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Transgressive segregation of morphological traits in populations derived from cross between *Solanum habrochaites* and *Solanum lycopersicum*

Solanum habrochaites ve *Solanum lycopersicum* melezlemesi ile elde edilen popülasyonda morfolojik özelliklerin transgresif açılımı

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ABSTRACT

Objective: Tomato (*Solanum lycopersicum* L.) is one of the economically important vegetables due to its worldwide economic in both production and consumption. Due to limited genetic diversity among cultivated tomato genetic resources, wild tomato species are commonly used for unlocking the genetic potential and transferring them to cultivated tomato. *Solanum habrochaites* is one of those wild tomato species that has great genetic potential for improving fruit quality traits in cultivated tomato.

Material and Methods: Analysis of segregating populations derived from the cross between *Solanum lycopersicum* and *Solanum habrochaites* is important for the identification and introgression of such genetic potential. Therefore, the present study analyzed transgressive segregation of fruit weight, fruit length, fruit diameter and color parameters in F1, F2 and F3 populations.

Results: For fruit weight, transgressive segregation was observed in just F3 population and five lines had higher fruit weight than maternal parent. Although *S. habrochaites* had smaller fruits than cultivated tomato, there was no significant difference between populations. Although transgressive segregation was observed in F2 and F3 populations for fruit length and diameter, there was no significant difference between mean values of populations.

Conclusion: The study showed that F3 population is sufficient to select larger fruits derived from *S. habrochaites*.

Keywords: Breeding, color parameters, interspecific populations, tomato, wild

ÖZ

Amaç: Dünya çapında üretim ve tüketim nedeniyle domates (*Solanum lycopersicum* L.), ekonomik önemi olan sebzelerden biridir. Kültür domatesleri genetik kaynakları arasındaki sınırlı çeşitliliğe sahiptir. Bu nedenle genetik potansiyelin ortaya çıkarılması ve kültür domatesine aktarılması için yabani domates türleri yaygın olarak kullanılmaktadır. *Solanum habrochaites*, kültür domatesinde meyve kalite özelliklerini geliştirmek için büyük genetik potansiyele sahip yabani domates türlerinden biridir.

Materyal ve Yöntem: *S. lycopersicum* ve *S. habrochaites* arasındaki çaprazdan türetilen ayrıştırıcı popülasyonların analizi, bu tür genetik potansiyelin tanımlanması ve introgresyonu için önemlidir. Bu nedenle, bu çalışmada F1, F2 ve F3 popülasyonlarında meyve ağırlığı, meyve uzunluğu ve çapı ile renk parametrelerinin transgresif ayrımı analiz edilmiştir.

Araştırma Bulguları: Meyve ağırlığı için, sadece F3 popülasyonunda transgresif segregasyon gözlenmiştir ve beş tane hat, anne ebeveynden daha yüksek meyve ağırlığına sahip olarak bulunmuştur. *S. habrochaites* kültür domatesinden daha küçük meyvelere sahip olmasına rağmen, popülasyonlar arasında önemli bir fark bulunmamıştır. Meyve boyu ve çapı için F2 ve F3 popülasyonlarında transgresif segregasyon gözlemlenmesine rağmen popülasyonların ortalama değerleri arasında önemli bir fark bulunmamıştır.

Sonuç: Çalışma, *S. habrochaites*' ten elde edilen F3 popülasyonunun daha büyük meyveleri seçmek için yeterli olduğunu göstermiştir.

Anahtar sözcükler: Islah, renk parametreleri, türler arası popülasyonlar, domates, yabani

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to Solanaceae family and it is an important vegetable in tropical and subtropical regions. The vegetable is rich for minerals such as iron, potassium, phosphorous, vitamins such as vitamin A, B and C. Also, tomato is a good source of plant sterols, antioxidants such as phenolic compounds and lycopene (Frusciante et al., 2007). Thus, it is consumed as fresh and processed forms such as tomato pasta and important for sustainable public health (Ensminger et al., 1994). Tomato is very important for the agricultural economy considering its worldwide production and consumption. China, India, USA, Turkey and Egypt are main tomato producers. Turkey ranks third after China and USA in terms of tomato production with 13.2 million tones of production (FAO, 2020). Tomato can be produced both in open field and under greenhouse, which can be marketed as both fresh and processed (Türk et al., 2019). Due to importance of the vegetable, its breeding is one of the main topics in plant breeding and several new tomato cultivars have been developed worldwide (Kabaş & Zengin, 2012). Genetic diversity of cultivated tomato germplasm is low due to due to shorter stigmas. (Rick, 1995; García-Martínez et al., 2006). Wild tomato species are an excellent source of diversity for tomato breeding not only for biotic and abiotic stress tolerances but also fruit quality traits. Especially, genetic potential of three wild tomato species *Solanum pimpinellifolium*, *Solanum habrochaites* and *Solanum peruvianum* has been investigated extensively for increased fruit quality traits in tomato. First step of utilization of the genetic potential of wild tomato species and development of tomato cultivars have high fruit quality traits is the development of experimental populations such as F2, RIL (Recombinant Inbred Lines) or IBL (Inbred Backcross Lines) to identify tomato lines exceed parents for traits due to transgressive segregation. Although wild tomato species are mainly used for abiotic and biotic stress tolerance breeding, limited studies focused segregation of morphological traits. Genetic potential of *S. habrochaites* was investigated in a BC2F2 and the study reported that *S. habrochaites* is better potential than *S. pimpinellifolium* and *S. peruvianum* due to a higher proportion of lines (20% and 15% for phenolics and antioxidants, respectively) had higher phenolic and antioxidants content than parents (Top et al., 2014). Despite good genetic potential of *S. habrochaites* for BC2F2, transgressive segregation of fruit quality traits in other populations such as F2 and F3 was not investigated. The aim of the current study is investigation of transgressive segregation of four fruit quality traits (fruit color, fruit weight, fruit length and diameter) in F2 and F3 populations derived from cross between *S. habrochaites* and *S. lycopersicum.*

MATERIAL and METHOD

Interspecific F1 plants derived from cross between *S. lycopersicum* (AK20215) and wild tomato species *S. habrochaites* (AK20212) were developed. Afterwards, F2 and F3 populations were developed from selfing of F1 and F2 plants, respectively (Figure 1). In this study, Akdeniz University Manavgat Vocational tomato gene pools were used to generate the population.

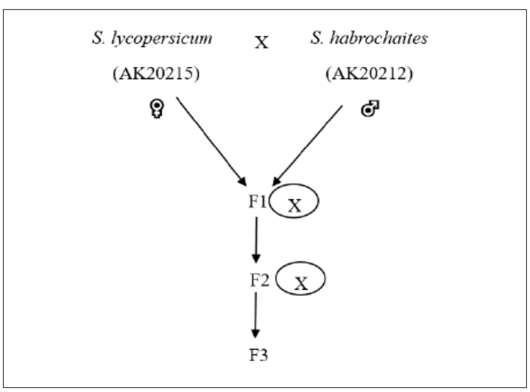

Figure 1. Populations derived from cross between *S. lycopersicum* and *S. habrochaites.*

***Şekil 1.** S. lycopersicum ve S. habrochaites arasındaki melezlemeden türetilen popülasyonlar.*

Seed of all plant materials were germinated in a small pot containing sterilized peat. Germinated seeds were transferred to fruit tray containing peat and perlite (3:1). Afterwards, the seedlings were transferred to greenhouse for growing. 36°48°30°N 31°23°19 °E (Figure 2). Plants were fertilized according to protocol reported by Jones et al. (1991). Fruit developmental stage was expressed as days post-anthesis (DPA): The flowers were tagged when they are full bloomed, and the fruits were harvested after 45 DPA corresponded to red ripe stage.

Figure 2. The location of the greenhouse.

Şekil 2. *Seranın lokasyonu.*

Morphological characterization

The average of 10 randomly selected fruits from each line were reported as fruit weight. The weights of the fruits were measured with a scale with a sensitivity of 0.01 g. Fruit length and diameter of randomly selected 10 fruits for each line measured by using a digital caliper. Diameters of the fruits measured from the equatorial part. Ratio between fruit length and diameter was calculated. Fruit color was measured using Minolta CR 400 based on CIE Laboratory parameters (*L*, a*, b*, h°* and *C**). The color of the fruits was determined by taking 3 different measurements from the equatorial region. Student t test performed to compare the populations in terms of morpholoical traits.

RESULTS and DISCUSSION

Transgressive segregation of fruit weight of populations was investigated. Cultivated tomato *S. lycopersicum* (AK20215) had larger fruits (5.50 ± 0.1 g) than wild tomato (1.70 ± 0.50 g). Average fruit weight of F1, F2 and F3 populations were 0.95 ± 0.10, 1.28 ± 0.84 and 2.48 ± 1.72, respectively (Table 1). Although segregation was observed in F2 population, non of the lines exceed maternal fruit weight (Figure 3). Majority of the lines (15 lines, 46.87%) had fruit weight between 1.4 and 2.8 g. Transgressive segregation was also observed and a total of five lines (%15.6 of total population) had bigger tomato than maternal parent (AK20215) (Figure 3, Table 2).

Table 1. Mean fruit weight of populations

Çizelge 1. *Popülasyonların ortalama meyve ağırlığı*

Plant material	Mean ± SD
*S. habrochaites (*AK20212)	1.70 ± 0.50
*S. lycopersicum (*AK20215)	5.50 ± 0.10
F1	0.95 ± 0.10
F2	1.28 ± 0.84
F3	2.48 ± 1.72

*Solanum lycopersicum (*AK20215) had bigger fruits as expected. Larger fruits of cultivated tomato is predominant domestication trait. Although mechanism of this bigger fruits is not clear, domestication of tomato leads bigger fruits might be due to mutation in a major QTL (fw.2.2) out of six QTLs control fruits weights (Alpert et al., 1995; Frary et al., 2000; Tanksley, 2004; Causse et al., 2007). F1 plants had lower mean of fruit weight than F1 plants derived from same wild species (6.76 g) in previous study performed by Rodríguez et al. (2005). This difference might be due to larger fruits (65.7 g and 3.99 g) of parents of previous study. Segregation of fruit weight in BC2F2 population derived from *S. habrochaites* was observed by Top et al. (2014). In that study, although population derived from *S. habrochaites* had larger fruits than cultivated tomato, non of lines had larger fruits than *S. lycopersicum*. This difference might be due to different populations used in two studies.

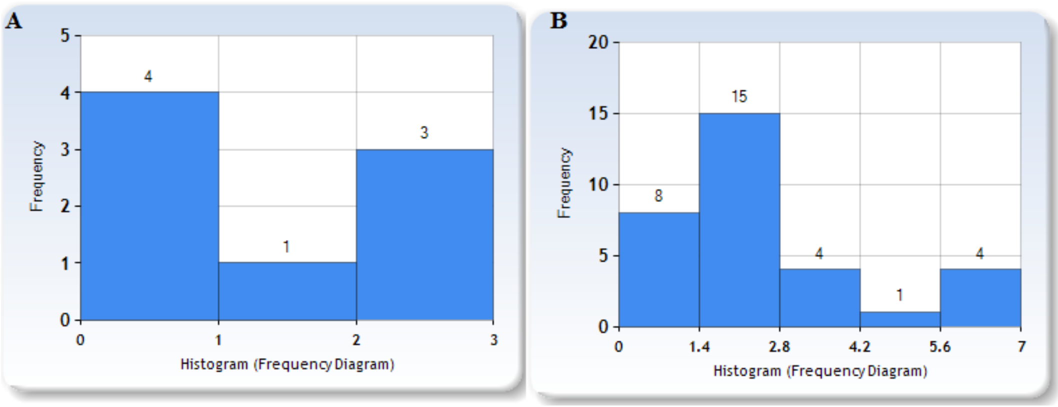

Figure 3. Frequencies of populations (A for F2 and B for F3) for fruit weight.

Şekil 3. *Meyve ağırlığı için popülasyonların frekansları (F2 için A ve F3 için B).*

Table 2. Fruit weight of tomatoes harvested from F3 lines

Çizelge 2. F3 hatlarında hasat edilen meyvelerin ağırlıkları

F3 Lines	Fruit weight (g)
85-1-12 F3	6.8
85-3-16 F3	6.6
85-3-18 F3	6.0
85-5-5 F3	5.6

Fruit diameter of population was also investigated. Cultivated tomato *S. lycopersicum (*AK20215) had longer fruit diameter (21.57 ± 0.28) and length (19.51 ± 0.95) than wild tomato species *S. habrochaites (*AK20212) (14.60 ± 0.36 and 12.27 ± 1.07 for fruit diameter and length, respectively) (Table 3). There was no significant difference between populations (F1, F2 and F3) for fruit diameter and length. While fruit diameter and length ratio of F2 population ranged from 0.86 to 1.18, the ratio of F3 population ranged from 0.84 to 1.34. There were no significant differences between parents and population for fruit diameter and length ratio (Figure 4).

Table 3. Fruit diameter and length of plant material

Çizelge 3. *Bitki materyalinde meyve çapı ve uzunluğu*

	Fruit diameter Mean ± SD (cm)	Fruit length Mean ± SD (cm)	Diameter length ratio Mean ± SD (cm)
S. habrochaites (AK20212)	14.60 ± 0.36	12.27 ± 1.07	1.20 ± 0.11
S. lycopersicum (AK20215)	21.57 ± 0.28	19.51 ± 0.95	1.11 ± 0.05
F1	16.11 ± 2.01	16.11 ± 2.15	1.11 ± 0.08
F2	13.06 ± 3.16	12.98 ± 3.18	1.01 ± 0.09
F3	15.87 ± 3.87	15.54 ± 3.72	1.02 ± 0.08

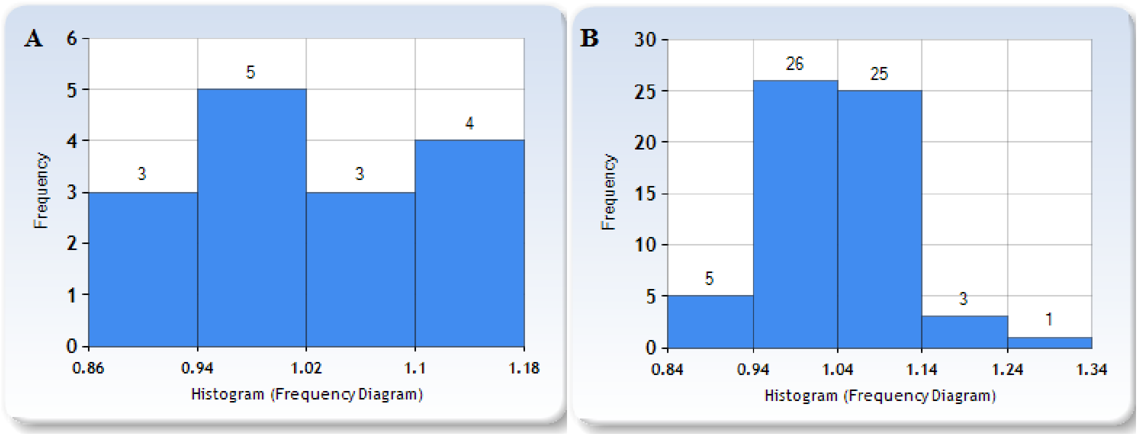

Figure 4. Frequencies of populations (A for F2 and B for F3) for fruit diameter and length ratio.
Şekil 4. *Meyve çapı ve boy oranı için popülasyon sıklıkları (F2 için A ve F3 için B).*

Surface color of tomato fruits harvested from parents and populations was measured using Minolta CR 400 chroma meter, which provide CIE *L**, *a**, and *b** values.Higher positive *a** indiates red purple, negative *a** values indicate bluish-green. Higher positive *b** values indicate yellow and negative *b** values indicate blue color (McGuire 1992). F1 population had significantly higher mean value of *L** than parents, F2 and F3 populations. Although F1 population (-3.52 ± 0.91) was similar to *S. habrochaites (*AK20212) (-4.93 ± 2.35), *S. habrochaites (*AK20212) had higher mean value than *S. lycopersicum (*AK20215) for *a**. There was no significant difference between populations for *b** value. Although there was no significant difference between parents for *C**, F1 population had lower mean value of *C** than parents and F2 and F3 populations. For *S. lycopersicum (*AK20215) had the lowest h° value (Table 4). Improved tomato color defined as a reduction in values of hue and *L** and an increase of *C** (Sacks & Francis, 2001). Based on this statement, as expected cultivated tomato *S. lycopersicum (*AK20215) had the highest improved tomato color. Also, lowest *L** and C* values of F3 population showed that F3 population was more improved than F1 and F2 populations.

Table 4. Mean values of color parameters of parents and populations
Çizelge 4. *Ebeveynlerin ve popülasyonların renk parametrelerinin ortalama değerleri*

	L*	a*	b*	*C**	*h*°
	Mean ± SD (cm)	Mean ± SD (cm)	Mean ± SD (cm)	Mean ± SD (cm)	Mean ± SD (cm)
*S. habrochaites (*AK20212)	39.87 ± 5.81	-4.93 ± 2.35	19.46 ± 1.74	20.16 ± 2.25	103.62 ± 5.34
*S. lycopersicum (*AK20215)	38.05 ± 0.15	18.09 ± 1.31	10.67 ± 0.24	21.01 ± 1.25	30.60 ± 1.25
F1	55.37 ± 0.27	-3.52 ± 0.91	16.37 ± 0.26	16.77 ± 0.45	102.04 ± 2.83
F2	45.08 ± 7.6	0.12 ± 5.34	18.35 ± 4.40	18.97 ± 4.86	93.64 ± 13.48
F3	40.40 ± 8.23	12.28 ± 5.04	23.77 ± 7.38	27.49 ± 6.33	61.4 ± 13.22

CONCLUSION

Wild tomato species have favorable alleles for fruit quality traits in addition to their high genetic potential for abiotic and biotic stresses. The present study reported that small-fruited *S. habrochaites* had good source of alleles for improved fruit weight in segregating populations. Also *S. habrochaites* leaded more globular fruits in F2 and F3 populations. The current study demonstrated that *S. habrochaites* is valuable genetic resource for development of tomato cultivars had improved fruit quality traits.

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