The Pharma Innovation Journal 2023; 12(3): 567-571

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 567-571

www.thepharmajournal.com
Received: 07-01-2023
Accepted: 19-02-2023

A review on mechanism and genetics of resistance and multiple resistance in Brinjal

Swathi Imandi and Vijay Bahadur

Swathi Imandi
Ph.D. Research Scholar, Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Associate Professor, Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Swathi Imandi
Ph.D. Research Scholar, Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Abstract
After tomato, potato, chili, and tobacco, eggplant is the fifth economically significant vegetable in the Solanaceae family. Two other under used eggplant species, the African eggplant (*Solanum macrocarpon* L.) and the scarlet eggplant (*Solanum aethiopicum* L.), were also cultivated with local importance where the leaves and fruits are used for food and medicinal purposes in addition to the well-cultivated brinjal or aubergine eggplant (*Solanum melongena* L.). Improved fruit quality, increased yield performance through heterosis breeding, and the introduction of pest and disease resistances from wild relatives are the main goals of the eggplant breeding programme. A large variety of germplasm resources with substantial potential for genetic advancement are present throughout Europe and Asia. While several fungus and bacteria can cause harm to produced eggplant, many of its wild counterparts may be resistant to these pathogens. This essay examines the genetic diversity and resources of domesticated eggplant and its wild counterparts. We start by looking at the crop's economic significance, domestication, taxonomic classification, and links to its wild cousins. Due to the significant underrepresentation of crop wild relatives, it is imperative to assess and protect them. This study's summary of genetic resources, biotic and abiotic stress resistance, pre-breeding, and breeding for sustainable eggplant production is an important section.

Keywords: Genetic resistance, multiple resistance, crop improvement

Introduction

In the Solanaceae family, eggplant (*Solanum melongena* L.), also known as brinjal in Southern Asia, aubergine in France, and tobacco are the next four most economically significant vegetables. Tomato (*Solanum lycopersicum* L.), potato (*Solanum tuberosum* L.), chilli (*Capsicum annuum* L.), (Chapman *et al.* 2019) [6] and eggplant are all members of the Solanaceae family (*Nicotiana tabacum* L.). The fruit is widely used in numerous local groups' staple cuisines, particularly in Africa, the subtropics (India, Bangladesh, Central America), the Middle East, and Southeast Asia (Collonier *et al.* 2001) [8]. It is also grown in a number of warm, temperate locales, including the Southern United States and the Mediterranean. Solanum is a huge genus with over 1400 species, many of which are toxic to humans, including *S. dulcamara L.* (the nightshades) (Dempewolf *et al.* 2017) [10]. Since it was domesticated in Africa, Asia, and Europe, eggplant is regarded as an Old World crop. Its relatives, like the tomato and potato, are New World plants that may be traced back to South America (Doganlar *et al.* 2002) [11]. The Asian eggplant (S. *melongena*) will be the primary subject of this review. The Gboma/African eggplant (S. *macrocarpon* L.) and the Ethiopian/scarlet eggplant (S. *aethiopicum* L.) are two other Solanum species that are related to the Asian eggplant, and they are somewhat discussed here (Gramazio *et al.* 2018) [16]. The leaves and fruits of the minor crops S. *macrocarpon* and S. *aethiopicum* are used for food and medicine, and they are important locally. The taxonomic categorization has in the past been clouded by the resemblances between these three eggplant species. Within the genus, they are, however, relatively distantly related. Kaushik et al. 2016 [23].

S. melongena L., often known as Asian eggplants, has had a number of non-exclusive theories put out regarding its origin (Liu *et al.*, 2015) [26]. The most recent and trustworthy consensus is that the Middle Eastern/African species of *S. incanum* L. was purposefully sent to the Indo-China region, where the real wild progenitor of *S. insanum* L. emerged and from which S. *melongena* was produced. Landraces and the relatively small-fruited *S. ovigerum*, from which other cultivated types are sprung, may be the first domesticated species (Mat-Sulaiman *et al.* 2020) [28].

More recently, Meyer *et al.* (2012) [29] reported that molecular data suggests that domestication of eggplant occurred more than once. The domestication of eggplant has, however, given rise to numerous disputes. Due to these factors, experts have used cutting-edge technology to answer some significant and intriguing issues about the evolution and genesis of the eggplant. Members of the Solanaceae have been domesticated as a model to examine independent evolution tendencies. Selection during domestication is based on fruit size, shape, flavour, and colour, which is common in other crops.

Little progress has been achieved recently in using wild progenitors of the eggplant to improve cultivated eggplants. The lack of genome sequence information is one of the main obstacles to using wild animals in breeding programs. This is frustrating, too, as the wild relatives are frequently the main providers of alleles for biotic and abiotic tolerance. It is also unable to create the genome-anchored markers needed for efficient trait transfer via marker-assisted selection because wild relatives' genome sequences have not been determined. It can be difficult to successfully introduce a desired gene from more distant eggplant relatives in real life.

Global Germplasm Collection and Conservation

The genetic resources of the eggplant have been methodically gathered in some Asian and European nations (Toppino *et al.* 2008) [38]. Over 1.5 million instances of *Solanum* have been noted by the Global Biodiversity Information Facility (GBIF), which may be biodiversity records, herbarium samples, or wild populations. According to AVGRIS, the Asian Vegetable Research and Development Center (AVRDC) in Shanhua, Taiwan, is one of the major genebank owners of the three farmed eggplants, holding 42 accessions of *S. macrocarpon*, 60 of S. *aethiopicum*, and 2256 of *S. melongena*. Weese *et al.* 2010 [39].

Classical Genetics and Traditional Breeding

Early classical mapping relied heavily on the *S. lycopersicum* (tomato) model, which was the focus of research, while *S. melongena* was disregarded (Hui *et al.* 2005) [19]. In addition to anthocyanin accumulation, mapping of phenotypic traits in eggplant is scarce. Studies on heredity in eggplant were challenging due to the quantitative nature of key agronomic variables, similar to other crop species (Kumar *et al.* 2011) [25]. After the development of molecular linkage maps and the ensuing advance in comparative genomics, formerly focused research on tomatoes has expanded to include eggplant, pepper, and potato (Jorge *et al.* 1998) [20]. On numerous levels, breeding activities are dependent on the molecular mapping of the eggplant genome. As a result, it became simpler to examine the inheritance of complex traits and remove undesired genotypes using marker-assisted selection from breeding populations. Sidhu *et al.* 2014 [33].

By adding disease and insect resistance into the crop, eggplant breeders aimed to increase output and enhance harvest quality. Increasing the eggplant's resistance to abiotic stress was a key goal of the breeding programme. Collonnier *et al.* 2001 [21].

Since the emergence of heterosis in brinjal, there have been concentrated efforts to produce hybrids from inbred lines that are more productive. As a result, F1 hybrids make up the majority of commercial cultivars (Kashyap *et al.* 2003) [21]. Despite this, the difficult procedure of creating hybrid seeds places a restriction on eggplant breeding (Choudhary *et al.*, 2009) [7]. Manually emasculating and pollinating the inbred parents takes time and is not cost-effective. As a result, efforts are being made to develop eggplants with cytoplasmic male sterility (CMS) (Mall *et al.* 1992) [27]. The traditional cultivation of eggplant is threatened by a number of factors, including abiotic (salinity, heat, cold, drought, and flooding), biotic (bacterial wilt, halo blight, and Tan spot), biotic (leafhopper, nematode, spider mite, beetle, and aphid), biotic (blight, mildew, and anthracnose), and biotic (leafhopper, nematode (mosaic virus). Singh *et al.* 2014 [34].

Infestations of the fruit and branch borer cause significant yield losses in locations where eggplant is grown, and it is exceedingly challenging to manage or prevent this pest. Farmers employ erroneous heavy chemicals with strong lasting effects carelessly during disease outbreaks, which pollutes the ecosystem. While some of their wild cousins have demonstrated adequate pest and disease tolerance, the generally cultivated cultivars have limited resistance to these occurrences (Akinci *et al.* 2004) [1]. Breeders started looking into ways to strengthen commercial kinds by introducing resistant genes into them as a result of this. However, the success of such efforts mostly depends on the genotype of the eggplant, the direction of the crossing, and the phylogenetic separation between the parents. Different biotechnological and traditional methods are used to create high-yielding, horticulturally superior types that are resistant to biotic and abiotic stressors. Monti *et al.* 2006 [30].

In general, meiotic recombination between homologues of the two parental species is required in attempts to introduce genes from wild species into cultivated germplasm. Somatic hybrids of *S. melongena* and *S. aethiopicum* have evidence of chromosomal exchange, and these hybrids can be utilized to give eggplants resistance to bacteria and Fusarium wilt (Brown 1987) [5]. Being a self-pollinating plant, eggplant is improved through breeding techniques such heterosis breeding, backcrossing, a combination of pedigree and bulk methods, bulk method, pedigree method, and pure-line selection. Plazas *et al.* 2013 [31].

Biotechnological Approaches for Genetic Improvement

Exploiting genetic diversity created *in vitro* may be achievable through somaclonal variation. Verticillium culture filtrate and atrazine resistance somaclonal variants in eggplant have been found. Dimethyl sulfonate has been used successfully in meristem culture to induce mutation *in vitro* (Farooqui *et al.* 1997) [15]. The mutant offspring displayed a variety of morphologic characteristics. For instance, some lines produced more fruit per plant than the control. Plants generated from somatic embryos induced by 2,4- D or NAA have shown inherited somaclonal differences in leaf and fruit morphology. However, there are still few practical uses for somaclonal diversity in eggplant. Du *et al.* 2015 [13].

Due to their tedious and time-consuming character, conventional methods for breeding crop plants with enhanced insect resistance and abiotic stress tolerances have so far had limited results. High-yielding types, on the other hand, typically demand a lot of input and are not well suited to extreme environmental conditions. Up until recently, landraces or wild cousins were crossed with most high-yielding types to increase their resistance to abiotic stress. In general, poor recombination is seen when landraces are crossed with high-yielding types to introduce genes that give tolerance to abiotic pressures. Alicchio *et al.* 1990 [3].

Genetic Transformation in Eggplant through Technical Aspects

Except for a few papers that used a biolistic system, all genetic transformation research in eggplant has so far been carried out using Agrobacterium. Guri and Sinks in 1988 was the first to report on successful genetic transformation through *Agrobacterium tumefaciens*. With a pMON200 vector harboring the nptII gene, they converted eggplant leaves that were produced *in vitro*. Many scientists have sought to create stable transgenic plants for use in breeding programs as well as to design the transformation technique. A thorough investigation, however, is yet lacking in order to optimize the influencing common elements (genotype, explants, Agrobacterium strains, selection markers, and culture conditions) in a single study. Dorica *et al*. 2006 [12].

Plant Regeneration mode

Effective transformation techniques essentially involve direct or indirect organogenesis to exert good control over the plant regeneration from the infected explants. A recent research lists the different ways that eggplants regenerate their plants. For the transformation research conducted, having an effective and genetic transformation-compatible procedure available is essential (Hitomi *et al*. 1998) [18]. Direct shoot regeneration from a variety of tissues, such as cotyledons, hypocotyls, and leaves, is highly possible with eggplants. The majority of known organogenesis systems rely on adding auxins and cytokinin's to culture conditions, either separately or together. Even while it was significantly greater than callus-generated shoots, the average number of regenerated shoots per explant (about seven shoots per explant) was modest. From a variety of explants, including leaf, cotyledon, hypocotyl, anther, and isolated microspores, callus induction and plant regeneration have been documented. Genetic modification is typically possible in regenerable calli. A few publications on the use of callus to infect with Agrobacterium and subsequently generate transgenic plants are, nevertheless, known. The impact of a binary vector system has been investigated using an Agrobacterium-mediated transformation system. Alam *et al*. 2010 [2].

Transformation for Insect Resistance

Numerous pests infest eggplant, which results in a significant reduction in output. These include red spider mites, jassids, fruit and shoot borers (FSB), epilachna beetles (hadda), stem borers, and epilachna beetles (Corral *et al*. 2012) [9]. The FSB is the most harmful and practically uncontrollable of them all. Insecticide applications in high doses are necessary for farmers. On the other hand, there aren't many "traditional" genetic sources of insect resistance in eggplant germplasm. This makes it difficult to create better cultivars using traditional breeding techniques that are resistant to harmful insects and illnesses. Since chemical management is the only way to control insects, consumers frequently have no choice but to accept fruit that has been eaten by insects, is infested with them, or has been exposed to a lot of pesticide residue (Subramanyam *et al*. 2013) [36]. The bacterium *Bacillus thuringiensis* (Bt) lives in soil and has a Gram-positive status. During sporulation, several Bt strains create -endotoxins, which are crystal proteins with insecticidal action.

Around the past 45 years, farmers all over the world have employed *Bt* (obtained by fermentation) widely as an insecticide through sprays or ground applications, notably in organic farming (Singh *et al*. 2015) [35]. Their main function is to penetrate the target membrane and create pores, lysing the midgut epithelial cells. To protect crops from insect attacks, molecular biologists use this opportunity to modify them. To make gene transfer and expression in agricultural plants easier, synthetic or semi-synthetic gene constructions have been created based on how plants use their codons. Over the years, eggplant has been genetically altered to express insecticidal crystal protein (cry) genes since it is an insect-prone crop (Khan *et al*., 2008) [24].

Editing of Genome in Egg Plant

An adaptive immune system known as the CRISPR-Cas system was found in bacteria and archaea for precise protection against bacteriophages and foreign plasmids. Later, this technology was successfully applied to modify the genomes of people, animals, and plants. A double-strand break in the DNA caused by the Cas9 protein sets off cellular DNA repair processes (Rajam *et al*. 1995) [32]. The error-prone non homologous end-joining procedure introduces random insertions, deletions, and substitutions if a homologous repair template is available. Gene function is typically disrupted as a result. The error-free homology-directed repair mechanism produces exact alterations if the donor DNA template homologous to the sequence near the double-strand break site is available. Consequently, precise gene alteration via gene knock-in, gene deletion, or gene mutation is feasible (Keshamma *et al*. 2008) [23]. On the knockout of the three target PPO genes (SmelPPO4, SmelPPO5, and SmelPPO6), only one article has been published thus far. PPOs catalyses the oxidation of polyphenols, which is what causes the flesh of the chopped eggplant fruit to turn brown. A desired quality for both industrial processing and fresh consumption is decreased browning. The produced alterations had no off-target effects and were extremely precisely acquired by the F1 and F2 progeny. Browning as a result of decreased PPO activity was seen. This example would undoubtedly open the door to additional eggplant targets (Tague *et al*. 2006) [37].

Conclusion

This review summarizes the various factor which are liable for the development of genetics resistance and multiple resistance in brinjal through different mechanism such as gene insertion, biotechnological approaches, germplasm collection etc. A meta-analysis of the transformation-influencing variables including explants, *Agrobacterium* strains, promoters to drive target genes, traits being attempted to be improved, and the geographic location of the research community, in particular those that generated transgenic eggplant.

References

1. Akinci IE, Akinci S, Yilmaz K, Dikici H. Response of eggplant varieties (*Solanum melongena*) to salinity in germination and seedling stages. N. Z. J. Crop Hortic. Sci. 2004;32:193-200.
2. Alam I, Kim KH, Sharmin SA, Kim YG, Lee BH. Advances in the molecular breeding of forage crops for abiotic stress tolerance. J Plant Biotechnol. 2010;37:425-441.
3. Alicchio R. Somaclonal variation in eggplant (*Solanum melongena* L.). In Somaclonal Variation in Crop Improvement I; Springer: Berlin/Heidelberg, Germany;

c1990.
4. BBS. Statistical Database of the Bangladesh Bureau of Statistics; B.B.o. Statistics, Ed.; Bangladesh Bureau of Statistics (BBS): Dhaka, Bangladesh; c2014.
5. Brown KF, Messem AB, Dunham RJ, Biscoe PV. Effect of drought on growth and water use of sugar beet. J Agric. Sci. 1987;109:421–435.
6. Chapman MA. Introduction: The importance of eggplant. In The Eggplant Genome; Springer: Cham, Switzerland; c2019. p. 1-10.
7. Choudhary B, Gaur K. The Development and Regulation of Bt Brinjal in India (Eggplant/Aubergine), in ISAAA Briefs; International Service for the Acquisition of Agri-Biotech Applications: New Delhi, India; c2009.
8. Collonier C, Fock I, Kashyap V, Rotino GL, Daunay MC, Lian Y, *et al*. Applications of biotechnology in eggplant. Plant Cell Tiss. Org. Cult. 2001;65:91-107.
9. Corral-Martínez P, Seguí-Simarros J. Efficient production of callus-derived doubled haploids through isolated microspore culture in eggplant (*Solanum melongena* L.). Euphytica. 2012;187:47-61.
10. Dempewolf H, Baute G, Anderson J, Kilian B, Smith C, Guarino L. Past and future use of wild relatives in crop breeding. Crop Sci. 2017;57:1070-1082.
11. Doganlar S, Frary A, Daunay MC, Lester RN, Tanksley SD. Conservation of gene function in the solanaceae as revealed by comparative mapping of domestication traits in eggplant. Genetics. 2002;161:1713–1726.
12. Dorica B. The study of *in vitro* induced somaclonal variations in eggplants (*Solanum melongena*). Buletinul USAMV ClujNapoca Seria Zootennie¸ si Biotehnologii. 2006:62:178-181.
13. Du L, Bao C, Hu T, Zhu Q, Hu H, He Q, Mao W. SmARF8, a transcription factor involved in parthenocarpy in eggplant. Mol. Genet. Genom. 2015;291:93-105.
14. FAO. International Treaty on Plant Genetic Resources for Food and Agriculture; Food and Agriculture Organization of the United Nations: Rome, Italy; c2009.
15. Farooqui MA, Rao AV, Jayasree T, Sadanandam A. Induction of atrazine resistance and somatic embryogenesis in Solanum melongena. Theor. Appl. Genet. 1997;95:702–705.
16. Gramazio P, Prohens-Tomás J, Plazas-Ávila MDLO, Mangino G, Herraiz-García FJ, Garcia-Fortea E, *et al*. Genomic tools for the enhancement of vegetable crops: A case in eggplant. Not. Bot. Horti Agrobot. Cluj-Napoca. 2018;46:1-13.
17. Guri A, Sink KC. Agrobacterium Transformation of Eggplant 1. Journal of Plant Physiology. 1988;133:52-55.
18. Hitomi A, Amagai H, Ezura H. The influence of auxin type on the array of somaclonal variants generated from somatic embryogenesis of eggplant, *Solanum melongena* L. Plant Breed. 1998;117:379-383.
19. Hui YH, Sherkat F. Handbook of Food Science, Technology, and Engineering-4 Volume Set; CRC Press: Boca Raton, FL, USA; c2005.
20. Jorge PAR, Neyra LC, Osaki RM, de Almeida E, Bragagnolos N. Effect of eggplant on plasma lipid levels, lipidic peroxidation and reversion of endothelial dysfunction in experimental hypercholesterolemia. Arq. Bras. Cardiol. 1998;70:87–91.
21. Kashyap V, Kumar SV, Collonnier C, Fusari F, Haicour R, Rotino G, *et al*. Biotechnology of eggplant. Sci. Hortic. 2003;97:1-25.
22. Kaushik P, Prohens J, Vilanova S, Gramazio P, Plazas M. Phenotyping of eggplant wild relatives and interspecific hybrids with conventional and phenomics descriptors provides insight for their potential utilization in breeding. Front. Plant Sci. 2016;7:677.
23. Keshamma E, Rohini S, Rao KS, Madhusudhan B, Kumars MU. Tissue culture-independent in planta transformation strategy: An Agrobacterium tumefaciens-mediated gene transfer method to overcome recalcitrance in cotton (*Gossypium hirsutum* L.). J Cotton Sci. 2008;12:264-272.
24. Khan H, Faisal M, Aniss M. Plant regeneration via somatic embryogensis in callus culuture of *Solanum melongena* L. Phytomorphology. 2008;58:153-157.
25. Kumar S, Prasanna P, Wankhades S. Potential benefits of bt brinjal in India-an economic assessment. Agric. Econ. Res. Rev. 2011;24:83-90.
26. Liu J, Zheng Z, Zhou X, Feng C, Zhuang Y. Improving the resistance of eggplant (*Solanum melongena*) to verticillium wilt using wild species Solanum linnaeanum. Euphytica. 2015;201:463-469.
27. Mall N, Pandey R, Singh S, Singhs S. Seasonal incidence of insect-pests and estimation of the losses caused by shoot and fruit borer on brinjal. Indian J Entomol. 1992;54:241-247.
28. Mat-Sulaiman NN, Rafii MY, Duangjit J, Ramlee SI, Phumichai C, Oladosu Y, *et al*. Genetic variability of eggplant germplasm evaluated under open field and glasshouse cropping conditions. Agronomy. 2020;10:436.
29. Meyer RS, Karol KG, Little DP, Nee MH, Litt A. Phylogeographic relationships among Asian eggplants and new perspectives on eggplant domestication. Mol. Phylogenet. Evol. 2012;63:685-701.
30. Monti A, Brugnoli E, Scartazza A, Amaducci MT. The effect of transient and continuous drought on yield, photosynthesis and carbon isotope discrimination in sugar beet (*Beta vulgaris* L.). J Exp. Bot. 2006;57:1253-1262.
31. Plazas M, Andújar I, Vilanova S, Hurtado M, Gramazio P, Herráiz FJ, Prohens J. Breeding for chlorogenic acid content in eggplant: Interest and prospects. Not. Bot. Horti Agrobot. Cluj-Napoca. 2013;41:26-35.
32. Rajam MV, Sharmas P. Genotype, explant and position effects on organogenesis and somatic embryogenesis in eggplant (*Solanum melongena* L.). J Exp. Bot. 1995;46:135-141.
33. Sidhu M, Dhatt A, Sidhus G. Plant regeneration in eggplant (*Solanum melongena* L.): A review. Afr. J Biotechnol. 2014;13:714–722.
34. Singh BK, Singh S, Yadavs SM. Some important plant pathogenic disease of brinjal (*Solenum melongena* L.) and their management. Plant Patho. J. 2014;13:208-213.
35. Singh D, Haicour R, Sihachakr D, Rajams MV. Expression of rice chitinase gene in transgenic eggplant confers resistance to fungal wilts. Indian J Biotechnol. 2015;14:233-240.
36. Subramanyam K, Rajesh M, Jaganath B, Vasuki A, Theboral J, Elayaraja D, *et al*. Assessment of factors influencing the Agrobacterium-mediated in planta seed transformation of brinjal (*Solanum melongena* L.). Appl. Biochem. Biotechnol. 2013;171:450-468.

37. Tague BW, Mantis J. In planta Agrobacterium-mediated transformation by vacuum infiltration. In Arabidopsis Protocols; Springer: Berlin/Heidelberg, Germany; c2006. p. 215-223.
38. Toppino L, Valè G, Rotino GL. Inheritance of fusarium wilt resistance introgressed from Solanum aethiopicum gilo and aculeatum groups into cultivated eggplant (S. *melongena*) and development of associated PCR-based markers. Mol. Breed. 2008;22:237-250.
39. Weese TL, Bohs L. Eggplant origins: Out of Africa, into the Orient. Taxon. 2010;59:49-56.