Plant Biotechnology:  
Current and Potential Impact  
For Improving Pest Management  
In U.S. Agriculture  
An Analysis of 40 Case Studies  
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Insect Resistant Eggplant  

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39. EGGPLANT

Insect Resistant

Production
Eggplant is a major vegetable crop in New Jersey, ranking sixth or seventh in crop value for the state. In 2000, 800 acres of fresh market eggplant were harvested, producing 20 million pounds with a total value of $4.7 million dollars [1]. New Jersey accounts for approximately 12% of the national production of eggplant annually. New Jersey is the major national supplier of eggplant in the summer. Transplanting is the preferred method of eggplant production. New Jersey eggplant fields can yield up to 20 pickings if pests are adequately controlled [4].

Colorado Potato Beetle
Colorado potato beetle (CPB) is the primary insect pest in New Jersey [2]. Both larval and adult CPB feed on eggplant foliage, flowers, growing tips, stems and fruit [3]. Feeding by CPB can defoliate plants, killing them or significantly reducing their yields. Younger plants are more likely to suffer yield loss as a result of defoliation by CPB, but once eggplants have passed the bloom stage, they may tolerate as much as 30% or more defoliation without yield loss. Eggplants are continually producing flowers until frost.

Colorado potato beetle feeds on solanaceous plants such as potato, tomato and eggplant. They overwinter as adults in the soil and when they emerge in early spring, the beetles either walk or fly to host plants such as eggplant and lay eggs on the underside of leaves. Each female deposits up to 200 egg masses containing about 30 eggs/mass [7]. Larvae emerging from eggs eat the empty egg cases, then start feeding on host plant foliage. Larvae feed for approximately three weeks, going through four larval stages, then drop into the soil to pupate. After pupating, adult beetles emerge and lay eggs for a second generation on available host plants.
CPB Management

In the case of the CPB and eggplant, current alternatives to insecticide use are either inadequate or nonexistent. Endemic natural enemies have been shown to be effective only at low CPB densities [4]. There are no resistant cultivars and no plant breeding for resistance is underway. Eggplant growers already annually rotate to other crops in order to avoid buildup of verticillium wilt [4].

The introduction of DDT in the 1940’s initially provided effective control of the CPB on eggplant [6]. However, CPB populations quickly developed resistance to DDT and a succession of organochlorines, organophosphates, carbamates, and pyrethroid insecticides subsequently were used to control the CPB in New Jersey eggplant. More than 20 foliar and systemic insecticides have completed the full cycle of high initial control efficacy succumbing to widespread CPB resistance [5, 6]. Growers were applying up to 12 sprays per acre per year for control of the CPB in the early 1980’s [15]. In response to this in the early 1980’s, a biological control management program was developed using an exotic egg parasitic wasp imported from Columbia. Research demonstrated that the exotic parasitoid killed 67-79% of all CPB eggs [9]. The wasp does not survive temperate winters and it has to be released each year. The New Jersey Department of Agriculture released wasps twice weekly for 6-8 weeks during the season for a total of 10000/ ha [4]. Growers typically supplemented the parasitoid release with two applications of rotenone usually prior to their release [17]. This program was widely adopted in New Jersey and resulted in significant reductions in the number of sprays applied to eggplant [2]. The New Jersey Department of Agriculture charged growers $100/a for release of the parasitic wasps [17]. Since imidacloprid, a member of a novel class of systemic insecticides, was introduced in the mid 1990s, it has dominated CPB management in New Jersey eggplant [8]. The soil formulation of imidacloprid is most commonly used, applied as a drench to transplants before planting, or as a broadcast soil application or an in-furrow treatment at planting, leading to the discontinuation of the parasitoid program [17].
Research has shown that a low rate of imidacloprid applied directly to transplants 3-7 days before planting produces effective control of CPB through mid-June [7].

Research that compared imidacloprid to an untreated check demonstrated a reduction of greater than 99% of larvae per 8 plants (220 to 1), with percent defoliation from first generation CPB reduced from 60% to 1% [16]. Imidacloprid is used on approximately 90% of New Jersey’s eggplant acreage at a rate of 0.26 lb ai/a/yr (208 lbs ai /yr total). New Jersey eggplant growers also use approximately 200 lbs of endosulfan per year (primarily for aphid control) and 500 lbs of fenbutatin oxide for mite control [14]. The cost of the imidacloprid applications is estimated at $74/a/yr based on a 0.26 lb ai/a rate and a cost of $567/gal, which contains 2 lbs of active ingredient [19].

Transgenic Eggplant

Researchers at Rutgers University have developed CPB-resistant eggplants by transforming them with a gene for the Bt toxin cryIIIB, which has activity against beetles. The ‘Black Jack’ variety was first transformed with a native Bt gene, but the resulting plants did not show resistance to CPB [10]. Subsequent work used a synthetic cryIIIA gene, designed for expression in plants, to transform ‘Harris Special’ eggplants [11, 12]. Laboratory evaluations showed expression of the synthetic gene and production of the cryIIIA protein toxin. Leaf feeding studies showed significant reduction in weight of CPB larvae fed transgenic leaves. The use of the transformed plants resulted in the lowest adult densities in the study (96% reduction vs. 89% for imidacloprid) [11]. Exposure to leaves containing the Bt toxin significantly reduced feeding by adult beetles when compared to plants not containing the toxin. The reduction in feeding was similar to that observed for leaves treated with imidacloprid indicating that the expression of the gene in eggplant provides commercially acceptable control of the beetle [11]. The effect of the toxic protein is swift and consistent:

1. on the leaves of transgenic plants, all the neonate larvae died within a few hours after hatching; and
2. adult insects, raised on nontransgenic plants and transferred onto transgenic leaves, languished within 8 to 10 days, causing minor damage before they died [12].

Field trials showed significant reductions in number of CPB present on transgenic plants as compared with untransformed plants. Field trials also showed that Bt plants produced harvestable yields higher than untreated, untransformed plants and comparable to untransformed plants that were treated with one application of imidacloprid [18]. In varietal field trials in which all plants were treated with imidacloprid, the Bt cultivars produced the highest percent marketable yields (93-94% vs. 82-91%) and met commercial standards for preferred plant and fruit qualities such as color and shape [13].

**Estimated Impacts**

Assuming Bt eggplant provides CPB protection equivalent to or better than that provided by imidacloprid, acreage planted to the Bt cultivar would not be treated with imidacloprid. Assuming the additional cost of the transgenic cultivars would also be equivalent to or less than the cost of imidacloprid use, adoption of Bt eggplant cultivars would be widespread in New Jersey. Estimated impacts of Bt eggplant adoption include a 22% reduction (208 lbs a.i.) in the state’s insecticide use on eggplant.
References


17. Chianese, Robert, New Jersey Department of Agriculture, Personal Communication, September 2001
