REVIEW ARTICLE

A REVIEW ON AVAILABILITY, UTILIZATION AND FUTURE OF EGG PLANT GENETIC RESOURCES IN INDIA

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Abstract: Egg plant is one of the most important indigenous vegetable crops of India, cultivated in the tropical and subtropical regions of the world. The global production of the crop has been seriously affected by various biotic and abiotic stresses and development of pest and disease resistance is a major challenge in brinjal breeding. Many wild species of the genus Solanum are available in the country, which have not been efficiently utilized in breeding programs. The present review attempted to gather information on the genetic resources of egg plant available, their distribution, sources of resistance to various pests, diseases and abiotic stresses and opportunities in their utilization for crop improvement programs using conventional and biotechnological interventions.

Keywords: *Solanum*, Genetic resource, Stress, Utilization

INTRODUCTION

Egg plant (*Solanum melongena* L.), also known as aubergine or eggplant is one of the most important vegetables cultivated throughout the warmer regions of the world. The crop is widely cultivated in the tropical and subtropical regions of both the hemispheres, especially in West Indies and southern United States. In India, Brinjal is the fourth important vegetable in terms of production (8.1%) after potato, tomato and onion while India enjoys second largest position in the world contributing 27.55 per cent of global production. Yet the productivity (17.5t/ha) is much lower than the word average (25t/ha), with only 0.01% share in the world export (Vanitha *et al*., 2013; APEDA, 2011). India's share in the world export of egg plants have drastically come down from 0.54% (2006) to 0.03% during 2010 wherein the demand from the major importing countries like Canada, Bahrain and Netherlands fell down sharply. This is because of various factors especially, due to the inferior quality of the produce through insect infestation. Though many varieties have been released with better yield and quality, development of pest and disease resistance is a major challenge in brinjal breeding.

Solanum Linnaeaus is one of the largest diversified groups of the Solanaceae family with more than 1250 species distributed throughout the tropics and sub-tropics (Mabberley, 2008). Although many researchers have varied opinion regarding the origin of egg plant, there is consensus that India or Indo-China is the Centre of diversity (Bhaduri 1951; Vavilov 1951; Zeven and Zhukovsky 1975; Lester and Hasan1991). Occurrence of about 42 species of *Solanum* has been reported in India (Deb, 1980). But the wild relatives of egg plant have not been utilized to their full potential in breeding programs due to lack of knowledge on their distribution, potential utility and reproductive biology. Egg plant is prone to many diseases such as *Fusarium* and *Verticillium* wilts, bacterial blight, *Phomopsis* blight, little leaf and nematodes (Gowda *et al*., 1974, Gopinath and Madalgeri, 1986, Sihachakr *et al*., 1993). The cultivated brinjal shows tolerance to majority of its pests like the shoot and fruit borer (*Leucinodes orbonalis*), leaf hopper (*Amrasca biguttula*), aphids (*Aphis gossypii*) and *Epilachna* beetles, but at rather lower levels (Raj and Kumaraswamy, 1979, Bindra and Mahal, 1981, Sambandam and Chellaiah, 1983, Messiaen, 1989, Daunay *et al*., 1991, Rotino *et al*., 1997). Use of wild species and relatives in the crop improvement programmes to gain vigour and resistance has been well recognized (Sarvayya, 1936). In 1977, egg plant was included in the list of species having priority for genetic resources preservation (Daunay *et al*., 1997). Eggplant ranks high among crops whose wild gene pools are poorly represented in ex situ collections and need urgent conservation (Muteqi *et al*., 2015). The present review attempts to gather information on distribution of genetic resources of egg plant available in India, their potential uses and challenges in their utilization in the crop improvement programmes.

Origin and distribution

India is considered as the centre of diversity for egg plant by many scientists. There are about 28 non-tuberous *Solanum* species found wild in india viz., *S.acculeatissimum, S. albicaule, S. arundo, S. barbisetum, S.dubium, S. dulcamara, S. elaegnifolium, S.erianthum, S. giganteum, S. glaucophyllum, S. gracilipes, S. grandiflorum, S. hispidum, S. incanum, S. indicum, S.kurzi, S. melongena var insanum, S. myriacanthum, S. nigrum, S. pubesense, S.sysimbrifolium, S.spirale, S. stramonifolium (*syn. *S. ferox), S. surattense (*syn. *S. xanthocarpum), S.torvum, S.trilobatum, S. vagnum and S. viarum (*syn. *S. khasianum*). In India, western

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and eastern peninsular regions and north eastern region exhibit maximum species diversity (Arora and Nayar, 1984). *Solanum incanum*, reported as a progenitor of *S. melongena* by many workers (Lester and Hasan, 1991) is widely distributed in at least 10 habitats in India (Arora and Nayar, 1984), especially in the Punjab and Kumaun hills upto 1200 m, Rajasthan and Sourashtra in Gujarat and is closely related to the semi wild weedy form *S. melongena* var. *insanum*. *Solanum acculeatissimum*, a very spiny shrub is seen wild in Kerala and Assam in damp and waste places. *S. dulcamara* or bitter sweet is a climbing shrub, frequently found in the temperate Himalayas from Kashmir to Sikkim at altitudes of 1200-2400 m. *S. elaegnifolium*, also known as white horse nettle is an exotic deep root spiny weed native to tropical America and naturalized in India. It is met within cultivated fields and gardens of Coimbatore. *S. erianthum*, commonly called as potato creeper, is shrub or small tree upto 6m tall, found growing throughout the tropical and subtropical India and the Andamans. It is also cultivated in south India for its fruits which are eaten in curries.

Solanum ferox, commonly called as hairy fruited egg plant, is a stout sub erect prickly herb, found in tropical parts of eastern India from Assam southward into the peninsular India and in the Andaman islands. *S. giganteum* is a spiny shrub 3-7m tall, occurring in the Western Ghats in Maharashtra and in the hills of South India at altitude of 300-2000m while *S. hispidum* is a native of South America, naturalized in the ravines of Dehradun and Mussoorie. Poison berry, the *Solanum indicum*, is a very common spiny herb found throughout the warmer parts of India upto an elevation of 1500m. *S. khasianum* (*S. viarum*) is a stout, much branched undershrub found in Khasi, Jaintia and Naga hills of Assam and Manipur upto an altitude of 1850 m. The black nightshade or *S. nigrum* is a herbaceous weed throughout India, in dry parts upto an elevation of 2100m. *Solanum seaforthianum* commonly known as Potato creeper is believed to be a native of dry forests and thorn scrub of islands in the West Indies and coastal northern South America in Columbia and Venezuela (Wagner *et al*., 1999, Nee, 1999, Knapp, 2010). But it is believed that the species have broader native distribution range viz., Florida, Mexico, Central America, the West Indies, Venezuela and Columbia (IISG, 2008, Gallagher *et al*., 2010, USDA-ARS, 2014, USDA-NRCS, 2014). Sekhar (2012) reported its occurrence in various parts of the country like, Andhra Pradesh, Jammu & Kashmir, Himachal Pradesh and north eastern states like Assam, Manipur, Meghalaya, Mizoram, Sikkim, Tripura and West Bengal. *S. surattens* commonly called as the yellow berried nightshade is commonly found throughout India while *S. sysimbrifolium* is a native of central and South America (Argentina, Southern Brazil, Paraguay, Uruguay, Bolivia and Colombia). The species is known to be distributed in North America (Canada, Mexico, United States), Europe (Spain and Netherlands), Asia (India, china, Taiwan), Africa (South Africa, Congo, Swaziland) and Australia. In india, *S. sysimbrifolium* is found distributed in Andhra Pradesh, Assam, Bihar, Kerala, Karnataka, Maharashtra, Manipur, Orissa, Punjab, Sikkim, Tripura, Uttar Pradesh and West Bengal. *S. torvum* known as Turkey berry is a small shrub native to West Indies, India, Myanmar, Thailand, Philippines, Malaysia, china, and tropical America (Nasir, 1985).

Sources of resistance

Biotic stresses

Low productivity in brinjal is mainly attributed by the losses due to insect pest infestation. Among the various pests, the shoot and fruit borer is the most destructive ones causing up to 70 per cent of yield loss (Srinivasan, 2009) in almost all the brinjal growing belts (Datta *et al*., 2011). Lack of resistance source in the cultivated *S. melongena* germplasm is the major bottle neck in the resistance breeding programme for shoot and fruit borer resistance (Pugalendhi *et al*., 2010). Several studies involving wild species of egg plant have been attempted for borer resistance (Gowda *et al*., 1990b, Anis *et al*., 1994, Behera and Singh, 2002, Praneetha, 2002). The wild species of brinjal like *S. sisymbrifolium* (Lal *et al*., 1965, Dhanker *et al*., 1979), *S. integrifolium*, *S. xanthocarpum* and *S. nigrum* have earlier been found free from the borer (Lal *et al*., 1976, Rao and Baksh, 1981). Pugalendhi (2010) reported that sexual hybridization of susceptible egg plant genotype EP65 with the resistant source *S. viarum* (*S. khasianum*) and selfing up to F9 generation could reduce the shoot and fruit borer infestation to a negligible level in the genotype. Also, the F9 recorded the highest peroxidase activity, poly phenol oxidase activity and equivalent quantity of total phenol to that of *S. viarum*. Thus the presence of these biochemical constituents acted as stimulants of resistance mechanism against shoot and fruit borer. The genotypes with high or moderate levels of these biochemical compounds suffered less borer infestation (Kkosuge, 1969, Praneetha, 2002 and Prabhu, 2004).Some resistant local brinjal forms have been identified in north western India which is the region wherein domestication of brinjal from *S. incanum* is believed to be taken place (Mathur *et al*., 2012; Samuels, 2013). Jassids, also known as egg plant leaf hoppers are reported to be the serious pests of brinjal in the tropical and subtropical regions due to the prevailing congenial climatic conditions (Nagia *et al*., 1993; Mall *et al*., 1992). It is reported that brinjal varieties viz., Var Dorli, Jumbli and Manjari Gota are resistant to jassids. Hairiness on the leaf surfaces is said to be one of the factors for resistance (More, 1982). In the recent years, damage due to a group of gall forming insects has been reported in egg plant. The infestation due to gall insects in egg plant flowers ranged from 2- 44 %

(Tewrai *et al*., 1987). The wild species of brinjal, *S. macrocarpon* is reported resistant to gall midges wherein the biochemical mechanisms governing resistance need to be investigated (Kumar *et al*., 2010).

Egg plant is infected by many pathogens. Resistance to bacterial wilt caused by *Ralstonia solanacearum* (Li, 1988; Daunay *et al*., 1991; Goth, 1991; Ali *et al*., 1992a, Hanudin *et al*., 1993; Peter *et al*., 1993) and fruit anthracnose by *Colletotrichum gloeosporioides* (Sitaramaiah *et al*., 1985, Kaan, 1973, Messiaen, 1989) is available within some varieties of *S. melongena*. But resistance to bacterial wilt has become insufficient in hot planting seasons and poorly drained soils (Ano *et al*., 1991). For rest of the diseases like *Verticillium* and *Fusarium* wilts and *Phomopsis* blight, only partial resistance or tolerance is reported in cultivated brinjal (Dhawan and Sethi, 1976; Nothman and Yephet, 1979; Yamakawa and Mochizuki, 1979; Messiaen, 1989; Ali *et al*., 1992b). Resistance to bacterial wilt has been reported in the wild species of brinjal viz., *S. torvum*, *S. nigrum*, *S. xanthocarpum* and *S. sisymbrifolium* (Sugha *et al*., 2002). Commercial propagation using rootstocks like *S. mammosum*, *S. integrifolium* and *S. torvum* is found beneficial in egg plant to avoid damage by bacterial wilt (Tamura *et al*., 2002). But it is also reported that though *S. integrifolium* is highly resistant to *Fusarium* wilt, its resistance to *R. solanacearum* is not sufficient to protect the scions under congenial conditions of the disease (Iwamoto *et al*., 2007). But the disease was effectively controlled by making interspecific hybrids between *S. integrifolium* selections and brinjal genotypes with some resistance to bacterial wilt. Leaf blight and fruit rot caused by *Phomopsis vexans* is a major constraint in egg plant production as it reduces the yield and marketable value by 20-30 per cent (Jain and Bhatnagar, 1980, Kaur *et al*., 1985). Kalda *et al*. (1976) found that *S.xanthocarpum*, *S.indicum*, *S.gilo*, *S.khasianum*, *S. nigrum* and *S. sisymbrifolium* were highly resistant to *Phomopsis* blight. Little leaf is nearly becoming a limiting factor for egg plant cultivation throughout the country. The wild species *S. viarum* is reported to be immune to the little leaf whereas *S. inacanum* and *S. sisymbrifolium* were found resistant (Anjaneyalu and Ramakrishnan, 1968; Chakrabarti and Choudhary, 1974). There are also reports that wild species *S. integrifolium* and *S. gilo* showed resistance to little leaf disease due to their hyper sensitive reaction to the pathogen. Also, the F1 progenies of Pusa Purple Long with these two species behaved like their resistant parents in the disease reaction. Among the varieties of brinjal, Pusa Purple Cluster was only variety observed to be resistant while Nurki, Bourad Local No. 4 and Chikkalgaon Local No. 1 were moderately resistant (Mayee and Munshi, 1973; Chakrabarti and Choudhary, 1974; mote *et al*., 1976 and Gill *et al*., 1978). *S. linnaeanum*, *S. sisymbrifolium* and *S. torvum* are reported to be sources of resistance to *Verticillium dahliae*. The sexual interspecific hybrid of egg plant carrying tolerance to *Verticillium* wilt was obtained using *S. linnaeanum* (Collonnier, 2001). The expression profiling of *S. torvum* responses to nematode infection revealed sesquiterpenes and chitinases as major effectors for nematode resistance (Bletsos *et al*, 2013). Though resistant sources are available in plenty among the wild species, the information regarding the gene responsible for these traits and their inheritance pattern is scanty.

Abiotic stresses

In a comparative study among three wild eggplant species, *S. aethiopicum*, *S.* sisymbriifolium, and *S. torvum*), *S. sisymbriifolium* lines were found as more tolerant to salinity than the other two wild species (Yasar ve Ellialtıoglu, 2008). *S. linnaeanum* is reported to have tolerance to salt stress (Daunay *et al*., 1991; Collonier *et al*., 2001) however, little is known about the mechanism in response to salt stres*S.* When leaf cell arrangement of cultivated *Solanum melongena* was compared with the drought tolerant wild species *Solanum* khasianum, higher amount of spongy mesophyll cells and lower height of palisade mesophyll cells in the petioles were observed in the susceptible eggplant genotypes. Also, the drought resistant wild genotypes had higher tissue ratio and (1-1.5) than the susceptible cultivated genotypes (0.50-0.53). In the wild *S. khasianum*, the stomatal number was 45–50% less as compared to cultivated genotypes on both lower and upper side of the leaf, greatly reducing evapo transpirational losses (Kulkarni *et al*., 2008). Grafting egg plants on *S. torvum* enhanced both drought and flood tolerance and improved the growth and fruit quality (Tsay and Lin, 2005). Traits related to frost damage have been observed in *S. mammosum*, *S. viarum* and *S. grandiflorum* (Baksh and Iqbal, 1979).

Table 1. Solanum wild species resistant to diseases and pests.

Species	Disease	Pests	References
S. aethiopicum	(1)*Phomopsis vexans*, (2)*Fusarium oxysporum*, (3)*Ralstonia solanacearum* (4)Mycoplasma	(5,6)*Leucinodes orbonalis*	(1)Ahmad,1987, (2)Yamkava and Mochizuki, 1979, (3)Sheela *et al*.,1984 (5)Khan *et al*., 1978, (6)Chellaiah and Sreenivasam, 1986

S. hispidum	(1)*Verticillium* dahliae & *Verticillium alboratum*, (2)*Ralstonia solanacearum*, (3)*Meloidogyne* sp. (4)Mycoplasma	Nil	(1)Daunay *et al*., 1982, (2)Hebert, 1985 (3)Daunay and Dalmaso, 1985, (4)Rao,1980
S. incanum	(1)*Phomopsis vexans*, (2)*Fusarium oxysporum*,	(3,4,5)*Leucinodes orbonalis*	(1)Rao,1981, (2)Yamkava and Mochizuki, 1979, (3)Singh, 1972 (4)Khan *et al*., 1978, (5)Chellaiah and Sreenivasam, 1986
S. indicum	(1)*Phomopsis vexans*,	(2,3)*Leucinodes orbonalis*	(1)Kalda *et al*., 1976 (2)Behera *et al*., 1999 (3) Behera *et al*., 2002
S. linnaeanum	(1)*Verticillium dahliae* & *Verticillium alboratum*, (2)Colletotrichum coccoides		(1)Daunay *et al*., 1991, (2)Pochard and Daunay, 1977
S. macrocarpon		(1)Tetrannychus urticae, (2)*Leucinodes orbonalis*	(1)Shaff *et al*., 1976, (2)Gowda *et al*., 1990
S. mammosum	(1)*Fusarium oxysporum*	(2)*Leucinodes orbonalis*,(3)*Epilachna* vigintioctopunctata (4)*Aphis gossypii* (5) *Tetranychus cinnabarinus*	(1)Telek *et al*., 1977 (2)Baksh and Iqbal, 1979, (3)Beyries, 1979 (4)Smabandam and Chellaiah, 1983 (5)Shalk *et al*., 1975
S. nigrum	(1)*Phomopsis vexans*, (2)*Ralstonia solanacearum*	Nil	(1)Kalda *et al*., 1977 (2)Hebert, 1985
S.sisymbrifolium	(1) *Phomopsis vexans*, (2,3)*Verticillium dahliae* & *Verticillium alboratum*, (4)*Ralstonia solanacearum*, (5)*Meloidogyne* sp.	(6)*Leucinodes orbonalis* (7) *Tetranychus cinnabarinus*	(1)Kalda *et al*., 1977 (2,5)Fassuliotis and Dukes, 1972 (3)Collonnier, 2001 (4)Mochizuki and Yamakawa, 1979b (6)Lal *et al*., 1976 (7)Shalk *et al*., 1975
S. torvum	(1) *Verticillium dahliae* & *Verticillium alboratum*, (2)*Ralstonia solanacearum*, (3)*Meloidogyne* sp. (4)Mycoplasma	(5) *Epilachna vigintioctopunctata*	(1)Daunay *et al*., 1991, (2)Hebert, 1985 (3)Daunay and Dalmaso, 1985, (4)Rao,1980 (5) Sambandam *et al*., 1976
S. viarum	(1) *Phomopsis vexans*, (2)Mycoplasma	(3)*Leucinodes orbonalis*, (4) *Epilachna vigintioctopunctata*	(1)Kalda *et al*., 1977 (2)Datar and Ashtaputre, 1984 (3)Lal *et al*., 1976 (4)Sambandam *et al*., 1976
S. violaceum	(1) *Phomopsis vexans*, (2)*Fusarium oxysporum* (3)*Meloidogyne* sp.	Nil	(1)Ahmad, 1987, (2)Yamakawa and Mochizuki, 1979 (3)Sonawane and Darekar, 1984

Limitations in exploiting wild *Solanum*s in egg plant crop improvement

Crossability

Although crossability between *S. melongena* and other *Solanum* species have been studied over the past few years, utilization of these wild species for introgression of resistance traits to the modern day egg plant cultivars has got limited success. Based on the available information on crossability between related species of egg plant, there is no natural crossing among cultivated and wild species of brinjal. Also, under forced crossing situations, even though crossing was possible, the viability was not retained. Sihachakr *et al*., 1994 reported that *S. melongena* can be crossed sexually with many species of same subgenus Leptospermonum. Eleven *Solanum* species were grouped into three groups by Nishio *et al* (1984) based on their interspecific compatibility wherein the first group included *S. melongena*, *S. incanum* and *S. macrocarpon*. The *S. integrifolium*, *S. gilo* and *S. nodiflorum* constituted the second group while *S. indicum*, *S. mammosum*, *S. torvum*, *S. sysymbrifolium* and *S. toxicarium* were included in the third group. They opined that crosses were combatable within and between the first and second groups but were otherwise incompatible. There are varied opinions on the crossability relation among the *Solanum* species. Rao (1979) reported that *S. melongena* cultivar as female parent when hybridized with *S. melongena* var. *insanum*, *S. incanum*, *S. integrifolium* and *S. gilo* produced viable seeds. But it did not hybridize with *S. indicum*, *S. sisymbrifolium* and *S. zuccagnianum*. Behera and Sigh (2002) reports successful crossing in *S. melongena* using *S. indicum* as pollen parent while the reciprocal crossing progenies died within 15 days of germination. Amomg the nineteen species of *Solanum* used for egg plant crop improvement worldwide, only four species viz., *S. incanum*, *S. linnaeanum*, *S. aethiopicum* and *S. macrocarpon* have been used successfully for developing progenies with partial fertility (Daunay and Lester, 1989). *S. xanthocarpum* and *S. incanum* are crossable with egg plant producing fertile or partially fertile hybrids (Singh, 1972). *S. melongena* was freely crossable with *S. incanum* and the hybrid exhibited field resistance to shoot and fruit borer and leaf rot (Siddiqui and Khan, 1979). *S. viarum*, a closely related wild species of egg plant is cross compatible with the cultivated egg plant (Pugalendhi *et al*., 2010). In a study carried out at IIVR, Varanasi, the results indicated that except *S. incanum*, all other species used for crossing program like *S. indicum*, *S. nigrum*, *S. sisymbrifolium* and *S. torvum* were incompatible with cultivated egg plant varieties. Fruit set was not obtained in crosses involving wild species as female parents. Rao and Baksh (1981) reported 60 % fruit set and 65 % seed germination when Pusa Purple Long was crossed by *S. integrifolium* as male parent. Although successful crossings involving wild species are reported, sterility is a major limiting factor in their utilization in crop improvement programs. For example, crosses were made by Rao (1979) using ten *Solanum* species viz, *S. melongena*, *S. melongena* var. *insanum*, *S. incanum*, *S. indicum*, *S. xanthocarpum*, *S. integrifolium*, *S. gilo*, *S. zuccagnianum*, *S. sisymbrifolium* and *S. khasianum* in all possible combinations. Among the ninety crosses made, only 39 resulted in fruit set, four produced parthenocarpic fruits and in the remaining 47 crosses, there was no fruit set. The partial sterility of interspecific hybrids of egg plant with its allied species may be linked to the self incompatibility problems brought by the wild parents and not by egg plant being self incompatible (Daunay *et al*., 1991).

Table 2. Inter-specific crossability studies in egg plant

Parents involved	Status of hybrid	References
S. melongena x *S. aethiopicum*	Fertile hybrids	Ignatova, 1971, Ano *et al*., 1991
S. melongena x *S. gilo*	F1 hybrids obtained Sterile F1 hybrids	Ali and Fujieda, 1990 Nasrallah and Hopp, 1963, Omidiji, 1981
S. melongena x *S. hispidum*	Sterile F1 hybrids	Rao, 1980
S. melongena x S. *indicum*	Obtained F4 plants Partially fertile Sterile F1 hybrids	Rao and Kumar (1980), Rao and Rao (1984) Krishnappa and Chennaveeraiah (1965), Rajasekaran (1968), Narasimha Rao (1968), Rangaswamy and Kadambavanasundaram (1973a,b, 1974a,b) Rao and Rao (1984)
S. melongena x *S. insanum*	Obtained F1 hybrids	Swaminathan (1949), Mittal (1950), Babu Rao (1965), Ali and Fujieda (1990)
S. melongena x *S. integrifolium*	Obtained F1 hybrids Partially fertile hybrids Sterile F1 hybrids	Rao and Baksh (1979) Hagiwara and Iida (1938, 1939), Tatebe (1941), Miwa *et al*. (1958), Kataezin (1965), Narasimha Rao (1968), Ludilov (1974) Berry (1953), Fukumotoh (1962), Rao and Baksh (1981), Kirti and Rao (1982),
S. melongena x *S. khasianum*	Obtained F1 hybrids	Sharma *et al*., 1984

S. melongena x *S. macrocarpon*	Fertile F1 and F2 plants Sterile plants	Schaff *et al*., 1982 Rajasekaran (1961), Wanjari (1976),Gowda *et al*. (1990)
S. melongena x *S. sisymbrifolium*	Sterile plants	Bletsos *et al*., 1998
S. melongena x *S. surattense*	Sterile F1 hybrids	Rao and Rao, 1984
S. melongena x S. *torvum*	Very low fertility in F1plants	McCammon and Honma (1983), Blestsos *et al*. (1998)
S. melongena x *S. xanthocarpum*	Partially fertile hybrids Sterile F1 hybrids	Swaminathan (1949) Rajasekaran (1968, 1971), Sarvayya (1936), Hiremath (1952)
S. melongena x *S. zuccagnianum*	Sterile F1 hybrids	Rajasekaran and Sivasubramanian (1971)

Seed dormancy

Solanum species are propagated mainly through seed*S.* But the seeds of majority species possess dormancy for extended period*S.* In *S. incanum*, the reduction in seed germination is due to its hard seed coat (Joshua, 1978). Prolonged dormancy upto 39 years was observed in buried seeds of *S. nigrum* in Britain (Edmonds and Chweya, 1997). Primary dormancy was also a problem in freshly harvested *S. nigrum* (Bithell *et al*., 2003). In *S.* aethiopicum, embryo dormancy is reported by which, it takes 4 to 5 months for germination (Abdoulaye, 1992). Uniform seed germination ia major constraint in *S. torvum* that has limited its use in breeding programs (Ginoux and Laterrot, 1991). The dormancy *S. torvum* can be overcome by 12 hour soaking, 30 minutes of prewashing, prechilling at 5 °C for one day , or treatment with 0.1 per cent KNO3 or 0.01 per cent GA3 (Hayati *et al*., 2005)

Opportunities in utilization

Many egg plant wild relatives have been insufficiently studied but have great potential as sources of useful genes (Daunay, 2013). The major bottle neck of using wild species for introgression of agronomically important traits into the cultivated egg plant is crossability. Barriers on crossability can be overcome through conventional and biotechnological interventions. Adoption of bridge crossing through related species can be a useful method to overcome crossability barriers for introgression of beneficial traits into cultivated egg plants. Also, Use of wild species as rootstocks can also be adopted in egg plant to minimize damages due to various biotic and abiotic stresses. Since egg plant responds well to the tissue culture, especially plant regeneration, biotechnological methods can play important role in exploiting the genetic resources in crop improvement programs (Collonnier *et al*., 2001).

Somatic hybridization

Production of somatic hybrids through protoplast fusion has proved promising for introducing beneficial traits. Transfer of resistant traits by somatic hybridization has been attempted by many researchers (Guri and Sink, 1988; Sihachakr *et al*., 1989, Stattman *et al*, 1994, Jarl *et al*., 1999). In egg plant, Mesophyll tissues have been the primary source of high quantity protoplasts (Bhatt and Fassuliotis, 1981; Jia and Potrykus, 1981). The first somatic fusion of *S. melongena* with *S. sisymbrifolium* resulted in 21 aneuploid somatic hybrids which had only the *S. sisymbrifolium* chloroplast genome. Though they showed high resistance to root knot nematodes and red spider mites, due to hybrid sterility, these hybrids had limited utility in breeding programmes (Gleddie et al., 1986). Somatic hybrids of S. melongena with S. khasianum were produced by elecrofusion by Sihachakr et al., 1988 which contained the egg plant ctDNA type. Tetraploid somatic hybrids of egg plant with *S. torvum* were produced by chemical and electrofusion wherein most of them had the egg plant ctDNA type, and were all resistant to *Verticillium* wilt, nematodes and partially resistant to spider mites (Guri and Sink, 1988a; Sihachakr et al., 1994). Tamura *et al*., 2002 could successfully produce somatic hybrids by electrofusion between *S. integrifolium* and the bacterial wilt tolerant wild egg plant *S. violaceum*. Tetraploid somatic hybrids produced by electrofusion of brinjal with *S. aethiopicum* or *S. integrifolium* protoplasts demonstrated that partial genetic recombination occurred between the genome of egg plant and those of allied species (Toppino *et al*., 2009). Highly fertile somatic hybrids of egg plant with *S. aethiopicum* were produced by electrofusion wherein better pollen fertility (30-85%) was observed in somatic hybrids when compared to their sexual counter parts (20-50%) under field evaluation (Daunay *et al*., 1993). Resistance to the herbicide Atrazine has been transferred from the Atrazine-resistant biotype *S. nigrum* into somatic hybrids of egg plant by using chemical (Guri and Sink, 1988b) and electrical (Sihachakr et al., 1989b) procedures of protoplast fusion. All the somatic hybrids had *S. nigrum* ctDNA, conferring resistance to 0.1M Atrazine. Though generally unfeasible by sexual hybridization, intergeneric crosses have been produced in egg palnt via protoplast fusion (Toki et al., 1990; Gurri et al., 1991). Although combination of complete genomes is easily possible, the somatic hybrids being partially or completely sterile, their usefulness in egg plant breeding programmes will be limittd since the somatic hybrids are amphidiploids in nature, intensive back crossing will be required for transfer desirable traits into the cultivated egg plant. Fertile hybrids with tolerance to Verticillium wilt, and particularly, a morphology close to the cultivated egg plant, were recoverd after asymmetric fusion between egg plant protoplasts and X- rays irradiated protoplasts of *S. torvum* (Jarl et al., 1999). Thus Somatic hybridization can effect in the resistance traits transfer in egg plant. But the success of tetraploids symmetric somatic hybrids in crop improvement programme depends on their ability to be back crossed with their recurrent egg plant geneotype (Collonnier *et al*., 2001).

Embryo rescue

Embryo rescue can also contribute to some extent in overcoming crossability barriers in distant hybridization. This technique was successfully used to recover sexual hybrids of egg plant with *S. khasianum* (Sharma *et al*., 1980), *S. sisymbrifolium* (Sharma *et al*., 1984) and *S. torvum* (Daunay *et al*., 1991; Kumchai et al., 2013). Bletsos et al., 1998 developed hybrids with S. torvum and S. sisymbrifolium through embryo rescue by culturing immature ovule in MS medium. Fertility was restored in hybrids of S. melongena with S. macrocarpon (Gowda et al., 1991) and S. torvum (Daunay et al., 1991), when diploid hybrids (2x) were brought to the amphidiploids status (4x) by colchicines treatment. In order to produce interspecific hybrids between S. melongena and S. indicum, embryo rescue technique was adopted and developing embryos of 15 days old responded better for regeneration at MS basal Medium + 5 ppm BAP+ 30 ppm IAA (Srinivasan et al., 2007). Verba et al., 2010 attempted embryo rescue technique successfully to transfer resistance gene from S. aethiopicum and S. integrifolium to the cultivated S. melongena. Also they have optimized the stage of embryonic development optimal for isolation and the nutrient media composition for embryo development and rooting of seedlings.

Molecular markers

The advent of molecular marker technology has led to the understanding of genetic diversity in various crop species. This technology has been widely used to identify and determine relationships at the species and cultivar levels (Rajaseger et al., 1997; Raina et al., 2001; Martins et al., 2003, Furini and Wunder, 2004). Earlier genetic diversity studies in egg plant were carried out using polymorphic and abundant markers viz., RFLP (Isshiki et al., 1998; Isshiki et al., 2001, Doganlar et al., 2002a) and RAPD markers (Karihaloo et al., 1995; Nunome et al., 2001, Ansari and Singh, 2013). More recently, simple sequence repeats (SSR) or microsatellite markers (Nunome et al., 2003a, b; Stagel et al., 2008; Munoz-Falcon et al., 2008, Nunome et al., 2009, Tumbilen et al., 2009, Demir et al., 2010; Sunseri et al., 2010; Qiu-jin et al., 2010; ge et al., 2011) and amplified fragment length polymorphism (AFLP) markers were developed and used in egg plant diversity assessment. Using SSR markers, Caguit and Hautea, 2014 could clearly differentiate the land races, cultivars and crop wild relatives of egg plant. The crop wild relatives were the most diverse group followed by the land races, while improved cultivars were the least diverse. Genic microsatellites (SSR) markers were identified from an expressed sequence tag library of S. melongena and used for analysis of 47 accessions of egg plant and closely related species (Tumbilen et al., 2011). The markers had very good polymorphism in the 18 species tested including 8 S. melongena accessions.

CONCLUSION

Being the centre of diversity, India has huge variability in egg plant genetic resources. Resistance to most of its biotic and abiotic stresses is present within the available wild gene pool. Since information on status of wild Solanum conservation is scanty, efforts should be made to collect, characterize and conserve the available genetic resources. Conservation of land races showing tolerance to various stresses has gained limited attention. Attempts to improve resistance through introgression of traits from wild relatives have had limited success owing to sexual incompatibilities. Efficient utilization of these genetic resources urges integration of conventional breeding methods with biotechnological techniques for effecting the transfer of beneficial genes (traits) into the cultivated egg plants. Mapping the location of occurrence will be helpful for the future research programs and through genomics and marker assisted studies, genes and mechanisms responsible for resistance to various stresses may be identified which could be useful in the future breeding programs.

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