Bt Brinjal

A Pioneering Push

P. Ananda Kumar

Brinjal (*Solanum melongena* L.) (2*n*=24), commonly known as eggplant, aubergine or guinea squash, is an important vegetable crop of tropical and temperate parts of the world. It is a good source of vitamins and minerals, especially iron. Besides being used as an important vegetable, eggplant has been exploited extensively in traditional medicine.

Genus *Solanum*, to which brinjal belongs is predominantly of Central and South American origin. The question of center of origin of brinjal has been debated but is generally believed to have originated in India. Germplasm resources and collections have been well documented, evaluated and conserved throughout the world *(see picture on pg.109)*. Based on fruit shape brinjal has been divided into three main types namely, egg-shaped (*S. melongena* var. *esculentum)*; long slender shaped (*S. melongena* var. *serpentium*) and dwarf type (*S. melongena* var. *depressum)*.

Brinjal has been cultivated for the last 4,000 years in India. Among the Solanaceous vegetables, brinjal is the most common vegetable crop grown in many geographical parts in India. Brinjal has become an intrinsic part of Indian folklore and tradition. The area under brinjal cultivation is estimated at 0.55 million hectares with a total production of 8.2 million tons (www.faostat.fao.org). About 1.4 million small, marginal and resource-poor farmers grow brinjal. It is an important cash crop for poor farmers, producing two or three crops, each of 150 to 180 days duration.

Brinjal cultivars are susceptible to a variety of stress conditions which limit crop productivity significantly. The most important biotic stress factor that affects brinjal is an insect pest known as Brinjal Shoot and Fruit Borer (BSFB). Resistance to BSFB in brinjal germplasm is not available. Efforts to impart pest resistance to the cultivated varieties have achieved only limited success due to sexual incompatibilities with the source species or wild relatives. BSFB causes significant losses of up to 60 to 70% in commercial plantings. Damage starts in the nursery prior to transplanting, continues upto harvest and is then carried-over to the next crop. BSFB damages brinjal in two ways. Firstly, it infests young shoots during vegetative phase which limits the ability of plants to produce healthy fruit bearing shoots, thereby reducing potential yield. Secondly, it bores into fruits during reproductive phase making them unmarketable *(see picture on pg.109)*. Because of the cryptic nature of the pest the larvae remains hidden within the shoots and fruits rendering insecticide applications ineffective. Farmers usually spray insecticide twice a week, applying 15-40 sprays, or more, in one season depending on the levels of ▶▶

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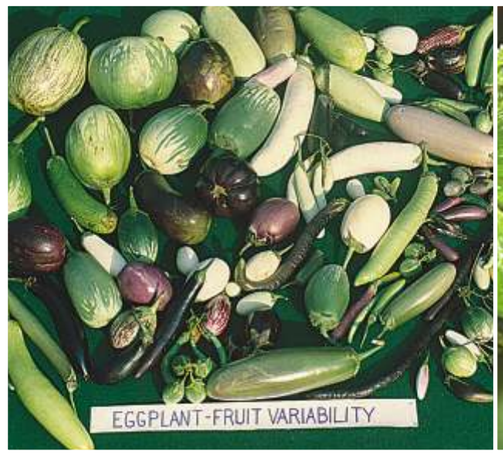


Diversity of brinjal in India

Brinjal shoot damaged by BSFB larva

▶ infestation. As a result, pesticides level are high in the fruits, which is a matter of serious concern from a health perspective. On an average, 4.6 kg of active ingredient of insecticide per hectare per season is applied on brinjal at a cost of Rs. 12,000 per hectare.

There is an urgent need to reduce the dependence on pesticides by using safer alternatives to manage insect pests. Many insecticidal proteins and molecules are available in nature, which are effective against agriculturally important pests but innocuous to mammals, beneficial insects and other organisms. Insecticidal proteins present in the soil borne bacterium, *Bacillus thuringiensis* (Bt), which has demonstrated its efficacy as a spray formulation in agriculture over the past six decades, have been expressed in many crop species with positive results. The Bt proteins are packed in the form of crystals and when ingested by the insect larvae are processed to an active form in the highly alkaline larval gut. The active protein binds to a compatible receptor protein present in the gut cell membranes resulting in perforations of the membrane and cell lysis leading to the death of the larvae. Human beings, other mammals and non-target organisms including beneficial insects do not contain receptors to Bt proteins and hence are not susceptible to Bt action

Three Bt transgenic crop species (cotton, corn and potato) have already been commercialized with substantial benefits to farmers. So much so that in 2008 Bt crops occupied an area of 43 million hectares out of the global transgenic area of 125 million hectares. Bt cotton was commercialized in India in year 2002 and has been a spectacular success story. In a short span of six years the area under Bt cotton cultivation has increased from 0.02 million hectares to 8.0 million hectares. In 2008, India occupied the second position in terms of global cotton production by turning out 32 million bales of cotton. The benefits of Bt cotton include increase in yields, reduction in cost of production (including a reduction of at least 50% in insecticide applications) and substantial environmental and health benefits to small producers. Reduction in the use of pesticides leads to lesser levels of insecticide contamination in aquifers, reduced farmer exposure to insecticides and improvement of human health, increased populations of beneficial insects, reduced risk for wildlife, reduced fuel and raw material consumption and decreased pollution. A similar effort is needed to replicate the success of Bt cotton in food crops to meet the challenges of food and nutritional security in the coming decades.

As early as 1995, efforts were made by the author to develop transgenic brinjal expressing insecticidal protein (Cry1Ab) of Bt. The transgenic lines were field tested on IARI farm which demonstrated limited protection against BSFB. Subsequently, an Indian seed company Mahyco developed transgenic brinjal expressing Cry1Ac protein of Bt. The best transgenic event 'EE-1' chosen out of several events showed a significantly lower number of ▶▶

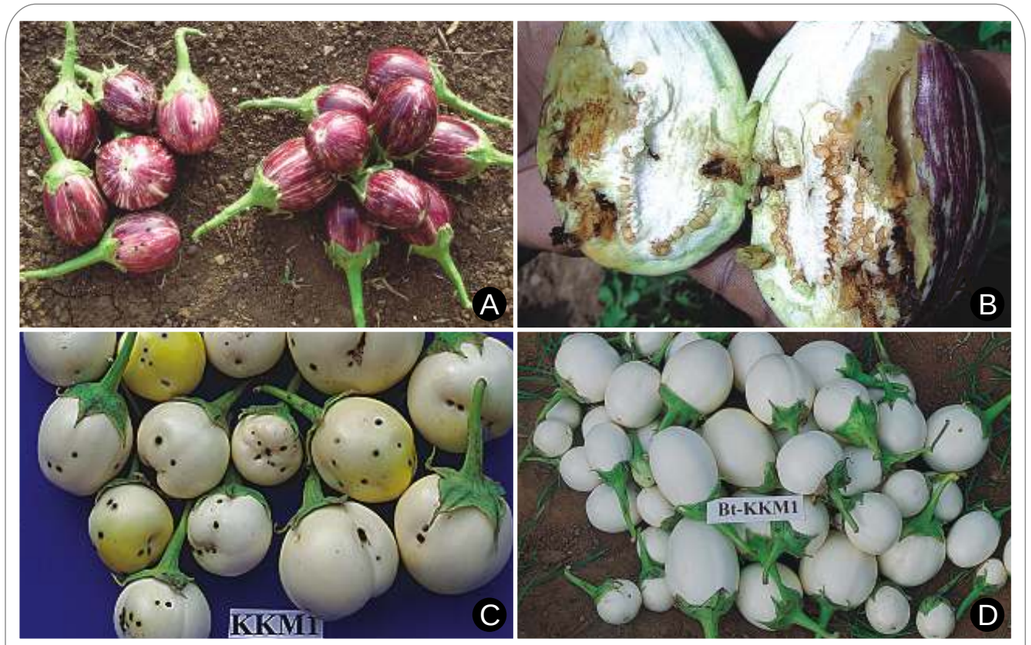
Bt CROPS UNDER DEVELOPMENT

Sr. No.	CROP	ORGANISATION (S)	TRAITS/GENE
1	Brinjal	Mahyco, Mumbai *(Recommended for commercialization by GEAC in Oct 2009 meeting)* TNAU Coimbatore, IVRI Varanasi, UAS, Darwad, IARI, New Delhi, Sungro Seeds Ltd., New Delhi	Insect resistance/ *cry*1Aa and *cry*1Aabc *cry*1Ac *cry*1Ac
2	Cabbage	Nunhems India Pvt. Ltd.	Insect resistance/ *cry* 1Ba and *cry*1CA
3	Cauliflower	Sungro Seeds Ltd., New Delhi Nunhems India Pvt. Ltd.	Insect resistance/ *cry1Ac, cry1Ba and cry1Ca*
4	Cotton	Mahyco, Monsanto, Rasi, Nuziveedu, Anku r, JK Seed, CICR,UAS-D	Insect Resistance, herbicide tolerance cry 1Ac gene
5	Groundnut	ICRISAT, Hyderabad	Virus resistance/ Chitinase gene
6	Maize	Monsanto, Mumbai	Shoot borer / cry1Ab gene
7	Chickpea	ICRISAT	Insect Resistance/ Pod borer, Cry 1Ac
8	Mustard	UDSC, New Delhi	Hybrid seed, barnase/ barstar gene
9	Okra	MAHYCO, Mumbai, Beejo Sheetal, Jalna	Borer *cry 1Ac , cry2Ab*
10	Pigeon pea	ICRISAT, MAHYCO	Pod borer and Fungal pathogene, Cry 1Ac and chitinase
11	Potato	CPRI, Shimla, NIPGR, New Delhi	*Ama1* and *Rb gene derived from Solanum bulbocastanum*
12	Rice	MAHYCO, Mumbai TNAU, Coimbatore	*cry1B-cry1Aa fusion gene* *cry1Ac, cry2Ab* *Rice chitinase (chi11) or tabacco osmotin gene*
13	Sorghum	NRCS, Hyderabad	Insect Resistance, Shoot borer
14	Tomato	IARI, New Delhi MAHYCO, Mumbai NIPGR, New Delhi	*Antisense replicase gene of tomato leaf curl virus* cry1Ac

Compiled by Dr. K. S. Charak, DBT

▶ BSFB larvae (0-20) on Bt brinjal, as compared to 3.5-80 larvae on the non-Bt counterpart. Multi-location and large scale trials (2004-2008) conducted by Mahyco, and independently by the Indian Council for Agricultural Research under the All-India Coordinated Research Program for Vegetable Crops confirmed that insecticide requirement for Bt brinjal hybrids was, on an average, 80% less than the same for the non-Bt counterpart. This not only translated into a 42% reduction in total insecticides usage, but also an increase of 100% in the average marketable yield of Bt brinjal compared to its non-Bt counterpart hybrids. It has been estimated that Bt brinjal farmers would enjoy a net gain of Rs. 50,000-60,000 per hectare compared to those cultivating conventional varieties.

Bt brinjal 'Event EE-1'has been subjected to a rigorous biosafety regulatory process encompassing all aspects of toxicity, allergenicity, environmental safety, socio-economic assessment etc. Studies on food and feed safety conducted on rats, rabbits, fish, chicken, goats and cows have ▶▶



A: Fruits of non-Bt and MHB 10 Bt B: Brinjal fruit damaged by BSFB larvae C: Brinjal without Bt D: Brinjal with Bt

▶ confirmed that Bt brinjal is as safe as its non-Bt counterpart. Similarly, environmental impact assessments to study germination, pollen flow, invasiveness, aggressiveness, weediness and effect on non-target organisms were also carried These confirmed that Bt brinjal behaves in a similar way as its non-Bt counterparts. Two expert committees constituted by the Genetic Engineering Approval Committee (GEAC) under the aegis of the Ministry of Environment and Forests (MoEF) have analyzed the biosafety data thoroughly and deliberated upon the representations made by various stakeholders including scientists and NGOs. Based on the observations made by the Expert Committees, GEAC has approved the environmental safety of Bt brinjal 'Event EE-1' on October 14, 2009.

The 'Event EE-1' has been transferred to brinjal varieties that are popular in the states of Karnataka and Tamil Nadu, by the scientists of the Agricultural Universities at Dharwad and Coimbatore, respectively. Indian Institute of Vegetable Research at Varanasi has also introgressed the event into its varieties. Mahyco has donated Bt brinjal technology to public sector institutions such as the Institute of Plant Breeding of the University of Philippines and Bangladesh Agricultural Research Institute in Bangladesh, an effort facilitated by the Agricultural Biotechnology Support Project (ABSP II) of the Cornell University, USA.

National Research Centre on Plant Biotechnology at New Delhi has developed a very effective event (Event 142) in brinjal cv. Pusa Purple Long and licensed it to private seed companies viz., Bejo Sheetal, Krishidhan, Nath Biogene and Vibha Seeds under Public Private Partnership. Hybrids containing Event 142 are currently undergoing biosafety tests and field trials.

In conclusion, cultivation of Bt brinjal will be a great boon to the resource poor vegetable farmers of India. This will go a long way in reducing pesticide usage in agriculture thus protecting human health, biodiversity and environment.■