



The Development and Regulation of Bt Brinjal in India (*Eggplant/Aubergine*)

by Bhagirath Choudhary and Kadambini Gaur

ISAAA Brief No. 38-2009

Executive Summary

This Brief is a comprehensive review of all aspects of the cultivation in India of the important vegetable brinjal, also known as eggplant or aubergine. Importantly, the Brief also summarizes the development and regulatory status in India of biotech Bt brinjal hybrids which confer resistance to the most important insect-pest of brinjal, the fruit and shoot borer, hereafter referred to as FSB. Bt brinjal was approved in India for experimental seed production in 2008-2009 and is under consideration for commercial release in the near term. Bt brinjal hybrid (referred to as Bt brinjal in this Brief) is of particular interest for three reasons. Firstly, it is likely to be the first biotech food crop commercialized in India, following the unparalleled success of the commercialization of the fibre crop, Bt cotton. Secondly, Bt brinjal technology has been generously donated by its private sector developer, Mahyco, to public sector institutes in India, Bangladesh and the Philippines for incorporation in open-pollinated varieties of brinjal for the use of small resource-poor farmers. Thirdly, sharing of knowledge and experience of the regulation process for Bt brinjal in India could greatly simplify and lighten the regulatory burden in Bangladesh and the Philippines by eliminating duplication of the significant effort already expended by India, thereby contributing to the important goal of harmonizing regulations between countries.

Brinjal is a very important common man's vegetable in India. After potato, it ranks as the second highest consumed vegetable in India, along with tomato and onion. A total of 1.4 million small, marginal and resource-poor farmers grow brinjal on 550,000 hectares annually in all the eight vegetable growing zones throughout India. It is an important cash crop for poor farmers, who transplant it from nurseries at different times of the year to produce two or three crops, each of 150 to 180 days' duration. Farmers start harvesting fruits at about 60 days after planting and continue to harvest for 90 to 120 days, thereby providing a steady supply of food for the family; it also provides a stable income from market sales for most of the year. Brinjal was one of the first vegetable crops adopted by farmers as hybrids, which occupied more than 50% of the brinjal planted area of 550,000 hectares in 2007, the balance being planted with openpollinated varieties. Brinjal is marketed in different sizes, shapes and colors to meet consumer preferences. Of the global production of 32 million tons (1ton=1,000kg) of brinjal produced on 2 million hectares worldwide annually, India produces 8 to 9 million tons, equivalent to one quarter of the global production, which makes India the second largest producer of brinjal in the world, after China. Brinjal is a hardy crop that yields well under stress conditions, including drought. Productivity has increased from 12.6 tons per hectare in 1987-88, to 15.3 tons per hectare in 1991-92 to 16.5 tons per hectare in 2005-06. Although the centre of origin for brinjal is not known for certain, cultivated and related wild species of brinjal in India represent a broad range of genetic diversity which has likely migrated from India, and China, to other countries in South- East Asia, Africa, Europe and the Americas.

Brinjal is prone to attack by many insect-pests, and diseases; by far the most important of which is the fruit and shoot borer (FSB), for which resistance has not been identified and thus it causes significant losses of up to 60 to 70% in commercial plantings. Damage starts in the nursery, prior to transplanting, continues to harvest and is then carried-over to the next crop of brinjal. FSB damages brinjal in two ways. First, it infests young shoots which limits the ability of plants to produce healthy fruit bearing shoots, thereby reducing potential yield. Secondly, and more importantly, it bores into fruits making them unmarketable at harvest - it is this decrease in marketable yield, as opposed to total yield, that is the most important yield loss caused by FSB. Due to the fact that FSB larvae remain concealed within shoots and fruits, insecticide applications, although numerous, are ineffective. Farmers usually spray twice a week, applying 15 to 40 insecticide sprays, or more, in one season depending on infestation levels. The decision of farmers to spray is influenced more by subjective assessment of visual presence of FSB rather than guided by the more objective science-based methodology of economic threshold levels. This reliance on subjective assessment of visual presence leads to gross over-spraying with insecticides, higher insecticide residues, and unnecessary increase in the farmers' exposure to insecticides. For example, for the more productive hybrid brinjal plantings, 54 litres of formulated insecticide per hectare is sprayed, compared with a requirement of only 16 litres when economic thresholds are used to trigger spraying. Similarly, for the less productive open-pollinated varieties, 26.7 litres of insecticides per hectare are used, compared with only 4.9 litres per hectare as required by economic thresholds. On 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; this is the highest quantity applied to any vegetable crop with the exception of chilli, which consumes 5.13 kg of active ingredient per hectare; okra consumes 3.71 kg of active ingredient per hectare. To illustrate the importance of FSB, of the 15 recommended insecticides for brinjal more than half, or eight are prescribed only for FSB. Typically, farmers indiscriminately apply a cocktail of insecticides on brinjal, including insecticides such as monocrotophos that are restricted or banned for use on vegetable crops. In a survey of pesticide residues in vegetable crops taken at the farm gate and markets from 1999 to 2003 confirmed that of the 3,043 samples, two-thirds were found to have pesticide residues, but these were within accepted tolerances, whereas 9% contained residues above the minimum recommended levels. The increasing amount of insecticide residues in vegetables and fruits has been a major concern to consumers who currently have no choice except to buy brinjals with high insecticide residues, but despite the application of many insecticides the brinjal fruits sold in the market are still of inferior quality, infested with larvae of FSB.

Bt brinjal has been under development by Mahyco in India for the last 8 years. It has undergone a rigorous science-based regulatory approval process in India and is currently at an advanced stage of consideration for deregulation by the Indian regulatory authorities which approved the experimental seed production of Bt brinjal hybrids by Mahyco in 2008-2009. Studies on food and feed safety, including toxicity and allergenicity tests, have been conducted on rats, rabbits, fish, chickens, goats and cows; these studies have confirmed that Bt brinjal is as safe as its non- Bt counterpart. Similarly, environmental impact assessments to study germination, pollen flow, invasiveness, aggressiveness and weediness, and effect on non-target organisms were completed, and it was confirmed that Bt brinjal behaves in a similar way to its non-Bt counterparts. Agronomic studies showed a significantly lower number of FSB larvae on Bt brinjal, 0-20 larvae, as compared to 3.5-80 larvae on the non-Bt counterpart. Multi-location research trials confirmed that insecticide requirement for Bt brinjal hybrids was on average 80% less than for the non-Bt counterpart for the control of FSB; this translated into a 42% reduction in total insecticides used for control of all insect-pests in Bt brinjal versus the control. As a result of the effective control of FSB, Bt brinjal's average marketable yield* increased by 100% over its non-Bt counterpart hybrids, 116% over popular conventional hybrids and 166% over popular open-pollinated varieties (OPVs) of brinjal. Thus, to-date the studies submitted to the regulatory authorities confirm that Bt brinjal offers the opportunity to simultaneously provide effective control of the most important pest of brinjal, FSB, decrease insecticides for this important insect-pest by 80%, and more than double the yield over conventional hybrids and open-pollinated varieties, thereby providing significant advantages for farmers and consumers alike. At the national level it can thus contribute to food safety and security and to sustainability.

**Marketable yield refers to the net yield of non-infested undamaged brinjal fruits that a farmer can sell at a premium price. It is the decrease in marketable yield of fruit, as opposed to total yield of fruit that is the most important yield loss caused by fruit and shoot borer (FSB) of brinjal.*