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Pomegranate Genetic Resources and Germplasm Conservation: A Review

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ABSTRACT

The genus *Punica* consists of two species, *Punica granatum* L. and *P. protopunica* Balf. Pomegranate is one of the oldest fruits known to mankind. It is important for its taste, nutritional and medicinal properties. The origin of pomegranate is considered to be in Central Asia from where it has spread to the rest of the world. Genetic diversity in pomegranate is found in a wide range of climatic conditions. Studies on center of origin, centers of diversity, characterization, evaluation and conservation would be useful for better understanding of this fruit plant and information on genetic resources and cultivars in pomegranate at different centers of the world would be quite useful for its utilization for crop improvement. In the present paper effort has been made to bring together information on pomegranate genetic resources, its conservation in different parts of the world.

Keywords: cultivars, crop improvement, diversity, germplasm

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INTRODUCTION

Punica granatum, commonly known as pomegranate belongs to family Punicaceae. The genus *Punica* consists of two species, *Punica granatum* L. and *P. protopunica* Balf. However, *P. nana* L. is an ornamental dwarf pomegranate and has been considered a distinct species by some authors (Melgarejo and Martínez 1992). It is native to Persia and is one of the oldest fruit known to mankind. The importance of pomegranate is not only for its taste but also for its nutritional and medicinal properties which helps in prevention of several medical problems in humans (Melgarejo and Martínez 1992; Melagarejo *et al.* 2000, 2004). Fruits are consumed fresh or processed for juice, syrup and other purposes. Different parts of the pomegranate tree (leaves, fruits and bark skin) have been used traditionally for their medicinal properties and for other purposes such as in tanning (Mars 2000).

The origin of pomegranate is considered to be in Central Asia, especially parts of Iran in the Transcaucasia-Caspian region (Harlan 1992) from where it has spread to the rest of the world (Simmonds 1976; Levin 1994). *P. protopunica* is endemic to Socotra Islands (Yemen) and is the only relative of the cultivated pomegranate (Zukhovskij 1950; Moriguchi *et al.* 1987; Guarino *et al.* 1990). It is presumed that *P. protopunica* has a role in the origin of *P. granatum.* However, some authors disagree with this view (Zuhkovskij 1950). Pomegranate was introduced from the Mediterranean region to the rest of Asia, North Africa, Europe and into the Indian peninsula where it was first reported to be grown in Indonesia during the 15th century (Levin 2006). Pomegranate is one of the earliest fruit crop to be domesticated. Historical evidence suggests that pomegranate was first planted during the 4000 and 3000 BC. Although, pomegranate has undergone intense selection pressure due to domestication, there is little difference between the domesticated and cultivated forms. The probable progenitor of pomegranate is very similar in appearance to the

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domesticated form, differing mainly in the fruit size (Still 2006). The process of domestication in pomegranate resulted in plants with larger seeds and fruit, non-dehiscent fruits and seeds, and different seed or fruit color (Harlan 1992; Hancock 2004). Today, pomegranate is cultivated throughout the world in subtropical and tropical areas in many variable climatic conditions. Mediterranean countries viz., Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, North Africa, Portugal, Spain, Syria, Turkey are the main center for commercial cultivation of pomegranate followed by Asian countries i.e. Afghanistan, Bangladesh, China, India, Iran, Iraq, Myanmar, Thailand, Vietnam and Armenia, Georgia, Kazakhstan, Kirgizstan, Tajikistan, Turkmenistan in the former USSR. There are reports of pomegranate cultivation in some parts of Argentina, Australia, Brazil, Chile, South Africa and The United States (La Rue 1980; Mars 1994; Frison and Servinsky 1995).

GENETIC DIVERSITY AND GERMPLASM COLLECTION

Pomegranate is adapted to a range of climatic conditions; therefore, it has a wide range of geographic distribution. Due to long history of use, a good amount of genetic diversity exists in this plant. It is a self-pollinated species with approximately 13% cross pollination (Jalikop 1990). The seedlings are not true to type and therefore, a lot of plant to plant variation exists in pomegranate. Its more than 500 varieties are known throughout the world, however, only a few (approx. 50) varieties are known to be in commercial cultivation (IPGRI 2001). The practice of utilizing only a relatively small portion of the total genetic diversity for commercial purposes is not only true with pomegranates but other crops also have similar trend. This has resulted in drastic reduction in genetic diversity in the modern cultivars of pomegranate. However, a good amount of genetic diversity exists in its wild progenitors. Hence, it is extremely important to conserve the genepool of wild forms along with cultivars to maintain a broad genetic base for future improvement of pomegranate through breeding and other programs.

Several international efforts have been initiated to collect, conserve and evaluate pomegranate germplasm. One of the richest areas for genetic diversity of pomegranate exists in Turkmenistan, which possesses rich diversity, but because of severe and widespread ecological degradation the wild pomegranates are threatened from these areas. Interestingly, wild and domesticated pomegranate collections have been reported in Asia, Europe, North Africa and North America. In addition, Albania, Cyprus, Italy, Spain, France, Germany, Hungary, Israel, Portugal, Russia, Tunisia, Turkey, Turkmenistan, Ukraine, the USA and Uzbekistan hold good genetic diversity in pomegranate (Frison and Servinsky 1995; Still 2006). A diverse collection of pomegranate also exists in India, Iran, Morocco, China, Greece, Egypt, and Tajikistan (Mars 2000; Fadavi *et al.* 2006; Zamani *et al.* 2007). However, the largest collection is at the Garrygala, Turkmenistan, and St. Petersburg, Russia (Still 2006). Recently, Levin (2006) has reported that the collection at Garrygala was destroyed when Turkmenistan separated from Russia.

WORLD WIDE GERMPLASM AVAILABILITY

Genetic diversity in pomegranate of some important countries has been detailed below and the centers maintaining the pomegranate collection in different counties has been listed in **Table 1**.

China

In China, there are several reports of diverse germplasm resources (Feng *et al.* 1998, 2000, 2006; Yang *et al.* 2007). More than 80 accessions of pomegranate exist in six geographical populations located at Shandong, Anhui, Shaanxi, Henan, Yunnan, and Xinjiang Provinces (Yuan *et al.* 2007). Chinese cultivars are characterized by a very large variability and sometimes unusual features, such as spur-type growth habit, double flowers, and white flowers and have small to very large sized fruits of sour or sweet taste. Some of the Chinese cultivars are very early, beginning in early August, and some are late, ending the season in November. Evergreen cultivars are also known (Dong 1997). Most Chinese cultivars are either selections from unknown origin or seedlings of known cultivars.

India

The Indian Himalayas holds a good diversity of wild pomegranates. The evergreen pomegranate cultivars have been reported to be originated in India (Singh *et al.* 2006). Therefore, the Indian center is expected to have a good genetic diversity in pomegranate varieties (Gulick and Van Sloten 1984; Mars 2000). Survey of wild pomegranates from the western Himalaya shows availability of a highly diverse collection of pomegranate in India (Rana *et al.* 2007). A number of important pomegranate varieties have also been introduced from different countries by the National Bureau of Plant Genetic Resources which have been characterized and conserved in the field gene banks at NBPGR Regional stations. Under the aegis of Indian Council of Agricultural

Table 1 A few sources of pomegranate germplasm availability in the world.

Country	Institute
Afghanistan	Kabul University, Kabul
Albania	Research Institute of Fruit Trees and Vineyard, Tirana
Cyprus	Agricultural Research Institute, Nicosia
France	CIRAD-FLHOR, Capesterre Belle-Eau
Hungary	University of Horticulture and Food Industry, Budapest
India	National Bureau of Plant Genetic Resources, Regional Station, Bhowali
	National Research Center on Pomegranate, Solapur
Iran	University of Tehran, Karaj
	University of Mashhad, Mashhad
Israel	Newe Yaar Research Center, Agricultural Research Organization Bet-Dagan
Italy	Institute of Agricultural Sciences, Verona
Jordan	National Center for Agricultural Research and Extension, Amman
Portugal	National Fruit Breeding Station, Alcobaça
Russia	NI Vavilov Research Institute of Plant Industry, St. Petersburg
South Africa	Alternafruit SA (Pty) Ltd., Wellington
Thailand	Chiang Mai, Bangkok
Tunisia	U.R. Agrobiodiversite, Institute Superieur Agronomique, Sousse
Turkey	Alata Horticultural Research Institute, Erdemli- Mersin-Turkiye and Cukurova University, Turkey
Turkmenistan	Turkmenian Experimental Station of Plant Genetic Resources, Garrygala
USA	USDA-ARS National Clonal Germplasm Repository, Davis, California
Uzbekistan	Schroeder Uzbeck Research Institute of Fruit Growing, Viticulture and Wine Production, Tashkent

Research (ICAR), a National Research Center on pomegranate, Solapur is actively involved in pomegranate collection and improvement programs in India. A significant proportion of Indian cultivars have been originated from active breeding programs. The Indian varieties have been characterized for sweet flavour low-acid, soft seeds, small to medium fruit, thin rind, and more juice content. The enormous area of the Deccan Plateau and its very divergent climatic zones clearly require cultivars that are adapted to each of the regions. In India, pomegranate has a tremendous potential for the production and export of good quality pomegranates which remains considerably untapped at present.

Iran

More than 700 accessions of pomegranate have been reported from the Yazd pomegranate collection (Shahrbabaki 1997; Zamani *et al.* 2007). These have been collected from different provinces and obvious similarities in appearance of the cultivars were observed among them (Zamani *et al.* 2007). These characteristics features of Iranian cultivars are late ripening, medium to large size with thick red rind and red arils. In addition, several other Iranian cultivars are important for earliness in maturity during August and are considered good for the export market. However, late maturing cultivars are also found in the Iranian collection which can be picked up to the month of December. Taste wise both sweet and sour type of the germplasm material is preferred in Iran. The Iranian collection is of special interest since it is expected to contain some of the more diverse pomegranate germplasm (Baddaf *et al.* 2003; Zamani *et al.* 2007).

Israel

The Israeli collection at the Newe Ya'ar Research Center contains more than 60 accessions which represent collection from Israel (including semi wild accessions) and introduced from the USA, Spain, China, India and Turkey. These accessions have been characterized for morphological characteristics excluding the effects of micro climatic conditions. The Israeli collections have been characterized for various phenological and morphological characteristics (Assaf *et al.* 1991; Bar-Yaakov *et al.* 2007). The Israeli germplasm collection was analyzed for its antioxidant constituents and levels of ellagic acid, punicalagin, punicalin, and galagic acid were reported to be the major contributors to antioxidant activity (Tzulker *et al.* 2007).

Russia

One of the most important and oldest collections of pomegranate is at the Garrygala Experimental Station established by N.I. Vavilov in 1934 in Turkmenistan. It has the world's largest collection and comprises of germplasm from more than 27 countries. This collection contains wild material (Levin 1978, 1979, 1981) as well as pomegranate cultivars. The Garrygala collection also has specimens from Transcaucasia and foreign countries such as Spain, the USA, Iran, Tajikistan and India. This collection also represents accessions from the central Asian region which is considered the center of origin of pomegranate. High levels of morphological diversity, including dwarf, decorative specimens, varieties which differ in shape, color, resistance to splitting, date of ripening, taste, juice content, and seed size etc. exist in this collection (Levin 1994). The pomegranate accessions maintained at Garrygala field genebank have economically-valuable traits and qualities that are important for breeding. The accessions have been characterized for resistance to frost and sunburn, high yield, large seeds, taste, high vitamin 'C' content, high juice yield, thin peel, long shelf life, and resistance to pests and disease. After the breakup of the former Soviet Union, this station has faced significant difficulties in managing its activities due to resource crunch. Many of the existing accessions are yet to be characterized and documented. The germplasm material maintained at the station is very valuable therefore a few international organizations have initiated efforts to assist this center and support characterization, evaluation and documentation of the pomegranate collection (IPGRI 2001).

Tunisia

This region is the most important secondary centre of origin and diversification of this crop (Levin 1994). The collections were made from traditional plantations and *ex situ* conserved in pomegranate germplasm collections at Gabès and Chott Mariem (Mars 2001). In Tunisia, more than 60 accessions have been identified mainly according to their geographical origin and fruit colour. Its utilisation includes numerous ecotypes locally called cultivars, which are clonally propagated by cuttings and they are selected by farmers mainly for their fruit qualities (Levin 1995; Mars 1996; Mars and Marrakchi 1999).

Thailand

A collection of 29 cultivars was established in Thailand (Thongtham 1986). Only five specimens of this collection are from Thailand and the rest are from India, the United States, Israel, Russia, Iran, Spain, and Italy.

Turkey

In Turkey, the Alata Horticultural Research Institute has a collection of more than 180 accessions. This collection contains genotypes from the Mediterranean, Aegean, South Eastern and Bitlis Turkish regions (Onur 1983; Onur and Kaska 1985; Ozguven *et al.* 1997; Ozguven *et al.* 2000). The collection also represents samples from the central and west Asia regions as well as Russia and the United States.

Ukraine

The Nikita Botanical Gardens of the Ukraine Academy of Agrarian Sciences (UAAS) was established in Crimea near Yalta on the Black Sea coast in Ukraine. A number of fruit plants including pomegranates have been conserved at this center. A collection of 370 accessions of pomegranate exist at this center which includes accessions from central Asia, Transcaucasia, Iran, Afghanistan, Spain, Italy and the United States.

United States of America

The USDA, National Clonal Germplasm Repository in Davis, California, has around 200 pomegranate accessions. The collection includes accessions from all over the world including Turkmenistan, Russia, Iran, and Japan (Stover 2007; USDA 2007). A significant proportion of the accessions are comprised of pomegranate cultivars introduced from Iran, Italy, Japan, Russia, Turkemenistan, USA and other sources.

CULTIVARS

Interesting pomegranate cultivars were reported from several locations all over the world, including Azerbaijan, China, Cyprus, Egypt, France, Greece, India, Iran, Israel, Italy, Kirgizstan, Morocco, Russia, Spain, Tunisia, Turkey, Turkmenistan and other countries by different authors. These cultivars are spread world over in different continents and it is probable that some of the pomegranate cultivars acquired different names in different countries and are same basic genotypes. The names of the cultivars give an idea about its place of origin. For example, the cultivars Kabul or Kandahari in the Indian collections hint to their possible origin from the Kabul and Qandahar provinces of Afghanistan. Similarly in the collection from Turkmenistan, one can find names such as Afghansky, Washingtonsky, Iran 29-3, and

Table 2 List of some important pomegranate cultivars.

Country	Accessions
China	Baihuayushizi, Baipisuan, Baiqianceng, Bingtangdong, Bingtangzi, Chongbaihongsuanshiliu, Chongbanmanao, Dabenzi, Dafenpi, Dahongpao, Dahongpisuan, Dahongpitian, Dahongsuan, Dahongtian, Damayatian, Daqingpisuan, Daqingpitian, Fenpiyushizi, Hetianpisuanshiliu, Heyinbopi, Heyinhuapi, Heyinruanzi, Heyinsanbai, Hongbaoshi, Hongfenpi, Hongpimayatian, Houpibenzi, Huanghua, Huilihongpi, Huilihuangpi, Jingpitian, Juzimi, Kaifengdahongtian 1, Kaifenglijihong, Linxuan-1, Linxuan-2, Linxuan-4, Linxuan-20, Luoke-4, Luyusuan, Manao, Mapitian, Miandianjuxing, Moshiliu, Mudanshiliu, Piyaman, Qiaojianuoni, Qingpibenzi, Qingpigangliu, Qingpiruanzi, Qingpixiehuatian, S1, S2, S3, S4, S5, S6, S7, Sanbai, Sanbaishiliu, Sanbaitian, Taishanhong, Taishansanbaishiliu, Tianhongdan, Tianlvzi, Xiaohongpitian, Yanshuitongke, Yechenghongzi, Yichuanling, Yuejishiliu, Yuliangbai, Yushiliu-1, Yushiliu-3, Yushiliu-5, Yushiliu-2, Yushizi, Zaozhuangduanzhihong and Zhenzhuhong.
EMFTS Database	Agridulce De Ojós 2, Agridulce De Ojós 3, Agridulce De Ojós 4, Agriniou, Albar De Blanca 1, Altsanidis Lefkadia 1, Altsanidis, Efkadia 2, Altsanidis Lefkadia 3, Altsanidis Lefkadia 4, Borde De Albatera 1, Borde De Blanca 1, Borde De Ojós 1, Casta Del Reino 1, Casta Del Reino 2, Chatzipsaltis, Dente Di Cavallo, Gitcos, Grafiadelis Imvros, Grafiedelis (1) Imvros, ICA-Pa 1 to 15, Ipsilantis, Lefladia, KT 1 to KT 9, Mollar De Albatera 1to 5, Mollar De Crevillente 1, Mollar De Elche 1 to Mollar De Elche 21, Mollar De Elche 31, Mollar De Orihuela 2 to Mollar De Orihuela 6, Neirana, Neromilos Gliko, Ntazis Xehasmeni, Pantazis Kavasila, Pavlidou Marina 1, Pavlidou Marina 2, Pavlidou Marina 3, Piñón Duro De Ojós 1, Piñón Duro De Ojós 2, Piñón Tierno De Blanca 1, Piñón Tierno De Ojós 1to 9, Piñonenca De Blanca 1, Prinolofos Platanias 1, Prinolofos Platanias 2, Profeta Partanna, Profeta Partanna, Puente Genil, Punica Nana 1 to Punica Nana 3, Racalmuto, Ragana, Rossa, Samaras, San Felipe De Blanca 1, Selinunte, Temenos Paranestiou 1, Temenos Paranestiou 2 and Valenciana De Albatera 1.
India	Achikdona , Alandi, Anar Bassein, Bedana, Bhagwa (Kesar), Bosco, Chawla, Dholka, Ganesh, Guleshah Jalore, Jodhpur Red, Jyoti, Kabul Yellow, Kandhari Malta, Muskat, Mridula, Arkta Nabha, Nana, Sharin, Srinagar Special and around 60 accessions of wild and introduced germplasm.
Iran	Alak Shirin, Alak Torsh, Ardesstani Mahvalat, Bajestan, Bajestani Gonabad, Esfahani Daneh Ghermez, Galou Barik, Ghojagh Ghoni, Khazr Bardaskn, Malas Yazd, Malas-e-Saveh, Malas-e-Yazdi, Maykhosh, Naderi-eBudrood, Rabab-e-Neyriz, Sefid, Tagh Gardan, Shavar Daneh Ghermez, Sishe Kape-Ferdos and Zagh.
USA	1/25 Rannii, 15/4 Pamyati Rozanova, 31/69, 32/30, Abdandan, Afganski, Agat, Alk Pust Ghermez Saveh, Al-sirin-nar, Ambrosia, Andalib, Anvari, Apseronski, Apseronski krasnyj, Ariana, Azadi. Bala Miursal, Balegal, Balkan, Blaze, Bejestoni, Cana, Chandyr, Chernaya Roza, Chico, Cloud, Crab, Cranberry, Dahistan, Dokhtar-hamomi Desertnyi, Dewey, Dorosht 5 hahanshahi Khoramabad, Dotch Legrelley, Double Red, Double Red #2, Double Red-white, Elf, Entek habi saveh, Eve, Fleischmans, Girkanets, Gissarskii Alyi, Gissarskii Rozovyi, Gold, Golden Globe, Golnar, Green Globe, Gulistan, Gulyalek, Haku-botan, Haku-taka, Hotuni Zigar, How Sweet It Is, Hvalynskii, Hyrdanar x Goulosha, Hyrdanar x Kirmizy-Akbuh, Ink, Kaim-anor, Kaj-acik-anor, Kara bala miursal, Kara Gul, Kara-Kalinskii, Kazake, Kemine, King, Ki-zakuro, Koinekasyrskii Kislosladkii Krasnyi, Kopetdag, Kubarchatyi, Kukurchinskii, Kunduzski, Kyz-Bibi, Loffani, Loulou, Lyubimyi, Malas Yazdi, Machtumkuli, Mae, Mahali Dezful, Medovyi Vahsha, Mejhos 6269, Messarian, Molla Nepes, Myagkosemyannyi Rozovyi, Myatadzhy, Nikitski ranni, Nisa, Nochi-shibori, Orange, Ovadan, Palermo, Parfianka, Parfyanets, Parfyanka, Phoenicia, Pink, Podarok, Purple Heart, Rosamia, Saartuzski (Yalta), Saharnyi, Sakerdze, Salavatski, Seidi, Sejanec 2-5/8, Shainakskii, Shihimderinskii, Shahidaneh, Suskiand Shahsavar. Shirin Pust Ghermez Saveh, Shirin Zigar, Sirenevyi, Small Leaf, Sogdiana, Sour, Sumbar, Sumbarskii, Surh-anor, Sverkhranniy, Syunt, Tabestani malas BIranden saveh, Toghmalas, Toryu-shibori, Turan, Vina, Vishnevyi, Vkusnyi, White Flower, Wonderful, Zubejda (Denau).
Tunisia	Andaloussi, Beyounsi, Chelfi, Florepleno Panaché, Gabsi, Gabsi Khadhouri, Garoussi, Garoussi Sahel, Jebali, Kalaii, Nabli, Tounsi, Zaghouani and Zehri.

Kalifornijsky (Levin 1996). In China pomegranate is known as "An Shi Uu", which means "the fruit of Kabul", thereby giving a hint about its origin in Afghanistan (Fazzioli and Fazzioli 1990). Though there is some confusion over the authenticity of names of the cultivars and their distinguishing characteristics, many cultivars can be clearly distinguished. The criteria for selecting fruits may be different at different places. In India, acidic fruit is not liked so non-acidic cultivars are selected. However, Israeli people prefer sweet-sour cultivars. Thus, part of the variability in pomegranate cultivars in the world is a reflection of the different tastes and priorities in each country. Most of the cultivars known today are selections from an unknown origin, mostly chance seedlings or mutations collected from places where there are no records documenting their origin. A list of some of the important cultivars maintained at different centers of the world is given in **Table 2**.

GERMPLASM CHARACTERISATION AND CONSERVATION

Morphological, biochemical and molecular markers have provided robust mechanisms for assessing genetic diversity in pomegranate. Diversity studies using various morphological and molecular markers in pomegranate cultivars have been done by various workers (**Table 3**). Morphological markers like woody and edible portions of seeds and chemical markers (e.g. pH of juice, acidity, soluble solids, etc.) was evaluated in indigenous cultivars from southeastern Spain (Martínez *et al.* 2006). Anthocyanin types and content have been assessed in Iranian cultivars Alighourchi and Barzegar 2009). RAPD as a molecular marker has been successful is analyzing genetic relatedness in several from Iran (Sarkhosh *et al.* 2009) and Turkey (Ercisli *et al.* 2007). Jbir *et al.* (2008) have found AFLP markers to be informative in distinguishing and also for survey the genetic diversity in pomegranate. Genetic diversity of the wild pomegranate collection of the Indian Himalayas is reported to have a good amount of genetic diversity and molecular studies have revealed varied patterns of diversity among those accessions (Narzary *et al.* 2009; Ranade *et al.* 2009; Narzary *et al.* 2010). The Tunisian collection has been reported to be highly divergent as revealed by the genetic studies (Hasnaoui *et al.* 2006; Jbir *et al.* 2006). The Turkey collection suggested a narrow variation and lack of significant genetic divergence (Aradhya *et al.* 2006; Yilmaz and Ozguven 2006) based upon RAPD and AFLP studies. As pointed out by Still (2006), much more sophisticated and elaborate research in pomegranate genomics will be required to reliably assess evolutionary relationships among different pomegranate accessions and relate genetic markers to morphological characteristics. It is highly probable that there is considerable redundancy among accessions.

Pomegranate germplasm conservation is mainly done in the field gene banks. However, recent reports on *in vitro* studies have been proved successful in pomegranate (Naik *et al.* 2003; Naik and Chand 2006). This technique can also be applied for transfer of germplasm between laboratories and reducing phytosanitary and quarantine problems.

Table 3 An account of different studies on germplasm characterization in pomegranate.

Type of study	Cultivars	References
Amount of major anthocyanins in cultivars from Iran	Shirin Shahvare Yilzd, Gorche Shahvar Yazdi, Malase Yazdi, Vahshe Kane Tehran, Mesri Torshe Kazeron, JangaU Pust Germeze Rodbare Torsh, Torshe MamoU Lasjer, Ardestani Torshe Semnan, Khoram Dizin Torshe Gorgan, Toghe Gardan, Zaghe Yazdi, Tabo Larze Mehr Mahi, Sefeede Robi Aval Brojen, Pust Syahe Yazd and Malase Porbarij Stahban.	Alighourchi *et al.* 2008
Fatty acid composition and RAPD profiles in collection from Turkey	Cekirdeksiz, Kirmizi kabuk, Siyah nar, Nuz eksi, Yesil kabuk and Kirli hanim.	Ercisli *et al.* 2007
AFLP analysis for cultivars collected from different places	Andaloussi, Beyounsi, Chelfi, Florepleno Panaché, Gabsi, Gabsi Khadhouri, Garoussi, Garoussi Sahel, Jebali, Kalaii, Nabli, Tounsi, Zaghouani and Zehri.	Jbir *et al.* 2008
Pomegranate diversity in Tunisia	Andalousi, Bellahi, Chelfi, Daroussi, Gabsi, Garoussi, Jebali, Kalaii, Mezzi, Tounsi, Zaghousani and Zehri.	Mars and Marrakchi 1999
DAMD and RAPD methods to study genetic diversity in wild genotypes in India	Forty-nine accessions representing two regions of Western Himalayas.	Narzary *et al.* 2009a
ISSR analysis for Genetic diversity across natural populations of Indian pomegranate	Collections from Dehradun Pithoragarh, Nainital, Almora, Tehri, Kangra, Mandi and Kullu.	Narzary *et al.* 2009b
SPAR profiles of Natural population from India	Collections from Assam, Mizoram, Madhya Pradesh, Maharashtra, Uttrakhand, Uttar Pradesh and Tamil Nadu.	Ranade *et al.* 2009
RAPD to determine diversity level among Iranian genotypes	Aghamohamad Ali, Alak Saveh, Alak Shirin, Alak Torsh, Amane Khatoni, Berit Kazeroon, Bihaste Ardestan, Bihaste Haji Abad, Gorch Shahvar, Haste Riz Shahdad, Malas Torsh, Nabati, Poost Sefid Bihaste, Poost Sefid Shirin, Poost Sefid Torsh, Poost Siyah Ardestan, Poost Siyah Saveh, Poost Siyah Shirin, Shirin Saveh, Tabestane Torsh and Zagh.	Sarkhosh *et al.* 2006
RAPD-based analysis of Iranian collection	Bihaste Neiriz, Bihaste Najaf Abad, Bihaste ladiz, Bihaste Dane Sefide Ravar, Behaste Sistan va Baloochestan, Bihaste Porbar Shirin, Bibaste Shirin Najaf Abad, Bitolf Dane Ghermez, Bihaste Khafre jahrom Bihaste Sangan, Bihaste Shirin Khabre Baft, Bidane Kashmar, Bihaste Ghasrodasht, Bihaste Shirin Kambar, Bihaste Ardestan, Bitolf Dane Sefid, Bihaste Shirin Saravan, Bidane Darjazin, Bihaste Chenche, Bihaste Dane Ghermez Kerman and Bihaste Hajiabad.	Sarkhosh *et al.* 2009

CONCLUSION

Pomegranates which have a long history of existence in different parts of the world still remain as a minor horticultural tree crop. It has a wide adaptability to a varied range of climatic conditions and therefore attention from the policy makers is required for better utilization of pomegranate germplasm. Detailed studies on center of origin, centers of diversity, characterization, evaluation and conservation (*in situ* and *ex situ*) would provide better understanding of this fruit plant. The research on pomegranate requires a mission-oriented approach to upgrade its quality as well as productivity through breeding superior varieties. There is a need for better production technologies and solving the problems arising from various kinds of stresses. This can be attained by tapping the potential of pomegranate genetic resources available globally. The wild germplasm can be screened for the desirable traits and used in breeding programmers. Numerous studies on genetic diversity indicated enough polymorphism among the landraces which can also be utilized for crop improvement. Collecting and evaluating more pomegranate populations for various characteristics may help in selecting desirable types. There is a need to assess various "adding value" initiatives to pomegranate crop diversity in order to link it with economic development of the farmers in traditional production systems. Free movement of pomegranate germplasm among the countries for research purpose with limited restrictions will help the growth of pomegranate industry in the world.

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