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Determination of relationship between some Turkish local tomato genotypes by using phenotypic characterization[*]

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Abstract

Turkey is the fourth producer country among the other countries in the world and tomato are produced around 11 million tons per year. Over many years, tomato adapted to the geography of Turkey has shown a high biodiversity. In this research, with 76 local tomato genotypes collected from 52 different provience, 4 foreign and 8 wild species, total 88 tomato genotypes were used. Morphological variations among these materials were investigated. Some of the local genotypes were determined to be accessions increasing variations. A cluster diagram obtained from the morphological descriptors produced ten main sub-cluster groups of tomato accessions at a coefficient of 0.15. Accessions were put into cluster groups based on certain qualities unique. It was observed that 86 out of 88 tomato accessions under study were distinct accessions. G80 and G83 were recorded similar (94%) accessions in all accessions. Similarity coefficient values among the 88 accessions ranged from -0.11 to 0.94. Accessions with similar quantitative and qualitative morphological characters appeared well grouped in the same cluster. These accessions are considered as important genetic resources in tomato breeding studies.

Keywords: Biodiversity, Local genotypes, *Solanum lycopersicum*, Morphological characterization, Clustering

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Bazı yerel domates genotiplerinin fenotipik karakterizasyonu ve akrabalık derecelerinin belirlenmesi

Özet

Türkiye, dünya domates üretici ülkeler arasında yıllık 11 milyon tonluk üretimi ile dördüncü sırada yer almaktadır. Domates, anavatanı olmamasına rağmen Türkiye coğrafyasında adapte bir sebze türüdür ve yüksek oranda biyoçeşitlilik göstermektedir. Bu araştırmada , 52 farklı bölgeden toplanan 76 yerel domates genotipi ile 4 yabancı ve 8 yabani tür olmak üzere toplam 88 domates genotipi kullanılmıştır. Bu genotipler arasında morfolojik değişimler incelenmiştir. Bazı yerel genotiplerin varlığının varyasyonu arttırdığı tespit edilmiştir. Morfolojik karakterizasyon sonucu elde edilen gözlemler değerlendirildiğinde 0.15 oranında farklılıkla 10 ana alt-küme oluşturduğu görülmüştür. Belirli özelliklere sahip materyallerin ayrı gruplarda yer aldığı tespit edilmiştir. Bu çalışma kapsamında 88 genotipten 86'sının diğerlerinden ayrı özelliklere sahip olduğu gözlenirken, G80 ve G83 genotiplerinin yüksek oranda (% 94) birbirine benzer olduğu gözlenmiştir. 88 genotip arasındaki benzerlik katsayısı - 0.11 ile 0.94 arasında değişiklik göstermiştir. Çalışma sonucunda oluşturulan grupların nicel ve nitel morfolojik özellikler bakımından birbirine benzer materyallerden oluştuğu görülmüştür. Bu materyaller sağladıkları genetik varyasyon sayesinde domates ıslah çalışmalarında önemli bir kaynak oluşturmaktadır.

Anahtar kelimeler: Biyoçeşitlilik, Yerel genotipler, *Solanum lycopersicum*, Morfolojik karakterizasyon, Sınıflandırma

1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most important and widely grown vegetable crops in both temperate and tropical regions all over the world. It is a self-pollinated crop and is a member of *Solanaceous* family with 2n = 24. Peru and Ecuador region is considered to be the center of origin (Rick, 1969; Peralta and Spooner, 2005). Tomato is being grown in China, India, USA, Turkey, Italy, Egypt, Spain, Brazil, Iran and Mexico as leading countries. Tomato is a strategic product with area of 4.751.530 ha and production of 159.347.031 tons in the world. In our country, tomato is an important vegetable crop in terms of 328.000 ha of area and 11.003.433 tons of production, in the 4th place of the world tomato production after China, USA and India (FAO, 2011).

Although our country is not their homeland for many vegetables, they have a considerable variety of types. There are a large number of different tomato genetic materials locally grown in our country. However, there isn't any detailed study about their relationships.

The objective of this study was to determine a genotypic morphological characterization of tomato genotypes, to compare some local (76 materials collected from 52 different provinces of Anatolia) tomato genotypes and to identify similarity of groups based on morphological features by using NTSYS pc (Numerical Taxonomy System) analysis program for using in future breeding programs.

2. Material and Methods

Eighty-eight accessions of tomatoes were used as experimental materials to assess the differences in morphological traits. Among the accessions, the eight wild types of tomato *(Solanum hirsutum,* S*. lycopersicum* var. *cerasiforme, S. pimpinellifolium*, *S. peruvianum*, *S. peruvianum* var. *humifusum*, *S. pennellii*, *S. chilense* ve *S. chimielewskii)* and the four accessions of tomatoes homeland (Galapagos Island, Brazil, Mexico and Equator genotypes from South America) (Rick and Holle, 1990) were obtained from the Tomato Genetic Resource Center (TGRC) of USA and the seventy-six accessions were obtained from Ege Agricultural Research Institute, Turkey. The identity of the materials used in this study is shown in Table 1. The study was conducted in the autumn season of 2008 at the experimental field of the Department of Vegetables of Batı Akdeniz Agricultural Research Institute (BATEM), Turkey. Randomized complete block design (RCBD) was used as experimental design with three replications and each plot contained ten plants of each accessions.

Data were collected on plant growth habit, general growth appearance/branching, flowering characteristics, pigmentation and pubescence of the various plant parts, fruit characteristics and leaf characteristics. Data were recorded from the four tagged plants in each plot.

The morphological characterizations were performed by using the selected characters in the description form developed for tomato by UPOV (The International Union for the Protection of New Varieties of Plants) with the reference number TG/44/10 (Table 2) (UPOV, 2001) and IPGRI (International Plant Genetic Resources Institute). A dendrogram showing the distinct clusters among the 88 tomato accessions were constructed using Numerical Taxonomy and Multivariate Analysis System (NTSYS version

Table 1. Tomato genotypes used in the research

No	Origin	G B.	GBID.	No	Origin	G B.	GBID.
G1	Antalya	ETAE*	TR 69155	G45	Kırşehir	ETAE	TR 69806
G2	Antalya	ETAE	TR 69156	G46	Çankırı	ETAE	TR 69812
G3	Antalya	ETAE	TR 69157	G47	Çankırı	ETAE	TR 69813
G4	Antalya	ETAE	TR 69160	G48	Yozgat	ETAE	TR 71370
G5	Mersin	ETAE	TR 72508	G49	Yozgat	ETAE	TR 71376
G6	Mersin	ETAE	TR 72509	G50	Kayseri	ETAE	TR 71389
G7	Mersin	ETAE	TR 72511	G51	Nevşehir	ETAE	TR 71398
G8	Mersin	ETAE	TR 72513	G52	Nevşehir	ETAE	TR 71402
G9	Burdur	ETAE	TR 68519	G53	Eskişehir	ETAE	TR 66038
G10	Isparta	ETAE	TR 68520	G54	Eskişehir	ETAE	TR 66056
G11	Isparta	ETAE	TR 68525	G55	Niğde	ETAE	TR 72516
G12	Adana	ETAE	TR 71519	G56	Sinop	ETAE	TR 37129
G13	Adana	ETAE	TR 72501	G57	Samsun	ETAE	TR 49449
G14	Hatay	ETAE	TR 72492	G58	Tokat	ETAE	TR 46511
G15	Hatay	ETAE	TR 72494	G59	Trabzon	ETAE	TR 55711
G16	Muğla	ETAE	TR 61675	G60	Çorum	ETAE	TR 69787
G17	Muğla	ETAE	TR 61697	G61	Amasya	ETAE	TR 70704
G18	Muğla	ETAE	TR 61727	G62	Kastamonu	ETAE	TR 70739
G19	Muğla	ETAE	TR 61768	G63	Artvin	ETAE	TR 52527
G20	Muğla	ETAE	TR 61752	G64	Van	ETAE	TR 40478
G21	Muğla	ETAE	TR 61746	G65	Van	ETAE	TR 40507
G22	Muğla	ETAE	TR 61785	G66	Erzincan	ETAE	TR 52128
G23	Muğla	ETAE	TR 61689	G67	Ağrı	ETAE	TR 52263
G24	İzmir	ETAE	TR 49646	G68	Kars	ETAE	TR 52361
G25	İzmir	ETAE	TR 63233	G69	Erzurum	ETAE	TR 52463
G26	Kütahya	ETAE	TR 64126	G70	Adıyaman	ETAE	TR 47820
G27	Aydın	ETAE	TR61514	G71	Şanlıurfa	ETAE	TR 47865
G28	Denizli	ETAE	TR 61870	G72	Mardin	ETAE	TR 40361
G29	Denizli	ETAE	TR 61921	G73	Diyarbakır	ETAE	TR 40395
G30	Uşak	ETAE	TR 66578	G74	Diyarbakır	ETAE	TR 40397
G31	Çanakkale	ETAE	TR 42996	G75	Siirt	ETAE	TR 40443
G32	Çanakkale	ETAE	TR 62367	G76	Siirt	ETAE	TR 40464
G33	Bolu	ETAE	TR 69201	G77	*S.l.*var *cerasiforme*	TGRC**	LA 3139
G34	Bilecik	ETAE	TR 64151	G78	*S. pimpinellifolium*	TGRC	LA 0100
G35	Bilecik	ETAE	TR 72530	G79	*S. pe.* var. *humifusum*	TGRC	LA 0385
G36	Balıkesir	ETAE	TR 62573	G80	*S. peruvianum*	TGRC	LA 3900
G37	Balıkesir	ETAE	TR 62613	G81	*S. hirsutum*	TGRC	LA 1777
G38	Bursa	ETAE	TR 66062	G82	*S. pennelli*	TGRC	LA 0716
G39	İstanbul	ETAE	TR 43261	G83	*S.chimielewskii*	TGRC	LA 1028
G40	İstanbul	ETAE	TR 43484	G84	*S. chilense*	TGRC	LA 1959
G41	Tekirdağ	ETAE	TR 43236	G85	Mexico	TGRC	LA 0146
G42	Konya	ETAE	TR 69163	G86	Galapagos	TGRC	LA 0423
G43	Ankara	ETAE	TR 69796	G87	Equator	TGRC	LA 0126
G44	Kırşehir	ETAE	TR 69805	G88	Brazil	TGRC	LA 1021

No: Genotype Number; G: Genotype; GB: Gene Bank; GBID: Gene Bank ID Number;
*ETAE: Ege Agricultural Research Institute- Plant Genetic Resource Center-Izmir, Turkey;
**TGRC: Tomato Genetic Resource Center at University of California, Davis, USA

Table 2. Criteria of phenotypic observation (UPOV, The International Union for the Protection of New Varieties of Plants, 2001)

No	Observed Criteria	No	Observed Criteria
1	Seedling: anthocyanin coloration of hypocotyls **(1)**:present, **(0)**:absent	**15**	Fruit: shape **(1)**:elliptic, **(2)**:circular, **(3)**:elliptic flattened, **(4)**:circular flattened, **(5)**:elliptic slightly flattened, **(6)**:circular slightly flattened, **(7)**:elliptic-flattened -slice, **(8)**: round-flattened -slice, **(9)**:ovate; **(10)**:cylindrical
2	Plant: growth type **(1)**: determinate, **(2)**:indeterminate	**16**	Fruit: color (at maturity) **(1)**:light red, **(2)**:red, **(3)**:orange-red, **(4)**:dark red, **(5)**:pink, **(6)**:orange; **(7)**: yellow; **(8)**: green
3	Plant: growth power **(1)**:weak, **(2)**:medium, **(3)**:strong	**17**	Fruits: mature fruits collar **(1)**:presence, **(0)**:absent
4	Stem : Pubescence **(1)**:absent, **(2)**:few, **(3)**:medium, **(4)**:many	**18**	Fruits: the average weight of fruit **(1)**:30gr≥, **(2)**:30-100gr, **(3)**:100-300gr, **(4)**:300-500gr, **(5)**:500 gr ≤
5	Stem: length of internodes **(1)**: short, **(2)**:medium, **(3)**: long	**19**	Fruit: width **(1)**:very small **(2)**:small, **(3):**medium, **(4)**:large, **(5)**:very large
6	Stem: thickness of plant internodes **(1)**: thin, **(2)**:medium, **(4)**:thick	**20**	Fruit: length **(1)**:very short **(2)**:short **(3)**:medium **(4)**: long **(5)**: very long
7	Leaf: attitude **(1)**:semi-erect, **(2)**:horizontal, **(3)**:semi-dropping, **(4)**:mixture	**21**	Fruit: shape of blossom end **(1)**:pointed, **(2)**:indented to flat, **(3)**:indented, **(4)**:flat **(5):**flat to pointed
8	Leaf: type **(1)**:type 1, **(2)**:type 2, **(3)**:type 3, **(4)**:type 4	**22**	Fruit: thickness of the epidermis **(1)**:thin **(2)**:medium, **(4)**:thick
9	Leaf: intensity of green color **(1)**:light green **(2)**:medium green, **(3)**:dark green	**23**	Fruit: thickness of the pericarp **(1)**:thin, **(2)**:medium, **(3)**:thick
10	%50 Blossom date	**24**	Fruit: color of the flesh **(1)**:red, **(2)**:orange red, **(3)**:pink, **(4)**: dark red, **(5)**:orange, **(6)**:green.
11	Flower: color **(1)**:yellow, **(2)**:orange	**25**	Fruit: cross section **(1)**:round, **(2)**:angular, **(3)**:irregular, **(4)**:eliptic
12	Inflorescence: type (2nd and 3rd truss) **(1)**:mainly uniparous, **(2)**:mainly multiparous , **(3)**:intermediate	**26**	Fruit: number of locules **(1)**:only two **(2)**:two, three or four, **(3)**:five or six , **(4)**:more than six
13	Fruit number in inflorescence **(1)**:few, **(2)**:medium, **(3)**:many	**27**	Fruit: size of core **(1):**very small, **(2)**:small, **(3)**:medium, **(4)**:large
14	Fruit: green shoulder (before maturity) **(1)**:present, **(0)**:absent		

2.20j) and similarity coefficients were calculated by simple matching produced by UPGMA (Rohlf, 2005).

3. Results and Discussion

3.1. General observations

In general, all the tomato accessions were shown relatively wide ranges of variations for all morphological characters observed. In this study, tomato genotypes with similar fruit characteristics were clustered together. The greater part of the variation was centered on fruit shape, fruit width, thickness of the fruit epidermis, fruit cross section and size of fruit core.

A cluster diagram was obtained from the morphological descriptors produced ten main sub-cluster groups of tomato accessions at a coefficient of 0.15. Accessions were put into cluster groups based on certain qualities (Figure 1). It was observed that 86 out of 88 tomato accessions under study were distinct accessions. G80 and G83 were recorded similar (94%) accessions in all accessions. Similarity coefficient values among the 88 accessions ranged from 0.11 to 0.94. Accessions with similar quantitative and qualitative morphological characters were grouped in the same cluster.

3.1.1. This-similarity per cluster group

Group A: The first cluster included two sub-cluster (A1 and A2) and ten accessions. Within cluster A, sub-cluster A1 and A2 difference was obtained from epidermis thickness of fruit with medium (5-9 mm) and thin (≤5 mm), respectively.

Group B: This group was clustered into two sub-groups consisting of eight accessions. The cluster B was differed from accession in each clusters by fruit width. B1 sub-cluster showed medium (45-60 mm) while sub-cluster B2 was large (60-75 mm).

Group C: It was composed of five accessions a single cluster. Mexico genotype was divided into a different branch by fruit shape in this group.

Group D: There were twelve accessions clustered into two sub-groups. Within cluster D, sub-cluster D1 produced accessions with round cross section as against D2 with elliptic cross section in the fruit.

Group E. Group E consisted of five populations in two sub-groups. Fruit shape was oval, or round shaped. Within cluster E, sub-cluster E1 formed inflorescence with type (2nd and 3rd truss-intermediate), fruits with mature collar (absent) and size of core (very small), while sub-cluster E2 showed inflorescence type (2nd and 3rd truss-mainly uniparous), fruits with mature collar (present) and size of core (medium).

Group F: It as the largest group composed of 16 accessions and was clustered into two sub-groups; the majority originating from the all part of region in Turkey. These were different from accessions in clusters by their growth power at the plant; length of internodes at-main-stem; forming type of leaf, attitude and intensity of green color on the leaf; green shoulder (before maturity) on fruit, fruit shape, mature fruits collar, the average weight of fruit and fruit width.

Group G: It was Group G consisted of nine populations with two sub-groups, named by G1 and G2. One of these genotypes was homeland genotypes from Brasil, in G2 sub–groups. The difference between the groups G1 and G2 is due to the growth type. Sub-cluster G1 produced six accessions with determinate growth type as against G2 with indeterminate growth type in the plants. Some features such as length of internodes, thickness of plant internodes, intensity of green color of leaf, fruit shape and fruit width showed differences between these sub-groups.

Group H: It was the smallest group, and consisted of four genotypes. Although they consisted of a single cluster, G58 (Tokat) was divided into a different branch on fruit length and fruit cross section in this group.

Group I: There were ten accessions which were clustered into two sub-groups. This group has more little fruit than the other local genotypes groups, except group J. Although there wasn't an important feature for separating the two sub-groups, I1 and I2 sub groups were differentiation by stem pubescence, fruit number in inflorescence, the average weight of fruit, fruit length and, shape of blossom end on fruit and thickness of epidermis on fruit.

Group J: There were eight accessions which were clustered only one group. Because of only wild types of tomato, this group especially had the smallest fruits in ten groups. J group was divided into four different branches. The one branch consisting of two genotypes, L. e. var. *cerasiforme* and L. *pimpinellifolium,* has been characterized by before maturity green shoulder on fruit (with present), the fruit color at maturity with dark red, color of the fruit flesh with red and size of fruit core with very small. The other group consisted of two genotypes, L. *hirsutum* and L. *pennelli,* has been characterized by fruit green shoulder before maturity (absent) and fruit width (small).

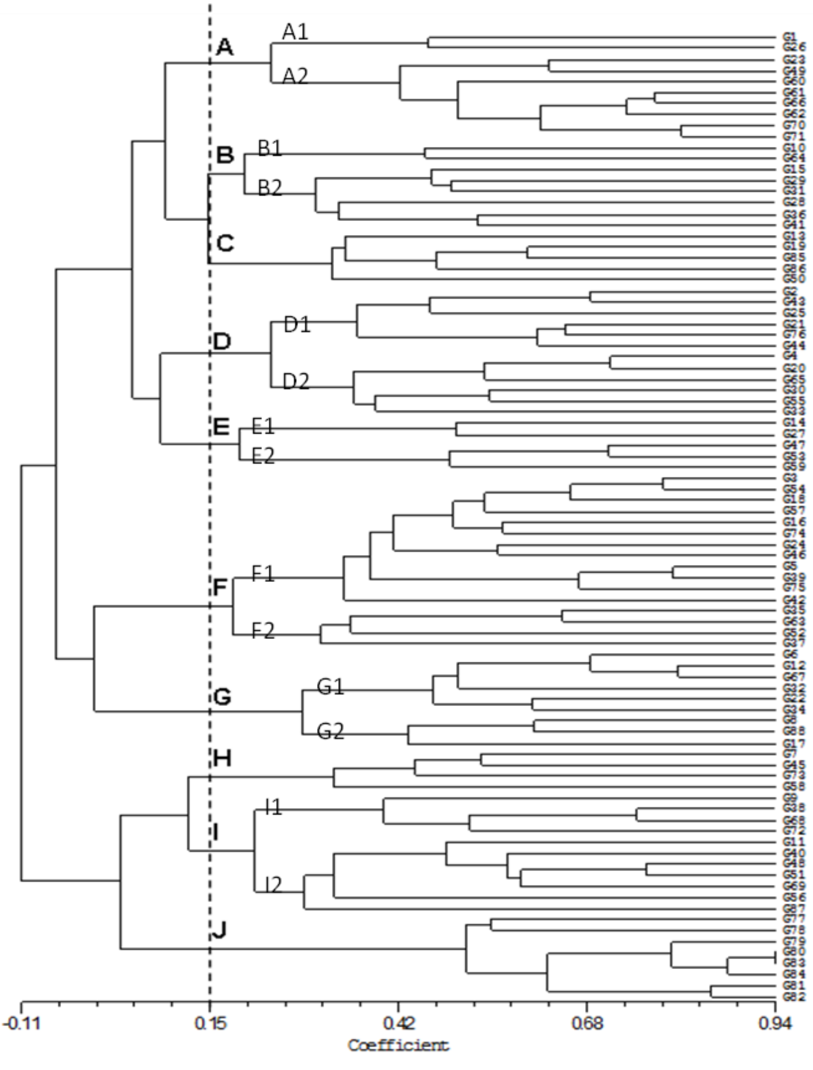

Figure 1. The genetic diversity of local tomato genotypes

4. Conclusion

Turkey is very rich in tomato genetic resources due to its diverse geography and ecology. *Solanaceae* is one of the most important families in Turkey for its genetic resources. There is a need for collecting, characterizing and evaluating the remnant local populations before they disappear. This study was performed for the considerable information gap concerning collection, classification and evaluation of all genetic resources in Turkey. In this study, tomato populations were collected from all parts of regions in Turkey, as a secondary center of genetic diversity for the species. In almost all regions of Turkey, landraces of *Solanaceae* were highly variable in morphology.

In present study, multivariate analysis was employed to better understand the diversity of tomatoes genotypes in Turkey, as well as to identify useful characters for use in breeding programs. As a result, the 88 collected tomatoes accessions were clustered into 10 groups (Figure 2). Across the groups, it was possible to distinguish useful traits for breeding because they possessed a great range of morphological variation. The current study has also identified the relationships among major tomato groups in the collected genetic materials. Phenotypes with similar fruit characteristics were grouped together, irrespective of collection region. The greater part of the variation was centered on fruit shape, fruit width, thickness of the fruit epidermis, fruit cross section and size of fruit core.

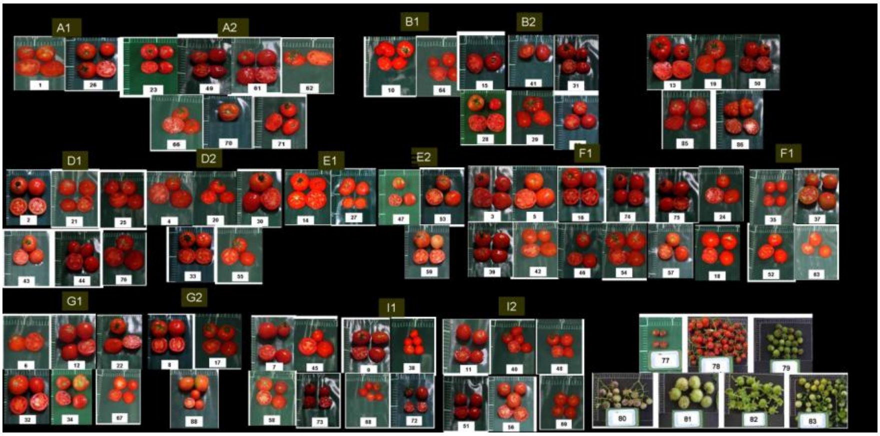

Figure 2. The genetic groups of local tomato genotypes

Within a certain region, variation of plant and fruit types was observed. Groups A, B, C and F came forward for high fruit width, which is very important for fresh fruit production; Groups H and I for fruit cross section. Additionally, the populations of Groups D, E, and G were also remarkable for size of fruit core, which is important for seed production.

In conclusion, it should be pointed out that the current study revealed considerable variation in multiple fruit characteristics of Turkish tomato populations. This genetic variation is an important of diversity which could be used in future breeding programs.

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