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Study of Genetic Variation and Association among Characters in Tomato Genotypes

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ABSTRACT: The study was conducted to determine the genetic diversity and correlation among the different traits in tomato germplasm. Ninety-seven landraces collected from Iğdır city (East Anatolian region) of Turkey and North-West of Iran, along with three commercial cultivars were studied during two years. Tomato genotypes showed genetic diversity in all the studied characters. Fruit shape of genotypes contained flattened, slightly flattened, rounded, cylindrical, cordate, ovate, obovate, pyriform and obcordate. In fruit color, red, dark red, orange, yellow and in fruit size, very small, small, intermediate and large were observed. Correlation analysis showed the genotypes with high yield, had large fruit, firm fruit, high blossom end rot and sun scald, small plant size, sparse foliage density, low seed amount/fruit size. Cluster analysis classified genotypes in six groups, so that genotypes with different vegetative and generative charactreristics were located separate groups.

Keywords: Genetic diversity, correlation analysis, morphological traits, *Solanum lycopersicum* L.

Domates Genotiplerinde Genetik Varyasyon ve Özellikler Arasındaki İlişkilerin İncelenmesi

ÖZET: Bu çalışma, Domates germplazmında genetik varyasyon ve özellikler arasında ilişkileri belirlemek amacıyla yapılmıştır. Çalışma kapsamında Iğdır ili (Doğu Anadolu Bölgesi, Türkiye) ve İran'ın kuzeybatısından toplanan 97 yerel genotip ve üç ticari çeşit iki yıl incelenmiştir. Denemede bulunan genotipler incelenen tüm özellikler bakımından farklılık göstermiştir. Meyve şekli açısından genotipler basık, hafif basık, yuvarlak, silindirik, kalp, yumurta, ters yumurta, armut ve ters kalp şeklinde olduğu gözlemlenmiştir. Meyve rengi açısından, kırmızı, turuncu, koyu kırmızı ve sarı, meyve büyüklüğü bakımından ise çok küçük, küçük, orta ve geniş gruplara ayrılmıştır. Korelasyon analizi sonucu olarak, verimi daha fazla olan genotiplerde, meyve büyüklüğü, meyve sertliği, çiçek burnu çürüklüğü, güneş yanıklığı yüksek, bitki boyu, yaprak yoğunluğu, tohum miktarı/ meyve büyüklüğü oranı düşük bulunmuştur. Küme analizinde genotipler 6 gruba ayrılmıştır. Farklı vejetatif ve generatif özelliklere sahip genotipler farklı gruplarda yer almıştır.

Anahtar kelimeler: Genetik çeşitlilik, korelasyon analizi, morfolojik özellikler**,** *Solanum lycopersicum* L

INTRODOCTION

Tomato is one of the most economically important vegetable crops in many parts of the world. Tomato has multipurpose uses in fresh as well as processed food industries and its production has increased in the world in recent decades. It is protective complementary food and dietary vegetable crop. Tomato is also a good source of polyphenolic compounds, such as flavonoids and hydroxycinnamic acids (Bugianesi *et al*., 2004).

Fruit quality has been a major objective of tomato breeding programs during recent decades. Main fruit quality characteristics of tomato include fruit size, shape, color, firmness, fruit homogeneity and flavor (Foolad, 2007). These characteristics have significant effects on fruit marketability.

Genetic variation assessment is one of the pre-requirements for successful breeding strategies of the crop plants. Heterogeneous landrace populations are important sources of genetic variation and are utilized in plant breeding programs (Terzopoulos and Bebeli, 2008). Tomato landraces have distinctive organoleptic traits (flavor and aroma) and nutritional value. Qualitative characteristics are the strongest determinants of the agronomic value and taxonomic classification of plants (Bernousi *et al*., 2011). The pattern of inheritance for qualitative characters is typically monogenetic, which means each character is only influenced by a single gene. The environment has very little influence on the phenotype of these characters and their heritability is high. Therefore selection based on these characteristics for plant population screening, improvement yield and fruit quality would be suitable (Yap *et al*., 1972). The degree of association among characters has always been a helpful tool for the selection of acceptable traits in a breeding program (Islam *et al.,* 2010).

The present study was undertaken to get the information on genetic diversity in landraces of tomato and determinate of correlations among desired traits in order to developing the superior gonotypes and improve tomato production.

MATERIAL AND METHODS

Ninety-seven tomato landraces in East Anatolian region of Turkey (Iğdır city) and North-West of Iran were collected in 2011. The characteristics such as size, form and color of fruit and plant size were used to identify and collect of different genotypes. At the time of collection, fruits were harvested from each genotype and then seeds were gathered. Each genotype was coded based on the name of collected site (Table 1). These genotypes and three commercial cultivars 'Peto Early CH', 'Rio Grande' and 'H-2274' were cultivated at the Kahriz Station of Agriculture and Natural Resources Research Center of West Azerbaijan (Iran) during two years (2012 and 2013) in an alpha lattice design. To assess the genetic diversity of tomato genotypes, numbers of morphological characters were studied based on UPOV descriptor. The studied characters consisted of: seedling size, plant size, foliage density, leaf type, green shoulder in immature fruit, fruit shape, fruit size, fruit size homogeneity, exterior color of mature fruit, shape of pistil scar in fruit, fruit cross-sectional shape, fruit firmness, ribbing at peduncle end of fruit, depression at peduncle end of fruit, shape at blossom end of fruit, amount of seed/fruit size, blossom end rot of fruit, fruit sunscald and fruit cracking. To record these traits, 10 plants were randomly selected from each plot. After elimination of marginal effects in plot, characters were recorded.

Frequency chart of morphological traits was drawn by using Excel program. Correlation analysis was performed to assess relationship among characters. For grouping genotype, cluster analysis was achieved using the method of Ward based on squared Euclidean distance. Correlation and cluster analysis were carried out by using statistic program SPSS version 20.

Table 1.Geographical origins and genotype codes of tomato landraces

No	Origin	Genotype code	No	Origin	Genotype code	No	Origin	Genotype code
1	Iran-Urmia	IR.U1	34	Iran-Piranshahr	IR.P2	67	Iran-Qaraziaediin	IR.Q5
2	Iran-Urmia	IR.U2	35	Iran-Piranshahr	IR.P3	68	Iran-Qaraziaediin	IR.Q6
3	Iran-Urmia	IR.U3	36	Iran-Piranshahr	IR.P4	69	Iran-Qaraziaediin	IR.Q7
4	Iran-Urmia	IR.U4	37	Iran-Piranshahr	IR.P5	70	Iran-Qaraziaediin	IR.Q8
5	Iran-Urmia	IR.U5	38	Iran-Piranshahr	IR.P6	71	Iran-Qaraziaediin	IR.Q9
6	Iran-Urmia	IR.U6	39	Iran-Piranshahr	IR.P7	72	Iran-Khoy	IR.KH1
7	Iran-Urmia	IR.U7	40	Iran-Piranshahr	IR.P8	73	Iran-Khoy	IR.KH2
8	Iran-Urmia	IR.U8	41	Iran-Piranshahr	IR.P9	74	Iran-Salmas	IR.SA1
9	Iran-Urmia	IR.U9	42	Iran-Piranshahr	IR.P10	75	Iran-Salmas	IR.SA2
10	Iran-Urmia	IR.U10	43	Iran-Naghadeh	IR.N1	76	Iran-Sardasht	IR.SR1
11	Iran-Urmia	IR.U11	44	Iran-Naghadeh	IR.N2	77	Iran-Sardasht	IR.SR2
12	Iran-Urmia	IR.U12	45	Iran-Miandoab	IR.MI1	78	Iran-Sardasht	IR.SR3
13	Iran-Urmia	IR.U13	46	Iran-Miandoab	IR.MI2	79	Iran-Sardasht	IR.SR4
14	Iran-Urmia	IR.U14	47	Iran-Miandoab	IR.MI3	80	Iran-Sardasht	IR.SR5
15	Iran-Urmia	IR.U15	48	Iran-Miandoab	IR.MI4	81	Iran-Sardasht	IR.SR6
16	Iran-Urmia	IR.U16	49	Iran-Miandoab	IR.MI5	82	Iran-Sardasht	IR.SR7
17	Iran-Urmia	IR.U17	50	Iran-Miandoab	IR.MI6	83	Iran-Sardasht	IR.SR8
18	Iran-Urmia	IR.U18	51	Iran-Miandoab	IR.MI7	84	Turkey-Iğdır	TR.I1
19	Iran-Urmia	IR.U19	52	Iran-Bokan	IR.B	85	Turkey- Iğdır	TR.I2
20	Iran-Urmia	IR.U20	53	Iran-Mahabad	IR.MA1	86	Turkey- Iğdır	TR.I3
21	Iran-Urmia	IR.U21	54	Iran-Mahabad	IR.MA2	87	Turkey- Iğdır	TR.I4
22	Iran-Urmia	IR.U22	55	Iran-Mahabad	IR.MA3	88	Turkey- Iğdır	TR.I5
23	Iran-Urmia	IR.U23	56	Iran-Mahabad	IR.MA4	89	Turkey- Iğdır	TR.I6
24	Iran-Urmia	IR.U24	57	Iran-Mahabad	IR.MA5	90	Turkey- Iğdır	TR.I7
25	Iran-Urmia	IR.U25	58	Iran-Mahabad	IR.MA6	91	Turkey- Iğdır	TR.I8
26	Iran-Urmia	IR.U26	59	Iran-Mahabad	IR.MA7	92	Turkey- Iğdır	TR.I9
27	Iran-Oshnavieh	IR.O1	60	Iran-Mahabad	IR.MA8	93	Turkey- Iğdır	TR.I10
28	Iran-Oshnavieh	IR.O2	61	Iran-Mahabad	IR.MA9	94	Turkey- Iğdır	TR.I11
29	Iran-Oshnavieh	IR.O3	62	Iran-Mahabad	IR.MA10	95	Turkey- Iğdır	TR.I12
30	Iran-Oshnavieh	IR.O4	63	Iran-Qaraziaediin	IR.Q1	96	Turkey- Iğdır	TR.I13
31	Iran-Oshnavieh	IR.O5	64	Iran-Qaraziaediin	IR.Q2	97	Turkey- Iğdır	TR.I14
32	Iran-Oshnavieh	IR.O6	65	Iran-Qaraziaediin	IR.Q3			
33	Iran-Piranshahr	IR.P1	66	Iran-Qaraziaediin	IR.Q4			

RESULTS AND DISCUSSION

Frequency of morphological traits

Tomato genotypes showed genetic diversity in all the studied characters. These genotypes according of studied traits were observed in different groups.

Seedling size

Genotypes based on the seedling size were divided into 4 groups (Figure 1.A). The most of genotypes (43%) had large seedling.

Plant size

Genotypes according to plant size were placed small, intermediate, large and very large groups

(Figure 1.B). Genotypes with large and very large size have long vegetative and reproductive growth period. These genotypes compared to genotypes with small size are late mature.

Foliage density

Genotypes were divided into 3 groups according to foliage density. 16% of foliage density was sparse, 66% intermediate and 18% dense (Figure 1.C). The genotypes with dense foliage had resistant to sunscald.

Leaf type

Three different leaf types were observed in genotypes. 87% of genotypes had standard leaf, 1% potato leaf and 12% cerasiform leaf (Figure 1.D).

Green shoulder in immature fruit

In 36% of the genotypes were viewed green shoulders (Figure 1.F). Green shoulder in fruit decreases apparent value and marketable of fruit.

Fruit shape

Based on the fruit shape, genotypes were placed into nine groups (Figure 1.E). These groups contained flattened, slightly flattened, rounded, cylindrical, cordate, ovate, obovate, pyriform and obcordate that the most of genotypes had slightly flattened fruit. In assessment of genetic diversity in 48 genotypes of Turkey, 25% of genotypes had flattened shape, 41.67% slightly flattened shape, %31.25 rounded shape and 2.83% cylindrical (Çukadar, 2011).

Fruit size

The results showed that 10% of genotypes had very small fruit, 16% small fruit, 50% intermediate fruit and 24% large fruit (Figure 1.G). Fruit size both fresh market and processing tomato is one of important characteritic of tomato (Foolad, 2007).

Fruit size homogeneity

The most of genotypes according to fruit size homogeneity were placed intermediate group (Figure 1.H). The genotypes with high fruit size homogeneity have high marketable value.

Exterior color of mature fruit

The colors of red, dark red, orange and yellow were observed in fruit of studied genotypes (Figure 1.I). Nowadays, breeders have obtained cultivars with fruit color of red, dark red, orange, yellow, white, black and purple. Fruit color is another quality characteristic in tomato that has received intensive attention (Foolad, 2007).

Shape of pistil scar in fruit

According to IPGRI (International Plant Genetic Resources Institute), tomatoes place in four groups of dot, stellate, linear and irregular (Figure 1.J). Studied genotypes in this research were divided into three groups: dot, stellate and irregular.

Fruit cross-sectional shape

Based on the fruit cross-sectional shape genotypes were situated into three groups (Figure 1.K). 45% of genotypes had round cross-sectional, 46% angular shape and 9% irregular shape.

Fruit firmness

Three different fruit firmness were viewed in genotypes. The most of genotypes (50%) had intermediate fruit firmness (Figure 1.L). The textural quality of tomatoes is influenced by flesh firmness, the ratio between pericarp and locular tissue, and skin toughness (Batu, 1998). In fresh market tomato, genotypes with soft firmness and processing tomato, genotypes with firm firmness have received intensive attention.

Ribbing at peduncle end of fruit

Tomato genotypes according to ribbing at peduncle end of fruit were placed in five groups of absent, weak, medium, strong and very strong. 47% genotypes have weak ribbing at peduncle end of fruit (Figure 1.M). In genotypes with very strong ribbing at peduncle end, fruit shape is not attractive and don't receive consumer attention.

Depression at peduncle end of fruit

Genotypes based on this character divided into four groups of absent, weak, medium and strong (Figure 1.N). With increase of depression at peduncle end, fruit separate from peduncle is difficulty and this isn't good particularly for processing tomato

Shape at blossom end of fruit

Based on the shape at blossom end of fruit genotypes were located in five groups of indented, indented to flat, flat, flat to pointed and pointed (Figure 1.O).

Amount of seed/Fruit size

Flavor of fresh tomato can be highly affected by amount of seed/fruit size. According to this trait, genotypes were separated three groups low, intermediate and high. This ratio in the most of studied genotypes (54%) in our research was high (Figure 1.R).

Blossom-end rot of fruit

Blossom-end rot of tomato is a physiological disorder that results when there is an inadequate supply of calcium available to the developing fruit. This disorder can result in direct losses in quality and yield on field and greenhouse-grown plant. Plum- or pear-shaped tomato cultivars have been found to be most susceptible. In 59% studied genotypes, this disorder was not observed (Figure 1.S).

Sunscald of fruit

Sunscald occurs when tomatoes are exposed to the direct rays of the sun during hot weather. It is more apparent on genotypes that have sparse foliage or plants that may have previously lost a good deal of leaves to a leaf-defoliating disease. According of this trait, studied genotypes were placed four groups (Figure 1.T).

Fruit cracking

Tomato cracking depends on the ability of the epidermis and its cells to stretch. Some cultivars have an epidermis that stretches well and will have very little or no cracking. The frequency of genotypes studied based on this trait was observed in figure 1.U.

Correlation among traits

Correlation analysis revealed genotypes with large seedling size, have high vegetative growth (Table 2). Plant size showed significant negative correlation with fruit size, fruit firmness, blossom end rot, fruit sunscald, yield and significant positive correlation with foliage density and ratio of amount seed/fruit size. A lot of studied genotypes in our research were cherry tomatoes. Cherry tomatoes have high vegetative growth, small fruit, soft fruit texture and low yield. Similar results were also reported by Agong *et al*., (2001). Foliage density had significant positive association with ratio of amount of seed/fruit size and significant negative correlation with fruit size, fruit firmness, blossom end rot, sunscald and yield. With increase in fruit size, ratio of amount of seed/fruit size and homogeneity of fruit size decreased and fruit firmness, ribbing at peduncle end of fruit, depression at peduncle end of fruit, fruit cracking and yield increased. Fruit size homogeneity displayed a significant negative correlation with ribbing at peduncle end of fruit, depression at peduncle end of fruit and fruit cracking. Also, correlation analysis demonstrated that genotypes with firm fruit firmness had less depression at peduncle end of fruit, ratio of amount of seed/fruit size, fruit cracking and more blossom end rot, yield than genotypes with soft fruit firmness. Ribbing at peduncle end of fruit showed significant positive correlation with depression at peduncle end of fruit, fruit cracking and negative correlation with blossom end rot. With increase in depression at peduncle end of fruit, blossom end rot decreased and fruit cracking increased. Blossom end rot showed significant negative correlation with fruit cracking and positive correlation with yield. With increase in sunscald, fruit cracking decreased and yield increased and this demonstrates that in genotypes with high yield, because of the increase in fruits number and fruit size compared to foliage density, fruit sunscald increases.

Cluster analysis

Based on the studied morphological characters, genotypes were placed into six groups (Figure 2). The first group (27 genotypes), had seedling size, plant size, foliage density, fruit cracking, ratio of amount of seed/fruit size less than and fruit firmness, sunscald more than other genotypes (Table 3). 38.5% from Urmia genotypes were located in this group. The genotypes with rather big fruits and high blossom end rot of fruit were observed in second group. In group III were viewed genotypes with high vegetative growth, the most of foliage density and the least of sunscald. The genotypes with the most of vegetative growth, fruit size homogeneity, ratio of amount of seed/fruit size and the least of fruit size, depression at peduncle end of fruit, ribbing at peduncle end of fruit was observed in group IV. All genotypes this group were cherry tomatoes and had soft fruit firmness. Group V contained 29 genotypes that had high vegetative growth and without blossom end rot. 42.9% from Iğdır genotypes were placed in this group. The genotypes with the most of seedling size, fruit size, depression at peduncle end of fruit, ribbing at peduncle end of fruit, fruit cracking and the least of fruit size homogeneity were viewed in group VI. Since genotypes with the same geographical origin clustered in different groups, it can be concluded that genotypes originating from the same region should be genetically distant. It could be possible to use genetically different genotypes with superior characteristics in tomato breeding programs aimed to quality improvement.

CONCLUSIONS

The results of the present work revealed high genetic variation for morphological traits in tomato landraces studied. A number of genotypes showed high values in view of the characters studied compared to the commercial cultivars. Since genotypes with the same geographical origin clustered in different groups, it can be concluded that genotypes originating from the same region should be genetically distant. It could be possible to use genetically different genotypes with superior characteristics in tomato breeding programs aimed to quality improvement.

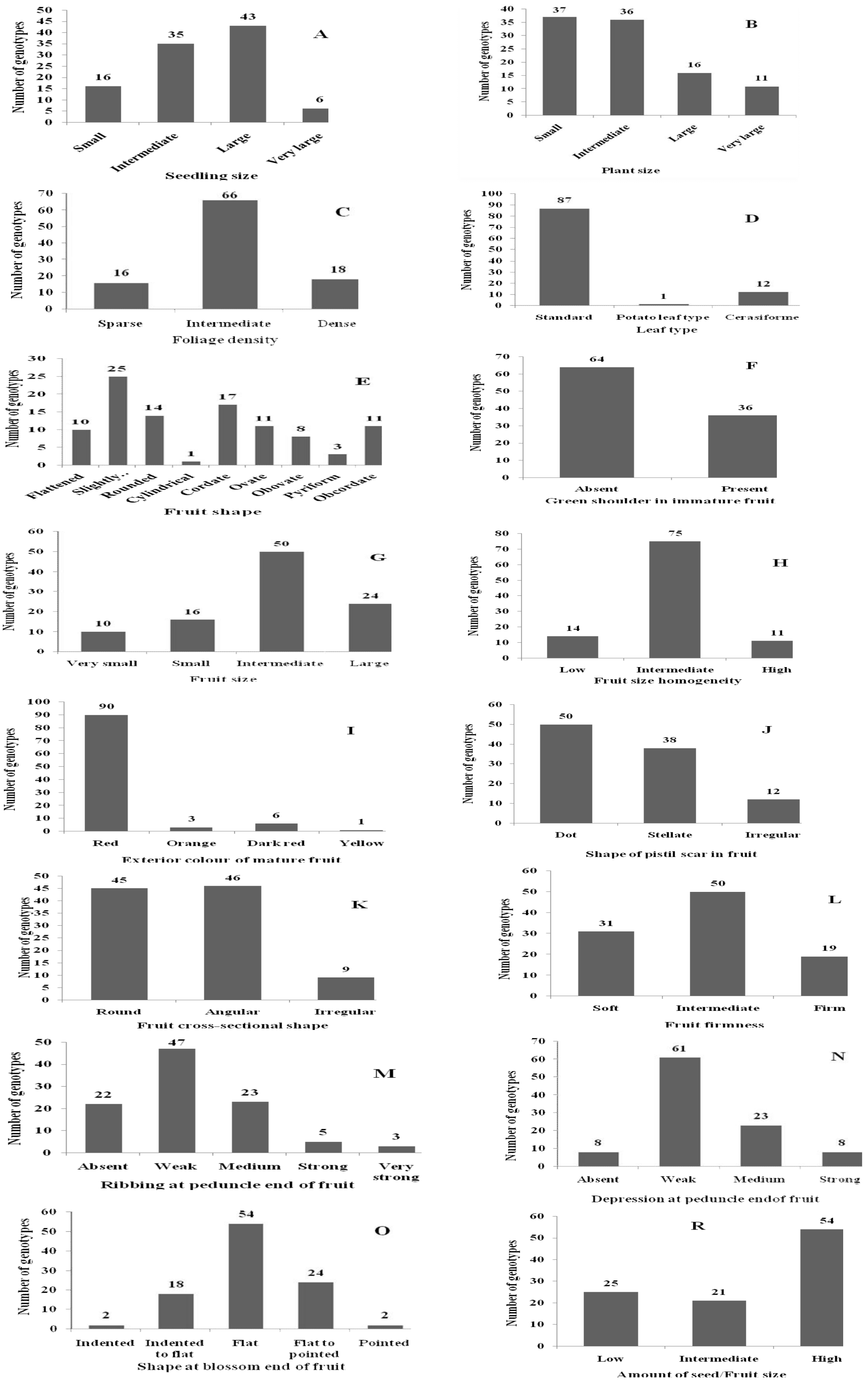

Figure 1. Frequency Chart of morphological traits in tomato genotypes studied

Figure 1, Continued

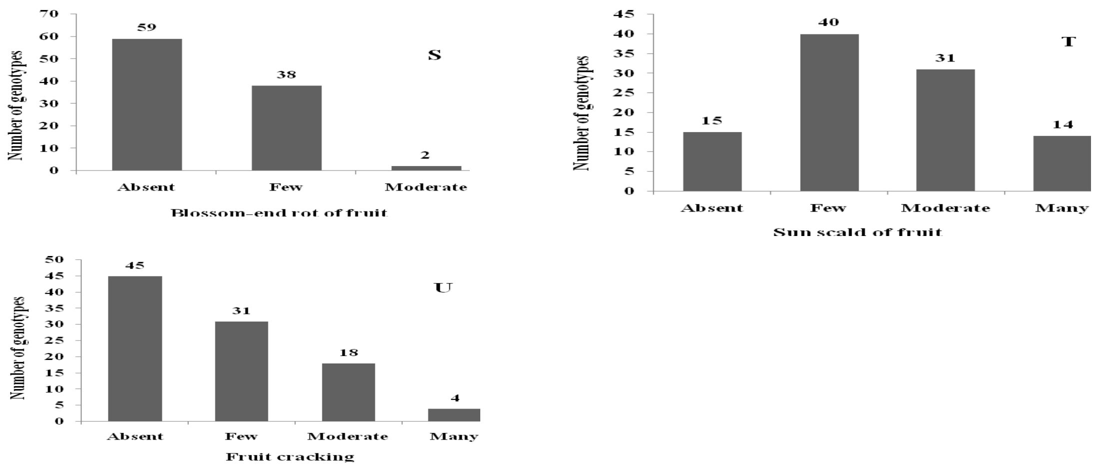

Table 2. Correlation coefficients between different morphological characters of tomato

	1	2	3	4	5	6	7	8	9	10	11	12
Seedling size (1)	1											
Plant size (2)	0.2^{*}	1										
Foliage density (3)	0.1	0.6^{**}	1									
Fruit size (4)	0.2^{*}	-0.4^{**}	-0.2^{*}	1								
Fruit homogeneity (5)	-0.3^{**}	0.1	0.1	-0.5^{**}	1							
Fruit firmness (6)	-0.2^{*}	-0.7^{**}	-0.5^{**}	0.3^{**}	0.04	1						
Fruit ribbing (7)	0.3^{**}	-0.1	-0.01	0.6^{**}	-0.6^{**}	-0.1	1					
Peduncle depression (8)	0.3^{**}	0.2	0.1	0.4^{**}	-0.5^{**}	-0.3^{**}	0.8^{**}	1				
Seed/Fruit size (9)	0.2^{*}	0.7^{**}	0.4^{**}	-0.5^{**}	0.1	-0.8^{**}	-0.1	0.1	1			
Blossom end rot (10)	-0.3^{**}	-0.6^{**}	-0.4^{**}	0.2	0.04	0.6^{**}	-0.3^{*}	-0.4^{**}	-0.6^{**}	1		
Fruit sun scald (11)	-0.2	-0.6^{**}	-0.7^{**}	0.2	-0.1	0.4^{**}	-0.1	-0.2	-0.4^{**}	0.5^{**}	1	
Fruit cracking (12)	0.3^{**}	0.3^{**}	0.2	0.4^{**}	-0.4^{**}	-0.4^{**}	0.6^{**}	0.6^{**}	0.1	-0.4^{**}	-0.3^{*}	1
Yield (13)	-0.2	-0.5^{**}	-0.2^{*}	0.5^{**}	-0.12	0.5^{**}	0.2	0.02	-0.5^{**}	0.4^{**}	0.3^{*}	0.01

Note: *,**significant at 5% and 1% probability level respectively

Table 3. Mean comparison of characters for each cluster

Traits	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Seedling size	4.33	6.50	6.09	5.29	6.45	7.14
Plant size	3.07	4.50	7.18	7.57	4.55	5.71
Foliage density	4.19	5.00	6.45	6.00	4.82	5.00
Fruit size	5.00	5.50	3.91	1.57	5.82	5.86
Fruit homogeneity	5.07	4.67	4.64	6.43	5.00	3.29
Fruit firmness	6.33	5.00	3.36	3.29	5.00	3.71
Fruit ribbing	2.85	2.83	3.36	1.14	4.00	6.29
Peduncle depressiton	2.78	3.00	4.27	2.29	3.91	6.14
Seed amount/Fruit size	3.37	4.83	6.09	7.00	4.82	5.29
Fruit blossem rot	3.07	3.17	1.00	1.00	1.09	1.00
Fruit sun scald	4.78	4.17	2.09	2.57	3.36	3.43
Fruit cracking	1.44	1.83	3.00	1.71	3.18	4.43

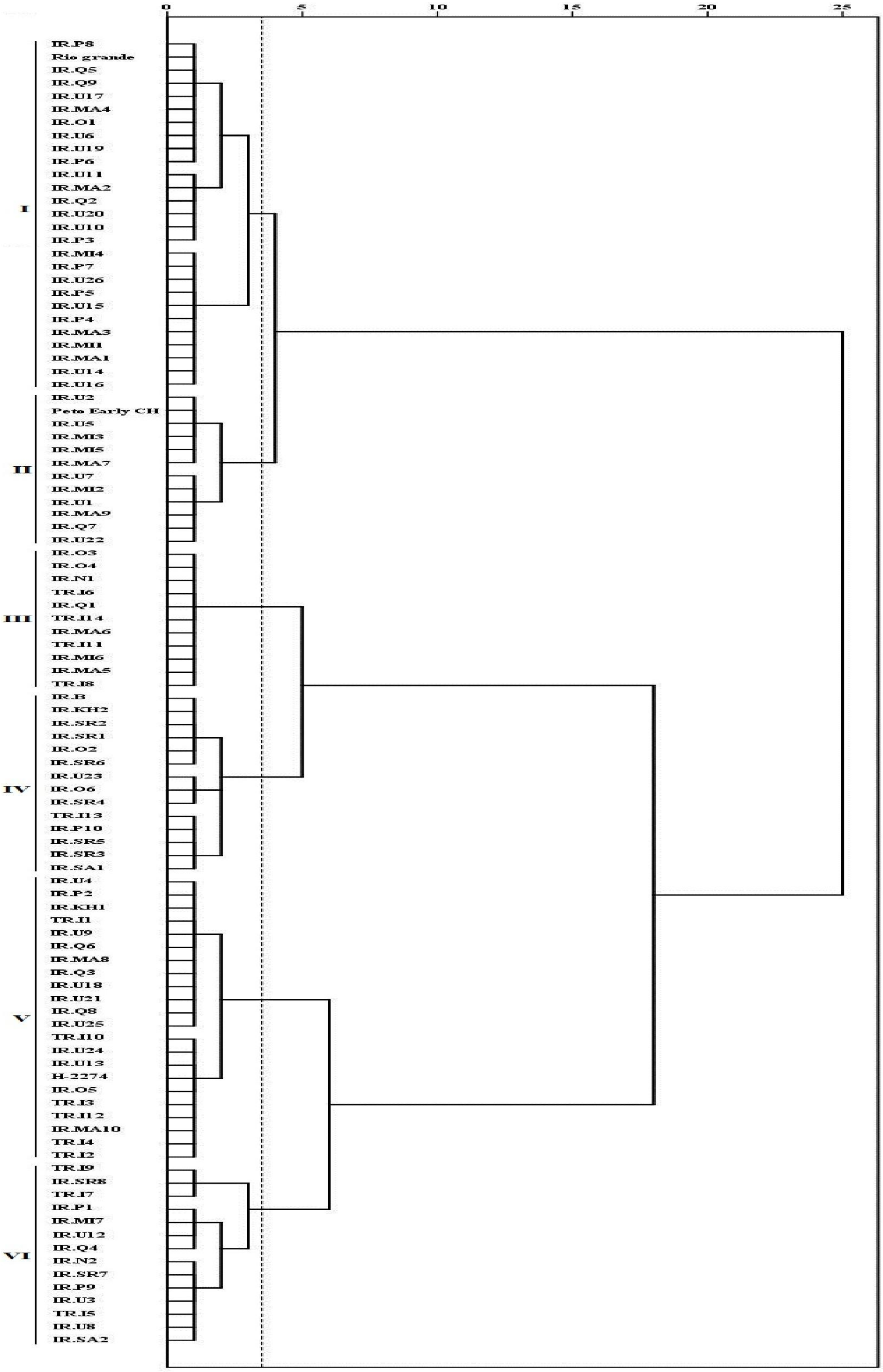

Figure 2. Dendrogram of tomato landraces and control cultivar constructed morphological characters

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