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Cross compatibility in interspecific hybridization of eggplant, *Solanum melongena*, with its wild relatives

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ABSTRACT

The eggplant, *Solanum melongena* L., is one of the most important warm season vegetable crops grown in India. In the present study, interspecific hybridization was carried out involving thirteen cultivated genotypes of eggplant and four wild *Solanum* species (*Solanum incanum, S. aethiopicum, S. integrifolium* and *S. indicum*). The cultivated genotypes were used as female parents and wild species as pollen parents in different cross combinations. The crossability relationship of *S. melongena* genoptypes with the wild species was determined by occurrence of fruit set (%), number of seeds per fruit and germination (%) of F_1 seed. The mean fruit set was maximum for DBSR-91 (41.25%) followed by DBR-G-190 (37.91%) and NDB-25 (32.08%). The maximum number of seeds per fruit (266.92) was obtained in DBR-G-190 followed by Pusa Uttam (101.42) and Sel-91-2 (92.00). The mean value of highest germination (%) of F_1 seed was observed for DBSR-91 (41.58%) followed by Pusa Uttam (40.25%) and Sel-91-2 (35.50%) when crossed with wild species. The maximum fruit set (80%) was recorded in cross DBSR-91 × *S. aethiopicum* followed by Pusa Bindu × *S. aethiopicum* (75%) and NDB-25 × *S. aethiopicum* (75%). The highest germination of F_1 seed (71%) was recorded in three cross combinations, Pusa Uttam × *S. aethiopicum*, Sel-91-2 × *S. aethiopicum*, DBR-G-190 × *S. aethiopicum*. The highest number of seeds per fruit (754) was recorded in DBR-G-190 × *S. incanum* followed by DBSR-52 × *S. incanum* (226.6), DBR-G-190 × *S. aethiopicum* (206). Among the four wild species, *S. incanum* was found highly crossable with the cultivated *S. melongena* genotypes. Interspecific crosses reported in this study will be used in transferring desirable traits in different genetic backgrounds of cultivated *S. melongena*.

1. Introduction

The eggplant, *Solanum melongena* L. ($2n = 2x = 24$), also known as aubergine or Guinea squash or brinjal is one of the most popular warm season vegetable crops grown in India and some other parts of the world. It is cultivated in more than 1.86 million hectares with an annual production of 49.4 million tonnes with China being the largest producer (58% of total production) followed by India (25% of world production), Iran, Egypt and Turkey. In 2013, eggplant production in India was approximately 13.5 million tonnes from 0.72 million hectares (FAO, 2013). This vegetable is an integral part of Indian cuisine and there is general preference for purple coloured fruits although green and white coloured fruits have recently become popular due to increasing consumer acceptance for novelty and colour. The eggplant is native to India and China is considered as a secondary centre of origin. *Solanum incanum*, a wild progenitor of cultivated eggplant is distributed in at least 10 habitats in India (Lester and Hasan, 1991). Rich diversity of eggplant exists in different parts of India, viz. Eastern Ghats, North Eastern region, Central, Eastern India particularly in states like Odisha, and West Bengal where there are more than 100 local cultivars grown under different names (Chattopadhyay et al., 2009). The hermaphrodite flowers are large and showy with purple coloured corolla. The stigma become receptive and dehiscence of pollen occurs at the same time which results in self-pollination. The extent of cross-pollination by insect has been reported to be 2–48%, hence, it is considered as an often cross-pollinated crop (Agrawal, 1980).

Interspecific hybridization is an important approach in plant breeding to incorporate useful genes to crop improvement (Sekara et al., 2007). The wild species of eggplant are a rich source of genes

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for resistance to diseases or insects. For example, several studies have identified resistance to bacterial wilt in *S. aethiopicum* L. (Ethiopian eggplant) (Collonnier et al., 2001); resistance to little leaf and shoot and fruit borer in *S indicum* L. (Bahgat et al., 2008; Patel et al., 2001), *Verticellium* wilt resistance in *S. incanum* (Prohens et al., 2013; Robinson et al., 2001) and resistance in *S. integrifolium* to *Phomopsis* blight, little leaf, bacterial wilt and shoot and fruit borer (Kalloo, 1993). In interspecific hybridization, the production of hybrid seed is greatly hampered due to certain fertilization barriers. The crossability and hybridization studies of different *S. melongena* accessions with its related species have been carried out with inconsistent results (Gowda and Seenappa, 1991; Behera and Singh, 2002). A number of researchers have reported unidirectional crossability, i.e., crossability is feasible only when *S. melongena* genotypes are used as female parents (Chopde and Wanjari, 1974; Rajasekaran 1970a,b; Wanjari, 1976). Successful hybridization was reported only when *S. macrocarpon* genotypes were used as the female parent (Omidiji, 1979; Rajasekaran, 1970c). Crossability of *S. melongena* with *S. incanum*, *S. aethiopicum* and *S. torvum* has also been reported (Daunay et al., 1991; Nee, 1999; Kameswara Rao, 2011). The information on both interspecific and intraspecific crossability is important in developing a comprehensive breeding strategy. The breeding materials developed through this programme will help in further improvement of eggplant particularly in resistance breeding. The present study was carried out to understand crossability behaviour between cultivated genotypes of *S. melongena* with its wild relatives and to develop innovative lines with desirable traits.

2. Materials and methods

2.1. Plant materials

The experimental material comprised of 13 cultivated *S. melongena* L. genotypes (Pusa Kranti, Pusa Shymala, NDB-25, Pusa Uttam, Pusa Bindu, DBSR-52, DBSR-91, Br-112, DBSR-195, G-190-10-12, Sel-129-5, Sel-91-2, DBR-G-190) and four wild species (*S. indicum*, *S. incanum*, *S. aethiopicum* and *S. integrifolium*), maintained at the Division of Vegetable Science, Indian Agriculture Research Institute, New Delhi, India. Many of the *S. melongena* genotypes are commercially grown in different parts of India. The cultivars or elite eggplant lines were selected based on their fruit size, colour, shape and cluster bearing behaviour. The cultivated genotypes and four wild species were selfed for three generations before being used in the present study. A standard package of practices was followed for raising the crops during rainy season.

2.2. Interspecific crossing

The interspecific hybridization was carried out in all possible combinations using *S. melongena* genotypes as female parent and wild species as male parents without reciprocal. Forty flower buds of female parent were taken from each *S. melongena* cultivar per cross combination. The mature balloon shaped buds with long style of the female parents were emasculated a day before anthesis and covered with butter paper bags. The leftover buds in the clusters and naturally pollinated ones were clipped off. The mature buds in the clusters of male parents were also bagged for collection of uncontaminated pollens. On the day of anthesis on the male parents, the pollen grains were dusted on the stigmatic surface of the emasculated flowers of the female parents. The flowers were re-bagged thereafter and labelled. The degree of crossability was determined as percentage fruit set, number of seeds per fruit, percentage of F_1 seed germinated and pollen viability in four wild related *Solanum* species.

2.3. Estimation of pollen viability

For the pollen viability analysis the mature flower buds were bagged with cotton puff a day prior to anthesis. On the day of anthesis, three flowers were collected at 8 a.m. from three plants of each wild species. The viable pollens were estimated by placing a single anther on glass slide and crushed with forcep followed by staining with 0.5% iodine and 1.1% potassium iodide solution for 15 min. Finally, the pollen grain were collected and counted under a microscope (Olympus CH-20i, Japan). Pollen grains with bright red stain were categorized as viable, pink stain as semi-sterile and unstained as sterile (Prasad et al., 2006).

2.4. Statistical analysis

The statistical analysis was carried out using SAS 9.4 software package available at Indian Agricultural Statistics Research Institute, New Delhi, India. The percentage data was transformed using arc sine transformation as suggested by Box and Cox (1964). The zero percentage data were first substituted by 0.0025 ($1/4n$, where n is the number of units in which the percentage data were based) before arc sine transformation. Subsequently, standard deviation (SD) was also calculated. Pair-wise comparisons on the least squares means (LSMEANS) were performed using the Tukey's Honest Significant Difference (HSD) test and least significant difference (LSD) test was used to describe means with 95% ($p < 0.05$) confidence.

3. Results

3.1. Estimation of pollen viability in wild Solanum species

The data on pollen viability of the four wild species are presented in Table 1. There was marked variation among the wild species. The maximum (34.78%) fertile pollen was observed in *S. indicum*, whereas, minimum (11.01%) was in *S. integrifolium*. Among the four wild species, *S. incanum* did not have any sterile pollen. The maximum pollen sterility was observed in *S. integrifolium* (71.56%) followed by *S. indicum* (15.22%) and *S. aethiopicum* (10.65%) (Fig. 1).

3.2. Crossability behaviour of each cultivated (S. melongena) genotypes with each of wild species

The crossing between cultivated *S. melongena* with wild species revealed three patterns of behaviour of the hybrids *viz.* (a) hybrid, Br-112 × *S. indicum* died after germination (b) hybrids, DBSR-52 × *S. indicum* (Fig. 2a), DBSR-91 × *S. aethiopicum* (Fig. 2b), DBR-G-190 × *S. aethiopicum*, Sel-91-2 × *S. aethiopicum*, G-190-10-12 × *S. aethiopicum* were vigorous in growth, similar to wild parent species, late flowering and fruiting with parthenocarpic fruits. (c) hybrids, Sel-91-2 × *S. integrifolium* (Fig. 3a), DBSR-52 × *S. integrifolium*, DBSR-52 × *S. incanum* (Fig. 3b), DBSR-91 × *S. incanum* (Fig. 3c), NDB-25 × *S. incanum* (Fig. 3d), Pusa Kranti × *S. incanum* were vigorous in growth and development, with early flowering and fruiting with normal fruits and seed.

The result on crossability of *S. melongena* genotypes with wild species for fruit set is presented in Fig. 4. The maximum fruit set (80%) was recorded in cross DBSR-91 × *S. aethiopicum* followed by Pusa Bindu × *S. aethiopicum* (75%), NDB-25 × *S. aethiopicum* (75%) and DBR-G-190 × *S. aethiopicum* (63.3%) which were statistically at par. The cross combinations Pusa Kranti × *S. aethiopicum*, Br-112 × *S. aethiopicum*, DBSR-195 × *S. aethiopicum*, Sel-129-5 × *S. aethiopicum*, Pusa Kranti × *S. integrifolium*, DBSR-195 × *S. integrifolium*, G-190-10-12 × *S. integrifolium*, Pusa Shymala × *S. indicum*, Sel-129-5 × *S. indicum* and Sel-129-5 × *S. incanum* did not produce any fruit.