species currently is cultivated [Levin 2006].

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Pomegranate (*Punica granatum* L.) is one of the important fruit grown in both tropical and subtropical conditions. More recently pomegranate production and consumption increased due to recognition of its multiple nutritional and medicinal health benefits for human [Viuda-Martos et al. 2010, Gozlekci et al. 2011a, Orhan et al. 2013]. The fruits of pomegranate are used for both fresh consumption and also processing in particular for juice production. The scientific literature contains many reports describing the value of bioactive compounds such as phenolics, flavonoids, ellagitannins (ETs), and proanthocyanidin compounds [Li et al. 2006], minerals, mainly potassium, nitrogen, calcium, phosphorus, magnesium, sodium [Mirdehghan and Rahemi 2007], and complex polysaccharides [Jahfar et al. 2003] in pomegranate edible parts (arils) and they have antioxidant, anticancer, antiviral and antibacterial effects [De Nigris et al. 2005, Malik et al. 2005]. The dietary antioxidant effects of pomegranate are strongly belongs to its high phenolic and anthocyanin content [Ozgen et al. 2008, Muradoglu et al. 2011].

Pomegranate has been cultivated and naturalized over the entire Anatolia since ancient times [Ercisli 2004, Orhan et al. 2014] and the commercial cultivation of pomegranate is confined to Mediterranean, Aegean and South East Anatolia regions in Turkey [Ercisli et al. 2007, Ozgen et al. 2008]. Pomegranate is traditional fruit species for Turkey and it was commonly used in folk medicine, for eliminating parasites, as an antihelmintic and vermifuge, and to treat and cure aphtae, ulcers, diarrhea, acidosis, dysentery, hemorrhage, microbial infections, and respiratory pathologies [Baytop 2004]. There are high morphological variations among pomegranate cultivars and genotypes due to continued sexual production for centuries in Turkey. These trees/shrubs shows a wide variation in their fruiting, yield and fruit quality characteristics. This high variation could be important to select better pomegranate genotypes in different regions in Turkey and bring them commercial cultivation. In fact all pomegranate commercial cultivars in Turkey such as 'Devedişi', 'Hatay', 'Çekirdeksiz', 'Fellahyemez', 'Hicaznar', 'Lefan', 'Yufka Kabuk' etc. previously selected among seed-propagated populations and the natural seedling variation is used in improvement of several pomegranate cultivars in Turkey [Ozguven and Yilmaz 2000, Ercisli et al. 2011]. Fruit size and shape, rind and seed color juiciness, sugar content and acidity, taste, seed hardiness etc. treatments are used the aim of breeding Turkish several pomegranate cultivars [Ercan et al. 1992, Ozguven and Yilmaz 2000, Ercisli et al. 2007, Gozlekci et al. 2011b, Orhan et al. 2013].

In Turkey, planting of pomegranates has increased rapidly in recent years in Turkey and the total pomegranate production of Turkey was 40.000 tons in 1990 and reached approximately 400.000 tons in 2013. Turkey is an important pomegranate exporter country in the world as well.

Modern objectives in plant breeding may be achieved by the evaluation of traits amongst genetic resources and combination of those in one cultivar. Morphological markers still keep importance and widely used in different fruit species, cultivars and genotypes and might be appropriate for classification [Ercisli and Esitken 2004, Gozlekci et al. 2011a, Yilmaz et al. 2012, Gunduz 2013, Koc and Bilgener 2013, Norouzi et al. 2013, Razi et al. 2013, Taain 2013]. Morphological characters must be recorded for selection of parents and are also the first choice used for describing and classifying the germplasm. Statistical methods including principle components or cluster analysis can be used as useful tools for screening the accessions. In addition, morphological characteristics sometimes have correlation or are associated with characteristics that are difficult to evaluate such as disease susceptibility. Therefore, they may be useful as markers in breeding programs [Karimi et al. 2009].

The essential goal of this study was to investigate pomegranate genetic resources of Narlıdere (Bitlis) district to identify promising genotypes and contribute to future cross breeding programs in Turkey.

MATERIALS AND METHODS

The research district is situated between 38º12' North latitude and 42°17' East longitude in East Anatolia region (Narlidere-Bitlis) at altitude of 892–1017 meters above sea level. The data of microclimates of the research district are presented Table 1. Bitlis province is one of the most important ancient pomegranates growing area in Turkey since antique age. There are approximately 10.000 trees of pomegranate in Narlidere district. Surveys of pomegranate (*Punica granatum* L.) trees were conducted during 2010–2011. The fruit samples were collected from seventeen promising genotypes.

Table 1. Average monthly maximum and minimum air temperature (°C) and total rainfall (mm) in the Narlıdere-Bitlis – 1975 to 2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	15.1	13.2	23.0	27.8	29.4	34.0	38.0	37.2	34.8	30.2	21.0	15.6
Min	-21.3	-22.0	-18.3	-12.0	-2.5	1.9	7.0	7.0	1.8	-6.0	-17.0	-21.9
Rainfall	142.1	189.1	175.6	166.7	101.9	25.7	6.0	4.4	14.6	94.5	161.6	158.4

The physico-chemical analyses were determined in 50 random mature fruits. Fruits from selected trees were randomly taken for measuring physical attributes like fruit weight, length diameter, calyx dimension, aril weight, aril ratio and seed hardness. Fruit and aril weight were measured by using a digital balance with a sensitivity of 0.001 g. Linear dimensions, length and width of fruits were measured by using a digital caliper gauge with a sensitivity of 0.01 mm. The chemical characters like total soluble solids of fruit juice were recorded with a hand-refractometer. The chemical constituents of the edible portion were estimated as per methods detailed in AOAC [1984]. Fruit skin and aril color as L* (lightness). a* (green to red) and b* (blue to yellow) was measured by Minolta Chroma Meter CR-400, (Minolta-Konica. Japan).

The statistical analyses were carried out using SAS [SAS Inst. 2005]. The pomological characteristics were subjected to principle component analysis (PCA) using the PRINCOMP procedure. The relationships were determined from a covariance matrix derived from standardized morphological and chemical characteristics means and the output data sets consisted of eigen-values, eigenvectors, and standardized principal component scores.

RESULTS AND DISCUSSION

The results regarding physical parameters showed differences on most parameters among selected pomegranate genotypes (tab. 2). Average fruit weight ranged between 515.97 g in genotype N-05 to 99.77 g in genotype N-15 (tab. 2). Yildiz et al. [2003] reported fruit weight between 192.3–388.3 g in some pomegranate genotypes in Turkey. The fruit weight has been reported for fifteen pomegranate (*Punica granatum* L.) genotypes from Iran between 288.5 and 204.3 g [Tehranifar et al. 2010]. The fruit weight was observed as 127 g ('Ambledane'), 173.0 g ('Mridula'), 217.0 g ('Ruby'), 248.0 g ('Ganesh'), 255.0 g ('Jyoti'), 263.0 g ('Jalore Seedless') and 265.0 g ('Bassein Seedless') in India [Tarai and Ghosh, 2006]. Orhan et al. [2013] reported great morphological variability among 56 pomegranate selectionds from Coruh valley in Turkey and the genotypes exhibited a range of 147–769 g for fruit weight. Muradoglu et al. [2006] described important fruit traits of 46 promising pomegranate selections from eastern Anatolia and they found that promising genotypes have a range of 131–337 g for fruit weight. The fruit weight obtained in N-05 genotype was higher than those obtained by Yildiz et al. [2003], Tarai and Ghosh [2006], Ozguven et al. [2009] and Tehranifar et al. [2010].

In this study aril weight ranged from 14.16 g (N-01) to 41.16 g (N-10) (tab. 2). The aril weight varied between 21.00 ('Ganesh') to 31.60 g ('Dholka') in Iran [Mir et al. 2007]. In India, the average aril weight of standard pomegranate cultivars was determined as 17.0 ('Ganesh') and 20.6 g ('Rubi') [Dhanumjaya and Subramanyam 2009]. N-05 genotype has higher aril weight compared to above studies.

The fruit length values were between 51.03 (N-15) – 90.99 mm (N-05), fruit diameter varied from 58.99 (N-03) to 103.11 mm (N-05) (tab. 2). These values were in agreement with Muradoglu et al. [2006], Tarai and Ghosh [2006], Mir et al. [2007], Ozguven et al. [2009] and Tehranifar et al.[2010], but higher than Singh et al. [2009].

The calyx length varied from 6.53 (N-10) to 17.25 mm (N-08), and calyx diameter changed from 11.38 (N-07) to 36.60 mm (N-04) (tab. 2). These results were close to the values reported by Mir et al. [2009]. Muradoglu et al. [2006] reported calyx length 11.0–26.1 mm and calyx diameter 11.2–18.1 mm.

The chemical composition of selected pomegranate genotypes presented in Table 3. It was clear that the SSC content of genotypes ranged between 5.96 (N-02) to 9.13% (N-03). The SSC in juice of different pomegranate cultivars in India and Iran ranged from 12.5 to 19.9% [Mir et al. 2007, Singh et al. 2009]. In all examined Turkish cultivars, it was determined that average SSC was determined between 14.7 to 18.2% in subtropical conditions in Turkey [Ozguven et al. 2009]. In general, the SSC value of our genotypes was low as compared to above studies. The chemical composition of the pomegranate fruits differs depending on the cultivar, growing region, climate, maturity, cultivation practice, and storage conditions [Poyrazoglu et al. 2002]. Titratable acidity was between 0.12 (N-12) and N-14 (0.91%) and pH values ranged from 2.51 (N-14) to 4.52 (N-10). These findings in agreement with the previous results [Ozguven et al. 2009, Mir et al. 2010, Tehranifar et al. 2010 and Gozlekci et al. 2011a].

Table 2. Fruit physical characteristics of seventeen genotypes of pomegranate (2010–2011)

Genotypes	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)	Calyx suture (mm)	Calyx length (mm)	100 aril weight (g)
N-01	214.49	77.00	64.14	16.17	9.76	14.16
N-02	112.43	61.34	52.47	14.64	11.72	24.12
N-03	108.48	58.99	51.71	12.25	9.64	28.96
N-04	309.47	89.59	76.68	36.60	15.18	34.24
N-05	515.97	103.11	90.99	19.06	9.61	39.52
N-06	110.20	64.65	55.01	17.89	8.39	22.28
N-07	100.42	59.68	51.93	11.38	7.01	22.28
N-08	99.77	60.50	52.82	17.81	17.25	14.92
N-09	209.34	74.31	66.69	14.36	7.17	35.00
N-10	157.71	68.91	59.06	11.73	6.53	41.92
N-11	252.34	83.45	69.12	19.44	7.59	37.12
N-12	225.36	74.81	64.54	16.91	15.7	37.28
N-13	217.90	75.58	64.41	13.89	9.43	31.76
N-14	156.49	67.64	59.40	14.18	12.00	15.04
N-15	99.77	59.12	51.03	16.64	13.74	26.40
N-16	247.74	71.94	64.14	14.19	10.40	37.56
N-17	185.74	73.39	63.99	16.24	14.56	34.44

Table 3. Fruit chemical composition of seventeen genotypes of pomegranate (2010–2011)

Genotypes	Juice yield (%)	Seed hardness	Taste	Soluble solid content (%)	Titratable acidity (%)	pH
N-01	72.07	hard	sweet	7.45	0.17	4.27
N-02	61.60	hard	sour	5.96	0.51	2.93
N-03	57.06	intermediate	sour	9.05	0.37	3.14
N-04	51.23	intermediate	sour	8.07	0.29	2.90
N-05	64.94	soft	sour	7.60	0.31	3.29
N-06	48.58	soft	sour	8.09	0.36	3.11
N-07	68.75	soft	sweet	7.89	0.18	3.75
N-08	60.27	intermediate	sweet	6.91	0.18	3.66
N-09	57.10	intermediate	sweet	9.13	0.18	3.65
N-10	64.31	intermediate	sweet	8.35	0.15	4.52
N-11	52.91	hard	sour	8.30	0.23	3.48
N-12	56.48	intermediate	sweet	8.44	0.12	3.02
N-13	66.20	intermediate	sweet	8.30	0.24	2.81
N-14	61.06	hard	sweet	7.89	0.91	2.51
N-15	56.44	hard	sweet	7.04	0.18	3.43
N-16	64.53	hard	sweet	6.75	0.18	3.66
N-17	57.96	intermediate	sweet	8.85	0.15	3.79

Table 4. *L*, *a* and *b* values of skin and aril of seventeen genotypes of pomegranate (2010–2011)

Genotypes	Skin			Aril		
	L (lightness)	*a**	*b**	*L* (lightness)	*a**	*b**
N-01	69.46	-5.83	40.67	43.72	10.36	12.79
N-02	68.75	2.76	37.03	45.41	20.44	19.58
N-03	66.34	21.84	30.95	32.24	22.62	17.44
N-04	65.07	12.78	38.06	50.82	15.37	18.19
N-05	71.37	11.79	38.02	34.23	18.18	17.73
N-06	69.04	13.6	34.80	35.64	23.31	17.62
N-07	71.06	2.12	37.83	40.53	6.03	14.29
N-08	62.69	6.08	37.38	46.91	8.21	14.25
N-09	70.03	13.63	37.16	28.73	18.86	14.48
N-10	70.17	14.72	35.57	40.63	4.97	13.56
N-11	74.23	4.02	40.00	46.49	12.26	15.13
N-12	68.79	14.48	37.27	35.01	19.44	16.56
N-13	72.16	8.50	38.85	31.18	23.89	17.01
N-14	58.78	4.40	37.00	38.84	49.84	20.73
N-15	60.39	26.53	29.18	111.51	31.65	43.35
N-16	74.22	7.53	40.41	28.06	23.75	16.02
N-17	67.46	11.04	36.91	37.68	14.16	15.66

Juice yield varied between 48.58 (N-06) and 72.07 (N-01) (tab. 3). Tarai and Ghosh [2006] reported that juice yield 51.2–64.2% among pomegranates grown in India. Orhan et al. [2013] reported a wide variability among juice yield (19.00–80.00%).

Skin and aril color is one of the main fruit traits that determine pomegranate fruit quality and is an important criterion in consumer's decisions. Skin color in our genotypes varied from yellow, yellow-red, yellow-pink, yellow-green, green, red and red-green. Also, aril color was observed as yellow, yellow-pink, pink, dark pink, red and dark red. Skin color of pomegranate genotypes was determined as *L* value (lightness) 58.78 (N-14) and 74.23 (N-11); *a* value 26.53 (N-15) and -5.83 (N 01) and *b* value 29.18 (N-15) and 40.67 (N-01) (tab. 4). Gozlekci et al. [2011a] reported that *L, a* and *b* values as 58.71, 32.72 and 28.97 in skin color of 'Hicaznar' in Turkey. Ercisli et al. [2007] determined *L* value between 41.14 and 73.47; *a* value -2.73 and 51.82 and *b* value between 17.47 and 42.46 skin color in native pomegranate genotypes in Turkey. Aril color of pomegranate genotypes was determined as *L* value (lightness) 28.06 (N-16) and 111.51 (N-15); *a* value 4.97 (N-10) and 49.84 (N-14) and *b* value 12.79 (N-01) and 43.35 (N-15) (tab. 4). Aril color of pomegranate cv. 'Hicaznar' was determined as *L* value (lightness) 34.97; *a* value 11.92 and *b* value 4.92 [Gozlekci et al. 2011a]. Ercisli et al. [2007] reported *L* value between 20.90 and 44.13, *a* value between 15.16 and 31.42, and *b* value between 11.41 and 20.51 at full ripe stage among pomegranate genotypes. According to these results, *L*, *a* and *b* values of skin and aril color was found to be similar in comparison to previous studies. Also, seed hardiness is important quality factor for consumer. Seed hardiness of promising genotypes varies soft, intermediate and hard. The taste of eleven genotypes was observed as sweet and six genotypes has source taste (tab. 3).

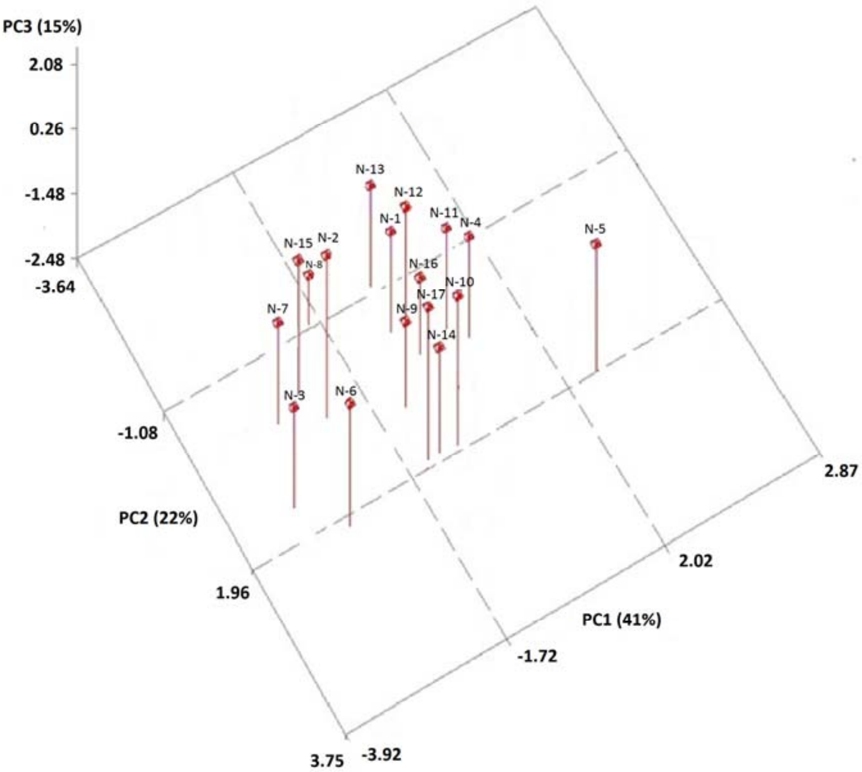

Fig. 1. PCA plot of the first three PCs depicting relationships among pomegranate genotypes sampled from Bitlis

The means of all traits were subjected to PCA (fig. 1). The results indicated that the first three components showed 41, 22 and 15% of the phenotypic variations, for a total of 78%. The most important trait positively correlated were fruit weight with PC1. The genotypes were plotted on three dimensions based on their PCA results (fig. 1) and were easily separated from each other with enough diversity. Continuous seed propagation in the region for centuries had resulted in a number of local genotypes differing in most of fruit characteristics in the study area. These genotypes are unknown origin and represent rich diversity.

CONCLUSION

The present study showed that genotype N-01 appeared as higher juice yield characteristic; N-05, N-06 and N-07 appeared as soft seed characteristics and N-05 for distinct higher fruit weight characteristics. Hence, these genotypes can be used in breeding programs for genetic development in fruit breeding in pomegranate. However, the study also suggests the testing of large number genotypes over years and environment for selection of genetically diverse genotypes in pomegranate. It further suggests that promising genotypes will be maintained in germplasm collections to conserve the biodiversity in order to check the genetic erosion in pomegranate.

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SELEKCJA GENOTYPÓW WEDŁUG FIZYKOCHEMICZNYCH CECH GRANATU (*Punica granatum* L.) W TURCJI

Streszczenie. Granat jest jednym z najstarszych owoców w Turcji, a jego uprawa gwałtownie rozwinęła się w ostatnich latach. W niniejszej pracy opisano pożądane pomologiczne i chemiczne cechy siedemnastu genotypów granatu z okręgu Narlidere (Bitlis) badanych w latach 2010–2011. Stwierdzono znaczne zróżnicowanie cech granatu ważnych dla jego uprawy, takich jak masa owocu, masa osnówki oraz szerokość owocu. Ich rozpiętość wahała się odpowiednio od 99,77 (N-15) do 515.97 g (N-05), 14,16 (N-01) do 41,92 g (N-10), 51,03 (N-15) do 90,99 mm (N-05) oraz 58,99 (N-03) do 103,11 mm (N-05). Cechy chemiczne także znacznie różnicowały badane genotypy. Zawartość rozpuszczalnych substancji stałych (SSC), kwasowość ogólna (TA), pH oraz plon soku wahały się odpowiednio od 5,96 (N-02) do 9,13% (N-03), 0,12 (N-12) do 0,91% (N-14), 2,51 (N-14) do 4,52 (N-10) oraz 48,8 (N-06) do 72,07% (N-01). Stwierdzono, że jeśli chodzi o świeżą konsumpcję i przetwarzanie, jest wiele obiecujących genotypów. Genotypy te stanowia cenne źródło genetyczne, a także mają duży potencjał dla prac hodowlanych.

Słowa kluczowe: granat, źródła genetyczne, cechy owoców, zawartość

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