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Evaluation and Selection of Suitable Red Pepper (*Capsicum annuum* var. *conoides* Mill.) Types in Turkey

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Abstract: This study was conducted in order to select valuable genetic resources of red conic pepper (*Capsicum annuum* var. *conoides* Mill.) in Bafra plain situated on Black Sea Region of Turkey during 2003 and 2005. Fifty six red pepper populations were collected from different eco-geographical areas in the research region. All native red pepper genotypes were examined with respect to morphological characteristics. Ranking method was used for selecting superior types. The results of ranking method revealed twenty two superior types. Research results also showed that all populations had 11.2-19.2 cm fruit length, 4.8-7.2 cm fruit width and 4.3-5.8 mm for flesh thickness. Fruit colours of selected types were in red and dark red tones. In the majority of populations harvest time occurred at 105 days. On the other hand, the genotypes exhibited a range of 653.9-1415.5 g for the total fruit weight plants⁻¹, 7.2-13.5 for the fruit number plant⁻¹, 53.0-155.0 mg/100 g for ascorbic acid, 5.2-8.0% for total soluble solids and 8.0-11.9% for total dry weight. At the end of this study, 12 types were selected as being promising for further breeding efforts.

Key words: *Capsicum annuum* var. *conoides*, genetic resources, selection, breeding, Turkey

INTRODUCTION

The genus *Capsicum* originated in the American tropics. Five species of *Capsicum* were cultivated in different parts of the World. *Capsicum annuum* was domesticated in highland of Mexico (Bosland, 1996; Pickersgill, 1997). Portuguese ships carried peppers from Spain to Arabia and from there it spread to all the conquered areas by the Ottoman Turks (Zatyko, 2006). Since, their introduction into the old world, peppers have been cultivated in various environments and different pepper types have also been developed (Zewdie and Zeven, 1997).

Turkey is one of significant and unique country in the world from plant genetic resources and plant diversity (Balkaya and Karaagac, 2005). Turkey is a micro-gene centre for many landraces including Solanaceae (Küçük, 2001). Therefore, these landraces are still grown by farmers in almost all regions. Turkey's total pepper production was 1.759.224 Mt and was ranked 3rd in the world. Peppers have a special role in Turkish cuisine and are consumed either fresh, processed or dried. Pepper are commonly grown in Black Sea Region of Turkey and Samsun is a producer province in this area. Red conic sweet pepper has a big share in production with 46.693 Mt (Anonymous, 2006). Traditional and native pepper

varieties are grown in small plots and growers produce their own seed (Abak, 1994). Recently, new cultivars have become common after introducing different cultivars which are suitable to consume fresh.

Up to now, cultivar selection studies have been conducted on pepper populations in Turkey. The first selection studies on pepper germplasm were initiated at the beginning of the 1980's in different regions of Turkey. From those studies promising selections have been described with regard to several fruit characteristics (Alan, 1984; Surmeli and Gursoy, 1985; Surmeli and Gungor, 1988; Inan, 1988; Akinci and Ersin, 2004). Results of these studies were summarized as follows:

Yaglik Pepper populations (*Capsicum annuum* var. *conoides* Mill.) were collected from Bursa region in 1978. Morphological and pomological characteristics, yield and technological characteristic were assessed during the selection. At the end of the study Yaglik-28 variety was registered (Surmeli and Gursoy, 1985). Now this variety has been used in pepper variety commonly used for fresh or processed. In another study, open pollinated Yalova Çorbacı 12, a bell pepper type, is a open pollinated cultivar developed from the population of Çorbacı peppers between 1982 and 1987. Morphological and pomological characteristics and yield were assessed during selection. Line 12 was selected for the highest

yield and the best characteristics. The standard variety of the Çorbacı population was named and registered as Yalova Çorbacı 12. The weight of the fruit is 18-22 g, the skin color is yellowish-light green and the fruit sweet to the taste (Surmeli and Gungor, 1988). Turkey is an important producer of spice peppers, especially in the south and South-East regions. One hundred and fifteen red hot pepper accessions for spice production, originally collected from the Kahramanmaraş region of Turkey, were evaluated for quantitative and qualitative characters. Eleven types were selected for its use in breeding (Akinci and Ersin, 2004).

On the contrary to other regions, there has been no comprehensive programs for collecting or characterizing red conic pepper genetic resources in the Black Sea region (North of Turkey) and no reported study evaluating them (Yanmaz, 2002). So, the aim of this research was to select the most promising red conic pepper genotypes for breeding efforts.

MATERIALS AND METHODS

Fifty six red pepper (*Capsicum annuum* var. *conooides* Mill.) populations were collected during August and October 2003 from Bafra plain, Black Sea Region, Turkey. Collected seeds were maintained in cold storage at 4°C at Faculty of Agriculture, Ondokuz Mayıs University up to sowing time.

The evaluations were carried out in the province of Samsun at the Black Sea Agricultural Research Institute. The seeds of red conic pepper populations were sown into plug trays (5.5 cm width and 5.5 cm depth) respectively, March 30th 2004 and April 4th 2005. Peat and perlite at 3:1 rate, respectively were used as the growing medium. The seedlings were transplanted to open field May 10th 2004 and May 18th 2005 with spacings of 80 and 40 cm between rows. Fertilization and weed control was done regularly during the growing period. Fruits were harvested when they reached the fully mature red stages. Every genotype was harvested at a time specific to the cultivar. Harvesting started at the end of August and lasted to the end of October each year. The selected characters were described by adapting the IPGRI *Capsicum* sp. descriptors list (Anonymous, 1995) to the characteristics of the genetic material and previous field observations. Fruit characteristic analyses were carried out on 5 fruits harvested from each of 96 plants for each genotype. Studied fruit characters included fruit length, fruit width, fruit shape of longitudinal section, flesh thickness, fruit color in maturity. Earliness and yield characteristics were also measured. The fruit number per plant and total fruit weight per plant values were

Table 1: Scores given to characteristics based on evaluation

Characteristics	Class value	Class Scores (CS)	Relative Scores (RS)
Fruit length (cm)	Long (19.2-15.9)	5	10
	Medium (15.8-12.5)	3	
	Short (12.4-9.1)	1	
Fruit width (cm)	Broad (7.2-6.3)	5	10
	Medium (6.2-5.5)	3	
	Narrow (5.4-4.6)	2	
Fruit number/plant	Many (16.1-12.3)	5	10
	Medium (12.3-8.5)	3	
	Few (8.4-4.7)	1	
Average fruit weight (g)	Heavy (124.1-104.6)	5	15
	Medium (104.5-85.1)	3	
	Light (85.0-65.5)	1	
Flesh thickness (mm)	Thick (5.8-5.0)	5	20
	Medium (4.9-4.2)	3	
	Thin (4.1-3.3)	1	
TSS (%)	High (8.0-7.0)	5	5
	Medium (6.9-6.0)	3	
	Low (5.9-5.0)	1	
TDW (%)	High (11.9-10.6)	5	5
	Medium (10.5-9.2)	3	
	Low (9.1-7.8)	1	
Ascorbic acid content (mg/100 g)	High (155.0-115.0)	5	5
	Medium (114.0-75.0)	3	
	Low (74.0-35.0)	1	
Fruit shape of longitudinal section	Rectangular	5	10
	Trapezoid	4	
	Triangular	3	
	Narrow Triangular	2	
	Horn shaped	1	
Fruit color in maturity	Dark red	5	10
	Red	3	
	Light red	1	

determined for each population during the harvest period. Mean fruit weight was calculated by dividing the total fruit weight by the fruit number. In addition, total soluble solids (TSS %), total dry weight (TDW %) and content of ascorbic acid (mg/100 g) of fruit were recorded for each type. Statistical analyses of results were done using Excel 7.0.

The fruit and yield characteristics data were evaluated by the Weighted-Ranked (WR) method (Balkaya and Yanmaz, 1999, 2005). The WR method is a tool commonly used in statistical analyses. This method is known as *Tartlı derecelendirme* in Turkish and almost exclusively used in the studies with multivariate data generated in horticultural research. Class values of selection criteria, Class Scores (CS) and Relative Scores (RS) were assigned (Table 1). The total points of types were calculated by summing Class Scores (CS) multiplied by Relative Scores (RS). Based on the results of the selection, twenty two genotypes were selected to use second year selection.

RESULTS

In this research, 56 genotype were evaluated in the first experiment year and 22 genotypes were selected according to the fruit characteristic (Table 2, 3). Fruit

Table 2: Some fruit characteristics of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations selected from Bafra plain, Turkey

Genotypes	Fruit length (cm)	Fruit width (cm)	Shape of longitudinal section	Flesh thickness (mm)	Fruit colour	TSS (%)	TDW (%)	Ascorbic acid (mg/100 g)
G1	16.1±1.0	6.3±0.1	Triangular	5.3±0.6	Red	6.2	8.6	75.0
G2	12.5±1.3	7.2±0.0	Triangular	4.6±0.2	Red	5.7	10.7	64.2
G3	15.9±1.6	4.8±0.5	Narrow triangular	5.7±0.4	Dark red	6.2	8.3	135.0
G7	14.6±1.2	6.0±0.1	Triangular	4.9±0.4	Dark red	6.2	9.6	152.6
G12	14.6±0.3	6.4±0.8	Triangular	5.1±0.2	Red	5.2	9.9	106.4
G14	17.8±0.3	5.6±0.2	Triangular	4.9±0.6	Red	6.0	9.8	138.0
G15	17.7±0.5	5.9±0.4	Trapezoid	4.5±0.6	Dark red	7.0	10.1	53.0
G16	16.7±0.9	6.7±0.3	Triangular	4.3±0.4	Red	7.5	10.5	78.8
G17	15.3±1.0	6.6±0.7	Triangular	5.2±0.2	Red	6.8	10.3	102.6
G19	15.7±1.5	6.1±0.1	Triangular	4.5±0.4	Dark red	6.7	9.9	77.0
G20	13.4±1.5	5.8±0.5	Triangular	5.1±0.4	Dark red	6.8	9.3	98.4
G24	19.2±1.1	6.2±0.6	Triangular	5.8±0.3	Red	6.4	8.0	155.0
G25	14.4±0.9	6.2±0.3	Triangular	5.4±0.3	Dark red	5.9	10.3	82.4
G26	14.8±0.8	6.7±0.7	Triangular	5.1±0.5	Red	6.2	9.2	81.0
G27	14.5±1.4	6.2±0.2	Triangular	5.0±0.6	Red	6.9	10.5	98.0
G28	15.6±0.6	6.4±0.2	Narrow triangular	5.2±0.7	Dark red	7.3	11.5	145.0
G33	11.2±1.1	6.0±1.1	Triangular	5.5±0.4	Dark red	7.2	11.2	120.0
G43	14.7±2.0	6.4±0.3	Triangular	4.5±0.4	Dark red	7.2	8.1	98.4
G49	15.3±1.9	6.5±0.3	Triangular	5.1±1.0	Red	7.1	9.8	115.0
G52	12.5±2.2	6.7±1.2	Trapezoid	5.6±0.5	Dark red	6.8	9.2	78.0
G53	14.8±2.1	5.6±0.6	Narrow triangular	4.5±0.3	Dark red	6.4	11.9	115.0
G54	12.0±0.4	6.1±0.4	Triangular	5.3±0.7	Red	8.0	9.2	111.4

Table 3: Some fruit characteristics of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations selected from Bafra plain, Turkey

Characters	Populations
Fruit length (cm)	
Long	G1, G3, G14, G15, G16, G24
Medium	G2, G7, G12, G17, G19, G20, G25, G26, G27, G28, G43, G49, G52, G53
Short	G33, G54
Fruit width (cm)	
Broad	G1, G2, G12, G16, G17, G26, G28, G43, G49, G52
Medium	G7, G14, G15, G19, G20, G24, G25, G27, G33, G53, G54
Narrow	G3
Fruit number/plant	
Many	G7, G16, G24,
Medium	G2, G3, G12, G14, G17, G19, G20, G25, G26, G27, G28, G33, G43, G49, G52, G53,
Few	G1, G15, G54
Average fruit weight (g)	
Heavy	G3, G7, G14, G15, G19, G24, G43, G49, G53, G54
Medium	G1, G2, G12, G16, G17, G20, G25, G26, G27, G28, G52
Light	G33
Fruit shape of longitudinal section	
Rectangular	-
Trapezoid	G15, G52
Triangular	G1, G2, G7, G12, G14, G16, G17, G19, G20, G24, G25, G26, G27, G33, G43, G49, G54
Narrow Triangular	G3, G28, G53
Hornshaped	-
Flesh thickness (mm)	
Thick	G1, G3, G12, G17, G20, G24, G25, G26, G27, G28, G33, G49, G52, G54
Medium	G2, G7, G14, G15, G16, G19, G43, G53
Thin	-
Fruit color in maturity	
Light red	-
Red	G1, G2, G12, G14, G16, G17, G24, G26, G27, G49, G54
Dark red	G3, G7, G15, G19, G20, G25, G28, G33, G43, G52, G53
TSS (%)	
High	G15, G16, G28, G33, G43, G49, G54
Medium	G1, G3, G7, G14, G17, G19, G20, G24, G26, G27, G52, G53
Low	G2, G12, G25
TDW (%)	
High	G2, G28, G33, G53
Medium	G7, G12, G14, G15, G16, G17, G19, G20, G25, G26, G27, G49, G52, G54
Low	G1, G3, G24, G43
Ascorbic acid content (mg/100 g)	
High	G3, G7, G14, G24, G28, G33, G49, G53
Medium	G1, G12, G16, G17, G19, G20, G25, G26, G27, G43, G52, G54
Low	G2, G15

Table 4: Weight-based ranking points of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations from the Black Sea region of Turkey. (Types selected with 380 or more points are shown in bold)

Genotypes	Selection criteria										Total
	A	B	C	D	E	F	G	H	I	j	
G1	50	50	10	45	100	15	5	15	30	30	350
G2	30	50	50	45	100	5	25	5	30	30	370
G3	50	20	30	75	60	15	5	25	20	50	350
G7	30	30	50	75	60	15	15	25	30	50	380
G12	30	50	30	75	100	5	15	15	30	30	380
G14	50	30	30	75	60	15	15	25	30	30	360
G15	50	30	30	75	60	25	15	5	40	50	380
G16	50	50	50	45	60	25	15	15	30	30	370
G17	30	50	30	45	100	15	15	15	30	30	360
G19	50	30	30	75	100	15	15	15	30	50	410
G20	30	30	50	45	100	15	15	15	30	50	380
G24	50	30	50	45	100	15	5	25	30	30	380
G25	30	30	30	75	100	5	15	15	30	50	380
G26	30	50	30	45	100	15	15	15	30	30	360
G27	30	30	50	45	100	15	15	15	30	30	360
G28	30	50	50	45	100	25	25	25	20	50	420
G33	10	30	50	45	100	25	25	15	30	50	380
G43	30	50	30	45	60	25	5	15	30	50	340
G49	30	50	30	45	100	25	15	25	30	30	380
G52	30	30	30	45	100	15	15	15	40	50	370
G53	30	30	50	75	60	15	25	25	20	50	380
G54	30	30	30	75	100	25	15	15	30	30	380

dimensions showed a range of 11.2-19.2 cm for fruit length, 4.8-7.2 cm for fruit width, 4.3-5.8 mm for flesh thickness (Table 2). Red sweet peppers were separated into five group such as rectangular, trapezoid, triangular, narrow triangular and horn fruit shape (Table 3). In this study, it was found that seventeen red pepper types had shape of longitudinal section. Colour is one of the most important attributes of red pepper (Bosland, 1993) and turning from red to dark red of fruit colour is increased market worth (Todorova *et al.*, 1999).

The selected types had 53.0-155.0 mg/100 g ascorbic acid, 5.2-8.0% TSS, 8.0-11.9% TDW (Table 2). G24 had the highest ascorbic acid with 155.0 mg/100 g and G7 (152.6 mg/100 g) and G28 (145.0 mg/100 g) followed it. The soluble solid content was lower in the three selections (G2, G12, G25) comparing to the other genotypes (Table 3). The TDW % was more than 11% for G53, G28, G33 (Table 2).

When total points were taken into consideration, it was found that the point range of the selected types varied from 340 to 420 (Table 4). The most promising types were considered to be those having a total of 380 or more points. Based on these criteria, 12 types (bold type in Table 4) were selected at the end of this research. Selected genotypes will be used in future years for breeding.

In the selected types time from seed sowing to harvest varied between 95 (G1) and 113 (G53) days. In the majority types, harvest time occurred at 105 days. The total fruit weight plants⁻¹ varied from 653.9-1415.5 g (Fig. 1). The G7 had the highest total yield plant⁻¹ with 1415.5 g and G24 (1324.6 g) and G14 (1182.8 g) followed it.

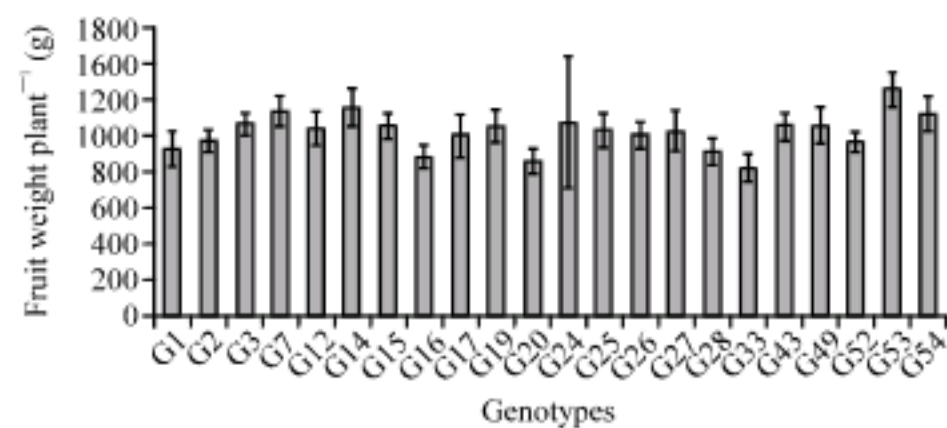


Fig. 1: Total fruit weight (g) of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations selected from Samsun, Turkey

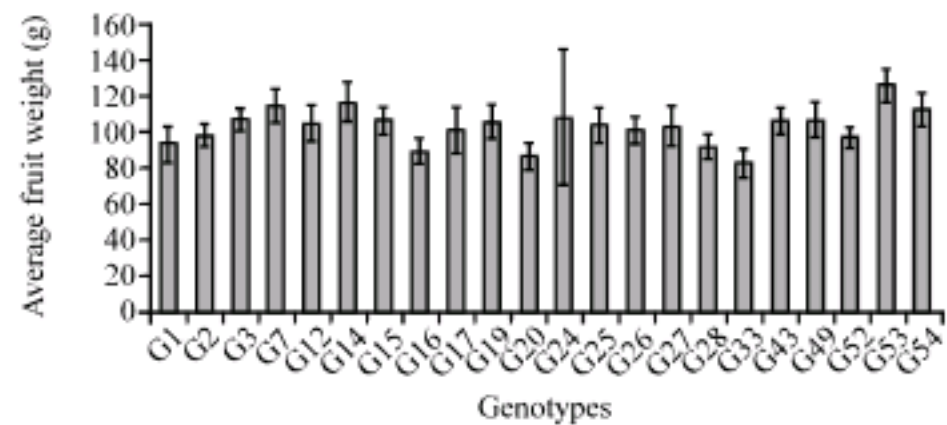


Fig. 2: Average fruit weight (g) of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations selected from Samsun, Turkey

The average fruit weights ranged from 85.1 g (G20)-125.2 g (G53) (Fig. 2). Range of the fruit number plant⁻¹ was between 7.2 and 13.5. G24 had the highest fruit number plant⁻¹ (13.5) while that of G1 was the lowest (7.2) (Fig. 3).

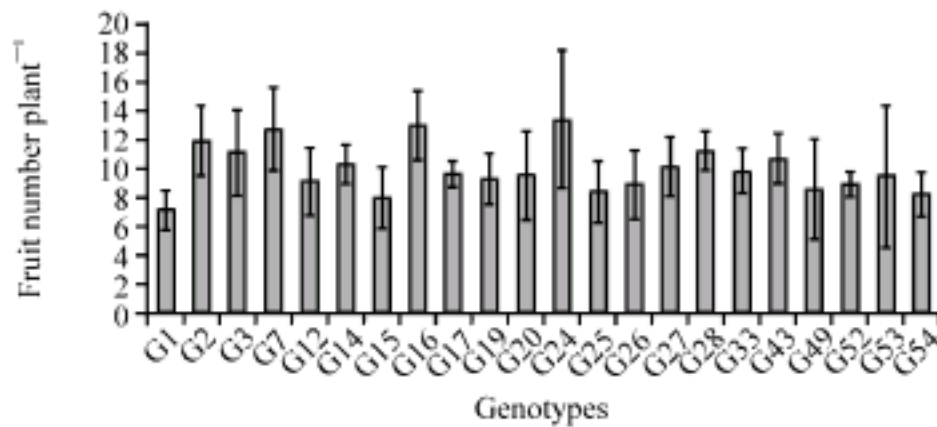


Fig. 3: Average fruit number plant⁻¹ of red pepper (*Capsicum annuum* var. *conoides* Mill.) populations selected from Bafra plain of Turkey

DISCUSSION

Genetic resources for a cultivated species are generally regarded as a gene pool of cultivars, species and genera that can be utilized as sources of additional genetic variation for crop improvement. Prospects are good for the further improvement of all cultivated species of *Capsicum* through breeding (Pickersgill, 1997). The strategy of the *Capsicum* breeder is to assemble into a cultivar the superior genetic potential for yield and improved quality (Bosland, 1993).

The variation for plant and fruit types was observed in the study and their presence was sourced by human preference. Selection within the various species for different uses, for example for consumption as a vegetable, or consumption fresh versus consumption dried, has led to a further partitioning of the genetic diversity within each species. The main difficulties are associated with the need to select simultaneously both for fruit yield components and for the very specific components of quality, such as fruit colour, flesh thickness, ascorbic acid, TDW, TSS, etc., required by the consumer.

This study showed that red pepper genotypes from Samsun province of Turkey may be used as a new genetic resource in breeding programmes. Conservation and maintenance of this valuable genetic material is necessary because these populations are an important source of genetic diversity. In present study, fruit weight and dimensions were found to be different from the other red pepper genotypes selected before in different regions of Turkey (Surmeli and Gursoy, 1985; Inan, 1988). Based on, the fruit yield components, four genotypes (G7, G24, G14, G53) were found superior genotypes for future breeding efforts. The yield may be highly affected by insufficient cultural practices and especially environment factors. Yield alone may not be sufficient criteria to describe the performance of a certain genotype, since it does not indicate the relative performance with other genotypes over different environments (Zewdie and Poulos, 1995).

So, it is essential to grow these types at different locations to explore genotype x environment interaction effects. For this reason, field experiments will continue at different locations (minimum three places) for two years during the second stage of this research and promising lines will be registered according to the results.

Earliness is an important character in an intensive and multiple cropping system in red pepper production (Ahmed *et al.*, 1993) and this is particularly important in areas where growing season being short for sufficient coloring makes it necessary to develop varieties which should not only matures early. In our studies there was significant difference in the earliness performance among the genotypes.

Red peppers have been consumed during the year as fresh, but also used to produce pepper sauce, preserved by freezing, roast over charcoal and used natural colorful (oleoresin) in Turkey, like the other countries. Therefore, higher vitamin C (ascorbic acid) content, TSS and TDW traits are desirable and important properties for red peppers. With regard to TSS, TDW and ascorbic acid, selected genotypes similar with the earlier literature (Surmeli and Gursoy, 1985; Casali *et al.*, 1986; Chalukova *et al.*, 1993; Ahmed *et al.*, 1996; Kumar *et al.*, 2003). Ahmed *et al.* (1996) reported a range of 7.17-14.67% for TDW and 36.0-114.0 mg/100 g for ascorbic acid. Ascorbic acid values were found between 78.3-188.3 mg/100 g (Kumar *et al.*, 2003) and 21.0-77.6 mg/100 g (Sheela *et al.*, 2004). Also, Brazilian studies for paprika selections showed that selected types had 8.9% TDW (Casali *et al.*, 1986).

In the light of the research results, pepper populations have been improved by farmers through mass selection for centuries in Turkey. Their cultivation as a percentage of the entire cultivated area for pepper is reducing. Compared with commercial cultivars, the populations of Turkish pepper are less productive and their fruits lack uniformity. In conclusion, we have presented some characteristics of red pepper genotypes grown in the Black Sea Region of Turkey. These populations are a valuable genetic resource and should either be registered and released as commercial cultivars, after evaluation and selection, or conserved in the Turkey Seed Gene Bank for use in future breeding programmes. Otherwise, more selection studies are necessary to provide the raw material for future breeding efforts in Turkey.

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