6. *Bt* Potato Plant-Pesticides

This section reviews the benefits from Cry3A protein which controls the Colorado potato beetle. The initial registration for commercial use of Cry3A expressed in potatoes was in May 1995 following an SAP meeting in March 1995 which considered EPA's risk and benefit assessments. The SAP supported EPA's assessments. In November of 1998, EPA approved the use of a plant-pesticide to control potato leaf roll virus. This new registration is expected to increase the benefits for Cry3A when the two plant-pesticides are "stacked" in the potato.

a. Insecticide Usage to Control Colorado Potato Beetle

Majority of potatoes are planted for fall harvesting. Total revenues for 1999 were $2.8 billion for an average revenue of $2,021 per acre (NASS, 1999 and 2000).

	Area Planted		Area Harvested		Yield	
	1999	2000	1999	2000	1999	2000
	-------- 1,000Acres ------				--------cwt---------	
Winter	18	17	18	17	229	278
Spring	87	82	85	80	300	281
Summer	69	65	64	63	295	289
Fall	1,203	1,224	1,166	1,200	369	
total	1,377	1,388	1,332	1,360	359	

Colorado potato beetle is the most important pest of potatoes in the United States, although it is not the most important pest in all potato growing states. The National Potato Council (1998) identified Colorado potato beetle as the most important insect pest of potatoes for seven of the top eleven potato producing states.

The adoption of *Bt* potato plant-pesticides has not been as large as it has been for other *Bt* plant-pesticides. In 1996 approximately 10,000 acres or 1% of the total of the potato crop was *Bt* potatoes. Levels of adoption have increased over the last five years up to 50,000 acres or just under 4% of the total 1999 potato crop was *Bt* potatoes. Initially only one potato variety was engineered to produce Cry3A and now four varieties, Russet Burbank, Superior, Shepody and Atlantic *Bt* potato varieties are available.

Chemical insecticides have a long history of use to control Colorado potato beetles. Thirty-four percent of total insecticide use on potatoes is for control of Colorado potato beetles, more than for any other insect pest (Doane Marketing Research, 1998). There are a variety of alternative materials available to control Colorado potato beetles including some *Bt* microbial pesticide products. The National Potato Council (1998) lists aldicarb, azinphos-methyl, carbofuran, cryolite, disulfoton, endosulfan, esfenvalerate, imidacloprid, metamidophos, permethrin, phorate, and phosmet as well as *Bt* microbial sprays and *Bt* potatoes as pesticide products to control Colorado potato beetles. In addition, there are several mechanical and cultural controls used to reduce populations of this pest.

Bt potato (trade name NewLeaf) technology fee was about $30 per acre in 1998 (Gianessi and Carpenter, 1999) and market share was 4%. Savings on the cost of treatment could be as high as $60/acre if one at-plant insecticide application was not needed (Gianessi and Carpenter, 1999). Using the simple simulation model, an upper limit benefit of *Bt* potato of $60 /acre, *Bt* seed premium of $30/acre, a market share of 4.0 %, upper limit *Bt* specific costs are $175/acre and net benefit per acre of $9.30. Upper limit *Bt* specific costs are 8.8% of the $2,021 average potato value per acre. At an average cost of $22/acre (Doane 1998), average acre treatment reductions are the benefits per acre plus seed premium divided by the cost per acre (39.30/22=1.8). National use reductions are 89,000 less acre treatments.

Grown	acres *Bt* (000's)	Benefit/acre	benefit ($m)	Market share
1377	50	$ 9.30	$0.5	4.0%

Environmental and human health benefits can also be attributed to cases where more toxic insecticides are replaced by *Bt* potato plant-pesticides. Several of the above list of pesticides are organophosphates, carbamates, and synthetic pyrethroids with potential or known adverse effects to non-target organisms and workers. *Bt* plant-pesticides fit well into IPM programs as well as reducing reliance on chemical pesticides.

6. Summary of Results

a. General Findings

Bt seed has positive benefit to growers and consumers by increasing yields and/or reducing input costs for chemical insecticides. *Bt* seed also has positive environmental benefits, especially for aquatic wildlife as it replaces more toxic organophosphate and pyrethroid insecticides, in cotton.

Direct benefits to growers for *Bt* corn, cotton and potatoes has likely exceeded $100 million in 1999. Cotton has the highest benefits/acre, but since *Bt* corn has five times the planted acres of *Bt* cotton, corn has the highest aggregate grower benefits.

	Acres of *Bt* (000's)	Benefit per acre	Grower Benefits Millions $	Market share	Reduced use (000's)
Field corn	19,755	$ 3.31	$ 65.4	25.5%	inconclusive
Cotton	3,585	12.80	45.9	28.0%	7,500
Sweet Corn	30	5.38	0.2	4.0%	127
Potatoes	50	9.30	0.5	4.0%	89
Totals	23,420		111.9		7,716

Sources: NASS, Cotton Council, registrant submissions, EPA estimates

Most of the conventional pesticide use reduction associated with *Bt* seed involves cotton insecticides in the Southeast and Southwest. The number of incidents and mortalities to aquatic wildlife are likely to be lower during the past four years as the use of pesticides toxic to aquatic wildlife has been reduced.

b. *Bt* Corn Plant-Pesticides Benefit Review

Bt field corn increases yield only when European corn borers and other stalk borers reach damage levels. In any given year, growers would not recover the cost premium of *Bt* corn when corn infestation levels are below damage levels. Some studies have suggested that *Bt* corn results in a reduction in conventional pesticide use. Reductions have been shown in areas with high European corn borer pressure and the use of those chemicals recommended for the control of European corn borer have also declined from 1996 to 1999. But whether there has been an overall decline in chemical use is inconclusive. Historical USDA/NASS chemical usage surveys do not indicate an overall pesticide reduction use reduction, even for states where infestation of stalk boring insects is high. *Bt* corn seed has affected pesticide selection but a definitive case cannot be made for use reduction.

Even though the 1999 *Bt* seed premium is $7- $10 for *Bt* corn, much lower than the $15- $30 per acre premium for *Bt* cotton, estimated *Bt* corn benefits are $3.31/acre compared to $12.80 for cotton. Due to the large acreage of *Bt* field corn, overall aggregate benefits are $65.4 million per year.

For sweet corn, the EPA review uses NASS data for acres planted with genetically modified crop varieties that were resistant to insecticides, NASS data for insecticide treatments per acre, registrant data on seed premiums, and the simple simulation model to estimate net benefits and use reduction. The estimated use reduction of 4.3 treatments per year applied to the 30,000 acres treated with plant pesticides, provides the total use reduction estimate of 127,000 acres in 1999. *Bt* sweet corn plant-pesticide primarily replaces organophosphate and pyrethroid insecticide treatments and thus would also benefit aquatic wildlife and workers.

c. *Bt* Cotton Plant-Pesticides Benefit Review

Bt cotton has the highest per acre grower benefits and the largest substitution for and reduction in conventional pesticide use. *Bt* cotton increases yields and reduces pesticide costs. Grower benefits have increased from $16 million in 1996 to $44 million in 1999, as adoption rates have gone from 17% to 28%. Benefits have grown as *Bt* cotton seed premiums have been reduced. Lower premiums have led to both higher adoption rates and increase in grower per acre benefits.

Environmental benefits accrue as *Bt* cotton substitutes for the use of conventional insecticides more toxic than *Bt*. *Bt* cotton controls the tobacco budworm, cotton bollworm and pink bollworm. Reductions in use of conventional insecticides are estimated to be 7.5 million acre treatments and 1.6 million pounds active ingredient. Pyrethroids account for over half of the acre treatment reduction while OP's account for over half of the pounds active ingredient. The use reductions are principally in the Southeast and Southwest. Without *Bt* seed, cotton would receive 37.5 million acre treatments of conventional insecticides.

Estimated Use Reduction of *Bt* Cotton Alternatives, 1999
(In millions)

Class	Acres (M)	lbs ai (M)
OP's	2.6	1.2
Pyrethroids	4.3	0.2
Other	0.5	0.3
All	7.5	1.6

Source: EPA estimates

The benefits of *Bt* cotton are largest for aquatic wildlife as it replaces use of 3 chemical pesticides listed in the top 10 for aquatic incidents from use on cotton.

Environmental and Human Health Benefits of *Bt* Cotton

Incidents to terrestrial and aquatic wildlife	Use reductions include 3 active ingredients listed for many aquatic incidents. EPA generally concerned about the ecological effects to terrestrial wildlife and aquatic organisms

Incidents of adverse health effects from pesticide exposure for which individuals require health care.	Occupational risk assessment indicates risk concerns for aerial mixer/loaders and aerial applicators Worker incident data not available for states affected (Southeast and Arizona)

Source: Environmental Protection Agency Ecological Incident Information System, Pesticide Reregistration Eligibility Decisions (RED's) http://www.epa.gov/REDs/

d. *Bt* Potato Plant-Pesticides Benefits Review

Bt potato plant-pesticide was registered in 1995, but the market share has remained low, even though the Colorado potato beetle accounts for a third of insecticide use. Like *Bt* sweet corn, the major benefit is to reduce chemical applications.

About 80% of current insecticide use on potatoes comes from older OP's, carbamates and pyrethroids. Recently registered safer alternatives (Imidocloprid and Spinosad) account for 15% of applications. These competitive products may explain some of the slow adoption of *Bt* potato plant-pesticides, but there may be additional reasons for the slow adoption not identified in this review.

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