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Genetic Diversity in Apricot

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1. Introduction

Apricot is a fruit species adopted to a wide geographical areas (De Poerderlé, 1788; Loudon, 1838; Arakelyan, 1968; Mehlenbacher et al. 1991; Huxley, 1992; Butner, 2001). 173 years ago, Loudon (1838) was first to mention that wild apricots with different shades of pink flowers had been used as ornamental purpose for centuries. Nowadays commercial production areas of apricots are still very limited with a small number of varieties, although they spread across a wide area all over the world. Looking at the statistics, the production value has been observed to show upward trend by years. This increase in production is closely related with breeding studies in different countries. Breeding programs were modified generally according to consumer's demands and also some subjects such as resistance to diseases (Sharka, Monilinia etc.) and frost damages, determination of self-(in)compatibility.

Germplasm collection and characterization is an early essential stage to initiate a breeding program for diversity. Traditionally germplasm collection and characterization had been done discribing phenological, pomological and morphological characteristics such as tree vigor and growth habit (Perez-Gonzales, 1992; Badanes et al. 1998; Asma & Ozturk, 2005), fruit quality features (Rehder, 1940; Bailey & Hough, 1975; Audergon et al. 1990; Souty et al. 1990; Crossa-Raynaud & Audergon, 1991; Parolari et al. 1992; Bassi & Bartolozzi, 1993; Badanes et al. 1998; Gurrieri et al. 2001; Ledbetter & Petterson, 2004; Asma & Ozturk, 2005; Ruiz & Egea, 2008; Milosevic et al. 2010), leaf (Bailey, 1916; Hou, 1983; Rostova & Sokolova, 1992), stone (Felföldi et al. 2009; Malik et al. 2010), flower (Rodrigo et al. 2006; Yilmaz & Paydas-Kargi, 2010), stigma and stylus (Viti et al. 2000) and pollen (Dezhong et al. 1995; Davarynejad et al. 2005; Arzani et al. 2005; Asma, 2008) comparing and combining the results of characaterization researches published by different groups is a difficult tusk since different variety of morphological, phenological and pomological characteristics have been assessed by the research groups. International UPOV and IPGRI criteria was created in order to overcome this unrequred situation and to enable researchers use common descriptor characteristics.

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In the last two decades, molecular studies have been integrated into the conventional germplasm characterization researches (Battistini & Sansavini, 1991; Badanes et al. 1996; Mariniello et al. 2002; Hurtado et al. 2001, 2002; Hormaza, 2002; Vilanova et al. 2003; Geuna et al. 2003; Zhebentyayeva & Sivolap, 2000; Zhebentyayeva et al. 2003; Sanchez-Perez et al. 2005; Romero et al. 2003, 2006; Rao et al. 2008; Yilmaz, 2008; Akpinar et al. 2010) and genetic diversity in apricot. Recent studies show that this genetic diversity originated in Central Asia and transfered to Middle Asia and Caucasia. Later on, the apricot was taken to Europe, and recently spreaded from Europe to North America and the rest of world.

2. Systematic and eco-geographical groups of apricot

Apricot belongs to Prunus genus. Some systematicians created different sections under Prunus genus and Prunuphora sub-genara or Rosaceae family and Prunoideae sub-family (Table 1). American apricots are seen Armeniaca sub-section and named *Armeniaca vulgaris* Lam. (Bailey & Hough, 1975).

Bailey (1916) (Ledbetter, 2008)		**Rehder (1940)** (Ledbetter, 2008)	
Genus	*Prunus*	Genus	*Prunus*
Sub-genera	*Prunophora* (plums, prunes & apricot)	Sub-genera	*Prunophora*
Prunus armeniaca L.		Sections	Euprunus (European/Asian Plums)
	Var. *pendulata* Dipp.		Pronocerasus (North American plums)
	Var. *variegata* Hort.		Armeniaca (Apricots)
	Var. *sibirica* Koch	Armeniaca (Apricots)	
	Var. *mandshurica* Maxim.		*P. brigantina* Vill.
	Var. *Ansu* Maxim.		*P. mandshurica* Maxim.
P. mume Sieb. & Zucc.			*P. sibirica* L.
	Var. *Goethartiana* Koehne.		*P. armeniaca* L.
	Var. *albo-plena* Hort.		*P. mume* Sieb. & Zucc.
Other wild forms			*P. dasycarpa* Ehrh.
	laciniata Maxim.	*P. armeniaca* L.	
	microcarpa Makino		*P. armeniaca variegata* Schneid.
	viridicalyx Makino		*P. armeniaca pendula* Jaeg.
	cryptopetala Makino		*P. armeniaca Ansu* Maxim.
P. brigantiaca Vill.		*P. mume* Sieb. & Zucc.	
P. dasycarpa Ehrh.			*P. mume alba* Rehd.
			P. mume Alphandii Rehd.

	P. mume albo-plena Bailey
	P. mume Pendula Sieb
	P. mume tonsa Rehd.

Lingdi & Bartholomew (2003) (Ledbetter, 2008)		
Family	*Rosaceae*	
Subfamily	*Prunoideae*	
Genus	*Armeniaca* (Apricots)	
	Armeniaca vulgaris L.	
		Var. *vulgaris* L.
		Var. *zhidanensis* Qiao & Zhu
		Var. *ansu* Maxim
		Var. *meixianensis* Zhang
		Var. *xiongyueensis* Li
	Armeniaca limeixing Zhang & Wang	
	Armeniaca sibirica L.	
		Var. *sibirica* L.
		Var. *pubescens* Kostina
		Var. *multipetala* Liu & Zhang
		Var. *pleniflora* Zhang
	Armeniaca holosericea Batal.	
	Armeniaca hongpingensis Li	
	Armeniaca zhengheensis Zhang & Lu	
	Armeniaca hypotrichodes Cardot	
	Armeniaca dasycarpa Ehrh.	
	Armeniaca mandshurica Maxim.	
		Var. *mandshurica* Maxim.
		Var. *glabra* Nakai
	Armeniaca mume Sieb. & Zucc.	
		Var. *mume* Sieb.
		Var. *pallescens* Franc.
		Var. *cernua* Franc.
		Var. *pubicaulina* Qiao & Shen

Bortiri et al. (2002) (Ledbetter, 2008)	
Sections	*Penarmeniaca*
Penarmeniaca	
	Prunus fremontii S. Wats.
	Prunus andersonii A. Gray.

Hayashi et al. (2008)			
Traditional Japanese classification (Mega et al., 1988; Horiuchi et al., 1996)			
Prunus mume			
	For fruit production		
	For ornamental "kei"		
		Yabai	
			Yabai sub-groups
			Naniwa sub-groups
			Benifude sub-groups
			Aojiku sub-groups
		Koubai	
			Koubai sub-groups
		Bungo	
			Bungo sub-groups
			Anzu sub-groups

Table 1. Apricot systematics according to various researchers

Leaf characteristics were accepted the most important criterion for apricot systematic by various researchers. Bailey (1916) examined the leaves emerged from dormant buds. Rehder (1940) used leaf shape and pubescence for classification of species. Chinese botanists utilized leaves in parallel Western researchers. However, Japanese researchers considered flower and branch color and flower size in Japanese apricots (*Prunus mume*) which is an ornamental plants for Traditional Japanese classification (Mega et al. 1988; Horiuchi et al. 1996). *Prunus fremontii* which is in Penarmeniaca section and reported in some studies (Bortiri et al. 2001, 2002) along with the desert dwelling species *Prunus andersonii* A. Gray. *Prunus fremontii* can be hybridized freely with other apricot species and differs from them (Ledbetter, 2008).

a. *Prunus armeniaca* var. *ansu* (www.flickr.com)
b. *Prunus mume* (http://commons.wikimedia.org/wiki/File:Prunus_mume_Yaekanko.jpg)
c. *Prunus brigantina* (http://luirig.altervista.org/cpm/albums/bot-042/001-prunus-brigantina.jpg)
d. *Prunus armeniaca*
e. *Prunus mandshurica* (http://www.lawyernursery.com)
f. *Prunus sibirica* (http://www.agroatlas.ru/en/content/related/Armeniaca_sibirica/)

Fig. 1. Different apricot species

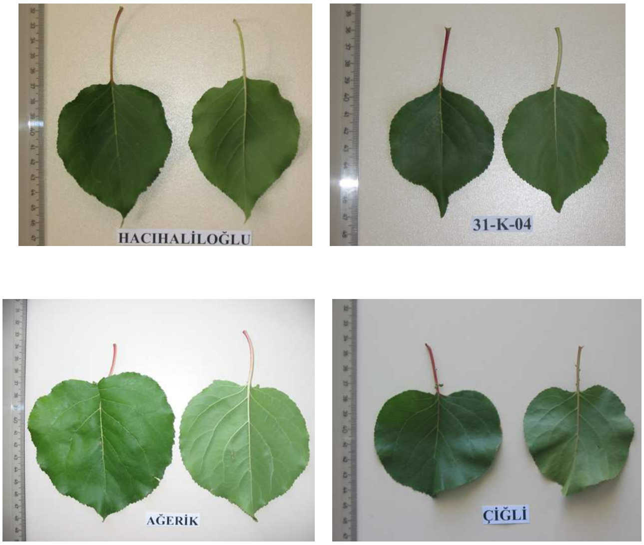

Fig. 2. Leaf shapes in *Prunus armeniaca* in Irano-Caucasian eco-geographical group (Turkish apricots - Yilmaz, 2008)

Apricot has 2n=16 chromosomes. Wide variations emerged in apricots because of seed propagation and growing in different ecological areas in time. Therefore, the systematicians reported that 6-8 eco-geographical groups and 13 regional sub groups occured.

a. Central Asian eco-geographical group (Kostina, 1969)
- Fergana regional sub-group (Bailey & Hough, 1975)
- Upper Zeravshan regional sub-group (Bailey & Hough, 1975)
- Semerkand-Shahrisiabz regional sub-group (Bailey & Hough, 1975)
- Horezm regional sub-group (Bailey & Hough, 1975)
- Kopet-Dagh regional sub-group (Bailey & Hough, 1975)

b. Irano-Caucasian eco-geographical group (Kostina, 1969)
- Iran-Caucasus regional sub-group (Mehlenbacher et al. 1991)
- Dagestan regional sub-group (Mehlenbacher et al. 1991)
- North Africa regional sub-group (Mehlenbacher et al. 1991)

c. European eco-geographical group (Kostina, 1969)
- Western European regional sub-group (Layne et al. 1996)
- Eastern European regional sub-group (Layne et al. 1996)
- Northern European regional sub-group (Layne et al. 1996)

d. Dzhungar-Zailig eco-geographical group (Kostina, 1969)
- Dzhungar regional sub-group (Mehlenbacher et al. 1991)
- Zailig regional sub-group (Mehlenbacher et al. 1991)

e. Northern China eco-geographical group (Bailey & Hough, 1975)
f. Eastern China eco-geographical group (Bailey & Hough, 1975)
g. Tibet eco-geographical group (Bailey & Hough, 1975; Asma, 2011)
h. Northeast China eco-geographical group (Bailey & Hough, 1975; Asma, 2011)

The oldest and richest in diversity is the Central Asian group which includes local apricots from Central Asia, Xinjiang, Afghanistan, Balucistan, Pakistan, and Northern India (Kashmir). This group is mostly self-incompatible and characterized with medium sized fruits and they have a tendency to bloom late spring. The secondary gene center of apricot is the Irano – Caucasian group which extends from Armenia, Georgia, Azerbaijan, Dagestan, Iran, Iraq, Syria, Turkey, to North Africa, and even to Spain and Italy. They are generally self-incompatible, but on contrary, they produce large fruits and blooms earlier than apricots of Central Asia and needs lower chilling hours. Apricots of North American, South African, and Australian are classified as the European group and this group was originated from the apricots of Armenia, Iran, Turkey, and other Arab countries. Apricots of this group are self-compatible, fruits are more precocious and the trees need low chilling. The Dzhungar-Zailig group with mostly small fruits includes selections from regions of Dzharskent, Taldy-Kurgan, Kazakhstan, and Xinjiang (Mehlenbacher et al. 1990; Layne et al. 1996; Faust et al. 1998). Later, two major groups proposed by Bailey & Hough (1975), the Northern China group that includes forms of *Prunus mandshurica* and *Prunus sibirica*, and the Eastern China group that includes forms of *Prunus ansu* (Romero et al. 2003). In addition, some researchers mentioned two more groups named Tibet and Northeast China. While Tibet eco-geographic group includes forms of *Prunus armeniaca* var. *holosericea*, Northeast China eco-geographic group includes varieties and types of *Prunus armeniaca*, *Prunus sibirica* and *Prunus mandshurica* (Bailey & Hough, 1975).

The Central Asian and Irano-Caucausian including Turkish and Iran cultivars eco-geographical groups show the richest phenotypic variability, while European group including cultivars grown in North America, Australia and South Africa is to exibit the least diversity (Mehlenbacher et al. 1991; Halasz et al. 2010).

3. Origin and spread of apricot to the world

According to the famous Russian Botanist Vavilov (1951), there are three important regions as origin of apricots although Armenia had been supposed apricot's origin and named as *Prunus armeniaca*, previously. These are;

a. The Chinese center (China and Tibet)
b. The Central Asian center (from Tien-Shan to Kashmir)
c. The Near-Eastern center (Iran, Caucasus, Turkey)

Also Vavilov (1951) reported that the Near-Eastern center could be secondary gene center because of cultured varieties and absence of wild apricot forms (Bailey & Hough, 1975; Asma, 2011).

The spread of apricots from Central Asia to the rest of world are explained by three different views. The first of these, dried apricot fruits and stones of natural apricot flora in Fergana Valley which is at the border of Uzbekistan, Tajikistan, and Kyrgyzstan and piedmont of Hind Kush and Tian Shan mountains were brought to Anatolia by soldiers on Iran and Transcaucasus during organized Asia campaigns by the Great Alexander in BC 334. Later on, apricot was moved to Europe from Anatolia during the Roman-Persian wars in BC 1 (Layne et al. 1996). The second view; apricot was brought to Anatolia by merchants from China and Center Asia on famous Silk Road, and then Roman soldiers carried apricot to

Italy from Anatolia (Bailey & Hough, 1975). The third view is that Romans removed apricot to west during their expeditions to seize the Near East (Syria, Iran, and Caucasus) in BC 2 (Layne et al. 1996). Apricot gradually spreaded to Africa on Meditarranean countries and Middle East, it was also carried to Balkans by Ottomans in XV. and XVI. century (Suranyi, 1999). Apricot was taken to Southern Europe from Eastern Europe countries (Asma, 2011), to England in 1524 or 1548 from Italy. It was removed to America continent by the Spanish in 1626 (Faust et al. 1998).

4. Apricot production of the world

Despite we observe rich distribution of apricot through the world, the commercial production areas are limited. The majority of production is done in Mediterranean countries and also in Iran, Pakistan, Uzbekistan, Morocco, Algeria, Ukraine and USA (Romero et al. 2003).

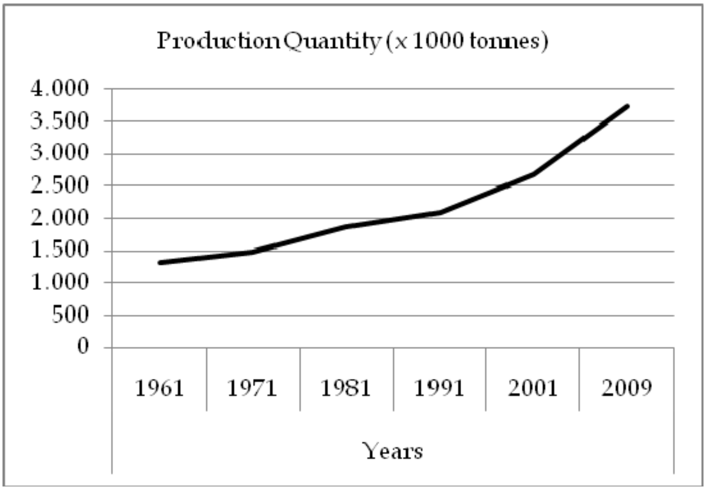

Fig. 3. World apricot production from 1961 to 2009 (FAOSTAT, 2011)

Analyzing the data by years from 1961 until 2009, we observe that the amount of production in the world have increased on a regular basis. During the last 50 years 1.317.607 tons per year production reached about 3.728.083 tons (Fig 3). Despite to this increase in the 50 years amount of production is actually low due to the limited capabilities of adaptation to different environments, limited numbers of variety, self-incompatibility, frost damage, susceptibility to Sharka and Monilinia (*Sclerotinia laxa* Aderh et., Ruhl.).

Turkey is the leading country at the production of apricots. Turkey with its rich genetic resources and high quality dried apricot cultivars has reached to monopolistic position in the world. In recent years, the farming of dried apricot has increased in China, Pakistan, Iran, Syria, Uzbekistan, Afghanistan, too. Especially the city of Malatya in Turkey (Fig 4) and the surrounding areas of the city provides more than half of production of the country. For this reason, the city, Malatya is called also the apricot capital of the world (Asma, 2007). Apricots have been traditionally a part of life and as a symbol of the city at every point

Fig. 4. Malatya province where is the most apricot produce in the world.

Fig. 5. Apricot is a symbol in Malatya.

(Fig 5). Malatya Apricot Research Station established in the city in 1937 played an important role at the development of apricot farming in the city (Fig 6). The station has a rich collection of 285 apricot accessions of different eco-geographical groups. It is third behind the Nikitsky Botanic Garden in Ukraine and Central Asian Experimental Station of the Institute of Plant Industry in Uzbekistan (Fig 7). The institution host thousands of seedlings obtained from constantly maintained crosses. In 2010, Malatya produced 661.000 tons of fresh apricot. Of the that production 101.000 tons dried apricots were obtained (TurkStat, 2010) (Fig 8).

Fig. 6. Apricot Research Station (1937)

Fig. 7. A view of Apricot Genetic Resources Collection Orchard in Apricot Research Station in Malatya / Turkey

Fig. 8. Best apricot competition in Malatya and new apricot cultivar Alkaya for table and dried consumption

Apricot cultivation in the Mediterranean countries generally base on early and middle season table apricots and Spain, Italy and France have authority in the trade of table apricots. USA, South Africa and Australia are producer of dried and flesh apricots. However production of USA decreases sharply.

Apricot rich countries has plenty of genetic diversity due to the production many years with seed. This increase shows that the studies need to be done in apricot. Indeed, in recent years, big, flashy, red-checked with orange flesh and resistant apricot variety has been the target of new development. Especially in Europe and the USA breeding programs released big new cultivars with cheek color of red but because of the low brix and poor flavor the release failed to succeed in the marked.

One of the main priority of apricot breeding programs in the mid of 1990s was to develop cultivars resistant to the late spring frost (Layne et al. 1996; Bassi & Sansavini, 1988). However, unlike almond breeding (Vargas & Romero, 2001), this aim was failed to succeed

(Demirtas et al. 2010). In the wild apricots and germplasm collections the lack of genotypes exhibiting resistance to the late spring frost was the main reason for this fail. But this failure was ignored by producer since apricot is high-profit production and good evaluation of adaptation studies (Occarso, 1977; Durie, 1988; Ogasanovic et al. 1991; Harsanyi, 1991; Ozvardar et al. 1991; Baktir et al. 1992; Bassi et al. 1995; Kaska et al. 1995; Egea et al. 1995; Audergon et al. 1995; Ayanoglu et al. 1995; Paydas et al. 1995; Draganescu & Cociu, 1997; Hofstee et al. 1997; Papanikolaou-Paulopoulo & Poulis, 1997; Yilmaz, 2002; Blanc et al. 2006).

One of the main goals breeding programs was to obtain varieties resistant to Monilinia [*Sclerotinia* (*Monilinia*) *laxa* Aderh et., Ruhl) (Cociu et al. 1991; Gulcan et al. 1994; Bassi et al. 1995; Bassi & Audergon, 2006; Guerriero et al. 2006; Nicotra et al. 2006; Acarsoy et al. 2011). Although this ended up with some success, economically important cultivars were not released into market. Using efficient fungusit prevented also Monilinia breeding programs.

All of these germplasm used in breeding and molecular genetic studies in recent years drawn towards different targets. The most important of these is Sharka (*Plum pox virus*) disease, unfortunately, which caused great losses (Lopez-Moya et al. 2000; Cambra et al. 2006).

In addition, problems related to self-incompatibility became main problem after Sharka, in terms of ensuring the efficiency of production. In this context, the presence of *S* alleles on behalf of researchers to understand the mechanism of conflict directed to this point.

5. Sharka (*Plum pox virus*) resistance in genetic diversity of apricot

Sharka or Plum pox virus (PPV) is the most serious disease of Prunus trees. The disease has spreaded throughout many European countries, especially in Mediterranean countries. Resistant cultivars are limited and only some North American cultivars are known to be resistant to the disease. 'Stark Early Orange' (SEO), 'Goldrich', 'Harlayne', 'Stella', and 'Harcot' are the resistant cultivars mostly used as resistant source for breedings (Martinez-Gomez et al. 2000). The resent focus on the disease increased also cruiosty on the source of resistance of American cultivars. It is believed that North American cultivars originated from a limited number of European cultivars. The source of the resistance is unknown. However, recent studies shows that Central Asian apricots is the most likely source of resistant genes in the North American donors. *Prunus mandshurica* was first to be offered as PPV resistance into North American germplasm (Badenes et al. 1996). Zhebentyayeva et al. (2003) showed that 'Harlayne' and 'Goldrich' clusters with native Central Asian cultivars. 'Stark Early Orange', LE 2904, LE 3276, and 'Vestar' are also grouped with native Chinese material on the genetic diversity study (Zhebentyayeva et al. 2003). Hormaza (2002) also demonstrated that Chinese cultivars contributed to the pedigree of 'Stark Early Orange'. The recent research of Zhebentyayeva et al. (2008) shows that cultivars 'Harlayne', 'Goldrich', and 'Stark Early Orange' has genetic similarity with native Central Asian genotypes. The researchers also showed that *Prunus davidiana* alleles in 'Stark Early Orange' and *Prunus mume* alleles in 'Stark Early Orange' and 'Goldrich' pointed out a contribution of these species to PPV resistance as well (Zhebentyayeva et al. 2008).

6. *S*-genotyping in genetic diversity of apricot

Like to other Prunus species, apricots show gametophytic self-incompatibility controlled by a single locus with multiple genes, *S*-haplotypes (De Nettancourt, 2001). The *S*-haplotype contains a female determinant, (*S-RNase*) encoding for a ribonuclease enzyme (McClure et al. 1989), and the recently identified male determinant, *S-haplotype-specific F-box* gene (Entani et al. 2003; Romero et al. 2004; Halasz et al. 2010).

The Irano – Caucasian group are usually self-incompatible whereas Europan apricots are mostly self-compatible (Halasz et al. 2005; Kostina, 1970). Mehlenbacher et al. (1991) stated Central Asian apricots are also mostly self-incompatible.

Cross-incompatibility between a pair of cultivars occurs frequently self-incompatible species. Cross-incompatibility was observed among the North American cultivars, Goldrich, Hargrand and Lambertin No.1 (Egea & Burgos, 1996), and also among giant-fruited Hungarian apricots (Szabo & Nyeki, 1991; Halasz et al. 2010). Halasz et al. (2010) determined total 12 cross-incompatiblity groups between Irano-Caucasian eco-geographical groups (Turkish apricots) and European eco-geographical groups (Hungarian and North American apricots) (Table 2).

Cross-incompatibility groups	Cultivars	*S*-genotype
I	Goldrich, Hargrand, Lambertin No.1	S_1S_2
II	Cologlu, Kadioglu, Seftalioglu, Cegledi orias, Ligeti orias	S_8S_9
II	Iri Bitirgen, Moniqui	S_2S_6
IV	Artvin PA, Priana	S_2S_7
V	Alyanak, Ziraat Okulu	S_2S_8
VI	Dortyol-4, Sebbiyiki	S_2S_{19}
VII	Sakit-3, Tokaloglu Izmir	S_3S_{19}
VIII	Cataloglu, Ozal, Soganci	S_6S_9
IX	Zerdali No.1, XI Zerdali	S_6S_{12}
X	Ordubat, X2 Zerdali	S_7S_{12}
XI	Adilcevaz-5, Hacihaliloglu, Kabaasi, Kamelya, Zerdali No.2	S_9S_{13}
XII	Shalakh (Aprikoz), Voski	$S_{11}S_{13}$
XIII	Levent, Sakit-1	S_6S_{19}
XIV	Cekirge 52, X3 Zerdali	S_9S_{20}
0: Universal pollen donors	Canakkale (S_cS_c), Ethembey (S_cS_8), Karacabey (S_cS_2), Mektep (S_cS_8), Pasa Mismisi (S_cS_8), Sam (S_cS_2), Yerli Izmir (S_cS_7)	

Table 2. Cross-incompatibility groups of apricot (Halasz et al. 2010; Egea & Burgos, 1996; Halasz et al. 2005)

To date, 21 *S-RNase* alleles are known in European apricots, 20 of which (S_1-S_{20}) code for self-incompatibility and one (S_c) allowing self-compatibility (Burgos et al. 1998; Halasz, 2007; Halasz et al. 2005, 2007) and recently it was confirmed that S_C haplotype is a pollen part mutant of S_8 haplotype (Halasz et al. 2007). Beside, some additional *S*-alleles have been also identified in Chinese cultivars (Wu et al. 2009; Halasz et al. 2010).

A gradually decreasing allele number was detected in apricot landraces from China to Western Europe, with some allelic exclusivity occuring in certain geographic areas (Halasz, 2007; Halasz et al. 2010).

7. Genetic diversity of apricot based on molecular markers

Apricot is a temperate and subtropical zones fruit. China, the Irano-Caucasian region (Turkey and Iran), Central Asia, Europe and North America are the main producer regions in the world. The Central Asia is the oldest and the primary genetic source of apricot group is the Central Asian accessions are self-incompatible; the Irano-Caucasian apricots which are mostly the cultivated ones are mostly self-incompatible, with large fruits and low chilling requirements. The European and the North American apricots are originated from Irano-Caucasia has relatively narrow genetic diversity and are self-compatible with large fruits (Mehlenbacher et al. 1991). For a long period, genetic diversity in apricot was studied with pomological, morphological and phenological characteristics (Guerriero & Watkins, 1984). DNA-based markers that have been used in the last decade clarify the relationship among the apricot accessions.

For breeding and commercialization of promising apricot cultivars, a precise characterization and discrimination of the cultivars are prerequest. Different types of marker such as morphological, molecular, biochemical systems have been used for genetic analysis in horticultural plants. However, due to the effects of environmental factors, asessment of morphological and pomological traits may be ambiguous. Therefore, markers independent from the environment are necessary for reliable identification and discrimination of genotypes and cultivars. DNA markers are well known independent from environmental interactions and they show high level of polymorphism. Therefore, they are considered invaluable tools for determining genetic relationships/diversity. Various types of DNA markers are now available. Among them, RAPD developed by Williams et al. (1990) has been commonly used method in apricot to assess genetic variability and relationships among cultivars (Takeda et al. 1998; Zhebentyayeva et al. 2000; Hormaza, 2001; Mariniello et al. 2002; Ercisli et al. 2009). More recently, ISSR (Chenjing et al. 2005; Yilmaz, 2008), RFLP (De Vicente et al. 1998), AFLP (Hurtado et al. 2001, 2002; Hagen et al. 2002; Panaud et al. 2002; Geuna et al. 2003; Krichen et al. 2006; Yuan et al. 2007), SSR (Hormaza, 2002; Romero et al. 2003; Zhebentyayeva et al. 2003; Maghuly et al. 2005; He et al. 2006; Maghuly et al. 2006; Ali Khan et al. 2008) and SRAP (Uzun et al. 2010) techniques has also been used in apricot to characterize different cultivars belongs to diverse eco-geographical groups.

The diversity determined between apricot cultivars was probably due to crosses between wild and cultivated apricots and cultivars from different eco-geographic origin (Uzun et al. 2010). Microsatellite analyses suggested that European cultivars might have originated through hybridization among Irano-Caucasian genotypes and also most of the European cultivars have originated by hybridization with genotypes from the Irano-Caucasian group (Maghuly et al. 2005; Faust et al. 1998; Kostina, 1969). The heterozygosity of the apricot genotypes narrowed while apricot transfer from China to Europe. Pedryc et al. (2009) show that Middle European and Chinese apricot are distantly related.

Molecular markes have created new era in genetic diversity researches since early nineties. Restriction fragment length polymorphism (RFLP), and PCR based markers such as randomly amplified polymorphic DNA (RAPDs), sequence-related amplified polymorphism (SRAP), single nucleotide polymorphism (SNPs), micro-satellites or simple sequence repeats (SSRs) are mostly used marker systems in plants and also in apricot genetic divesity researches. Microsattelites among all is a very useful tool for apricot diversity studies, and most promising to cleary genetic relation among the apricots and travel routes of apricots (Romero et al. 2003; Maghuly et al. 2005).

Amplified fragment length polymorphism (AFLP) molecular markers assesment for the genotyping of 118 commercial apricot accessions and some related apricot species (Geuna et al. 2003). The researchers clustered the apricots into four groups corresponding to their geographic distribution; (1) Mediterranean apricots, (2) Chinese apricots, (3) apricots of continental Europe and (4) Europe-North American apricots. Their data confirmed that the migration of apricot from the East to West. They also showed with molecular markers that *Prunus sibirica* and *Prunus mandshurica* are different from *Prunus armeniaca*, but they group together with Chinese accessions (Geuna et al. 2003). In anohter study Romero et al. (2003) studied apricots by using of SSR markers to determine the genetic relationships among genotypes from different eco-geographical groups. They observed that Western European and North American subgroups clustered together in aggrement with their common origins from ancient European cultivars (Kostina, 1969; Bailey & Hough, 1975; Badanes et al. 1996). However their study placed Hungarian cultivars closer to the Central Asian group than to the other European cultivars.

Hayashi et al. (2008) studied Japanese apricot (*Prunus mume*) germplasm and reported that the genetic diversity and relationships among 127 Japanese apricot germplasms assessed by SSR markers. Their study supported the two hypotheses that Japanese apricot cultivated in Japan had been introduced from China and that fruiting cultivars had been selected from flower-ornamentals.

Turkish germplasm was studied by Yilmaz (2008) and Uzun et al. (2010) and genetic diversity and relationships among the accesessions were determined using RAPD, ISSR, SRAP and SSR markers. The researchers reported the high genetic diversity in Turkish apricots. Four high chilling requiring cultivars originated from Eastern Turkey clustered apart from the rest. European, South African, North American and other Turkish cultivars were not clearly grouped regarding to their geographic districts. Therefore the researchers suggested that these cultivars, despite their different geographic origins, have similar genetic background.

8. References

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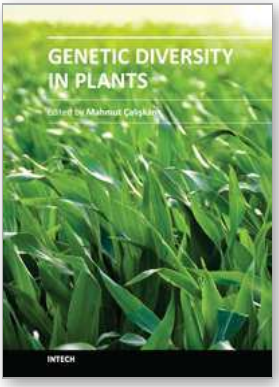

Genetic Diversity in Plants
Edited by Prof. Mahmut Caliskan

ISBN 978-953-51-0185-7
Hard cover, 498 pages
Publisher InTech
Published online 14, March, 2012
Published in print edition March, 2012

Genetic diversity is of fundamental importance in the continuity of a species as it provides the necessary adaptation to the prevailing biotic and abiotic environmental conditions, and enables change in the genetic composition to cope with changes in the environment. Genetic Diversity in Plants presents chapters revealing the magnitude of genetic variation existing in plant populations. The increasing availability of PCR-based molecular markers allows the detailed analyses and evaluation of genetic diversity in plants and also, the detection of genes influencing economically important traits. The purpose of the book is to provide a glimpse into the dynamic process of genetic variation by presenting the thoughts of scientists who are engaged in the generation of new ideas and techniques employed for the assessment of genetic diversity, often from very different perspectives. The book should prove useful to students, researchers, and experts in the area of conservation biology, genetic diversity, and molecular biology.