



Review

Pomegranate biology and biotechnology: A review



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ABSTRACT

Pomegranate (*Punica granatum* L.) is one of the oldest known edible fruit tree species, originating in Central Asia, but with a wide geographical global distribution, reflecting its adaptation to a wide range of climatic conditions. It is important for its nutritional, medicinal and ornamental properties and its high consumption and industrial value. In a bid to better utilize and improve the current genetic resources, there is a need to understand and appreciate studies related to the use, centre of origin and diversity, as well as the characterization, evaluation and conservation, taxonomy and systematics of the genus *Punica*. In addition to understanding the basic biology of the plant, how biotechnological tools, including cell and tissue culture and micropropagation (i.e. somatic embryogenesis, organogenesis, synthetic seeds, somaclonal variation, mutagenesis, haploidy, and *in vitro* conservation), genetic transformation and marker technology, have been used to improve pomegranate germplasm are all topics that have been covered in this review.

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1. Introduction, origin, history and domestication

The present scientific name of pomegranate, *Punica granatum*, is derived from the name *Pomum* (apple) *granatus* (grainy), or seeded apple. Pomegranate is native to Persia and possibly also to some surrounding areas. Moreover, it is believed that the origin is in Central Asia, particularly parts of Iran, from where it spread to the rest of the world (Harlan, 1992; Simmonds, 1976; Levin, 1994, 2006a; Verma et al., 2010). According to Levin (2006a,b, and reviewed by Chandra et al., 2010a), there are three mega-centers (primary, secondary and tertiary) and five macro-centers (Middle Eastern, Mediterranean, Eastern Asian, American and South African) of origin and genetic diversity of pomegranate. It was cultivated in ancient Egypt and early in Greece, Italy and Iraq. Later, it spread into Asian countries like Turkmenistan, Afghanistan, Iran, India, China, North Africa and Mediterranean Europe (Melgarejo and Martínez, 1992). The pomegranate family has a single genus *Punica* with two species viz., *P. granatum* and *P. protopunica*. The latter is considered to be the ancestor of the genus *Punica* which might have contributed to the evolutionary process of the cultivated form of pomegranate. *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*. According to Levin (2006a), “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”. Chandra et al. (2010a) provide a detailed description of the history of pomegranate, which was one of the earliest fruit crops to be domesticated and was first planted during 4000 and 3000 BC and is among one of the oldest known edible fruits, even mentioned in the Bible and the Koran. Despite pomegranate’s intense selection pressure due to domestication, there is little difference between the domesticated and cultivated forms. Still (2006) claims that the probable pomegranate progenitor has a very similar appearance to the domesticated form, but that the primary difference would be fruit size, although domestication resulted in larger seeds and fruit, non-dehiscent fruits and seeds, and different seed or fruit color (Harlan, 1992; Hancock, 2004).

The domestication of pomegranate started somewhere in the Neolithic era (Levin, 2006a; Still, 2006), initially in the Transcaucasia-Caspian region and northern Turkey (Zohary and Spiegel-Roy, 1975; Harlan, 1992). Since approximately 13% of

outcrossing occurs in pomegranate (Jalilop and Kumar, 1990), seedlings are not “true to type” resulting in plant-to-plant variation. As a result, morphological changes might have occurred during domestication, distinguishing cultivated forms from the non-domesticated progenitor. However, pomegranate selections are made on the basis of flower, rind and aril colour, fruit size, sugar and acid contents, resistance to biotic and abiotic stresses, yield, keeping quality, seed hardness, etc. (Harlan, 1992; Hancock, 2004; Levin, 2006a; Holland et al., 2009).

Today, pomegranate is cultivated throughout the world in subtropical and tropical areas in many variable climatic conditions, indicating its flexibility, adaptability, and wide range of genetic diversity. Mediterranean countries are the main center for commercial cultivation of pomegranate followed by Asian countries and countries of 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). The genetic diversity of pomegranate is demonstrated by an excess of 500 globally-distributed varieties, approximately 50 of which are known to be commercially cultivated (IPGRI, 2001). This practice has resulted in a drastic reduction in genetic diversity of modern pomegranate cultivars, although a good amount of genetic diversity exists in its wild progenitors. Hence, it is extremely important to conserve the gene pool of wild forms as well as of cultivars to maintain a broad genetic base for future improvement of pomegranate through breeding and other programs (Rana et al., 2007).

There is a considerable effort by international groups working on pomegranate biodiversity to collect, conserve and evaluate pomegranate germplasm from around the world (Frison and Servinsky, 1995; Mars, 2000; Fadavi et al., 2006; Levin, 2006a; Still, 2006; Zamani et al., 2007a), the largest collection being in Russia (Still, 2006). Genetic diversity in pomegranate of some important countries as well as detailed listings of important cultivars and germplasm on a country-by-country basis has been provided in considerable detail by Verma et al. (2010).

India has globally the largest area of pomegranate culture and production (Jadhav and Sharma, 2007; reviewed in Chandra et al., 2010b). Iran is the greatest exporter (60,000 t) followed by India (35,176 t) (Holland and Bar-Ya’akov, 2008; Chandra and Jadhav, 2009). There is no exact data available on area and production in the world due to the rapid increase in the production and expansion, although it is estimated that around 1.5 million tonnes of

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