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Determination of Superior Turkish Eggplant (*Solanum melongena* L.) Genotypes by Pedigree Selection Method

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ABSTRACT

Eggplant (*Solanum melongena* L.), belonging to the *Solanaceae* family, is widely grown in Turkey. It is also one of the important vegetable species in Turkey. Additionally, Turkey has valuable eggplant populations. This study was conducted to select valuable local eggplant genetic resources under the ecological conditions of Samsun province in 2016. In this study, 75 eggplant genotypes were detailed from different eco-geographical regions of Turkey. The weighted ranking method was also used to select superior eggplant genotypes with pedigree selection. It was determined that the total weighted ranking scores of eggplant genotypes studied was in the range of 290-475 point. According to the total weighted ranked scores, 20 promising eggplant genotypes with a score of 420 and above were determined for use in the variety breeding program. At the end of this research, the genotypes G30, G43, G49, G51 and G55 were determined to be superior for further breeding studies.

Keywords: *Solanum melongena*, genetic resources, selection, Turkey

Introduction

The genus *Solanum* shows a wide and rich genotypic variation with more than 1000 species (Fukuoka et al. 2010). The origins of eggplant (*Solanum melongena* L.) in the genus *Solanum* has been reported in the literature as India, Burma, and China (Küçük 2003; Daunay et al. 2001; Tümbilen, 2007). It was brought to the Mediterranean basin and then to Spain first by the Arabs. It was later spread by the Turkish people all over Europe through the Balkan countries (Cakir et al. 2017). It has been reported that eggplants first reached Anatolia in the late 16th and early 17th centuries (Kalloo, 1993; Vural et al. 2000).

Eggplant is an important vegetable crop in Turkey cultivated as a summer vegetable in the open field, while grown in the greenhouses in the winter and spring season. China (32,001,667 tons) and India (12,552,000 tons) are the leading eggplant producers in the World. Turkey is in the fourth place in production in the World with 854,049 tons (FAO, 2016). It is grown in almost every region in Turkey. The regions with the highest eggplant production in Turkey include the Mediterranean Region (406,675 tons), the Southeast Anatolia Region (101,527 tons) and the Aegean Region (98,151 tons) (TUİK, 2016).

Plant genetic resources have an important values and importance in terms of variety breeding studies since they contain the determined cultural plants and their wild relatives (Engels et al. 1995). In addition, local genetic resources, due to their adaptability to different ecologies, their resistance to diseases and pests, and the demanded quality attributes they possess, they are unique sources of breeding activities. Plant breeders have achieved significant success in recent years to select or develop varieties with the desired traits in terms of adaptation, yield, quality, resistance to diseases and pests by utilizing the existing genetic diversity in Turkey. The detailed studies on the collection of local eggplant genetic resources, identification of plant characteristics are fewer compared to other Solanaceae species in Turkey (Çakır, 2018). This show the fact that eggplant breeding studies should be increased.

Turkey has very high phenotypic diversity and genotypic variability in many vegetable species such as eggplant of which it is not their gene centre (Karaağaç and Balkaya, 2017). Morphological variations are of great importance in variety breeding studies. Because, it is very important to know the existing variations in the cultivated species for plant breeding programs (Bliss, 1981).

Selection is the most important factor that changes the structure of a population. Selection reduces or increased some genotypes since it changes the gene frequency in a population. The effect of selection on measurable traits is examined by considering some quantitative parameters (Balkaya et al. 2011). Phenotypic diversity in eggplant populations is very high. The variations are mostly determined by fruit shape, fruit colour, fruit bitterness, fruit flesh thickness, fruit flesh colour, fruit size, prickliness, the number of seeds (Frary et al. 2005; Çakır, 2018).

Local eggplant genetic resources have been collected by many researchers from different geographic regions of Turkey (Filiz and Özçalabı, 1992; Pirinç, 1999; Tümbilen, 2007; Boyacı et al. 2010; Topcu, 2014). However, few studies had been conducted to determine the genotypes suitable for fresh consumption by selection breeding. Kaplan and Koludar (1986) were selected seven eggplant genotypes from local Şeyhkent eggplant population in Diyarbakır province. In another study, Surtepe 1, Surtepe 2, Mezra 5 and Keskince 3 namely eggplant genotypes were selected as suitable eggplant local varieties for fresh consumption from local Şanlıurfa eggplant populations (Pirinç, 1999). In the other selection study conducted on eggplant populations collected from Diyarbakır province, three eggplant genotypes were determined. Among these, the genotype Şeyhkent-3 was reported as eggplant genotype with the highest weighted ranking score (725 point) (Pirinç and Pakyürek, 2004). Boyacı et al. (2010) found that the average fruit weight of the local genotypes, grown with the name of 'Göl Patlıcanı' in Burdur province and it had different types, ranged from 110.3 g to 199.6 g.

The present study comprises the first start-up phase of the eggplant breeding studies for new developing varieties. Accordingly, the aim of this study was to determine the promising eggplant genotypes suitable for fresh consumption in eggplant populations collected from different regions in Turkey by pedigree selection method.

Materials and Methods

Materials: This study used a total of seventy five eggplant seeds collected from different regions of Turkey (Table 1). Forty accessions of the *S. melongena* populations were obtained from the USDA-ARS National Germplasm Bank, twenty accessions of the *S. melongena* populations were provided from the Turkish National Seed Gene Bank (AARI) and fifteen accessions of the *S. melongena* populations were collected by Prof. Dr. Ahmet Balkaya, of the Horticulture Department of the Faculty of Agriculture of Ondokuz Mayıs University (Table 1). The genetic material consisted of landraces and local populations maintained by farmers for generations.

Growth conditions: The field component of this study was carried out in the Samsun province in 2016. The seeds of all populations were sown into plug trays containing peat and perlite (in the ratio 3:1) on April 16, 2016. After the field in which the trial was established was plowed, in the field, cultivation places were prepared. The cultivation places were mulched with mulch; drip irrigation system was set and made ready for seedling planting. Soil tests were carried out before planting. The soil of the experimental area was sandy loam with pH 6.5. Fifteen seedlings from each eggplant genotype was planted at the 4 to 5 true leaf stage at a spacing of 50x50 cm on May 20, 2016. Standard fertilization and weed control practices were applied.

Determination of eggplant genotypes suitable by pedigree selection method: The aim was to determine the eggplant genotypes suitable for fresh consumption with long-cylindrical smooth fruits with black or dark purple color and with little or no seeds in the selection breeding. Accordingly, pedigree selection method was used in variety breeding. The fruit and yield characteristics data were evaluated by the modified weighted ranked (WR) method (Çakır, 2018).

The WR method is a tool commonly used in statistical analyses. This method is known as "Tartılı derecelendirme" in Turkish and almost exclusively used in the studies with multivariate data generated in horticultural research (Balkaya and Yanmaz, 2005; Balkaya and Ergün, 2008). Class values of selection criteria, Class Scores (CS) and Relative Scores (RS) were assigned (Table 2). The total points of types were calculated by summing Class Scores (CS) and multiplied by Relative Scores (RS). Accordingly, genotypes that were above the average score were selected as the promising eggplant genotypes. Otherwise, eggplant genotypes were also classified according to the characteristics examined, and accordingly, the distribution frequencies of genotypes were shown in this study.

Results and Discussion

All local eggplant genotypes were evaluated according to the weighted ranking method. The results of the weighted rankings are given in Table 3. Examining Table 3, local eggplant genotypes were found to have a total score in the range of 290-475 points. Among all the genotypes, the genotype G51 (475 points) determined the highest score. This was followed by G30 (470 points), G43 (470 points), G55 (470 points) and G49 (465 points) genotypes. It was determined that the majority of the eggplant genotypes that received high scores had the highest scores in terms of all the characteristics of the selection. As a result of the evaluations, the lowest value as found in the G25 genotype with 290 points. According to the results of weighted rankings, it was found that 37 eggplant genotypes had a total score of Promising genotypes which found a score between 420 and 475 were selected for the second-year study.

In terms of average fruit length, it was found that 63 of the local eggplant genotypes had long, 8 genotype had medium-sized, and 4 genotype (G42, G62, G65, G60) had very long fruits (Table 3). According to the demands of consumers and producers, long eggplant fruits are preferred for fresh consumption in Turkey. In this study, in terms of frequency distribution, 84% of the local eggplant genotypes had long fruits which is important in terms of the selection of many eggplant genotypes suitable for fresh consumption. In another study carried out by Topçu (2014), of the 100 eggplant genotypes collected from different regions of Turkey, 32 had long fruit sized while 31 had medium-sized, 15 had short, 4 had oval, 8 had pear-like and 10 had round fruit shapes. The research results were shown similar with this literature.

The fruit diameters of the majority of eggplant genotypes varied between 50 mm and 100 mm. In terms of fruit diameter values, 65.3% of genotypes were found to be medium-sized and 26.7% were large sized (Table 3). In terms of fruit colours, the eggplants were divided into different groups as purple (20 genotypes), reddish (10 genotypes), black (16 genotypes), green (13 genotypes) and light purple/lilac (16 genotypes) (Table 3). Filiz and Özçalabı (1992) were mentioned that on the phonological, morphological and pomological characteristics of some local eggplant varieties in Turkey, fruit skin colour ranged from green and yellow to dark purple and black. These results showed that the eggplant gene pool is heterogeneous and the level of variation is high in terms of fruit shape and fruit colours.

The sepal size in eggplant fruits is a very important criterion in terms of storing ability (Çetinkaya et al. 2009). In terms of the sepal size, 32 of the eggplant genotypes were found to be medium-sized, 38 genotypes were small-sized and 5 genotypes (G5, G14, G15, G29, G50) were very small-sized (Table 3). In sepals, prickliness was either absent or almost absent in 51 eggplant genotypes. The selected genotypes G35, G43, G51, G52, G55 and G56 had no prickliness in their sepals. This trait is a desired trait for the development of new eggplant varieties by the breeders.

It was determined that there were great differences between the eggplant genotypes in terms of yield components. In addition to the role of multi-gene inheritance in yield, this explains the fact that the types are quite different from each other. Comparing the eggplant genotypes, it was determined that four genotypes (G18, G23, G27, G44) had average fruit weights less than 150 g. However, it was found that there were 59 genotypes with fruit weights in the range of 150-300 g and 12 genotypes with fruit weights higher than 300 g (Table 3). It was determined that difference between the lowest and the highest yield values were approximately two-fold. High yield are more preferred in eggplant cultivation. Of the selected eggplant genotypes, 53.3% had low yield per plant values, 38.6% had moderate yield per plant values and 8.1% had very high yield per plant values. The majority of the selected genotypes were found to be superior in terms of yield components. The other remain genotypes are considered to be evaluated in the other breeding studies. As a result, G30, G43, G49, G51 and G55 genotypes were found to have higher yield values than other genotypes (Table 4). These superior genotypes are planned to be re-evaluated in terms of yield components in different environmental conditions.

Conclusion

In this study, pedigree selection method was carried out in the eggplant population collected from different locations in Turkey. The evaluations were made according to the weighted ranking method. It was determined that the eggplant genotypes have a total score between 290 and 475 point. According to the selection scores, a total of 20 eggplant genotypes with a score of 420 point and above were selected for using in the eggplant variety breeding program. At the end of this study, G30, G43, G49, G51 and G55 determined as superior genotypes. It will be possible to evaluate the different frequency distributions of the fruit characteristics of the eggplant genotypes collected from different locations in Turkey according to their breeding purposes. In the future, these studies are planned to continue to obtain new hybrid eggplant varieties in Turkey. In addition, this study provides a general overview of the status of present in morphological variation at gene pools. Thus, detailed information on the morphological variability between local eggplant genotypes was obtained.

Table 1. Code, accession number and collected sites of *Solanum melongena* in Turkey.

Code	Accession Number	Collected Sites	Code	Accession Number	Collected Sites
G1	PI 166994 01	Hatay/USDA	G39	PI 204630 01	Kayseri
G2	PI 167381 01	Adana/USDA	G40	PI 204731 01	Kayseri
G3	PI 169642 01	Aydın/USDA	G41	TR 61766	Muğla
G4	PI 169644 01	Muğla	G42	TR 55995	Trabzon
G5	PI 169649 01	İzmir	G43	TR 70757	Samsun
G6	PI 169658 01	Kırklareli	G44	TR 70758	Samsun
G7	PI 169667 01	Kocaeli	G45	TR 70756	Amasya
G8	PI 171850 01	Kastamonu	G46	TR 69835	Çorum
G9	PI 171851 01	Samsun	G47	TR 70768	Kastamonu
G10	PI 171853 01	Tokat	G48	TR 70767	Kastamonu
G11	PI 173104 01	Artvin	G49	TR 70766	Sinop
G12	PI 173106 01	Ağrı	G50	TR 68531	Bartın
G13	PI 173111 01	Kahramanmaraş	G51	TR 68532	Bartın
G14	PI 174359 01	Van	G52	TR 68528	Zonguldak
G15	PI 174360 01	Diyarbakır	G53	TR 55678	Giresun
G16	PI 174362 01	Mardin	G54	TR 77307	Edirne
G17	PI 174369 01	Gaziantep	G55	TR 69211	Antalya
G18	PI 174371 01	Gaziantep	G56	TR 75349	Artvin
G19	PI 174373 01	Malatya	G57	TR 70764	Sinop
G20	PI 174374 01	Elazığ	G58	TR 70765	Sinop
G21	PI 175909 01	Balıkesir	G59	TR 75345	Artvin
G22	PI 175913 01	Çorum	G60	TR 70759	Samsun
G23	PI 175914 01	Yozgat	G61	OMU-ZF/BAH	Aydın
G24	PI 175916 01	Kayseri	G62	OMU-ZF/BAH	Aydın
G25	PI 176758 01	Niğde	G63	OMU-ZF/BAH	Manisa, Salihli
G26	PI 176760 01	Konya	G64	OMU-ZF/BAH	Aydın, İncirliova
G27	PI 176761 01	Konya	G65	OMU-ZF/BAH	Aydın
G28	PI 176762 01	Bilecik	G66	OMU-ZF/BAH	Kemer
G29	PI 176763 01	Eskişehir	G67	OMU-ZF/BAH	İzmir, Bayındır
G30	PI 177073 01	Çanakkale	G68	OMU-ZF/BAH	Aydın
G31	PI 177074 01	Kayseri	G69	OMU-ZF/BAH	Diyarbakır
G32	PI 177076 01	Konya	G70	OMU-ZF/BAH	Hatay,Samandağ
G33	PI 179045 01	Tekirdağ	G71	OMU-ZF/BAH	Aydın, Nazilli
G34	PI 179496 01	Bursa	G72	OMU-ZF/BAH	Şanlıurfa, Birecik
G35	PI 179498 01	İstanbul	G73	OMU-ZF/BAH	Mersin, Mut
G36	PI 182299 01	Muş	G74	OMU-ZF/BAH	Bursa
G37	PI 182300 01	Kahramanmaraş	G75	OMU-ZF/BAH	Mersin, Mut
G38	PI 183718 01	Kahramanmaraş	-	-	-

Table 2. Weighted Ranking criteria examined in pedigree selection of eggplant genotypes.

Selection Criteria	Classes	Class Score (CS)	Relative Score (RS)
Fruit length (cm)	very short (<10 cm)	1	10
	short (11-15 cm)	2	
	intermediate (16-20 cm)	4	
	long (21-25 cm)	5	
	very long (>26 cm)	3	
Fruit diameter (mm)	very small (<10 mm)	1	10
	small (11-30 mm)	2	
	intermediate (31-50 mm)	5	
	large (51-100 mm)	3	
	very large (>100 mm)	2	
Fruit colour	white	1	5
	black	3	
	purple	5	
	reddish	3	
	light purple/lilac	4	
	green	1	
Fruit colour homogeneity	homogeneous	5	5
	mottled	3	
	striped	2	
Fruit colour tones	light	1	5
	intermediate	3	
	dark	5	
Size of the calyx	very small	1	5
	small	3	
	İntermediate	5	
	large	2	
	very large	2	
Maturing period (day)	early (<60)	4	10
	mid-season (60-75)	5	
	late season (>75)	2	
Seed number per fruit (unit)	No seed	1	10
	Little	5	
	More	3	
Prickliness	None	5	5
	Weak	4	
	Intermediate	3	
	Powerful	2	
	Very powerful	1	
Average fruit weight (g/plant)	<150 g	2	15
	150-300 g	5	
	>300 g	4	
Total yield per plant (g/plant)	Little<480	2	20
	Intermediate 480-945	5	
	Much>945	4	

Table 3. Frequency distribution of the fruit characteristics examined in the eggplant genotypes.

Traits	Class ranges	Frequency ratio (%)
Fruit length (cm)	intermediate long very long	10.7 84.0 5.3
Fruit diameter (mm)	small intermediate big	8.0 65.3 26.7
Fruit colour	purple reddish black light purple/lilac green	26.7 13.3 21.3 21.3 17.4
Fruit colour homogeneity	homogeneous mottled striped	64.0 34.7 1.3
Fruit colour tones	dark intermediate light	52.0 26.7 21.3
Size of the calyx	very small small intermediate	6.7 50.7 42.6
Maturing period (day)	early mid-season late season	26.7 42.7 30.6
Seed number per fruit (unit)	little more	20.0 80.0
Prickliness	none or less little intermediate powerful	68.0 21.3 6.7 4.0
Average fruit weight (g/plant)	<150 g 150-300 g >300 g	5.3 78.7 16.0
Total yield per plant (g/plant)	little intermediate much	53.3 38.7 8.0

Table 4. The total score of eggplant genotypes with relative scores x class scores for each trait.

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G1	50	30	15	25	25	25	20	30	25	60	40	345
G2	50	30	5	15	15	25	20	30	25	60	80	355
G3	50	50	15	15	15	25	50	30	25	60	80	415
G4	50	50	15	25	25	25	40	30	25	75	80	440
G5	50	30	15	25	25	5	40	50	25	60	100	415
G6	50	40	15	25	25	20	30	40	20	75	80	415
G7	50	50	20	15	15	25	50	30	20	75	80	430
G8	50	50	25	25	25	25	40	30	20	75	80	445
G9	50	50	15	25	15	15	40	30	15	75	40	370
G10	50	50	20	15	15	15	50	30	25	75	40	385
G11	50	50	5	15	15	15	20	30	25	75	40	340
G12	50	50	5	15	5	15	50	30	25	75	80	400
G13	50	30	25	25	25	15	50	30	15	60	80	405
G14	50	50	15	15	25	5	20	30	25	75	40	350
G15	50	50	25	25	25	5	20	30	25	75	40	370
G16	50	30	5	25	15	15	50	30	25	75	80	400
G17	50	50	20	15	5	15	20	30	25	75	40	345
G18	40	50	20	25	5	15	50	30	10	30	40	315
G19	50	30	25	25	25	15	20	50	20	75	40	375
G20	50	50	15	25	25	15	50	30	25	75	40	400
G21	50	50	20	25	15	15	50	30	25	75	80	435
G22	50	50	20	25	5	15	20	30	25	75	40	355
G23	50	50	5	15	15	15	20	30	20	30	40	290
G24	50	50	15	25	15	25	20	30	20	75	40	365
G25	40	50	20	25	5	15	50	30	20	75	40	370
G26	40	50	25	25	25	25	50	30	10	75	60	415
G27	40	50	5	15	5	15	50	30	25	30	40	305

Continuing table 4

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G28	50	50	5	15	5	15	50	30	25	75	80	400
G29	50	30	5	15	25	5	40	30	25	75	80	380
G30	50	50	25	25	25	25	40	30	25	75	100	470
G31	40	30	5	15	5	15	40	30	25	75	80	360
G32	50	50	20	15	15	15	50	30	10	75	80	410
G33	50	30	15	25	25	15	50	30	20	75	40	375
G34	50	30	15	25	15	25	20	50	25	75	40	370
G35	50	30	25	25	25	15	40	30	25	60	100	425
G36	50	50	20	25	25	15	50	30	25	75	80	445
G37	50	30	5	25	5	15	50	30	15	75	80	380
G38	40	30	20	10	5	15	20	30	25	75	40	410
G39	50	30	25	15	25	15	50	30	20	60	80	400
G40	40	50	15	15	25	10	50	30	25	75	80	415
G41	50	20	15	15	15	25	50	30	25	75	40	360
G42	30	50	25	25	25	15	50	30	25	75	40	390
G43	50	50	25	25	25	25	40	50	25	75	80	470
G44	50	20	5	15	5	15	50	50	25	30	40	305
G45	50	50	20	25	15	15	50	30	25	75	40	395
G46	50	30	15	25	25	15	20	30	25	60	40	335
G47	50	50	20	15	15	15	50	30	25	75	40	385
G48	50	50	20	25	15	25	40	30	15	75	80	425
G49	50	50	25	25	25	25	40	30	20	75	100	465
G50	50	50	5	15	5	5	50	30	20	75	40	345
G51	50	50	25	25	25	25	50	30	20	75	100	475

Continuing table 4

Genotype	A	B	C	D	E	F	G	H	I	J	K	Total
G52	50	50	20	15	5	15	40	30	25	75	100	425
G53	50	20	20	15	5	15	50	30	25	75	40	345
G54	50	50	20	10	15	25	40	30	20	75	80	415
G55	50	50	25	25	25	25	40	50	25	75	80	470
G56	50	50	25	25	25	25	40	30	25	75	80	450
G57	50	50	15	25	25	25	50	50	25	75	40	430
G58	50	50	25	25	25	25	50	30	25	75	40	420
G59	50	50	25	25	25	25	50	30	25	75	40	420
G60	50	50	25	25	25	25	40	50	25	75	40	430
G61	40	30	20	15	15	15	20	50	20	60	80	365
G62	30	20	25	25	25	25	50	30	25	75	40	370
G63	50	50	5	15	5	25	20	50	20	75	40	355
G64	50	50	25	25	25	25	50	50	25	75	40	440
G65	30	20	25	25	25	25	20	30	25	75	40	340
G66	50	50	15	25	25	15	40	30	20	75	80	425
G67	40	30	25	25	25	15	50	30	15	75	80	410
G68	50	30	15	15	15	15	20	50	25	60	40	335
G69	30	20	15	25	25	25	20	50	25	75	40	350
G70	50	50	15	25	25	15	20	30	25	75	40	370
G71	50	50	15	25	25	25	20	50	25	75	40	405
G72	50	30	15	25	25	25	20	30	25	60	80	385
G73	50	30	15	25	25	15	50	30	25	60	80	405
G74	50	50	15	15	5	15	20	30	25	75	40	340
G75	50	50	15	15	15	25	20	30	20	75	40	355

***A:** The average fruit length (cm), ***B:** The average fruit diameter (mm), ***C:** Fruit colour, ***D:** Fruit color homogeneity, ***E:** Fruit color tones, ***F:** Sepal size, ***G:** Ripening period, ***H:** Number of seeds in fruit, ***I:** Prickliness, ***J:** Average fruit weight (g/plant), ***K:** Total yield per plant (g/plant)

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