Genetically Engineered Cotton in the World - 2002

Biotechnology is the latest addition to the tools used by researchers, in particular by breeders, to improve the productivity of crops. According to the International Service for Acquisition of Agri-Biotech Applications (ISAAA), transgenic crops were planted on 52.6 million hectares in the world during 2001/02. Data are not yet available for 2002/03, but all indications are that transgenic crop area will increase in the current season. Over the last six years, transgenic crop area has increased by 30 fold. Commercial production of most transgenic crops, including cotton, started in 1996/97. Transgenic crops, including cotton, were planted on 1.7 million hectares. Genetic engineering technology has been accepted at a faster rate than any other agricultural technology in history.

The first field trials of transgenic crops resistant to herbicides, used as a marker gene, were conducted on tobacco in the USA and France in 1986. However, China (Mainland) is the first country to initiate commercial production of transgenic crops in the early 1990s with the introduction of a virus-resistant tobacco, and later a virus-resistant tomato. In May 1994, the first approval for commercialization of a genetically engineered product for food use was granted in the USA. Calgene marketed its FlavrSavr™ delayed ripening tomato in the USA from mid 1994. By then, many candidates that were products of recombinant technology were in line for approval. By the end of 1995, nine crops had been permitted to be grown in transgenic forms. By 1996/97, the USA, which now has the most transgenic crop area in the world, had approved commercial production of a tomato with delayed ripening qualities; cotton with insect resistance conferred by the Bt gene, and herbicide resistance; soybeans with herbicide resistance; corn/maize with insect or herbicide resistance or male sterility; canola/rapeseed with modified oil quality; an insect resistant potato; and squash with virus resistance. By then, Argentina, Canada and Mexico also had gone into commercial production of transgenic crops.

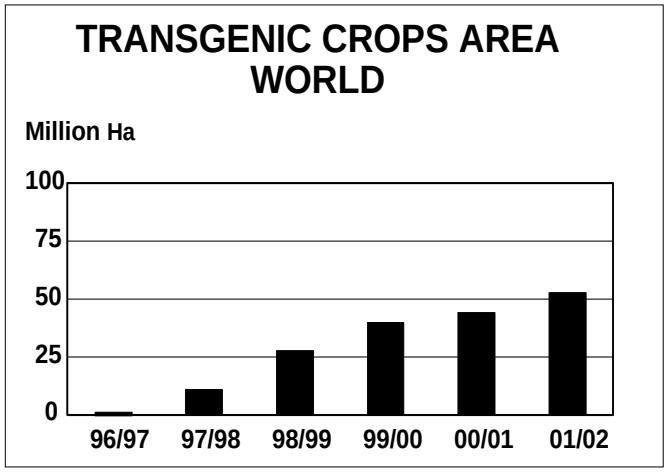
A number of crops have been transformed, but cotton, soybeans and maize occupied 95% of the total transgenic area in 2001/02. Many other crops, including squash and papaya were planted on less than 5% of the transgenic area in the world. Soybeans accounted for 63% of the total area, followed by maize on 19% and cotton on 13%.

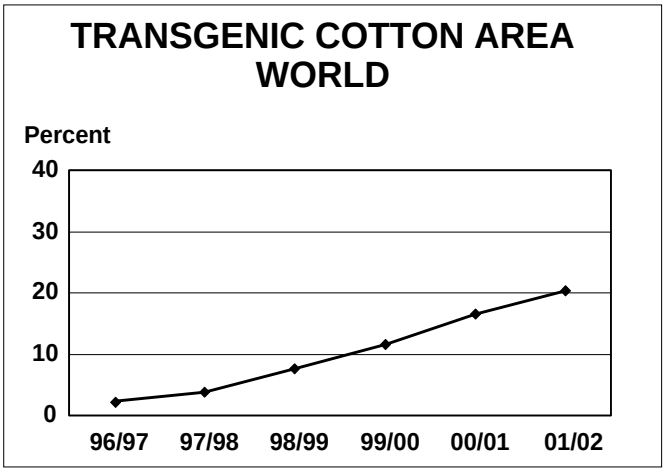
Fifteen countries have gone into commercial production of transgenic crops, but only four: Argentina, Canada, China (Mainland) and the USA, grew 99% of the total transgenic crop area in 2001/02. The USA planted 68% of the world transgenic area, followed by Argentina 22%, Canada 6% and China (Mainland) 3%.

Efforts have been made to improve a number of traits in various crops. But, insecticide and herbicide resistance are still the only two traits used on a commercial scale, apart from virus resistance and others planted on less than 1% of the total transgenic area. Herbicide resistance, the most popular character, occupies 77% of the total transgenic area, 15% of transgenic area is Bt crops, while stacked genes for herbicide and insect resistance occupied only 8% of the total area. In 2002, stacked gene varieties were available only in cotton and maize.

Since the initiation of commercial production of Bt cotton in 1996/97, transgenic cotton has been commercialized in eight countries: Argentina, Australia, China (Mainland), India, Indonesia, Mexico, South Africa and the USA. Indonesia planted only a few thousand hectares for the second year in 2002/03, and India planted Bt hybrids for the first time in 2002/03. In India, the Bt gene (Cry1Ac-Bollgard) has been introduced only through commercial cotton hybrids, and it is estimated that three commercial cotton Bt hybrids were planted on 42,198 hectares during 2002/03.

Commercial cultivation of herbicide resistant transgenic varieties is allowed in Argentina, Australia, South Africa and





Transgenic Cotton Growing Countries

Country	Transgenic Character	Approval Year		
		Bt (Bollgard)	Bollgard II	Herbicide Resistance
Argentina	Bt + Herbicide resistance	1998/99	-	2001/02
Australia	Bt + Herbicide resistance	1996/97	2002/03	2001/02
China (Mainland)	Bt	1997/98	-	-
Indonesia	Bt	2001/02	-	-
India	Bt (Commercial hybrids)	2002/03	-	-
Mexico	Bt + Herbicide resistance	1997/98	-	1999/00
South Africa	Bt + Herbicide resistance	1998/99	-	2002/03
USA	Bt + Herbicide resistance	1996/97	2002/03	1996/97

the USA. Only Bt cotton has been approved for commercial production in other countries. 2002/03 was the first year for herbicide resistant transgenic cotton in Argentina, Australia and South Africa.

In the USA, where over four million hectares were planted to transgenic cotton varieties in 2002/03, 50% of the area was planted to herbicide resistant varieties, 48% to stacked gene herbicide and insect resistant varieties while only 2% was planted to Bt varieties.

Technology Fee

The technology fee is related to the savings in insecticide use. Thus, the fee in Australia, where the number of sprays is more than in the USA, was higher. Originally the fee was US$154/ha, but was lowered to US$116/ha, and now it is US$98/ha for Bt cotton in Australia. In South Africa, the technology fee for a 25 kg bag of planting seed, enough for one hectare, was US$60 for four years. Plans were to increase the fee by US$10/bag in the current year. So, it may not be economical to grow Bt cotton under all production conditions, because the economic benefit varies depending on pest pressure and the pest complex. If a country does not have a major threat from bollworms and budworms, it will not be cost-effective to grow Bt cotton. The extent of economic benefit may be different for different production conditions or countries, depending upon the number of sprays required to control boll and budworms. The benefit from the Bt gene may also vary year to year as the pest pressure varies from year to year. Thus, the two factors that will determine the usefulness of Bt cotton for many countries will be the technology fee and the cost of pesticides used to control pests targeted by the Bt gene, or any other gene meant to control those pests.

Transgenic Cotton Area in 2002/03

Country	Area
Argentina	5%
Australia	30%
China (Mainland)	45%
Indonesia	< 1%
India	< 1%
Mexico	50%
South Africa	74%
USA	77%

Argentina

Bt cotton was introduced in Argentina through a joint agreement between the Instituto Nacional de Tecnologia Agropecuaria (INTA) and Monsanto. Under the agreement, the Bt gene had to be transferred into commercially grown varieties that were developed by INTA. Distribution of the seed was undertaken through two joint ventures with private seed companies. Commercial production of Bt varieties started in Argentina in 1998/99, and Roundup Ready herbicide resistant varieties were approved for planting in 2002/03. The area planted to transgenic varieties has not exceeded 6%. For more details on Bt cotton in Argentina, refer to the article, «The Cotton Production System and Bt Cotton in Argentina» published in the June 2002 issue of the *ICAC RECORDER*.

Australia

Australia started growing transgenic cotton at the same time as the U.S. in 1996/97. Bt cotton producing the toxin Cry1Ac, the same toxin used in the USA and other countries, was called «Ingard» in Australia. Insecticide use is higher in Australia, so the potential savings from use of Ingard are higher, and Monsanto fixed a higher technology fee in Australia than in the USA. However, from 1997/98 onwards there have been rebates for full compliance with the Resistance Management Plan. In order to overcome the danger of resistance development, the Australian cotton industry decided to cap Ingard cotton area at 30% instead of growing refuge crops. The 30% limit on area was reached in the fifth year of production of transgenic cotton.

In Australia, the Office of the Gene Technology Regulator approved cultivation of Bollgard II varieties on a limited scale in 2001/02. Trials were conducted in 13 locations, and the results were encouraging but final approval for commercial production of Bollgard II was not granted before the beginning of the planting season. Bollgard II varieties may have been planted on 5,000 hectares in 2002/03, mainly for seed multiplication purposes. Bollgard II has been approved for trial cultivation, with 20 trials each not exceeding 200 hectares in northern Australia. However, Bollgard II has been approved in Queensland and New South Wales equivalent to Ingard.

Transgenic Cotton in Australia

Year	Ingard Area (Ha)	% of Total Area	Technology Fee (Australian $)
1996/97	30,000	10	$245
1997/98	60,000	15	$245 net $210
1998/99	85,000	20	$185 net $155
1999/00	125,000	25	$185 net $155
2000/01	165,000	30	$185 net $155
2001/02	186,000	30	$185 net $155
2002/03	85,000	30	$185 net $155

In 2001/02, Monsanto compared Bollgard II lines, developed by Australian seed companies, for their performance with regard to protein expression in leaf and squares in transgenic varieties versus non-transgenic varieties. The results showed that Bollgard II lines delivered 2-3 times the total expression of toxin in the terminal leaf. The protein expression in the squares showed that the Cry1Ac toxin in Ingard was 27 micrograms per gram of dry weight compared with 150 micrograms in Bollgard II. Analysis of squares showed that Bollgard II lines had almost double the protein toxin compared to Ingard lines, 27 micrograms versus 50 micrograms in Bollgard II. Higher toxin levels mean higher protection against bollworms and budworms. Plans are to replace all Ingard varieties with Bollgard II as follows:

2002/03 = 1% Bollgard II and 29% Bollgard
2003/04 = 12% Bollgard II and 18% Bollgard
2004/05 = 50% Bollgard II and 0% Bollgard

China (Mainland)

In the late 1980s and early 1990s, *Helicoverpa armigera*, the American bollworm, struck most of the cotton growing area, particularly the Yellow River Valley region of China (Mainland). The American bollworm developed resistance to most insecticides including pyrethroids, and yields suffered. The Yellow River Valley includes the provinces of Hebei, Shandong, Henan and Shaanxi, which had been China's largest and highest yielding cotton area with a long history. The share in cotton production contributed by the Yellow River Valley dropped significantly due to the high cost of cotton production caused by the use of insecticides and lower yields. The government of China (Mainland) realized the problem and adopted a number of insecticide resistance management programs to tackle it. The resistance management programs helped to contain the problem, but there would be no better time for China to utilize Bt gene varieties on a commercial scale. China (Mainland) started its research, development and application of transgenic insect resistant cotton in the early 1990s and in less than ten years reached the commercialization stage. The insecticide resistance problem and the losses in yield were so severe that Bt cotton became popular very quickly. The use of Bt cotton led to a recovery in yields in the Yellow River Valley, and the share of the region in national production increased to 40% in 2001/02.

The Chinese Cotton Research Institute of the Chinese Academy of Agricultural Sciences and the Biological Scientific Research Institute played key roles in the development and adoption of transgenic cotton, but almost 40 other research and administrative agencies were involved in the commercialization of transgenic cotton in China (Mainland). By 1994, Chinese researchers had developed their own transgenic cotton with a gene resistant to lepidopterans, equivalent to the Bt gene from Monsanto. Currently, three series of cotton varieties are commercially grown in China (Mainland):

Guokang Series: Varieties researched by the Life Scientific Research Institute,

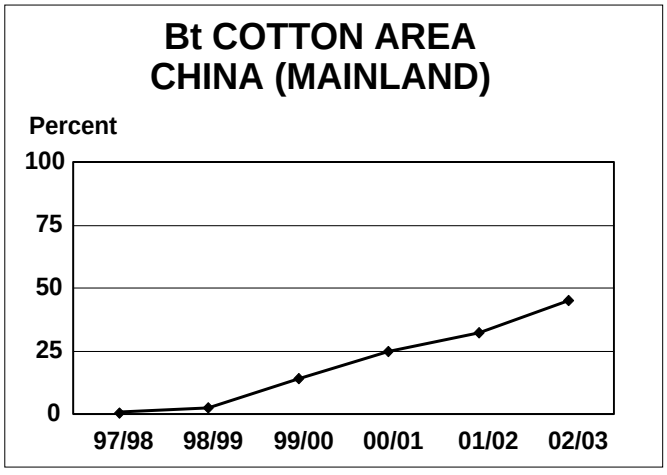
Zhongmian Series: varieties developed by the Chinese Cotton Research Institute and others,

Xinmian Series: Varieties imported by Monsanto.

ZM-38 and ZM-41 have been developed at the Chinese Cotton Research Institute (CCRI) and are also called CCRI-38 and CCRI-41 respectively. RH-1 is also regarded as one of the CCRI series. JZ-566, NK-3 and LCR-15 were bred at the Hebei Provincial Cotton Research Institute, the Nanjing Agricultural University and the Shandong Cotton Research Center respectively.

India

In India, cotton is grown on just 5% of agricultural land, but 55% of all pesticides used in India are used in cotton production. Pest infestations have increased dramatically in recent years because of the intensified use of chemicals, particularly pyrethroids, and many pests have developed resistance to the available insecticides. The commercialization of Bt cotton in India, has been realized through a joint venture between Hybrid Seeds Company (Mahyco) and Monsanto India. By July 2000, Mahyco had received approval from India's Genetic Engineering Approval Committee (GEAC) of the Ministry of Environment and



Bt Cotton Varieties in China (Mainland)

Series	varieties	Producing Provinces
Guokang	GK-1	Anhui
	GK-12, GK-30, GKZ-10, GKZ-13	Shandong
	GK-19, SGK-321, GKZ-4	Hebei
	GK-22, GKZ-8	Jiangsu
	GK-36, SGK-9708, GKZ-6	Henan
	GK-95-1	Shanxi
Zhongmian	ZM-38, ZM-41	Henan
	LCR-15, RH-1	Shandong
	NK-3	Jiangsu
	JZ-566	Hebei
Monsanto	32B	Anhui
	33B, 99B	Hebei, Henan
	1560B	Hebei, Henan, Shandong
	410B	Anhui, Hebei

Forests to conduct countrywide field trials on a total of 85 hectares and to produce seed on 150 hectares. According to Monsanto India, 55,000 farmers in India planted 42,200 hectares of three Bt hybrids in 2002/03. Bt hybrids have been planted in six states: Maharashtra 16,685 hectares, Karnataka 6,860 hectares, Gujarat 6,532 hectares, Tamil Nadu 5,083 hectares, Madhyya Pradesh 3,638 hectares and Andhra Pradesh 3,400 hectares.

Reports appearing in the press in November 2002, indicated that the Bt hybrids have suffered due to a new wilt disease that has been called «parawilt». According to the response from Mahyco Monsanto Biotech (India), the so called parawilt phenomenon was a physiological disorder which occurred when Bt cotton hybrids were exposed to a prolonged dry-spell or unusually high temperatures during boll formation followed by heavy rains. Since the Bt hybrids had greater boll loads, the environmental stress was more severe than on normal varieties or even on non-Bt hybrids. Reports showed that normal varieties and non-Bt hybrids were also affected by parawilt. It will be important to compare yields to determine the performance of the Bt hybrids.

India ultimately might allow commercial production of cotton varieties that are not hybrids, but until that happens, farmers must buy planting seed every year as in the case of any commercial hybrid. It is potentially important for farmers to buy Bt hybrids, since each year hybrids will develop some non-Bt plants in the F_2 generation. The North region of India will be able to use the Bt gene technology only if the Bt gene is introduced into straight varieties. However, the Bt gene's impact on yield may not be prominent in the North because the yield limiting factors in North India are not dominated by poor pest control.

Share of Insect Resistance Genes in China (Mainland)

Year	Source of Gene (% Area)	
	Monsanto	Chinese
1997/98	20	80
1998/99	25	75
1999/00	31	69
2000/01	36	64
2001/02	38	62

Indonesia

PT Monagro Kimia, a subsidiary of Monsanto (US), started testing Bt varieties in 1996. The main objective of the trials was to identify suitable varieties for cultivation in the country, specifically in South Sulawesi. On February 7, 2001, the Ministry of Agriculture issued a decree allowing the limited release of transgenic cotton Bt DP 5690B under the trade name NuCOTN 35B or Bollgard in seven districts in South Sulawesi. The next month, 40 tons of Bt cottonseed were imported from South Africa and Australia. Fewer than 2,000 hectares have been planted to Bt varieties in the last two years. There have been some challenges regarding the performance of Bt cotton, but the government extended PT Monagro Kimia's permit to expand Bt cotton plantings in Southern Sulawesi in 2002/03, and to start planting in East and Central Java.

Mexico

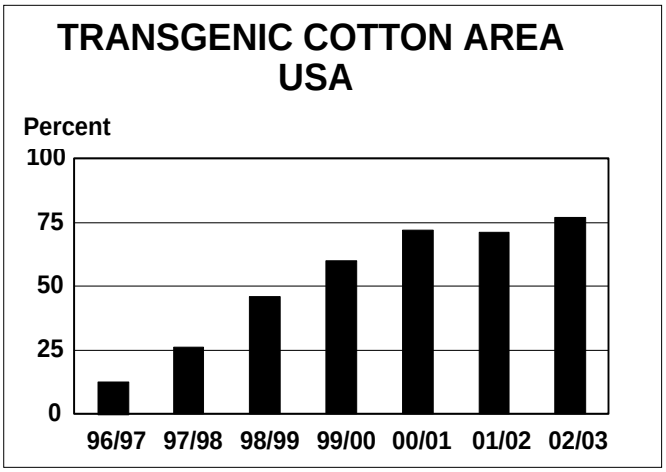
Bt cotton was introduced in Mexico in 1996 through an alliance between Monsanto and Delta and Pine Land Company. The same Delta and Pine Land Bt varieties grown in the US have been marketed in Mexico. There was no need for a breeding program, but Delta and Pine Land and Monsanto do have facilities for agronomic research in Mexico. The transgenic varieties have been sold through regional input distributors. About 2,000 hectares were planted to genetically engineered varieties in 1996/97 although Bt cotton was approved for general production in 1997/98. Herbicide resistant Roundup Ready varieties were approved for commercial production in 1999/00. It is estimated that for the last two seasons at least 50% of the total area in Mexico has been planted to transgenic varieties. According to the report "Transgenic Cotton in Mexico: Economic and Environmental Impacts" available on the internet at http://www.biotech-info.net/Bt_cotton_Mexico.html, 85% of the economic benefit accrued to cotton growers and only 15% to seed companies.

South Africa

South Africa started commercial production of transgenic varieties in 1998/99. Herbicide resistant varieties were approved in 2000/01. In 2001/02, 14% of the total area was under transgenic varieties, 63% under Bt varieties and 11% under Roundup Ready herbicide resistant varieties. In South Africa, transgenics have been adopted through Delta and Pine Land and Australian varieties. Refuge cultivation is recommended as in the USA. The technology fee for the last four years is US$60 for a bag of 25 kg of planting seed which is enough to plant one hectare. In South Africa, small farmers have seen higher economic benefits in planting Bt cotton compared to large growers. Monsanto and Delta and Pine Land Company were working together to convince the government that the refuge requirement are not necessary under small scale farming systems. A refuge crop is not required when equally attractive alternate host crops are available in the field at the same time that cotton is in the field. A detailed article «Transgenic Cotton in South Africa» was published in the September 2002 issue of the *ICAC RECORDER*.

USA

The transgenic cotton area in the USA increased from zero in 1995/96 to almost 3/4 of the total area in five years. Further increases in the USA are limited due to the need to plant a refuge crop along with Bt cotton. In the USA, the most popular character in transgenic cotton is the herbicide resistance character. A total of four million hectares planted to genetically engineered varieties in 2002/03, 96% had the herbicide resistant gene.



Genetically Engineered Cotton Area in the USA – 2002/03

Herbicide resistant – BXN	= 2%
Herbicide resistant – RR	= 35%
Total	= 37%
Bt + RR	= 37%
Bt	= 3%

The technology fee in the USA is as follows:

Bt cotton varieties	US$80/ha
Roundup Ready	US$17-22/ha
BXN	US$15-25/ha
Bt + RR	US$101/ha

2nd Meeting of the Asian Cotton Research and Development Network

Tashkent, Uzbekistan, November 14-16, 2002

The Technical Information Section of the ICAC has a mandate to facilitate communication and encourage cooperation among cotton researchers. The objective is achieved through publication of the *ICAC RECORDER* and the organization of regional networks and World Cotton Research Conferences. Currently, the Technical Information Section is supporting the following networks.

- Latin American Association for Cotton Research and Development - ALIDA
- Interregional Cooperative Cotton Research Network for the Mediterranean and Middle East Regions
- Southern and Eastern African Cotton Forum - SEACF
- Asian Cotton Research and Development Network (ACRDN)

The ACRDN is the youngest. In June/July 1999, the Technical Information Section of the ICAC, in collaboration with the Central Cotton Research Institute of the Ministry of Food, Agriculture and Cooperatives, government of Pakistan, organized a regional consultation on insecticide resistance management at Multan, Pakistan. Delegates from 13 countries in Asia plus Australia, UK and the USA attended the consultation. Researchers at the meeting decided to launch the ACRDN and have meetings every two years. India offered to host the 2nd meeting of the Network. However due to the international tension and changes in the positions of researchers