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ALTERNATIVES TO Bt- BRINJAL

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ABSTRACT: The *Bt* brinjal is a suite of transgenic Brinjals created by inserting a crystal protein gene (*Cry1Ac*) from the soil bacterium *Bacillus thuringiensis* into the genome of various brinjal cultivars. The dispute over *Bt* Brinjal still continues and a proper decision has not yet been reached neither by the Ministry of Environment and Forests nor by the general public and scientists. Currently farmers rely exclusively on the application of pesticides to control EFSB and to produce blemish-free eggplant fruit. Small and marginal farmers use 25-80 sprays of pesticides in Brinjal cultivation. Therefore, alternative strategies of IPM will help to control and manage the EFSB.

INTRODUCTION: India is the centre of origin for brinjal. It has been cultivated in India for the last 4000 years. There are approximately 2500 varieties of brinjal in India of various shapes and colors. It is estimated that the damage caused by the Shoot & Fruit Borer in brinjal ranges from 50 to 70% and in economic terms it is around $221 million. It is to lend tolerance to this pest primarily that the Bt Brinjal has been developed. Bt Brinjal is a transgenic brinjal created by inserting a gene cry1Ac from the soil bacterium *Bacillus thuringiensis* into brinjal through an Agrobacterium-mediated gene transfer. The transgenic brinjal hybrid is developed by Mahyco, a subsidiary of global seed giant Monsanto.

Bt-Brinjal is resistance against *lepidopteran* insects like the Brinjal Fruit and Shoot Borer *Leucinodes orbonalis* and Fruit Borer *Helicoverpa armigera.*

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When fruit and shoot borer larvae feed on *Bt* brinjal plants, they ingest the *B*t protein Cry1Ac along with plant tissue. In the insect gut which is alkaline with a pH >9.5, the protein is solubilized and activated by gut proteases crystallizing into fine needle-like shards that pierce the insect gut lining making holes in it. This leads to disruption of digestive processes, paralysis and subsequent death of the fruit and shoot borer larvae.

The dispute over *Bt* Brinjal still continues and a proper decision has not yet been reached neither by the Ministry Of Environment and Forests nor by the general public and scientists. The invention rather being accepted was hugely criticized by the general public, NGO‘s and Government. Large scale protests were held all throughout India against it. Consumption of *Bt* Brinjal would affect arguing that the genes were toxic and would affect the health of the consumers. Several studies on *Bt* crops in particular and GM crops in general show that there are many potential health hazards in foods bio-engineered in this manner. GM-fed animals in various studies have shown that there are problems with growth, organ development and damage, immune responsiveness and so on.

The current reality is that the Indian regulatory regime with regard to GM crops has never been assessed thoroughly as to whether the right questions are being asked with regard to GM risk assessment in Indian conditions. As in other parts of the world, the current safety assessments are inadequate to catch most of the harmful effects from GM crops, that too in an early warning system. It is no longer in question that GM technology is unpredictable and imprecise, that too when released in an open environment situation. Therefore, there are many worrisome issues with regard to this *Bt* Brinjal too.

Currently farmers rely exclusively on the application of pesticides to control EFSB and to produce blemish-free eggplant fruit. Pesticide use is very intensive for killing the larvae before they bore inside shoots or fruits; once in the shoots or fruits, larvae are inaccessible to the killing action of surface applied chemicals. Since neonate larvae can enter fruits or shoots within only a few hours of hatching from eggs, pesticides have to be applied frequently in order to have sufficient toxic residues on the plant surface adequate enough to kill the crawling larvae. Small and marginal farmers use 25-80 sprays of pesticides in Brinjal cultivation

The research and development activities to combat EFSB have largely been confined to screening pesticides to select the most effective chemical and determining the frequency of their use. At one time, researchers developed pesticide spray schedules that involved calendar spraying whether the pest was present or not [3, 12]. This approach has led to increased dependence on pesticides and consequent adverse effects of higher costs of production, environmental pollution, destruction of natural enemies, and development of pesticide resistance in EFSB. The current pesticide use is not only non-sustainable but, if continued, it will adversely affect brinjal plant and other vegetable production. There was, therefore, an urgent need for developing alternative control strategies

Arguments made against *Bt* brinjal:

1. Effective non-pesticide pest management and Integrated Pest Management exist and are being practiced by Farmers.
2. The question of internal destruction of pests is dangerous to the health of the consumer. The integrated pest management systems, in combination with good farming practices, are the only healthy solution to good crops. A healthy farm ecosystem is the key to pest management. This includes selection of good seeds, appropriate irrigation system and improving soil quality.
3. The experiences with a few other GM crops released in India and other parts of the world, especially *Bt* cotton, shows that over a period of time the total pesticide usage in GM crops has gone up due to increased secondary pest attacks and in some cases due to tolerance developed by the target pest. The Nagpur case study of the pest attack on *Bt* cotton plants shows that *Bt* does not have a full proof mechanism to remove pest threat.
4. Controlling pests with single toxic molecules either produced in factory or plant cell is an unscientific way of managing pests. Pests should be managed, not killed.
5. The studies on non-target pests at best were inadequate and inaccurate. The studies have been focused on a limited number of insects and for only a limited period of time.
6. The studies were also done with a surrogate protein and not with the modified Cry1Ac used in *Bt* brinjal.
7. As *Bt* brinjal is created to produce the Cry1Ac toxin in every cell, the 'pesticides' have actually moved from exterior to the interior of brinjal, and this cannot be removed by washing as in the case of the usual pesticide at present.
8. The studies on soil microflora were for a very short period. The impact of the break down products of the protein Cry1Ac on soil micro flora has not been conducted.

Biodiversity:

9. India is a centre of origin and diversity of brinjal which has been cultivated here for over 4000 years. There are about 2000 varieties grown across India.
10. The transgene transfer to local and hybrid varieties of brinjal will effectively destroy our

brinjal diversity. As a general rule GM crops should not be cultivated in the center of origin as it could lead to the loss of original varieties by transgenic cross pollination.

FIGURE 1: SOME OF THE INDIGENOUS VARIETIES OF BRINJAL

Human Health and Bio-safety:

11. Inadequacy of tests: No third party or independent tests have been conducted so far on the *Bt* impact on human health.

12. Significant chronic toxicity studies including carcinogenicity studies have not been conducted. Studies on the accumulation or wash-out time span on this specific endo-toxin in *Bt*. Brinjal have not been done. Historically the absorption and accumulation of the endo-toxins can be carcinogenic to humans.

13. Brinjal itself has an inherent property of allergenecity which may be enhanced further in the *Bt* variety.

14. When pesticides were first introduced and promoted, they were said to be harmless to human health. However, tough lessons have been learnt since then about the actual effects of pesticides. Genetic Engineering will have huge and as yet unknown implications for human health.

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Alternate strategies: There is a lot of experience in mechanical control as well as non-chemical IPM strategies within the Indian research system. Further, there is much experience of non-chemical brinjal cultivation in farmers' fields by many practicing organic and NPM farmers in the country.

Simple things like pheromone traps for mass trapping, sanitation of the field [timely removal and destruction of affected shoots & fruits], mechanical barriers, use of some local plant extracts for pest control etc., have all worked well for farmers

As practicing Natural Pest Management (NPM) and organic farmers from various parts of the country would testify, pest management in Brinjal does not need either pesticides or GM seeds when safer, cheaper alternatives in the control of farmers are available.

What is needed is a public support system for such alternatives to be promoted, spread and practiced. Such alternatives inevitably show that the farmers benefit out of increased net incomes, derived from internalizing various inputs including Seed. Host-plant resistance, biological control, sex pheromone, and mechanical control are some alternatives to the use of pesticides

Sex Pheromone Traps: AVRDC obtained pure chemicals and tested mixtures of varying proportions of E11-16: Ac and E11-16: OH in selected locations in Asia. Results of field studies in Bangladesh and later in India indicated that high concentrations of E11-16: Ac alone or low concentrations of mixtures of E11-16: Ac and E11-16: OH (10:0.5 or 10:1) attract large numbers of male moths to pheromone-baited traps (AVRDC, 1996; Praveen Kumar and Sundara Babu, 1997; Srinivasan and Sundara Babu, 2000). These results formed the basis for inclusion of sex pheromone as one of the components of IPM of EFSB in this project.

EFSB MALE ADULTS CAUGHT IN PHEROMONE-BAITED TRAP

FSB SEX PHEROMONE LURES IN INDIA; from left to right, products from Agriland Biotech, Pest control India, and Ganesh Bio-Control

Host-Plant Resistance: Although numerous reports from India have indicated the availability of FSB-resistant cultivars, these reports were based on testing of a few, rarely over a dozen, local commercial cultivars [5].

These results were never pursued further possibly because the level of resistance was inadequate to reduce pest populations. Some wild *Solanum* species showed high levels of resistance, but it proved to be impossible to incorporate the genes for resistance from wild species into commercial cultivars due to breeding incompatibilities [6]. Later research in Taiwan identified one eggplant accession possessing genetic resistance that can be exploited in breeding pest-resistant eggplant cultivars (AVRDC). Also found a new source of resistance in Turbo, a commercial F1 hybrid cultivar grown by farmers in Thailand.

In two identical tests in Thailand and Taiwan, this cultivar was consistently less damaged than the susceptible check. Turbo has green rind, succulent flesh, and good quality fruits. It is, however, an F1 hybrid currently available in Thailand only. Its commercialization in other countries, if the fruit type is acceptable to local taste, will go a long way toward reducing FSB damage and pesticide use. At the same time, introducing purple fruit color in Turbo could make this cultivar popular in countries where purple color is preferred.

Mechanical Control: Mechanical control techniques give immediate and tangible results, even though they are time consuming. Some of the common practices include: handpicking of large larvae or adults; erecting mechanical barriers; cleaning of planted areas prior to, during or after the cropping season (also termed sanitation); and denying pests alternate sources of food. An experiment to this effect was conducted in which a combination of barrier and sanitation was utilized to minimize FSB damage to brinjal plants.

This experiment was based on two premises. First, the EFSB adult is a relatively small moth and flies short distances when disturbed. Such insects, therefore, can be prevented from spreading from field to field by erecting suitable barriers. Second, larvae of EFSB bore inside tender eggplant shoots, especially before fruit set, and cause wilting of shoots. The insects inside these damaged shoots eventually develop into pest adults that spread and lead to future yield losses. Therefore, the combination of mechanical barriers and prompt destruction of freshly wilted shoots harboring pest larvae has potential in controlling EFSB effectively

Biological Control: A report from Sri Lanka indicates that the occurrence of a larval parasitoid, *Trathala flavo-orbitalis* (Cameron), which has potential for providing some degree of pest control [10]. Another larval parasitoid, *Eriborus sinicus*, was observed in Taiwan and presented an opportunity for biological control of the pest (AVRDC, 1996). A two-component pheromone of this pest was identified in late 1980s [13, 2], but its use in combating FSB was never exploited. As many as sixteen parasitoids, three predators, and three species of entomopathogens have been reported as natural enemies of EFSB from all over the world [7].

However, they do not seem to play any significant role in keeping EFSB damage under reasonable control [12] especially in South Asia. The sole exception is a study from Sri Lanka where [10] reported a high level of parasitism of EFSB larvae by a parasitoid, *Trathala flavo-orbitalis* (Cameron) (Hymenoptera: Ichneumonidae). This parasitoid has been reported to be present in India [8] and Bangladesh [1], however, its contribution to pest control was rarely documented and does not appear to be significant. Since, biological control is an important component in IPM and very little information is available on the role of biological control agents in combating EFSB in the region.

Integration of these control approaches, the only ones readily available, was needed in order to develop a safe and sustainable control strategy that would reduce farmers' dependence on toxic chemicals.

FIG. 4: ADULT OF TRATHALA FLAVO-ORBITALIS

Some alternatives to the use of Pesticides: The FSB is only vulnerable to sprays for a few hours before it bores into the plant, forcing farmers to spray insecticides as often as every 2-3 days (AVRDC, 2001).

The farmers were frequently changing insecticides because no one insecticide could control EFSB. But farmers were not spraying one insecticide at a time; generally they were mixing one powder insecticide with one liquid insecticide and then spraying the mixture formulation.

IPM: This dynamic and paradigm shift in management strategies satisfies all the bio-safety concern as well as playing a pivotal role in combating insect pests of high-value and damage sensitive crop

The Setting of only pheromone trap @ 75 numbers per hectare gave quite substantial protection in shoot damage (58.35%), fruit damage (33.73%) and yield (28.67%) while simultaneous use of trap + azadex afforded 71.72 and 39.06 per cent protection against shoot and fruit damage, respectively [4].

SUMMARY: An Integrated Pest Management (IPM) strategy helps to control FSB with minimal use of pesticides. It involves field sanitation, especially proper disposal of eggplant stalks, to prevent carryover of EFSB from previous season; prompt excising and disposal of EFSB-damaged shoots, with larvae inside, throughout the season; installation of traps baited with sex pheromone to attract and kill EFSB adult males; and withholding of insecticide use for as long as possible to allow native natural enemies of EFSB to proliferate and help control the pest. Integration of all four approaches is essential for successful control of EFSB.

Also, possible use of mechanical barriers to reduce immigration of the pest from elsewhere to newly planted crops; multi-location testing of available sources of resistance within *Solanum melongena* germplasm to judge stability of resistance, a survey of the occurrence of local parasitoids and their role in reducing pest populations and understanding the socio-economics of eggplant production and protection is required.

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