Pocket K No. 5

Documented Benefits of GM Crops

The global area planted to GM crops has consistently increased over the past years. Substantial share of GM crops has been grown in developed countries. In the last few years, however, there has been a consistent increase in the number of hectares being planted to GM crops in the developing world. Thirty percent of the total global GM crop area is now being grown in developing countries. A significant increase in GM crop area was reported in developing countries of Africa, Asia, and Latin America. Experiences from these countries show that resource-poor farmers can also benefit from this technology.

This Pocket K documents some of the GM crop experiences of selected developing countries.

Global Impact of GM Crops

Farm Income

Biotech crops have had a positive impact on farm income worldwide due to enhanced productivity and efficiency gains. In 2004, direct global farm income benefit was $4.8 billion. If the income gained from the additional plantings of soybean in Argentina is included in the estimate, the value rises to $6.5 billion. Over the period of nine years between 1996-2004, farm incomes have increased by over $19 billion or $27 billion inclusive of second-crop GM soybean gains in Argentina.[1] Soybeans planted right after the wheat harvest are called second-crop soybeans. This double-cropping is practiced by farmers to maximize land productivity and is usually done only when the timing, weather and soil conditions are favorable.

Global farm income benefits from growing GM crops, 1996-2004 (US$ million)

GM Trait	2004 increase in farm income	1996-2004 increase in farm income
HT Soybean	2,440 (4,141)	9,300 (17,351)
HT maize	152	579
HT cotton	145	750
HT canola	135	713
IR maize	415	1,932
IR cotton	1,472	5,726
Others	20	37
Totals	**4,779 (6,480)**	**19,037 (27,088)**

Note: HT = herbicide tolerant, IR = insect resistant, others = virus-resistant papaya and squash, rootworm-resistant maize. Figures in parentheses include second-crop benefits in Argentina. Adopted from: G. Brookes and P. Barfoot, 2005

Pesticide Use

Since 1996, farmers planting biotech crops have reduced pesticide inputs in their fields by 6.3% or over 172.5 million kg which led to an overall reduction in the environmental footprint of biotech crops by 14%. Environmental footprint is a measure of the effect or impact a product, process, operation, an individual or corporation places on the environment, in this case, measuring the environmental effects of pesticides.

The largest environmental gain was recognized in fields where HT soybeans were planted. The volume of herbicides used by soybean farmers has decreased by 41 million kg over the past nine years. Similarly, significant reductions in pesticide loads were experienced by farmers planting insect resistant (IR) and herbicide tolerance (HT) biotech cotton.[1]

Impact of changes in the use of herbicides and insecticides in GM crops globally, 1996-2004 (US$ million)

GM Trait	Change to Pesticide Use (million kg)	Change in field EIQ (million field EIQ/ha units)	% Change in Pesticide ai Use	% Change in EIQ Footprint
HT Soybean	-41.4	-4,111	-3.8	-19.4
HT maize	-18.0	-503	-2.5	-3.4
HT cotton	-24.7	-1,002	-14.5	-21.7
HT canola	-4.8	-252	-9.7	-20.7
IR maize	-6.3	-377	-3.7	-4.4
IR cotton	-77.3	-3,463	-14.7	-17.4
Totals	**-172.5**	**-9,708**	**-6.3**	**-13.8**

Note: HT = herbicide tolerant, IR = insect resistant, Ai = active ingredient, EIQ = environmental impact quotient.

(Environmental Impact Quotient (EIQ), a universal indicator where the various environmental impacts of individual pesticides are integrated into a single field value per hectare. This EIQ value is multiplied by the amount of pesticide active ingredient (ai) used per hectare to produce a field EIQ value.) Source: G. Brookes and P. Barfoot, 2005

Developed Country Experiences

Several studies on GM crop adoption in North America and elsewhere highlighted the multiple benefits derived from GM crops. Examples are the following:

United States

- An estimate cost savings by farmers planting HT soybean was $78/ha in 2004, three times higher compared to the early years of adoption. The annual total national farm income

benefit from HT soybean has dramatically risen from $4 million in 1996, to nearly $1.6 billion in 2004. [1]
- Glyphosate- and glufosinate-resistant corn reduced the herbicide use in corn production by 18.5 million pounds (15.2 and 3.3 million pounds, respectively) in 2004. US farmers saved $139 million from the reduced pesticide use. [5]
- The US is estimated to have enhanced farm income from biotech crops by $10.8 billion in the period 1996 to 2004. [3]

Canada
- HT canola has boosted the total canola production in Canada by 8% in 2004. Adopters of biotech canola earned $121 million in 2004 - twenty times more than in 1996. [1]
- The net increase in farm income by HT maize farmers in 2004 was $3.5 million. Average annual profits have improved by $14-16/ha since 1999. [1]
- Canada is estimated to have enhanced farm income from biotech crops by $0.8 billion in the period 1996 to 2004. [3]

Spain
- Bt maize adoption in Spain in 2005 resulted in yield increases of 6% on average, the net impact on gross margin $112 per hectare. [3] Farmers also experienced savings on pesticide use by €24 to €102/ha. [13]

Australia
- For 2003 and 2004, Australian farmers planting IR cotton have significant cost savings of about $60-70/ha despite the high cost of technology. In 2004, net farm income at the national level was $15 million. [1]

Has adoption of biotech crops also benefited small-scale farmers in developing countries? The developing country experiences above provide the answer.

Developing Country Experiences

Bt cotton adoption in India

Cotton is a very important crop for India, accounting for 30% of its agricultural GDP. India ranks third in cotton production worldwide, and in 2005 India produced 4.13 million tons,, following China (6.31 million tons) and the US (5.06 million tons)[9]. However, due to the high incidence of pests, especially the cotton bollworms, India falls short of the world's average yield of cotton by 48%, an equivalent of 280 kg/ha[2]. Indian farmers often lose up to 50-60% of their crop to the cotton bollworm.[10]

Adoption of Bt cotton started in 2002 with 3 hybrids planted in six Indian states: Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka, Maharashtra and Tamil Nadu[2]. By 2005, there were 20 Bt cotton hybrids approved for planting and a total of 1.3 Million hectares of Bt cotton plantations in India.[2] In a landmark decision, the Genetic Engineering Approval Committee

(GEAC) of the Ministry of Environment and Forestry (MOEF) approved 43 new additional hybrids of Bt cotton varieties in 2006.

Year	Hectarage (Million Has.)
2002	0.44
2003	0.1
2004	0.5
2005	1.3
Source: ISAAA	

Maharashtra Study

Actual farmer fields' studies[2] in 2002 and 2003 in the state of Maharashtra revealed that:

- Bt cotton yield increaed by 45% in 2002, and by 63% in 2003 compared to non-Bt cotton varieties
- Higher revenues were attained by Bt cotton farmers compared to those who planted conventional cotton. The average income difference for 2002 and 2003 were 43% and 63%, respectively.
- The average gross margin (difference of the revenue and variable costs which include seed and insecticide costs) is much higher for Bt growers compared to growers of non-Bt varieties.

Cotton Yield						
	Cotton yield (tons/ha)		Revenue from cotton yield (rupees/ha)		Gross margin (rupees/ha)	
Year	Adopters	Non-Adopters	Adopters	Non-Adopters	Adopters	Non-Adopters
2002	2.18***	1.50	44,600***	31,078	38,796***	26,005
2003	2.25***	1.38	56,357***	34,597	50,904***	29,279
*** P < 0.001; ns = not significant at 0.05						
Source: Bennett et al., 2004.						

- Less insecticide input against cotton bollworms resulted in an average reduction in expenditure per hectare of 72% and 83% in 2002 and 2003, respectively. Savings in spray was around Rs 2,471 or around $54 per hectare on average (1 US Dollar = 46 Indian Rupee)

Number and cost of insecticide sprays against cotton bollworms				
	Number of bollworm pest sprays per plot		**Cost of bollworm pest sprays (Rupees/ha)**	
Year	Adopters	Non-Adopters	Adopters	Non-Adopters
2002	1.44***	3.84	692***	2,432

2003	0.71***	3.11	482***	2,881
** P < 0.01; *** P < 0.001; ns = not significant at 0.05				
Source: Bennett et al., 2004.				

Bt Corn Adoption in the Philippines

A common corn pest in the Philippines is the Asiatic corn borer which causes losses of up to 80% of production. Across the country, corn yield levels averaged only 2.8 tons per hectare.

The Philippine government approval of the commercial release of Bt corn marked the first time that a GM food/feed crop was ever approved for planting in Asia. Initial plantings of Bt corn for the first year commercialization (2003) covered more than 10,000 hectares. Its total hectarage in the wet and dry seasons in 2005 was 52,000 hectares, up from 50,000 hectares in 2004.

Adoption of Bt corn in the Philippines provided the following benefits to small-scale farmers: [4]

- Yield advantage of about 1.1 ton/ha or 30% yield increase over conventional corn hybrids
- Pesticide cost reduction by as much as 56%
- Incremental income of up to PhP7,500/ha (US$135)
- Premium price for Bt corn because of good quality grains

Economic indicators between Bt and non-Bt corn farms

Item	Wet Season 2003			Dry Season 2004		
	Bt	**Non-Bt**	**% Diff**	**Bt**	**Non-Bt**	**% Diff**
Yield (ton/ha)	4.30	3.31	30.0	4.89	3.79	29.0
Pesticide cost (PhP/ha)	121	159	-23.8	178	410	-56.5
Price received (PhP/kg)	7.20	6.75	6.5	8.95	8.30	8.0
Net cash income (PhP/ha)	8,552	6,249	36.8	23,341	15,489	50.6

Bt rice in China

Rice is the most important crop in China, with the highest level of production accounting for 28% of the world's total production..[11] Because of the importance of rice, biotech research are being conducted to combat insect pests in rice. It was estimated that the decrease in rice yield due to insect damage is estimated to cost at least several billions of dollars worldwide.[12]

In China, farm-level pre-production field trials of insect-resistant GM rice are already underway. To establish whether farmer's welfare improved by planting GM rice, farm surveys of randomly selected farm household that cultivated the biotech crop were conducted.

The surveys showed that small and poor farm households who adopted GM insect-resistant rice benefited by having higher crop yields and lower pesticide usage compared to non-GM adopters. GM rice yields were 6 to 9% higher compared to conventional varieties and it required less pesticide input by as much as 80% or 16.77 kg/ha, which contributed to improved health to farmers.[7]

Conclusion

The increasing number of farmers who have grown GM crops both in the developed and developing countries is strong evidence of their advantages in agricultural production and value to farmers. In 2005, after a decade of GM crop adoption, the billionth acre, or the 400 millionth hectare equivalent, was planted by one of 8.5 million farmers, in one of 21 countries. This unprecedented high adoption rate reflects the trust and confidence of millions of farmers in crop biotechnology.[3]

Experiences of small farmers from China, South Africa, the Philippines and other developing countries using GM crops clearly show that small farmers can also benefit from the technology. The most consistent observation from these countries is that growing GM crops is a profitable farming endeavor.

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Revised September 2005