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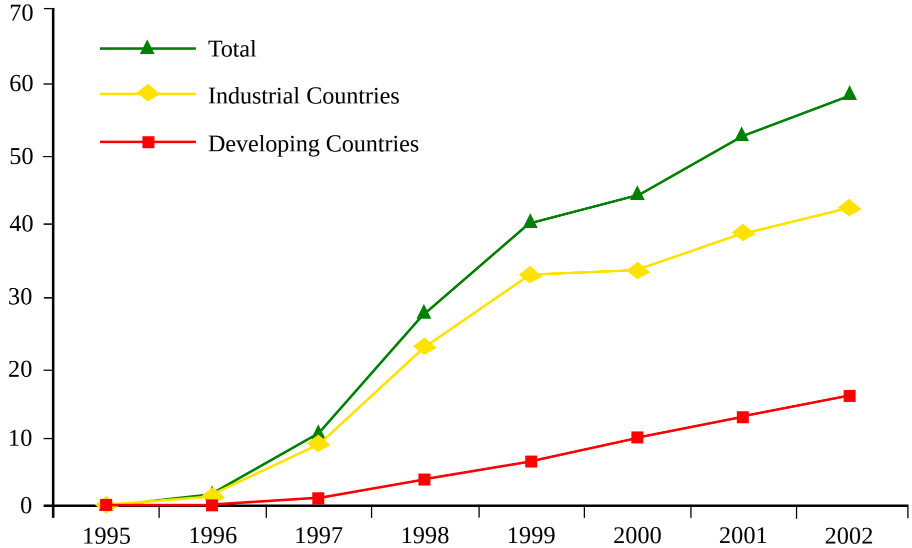
PREVIEW

Global Status of Commercialized Transgenic Crops: 2002

by

Clive James
Chair, ISAAA Board of Directors

Global Area of Transgenic Crops
Million Hectares (1996 to 2002)



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In 2002, the global area of transgenic crops continued to grow for the sixth consecutive year at a sustained growth rate of more than 10%. The estimated global area of transgenic or GM crops for 2002 is 58.7 million hectares or 145 million acres, grown by between 5.5 and 6.0 million farmers in 16 countries, up from approximately 5 million farmers and 13 countries in 2001. The increase in area between 2001 and 2002 is 12%, equivalent to 6.1 million hectares or 15 million acres. During the seven-year period 1996 to 2002, global area of transgenic crops increased 35 fold, from 1.7 million hectares in 1996 to 58.7 million hectares in 2002. More than one quarter (27%) of the global transgenic crop area of 58.7 million hectares in 2002, equivalent to 16.0 million hectares, was grown in developing countries where growth continued to be strong. Whereas the absolute growth in GM crop area between 2001 and 2002 was higher in industrial countries (3.6 million hectares) compared with developing countries (2.5 million hectares), the percentage growth was more than twice as high in the developing countries of the South (19%) than in the industrial countries of the North (9%).

In 2002, four principal countries grew 99% of the global transgenic crop area. The USA grew 39.0 million hectares (66% of global total), followed by Argentina with 13.5 million hectares (23%), Canada 3.5 million hectares (6%) and China 2.1 million hectares (4%). Of the four leading GM crop countries, China had the highest year-on-year growth with a 40% increase in its Bt cotton area from 1.5 million hectares in 2001 to 2.1 million hectares in 2002, equivalent to 51% of the total cotton area of 4.1 million hectares; this is the first time for the Bt cotton area in China to exceed more than half of the national cotton area. Despite the economic crisis in Argentina, its GM crop area grew at 14% from 11.8 million hectares in 2001 to 13.5 million hectares in 2002. A growth rate of 9% was achieved in both the USA (equivalent to 3.3 million hectares) and Canada (0.3 million hectares). GM crop hectarage increased in South Africa by over 20% to 0.3 million hectares. GM cotton area in Australia decreased by half because total area planted to cotton decreased by approximately half due to the very severe drought, the worst in decades. Three countries, India, Colombia and Honduras grew transgenic crops for the first time in 2002. Notably, India the largest cotton growing country in the world, with 8.7 million hectares equivalent to 25% of the world cotton hectarage, planted 45,000 hectares of commercial Bt cotton for the first time in 2002. Colombia also planted an introductory pre-commercial area of up to 2,000 hectares of Bt cotton for the first time in 2002.

Honduras became the first country in Central America to grow an introductory pre-commercial area of approximately 350 hectares of Bt corn in 2002. Thus, the number of countries that grew GM crops increased from 13 in 2001 to 16 in 2002 – these include 9 developing countries, 5 industrial countries and 2 Eastern Europe countries.

Globally, in 2002, the principal GM crops were: GM soybean occupying 36.5 million hectares (62% of global GM area), up from 33.3 million hectares in 2001; GM corn at 12.4 million hectares (21% of global GM area), up from 9.8 million hectares in 2001; transgenic cotton at the same level of 6.8 million hectares (12% of global GM area); and GM canola at 3.0 million hectares (5% of global GM area), up from 2.7 million hectares in 2001. During the seven-year period 1996 to 2002, herbicide tolerance has consistently been the dominant trait with insect resistance second. In 2002, herbicide tolerance, deployed in soybean, corn and cotton, occupied 75% or 44.2 million hectares of the global GM 58.7 million hectares, with 10.1 million hectares (17%) planted to Bt crops. Stacked genes for both herbicide tolerance and insect resistance deployed in both cotton and corn occupied 8% or 4.4 million hectares of the global transgenic area in 2002. The two dominant GM crop/trait combinations in 2002 were: herbicide tolerant soybean occupying 36.5 million hectares or 62% of the global total and grown in seven countries; and Bt maize, occupying 7.7 million hectares, equivalent to 13% of global transgenic area and also planted in seven countries - notably South Africa grew 58,000 hectares of Bt white maize for food, up ten fold from 2001; herbicide tolerant canola planted in Canada and the USA occupied 3.0 million hectares equivalent to 5% of global transgenic area; the other five GM crops, herbicide tolerant maize and cotton, Bt cotton and Bt/herbicide tolerant cotton and maize, each occupied 4% of global transgenic crop area.

Another useful way to portray the adoption of GM crops is to express the global adoption rates for the four principal GM crops in 2001, soybean, cotton, canola and corn. The data indicate that for the first time the GM soybean area exceeded 50% of the global hectarage of soybean. In 2002, 51% of the 72 million hectares of soybean planted globally were transgenic - up from 46 % in 2001. Twenty percent of the 34 million hectares of cotton were GM, the same as last year; decreases in total plantings of cotton in the US (down approximately 10%) and Australia (down approximately 50% due to a severe drought) were offset by a significant increase in GM cotton in China and the first planting of Bt cotton in India. The areas planted to transgenic canola and maize, both increased in 2002. Of the global 25 million hectares of canola, the percentage GM increased from 11% in 2001 to 12% in 2002. Similarly, of the 140 million hectares of maize globally, 9% were GM in 2002 - up significantly from 7% in 2001. If the global areas (conventional and transgenic) of these four principal GM crops are aggregated, the total area is 271 million hectares of which 21%, up from 19% in 2001, is transgenic in 2002. The biggest increase in 2002 is a 3.2 million hectares increase in GM soybean equivalent to a 10% year-on-year increase, followed by a 2.6 million hectares increase in GM maize equivalent to a significant 27% year-on-year growth.

The most compelling case for biotechnology, and more specifically GM crops, are their capability to contribute to: increasing crop productivity and thus contribute to global food, feed and fiber security; conserving biodiversity, as a land saving technology capable of higher productivity; more efficient use of external inputs and thus a more sustainable agriculture and environment; increasing stability of production to lessen suffering during famines due to abiotic and biotic stresses; to the improvement of economic and social benefits and the alleviation of abject poverty in developing countries.

The experience of the first seven years, 1996 to 2002, during which a cumulative total of over 235 million hectares (over 580 million acres) of GM crops were planted globally in 19 countries, has met the expectations of millions of large and small farmers in both industrial and developing countries. In 2002, coincidental with evidential confirmation that GM crops continue to deliver significant economic, environmental, and social benefits to both small and large farmers in developing and industrial countries, the global area of transgenic crops continued to grow at an annual sustained rate of more than 10%. The number of farmers that benefited from GM crops continued to grow and reached between 5.5 million and 6 million in 2002. More than three quarters of the farmers that benefited from GM crops in 2002 were resource-poor farmers planting Bt cotton, mainly in nine provinces in China and also in the Makhathini Flats in KwaZulu Natal province in South Africa.

In 2002 the global market value of GM crops is estimated to be approximately $4.25 billion having increased from $3.8 billion in 2001 when it represented over 12% of the $31 billion global crop protection market and 13% of the $30 billion global commercial seed market. The market value of the global transgenic crop market is based on the sale price of transgenic seed plus any technology fees that apply. The global value of the GM crop market is projected at approximately $5 billion for 2005.

There is cause for cautious optimism that the global area and the number of farmers planting GM crops will continue to grow in 2003, particularly in the six principal countries that grow GM crops - USA, Argentina, Canada, China, South Africa and Australia. Amongst the other ten countries growing transgenic crops in 2002, India is expected to increase its Bt cotton significantly and one or more new countries will also grow GM crops for the first time in 2003; Philippines approved Bt corn as its first commercial GM crop in early December 2002 with the expected first plantings in early 2003. Taking all factors into account, the outlook for the near term points to continued growth in the global hectarage of GM crops and the number of farmers. The global proportion of small farmers from developing countries growing GM crops is expected to increase as countries like India increase their GM hectarage of Bt cotton and approve other advanced products like GM mustard that are already under consideration. New input trait products from industry include the dual Bt gene Bollgard® II, in cotton, approved in Australia in 2002, and expected to be available in the US in 2003, with another dual Bt gene cotton becoming available in 2004 as well as an insect resistant cotton with a novel Bt gene. A new trait in corn for the North American market for corn root worm control will probably also be available in the US in 2003. The global GM corn area with insect resistance and herbicide tolerance traits, as well as the stacked traits, is likely to increase significantly in the near term. Bt cotton is also likely to increase as established markets continue to grow modestly and new GM countries like India grow faster. Despite the fact that GM soybean now occupies 75% or more of the US soybean area and 99% of the soybean area in Argentina, GM soybean area is likely to grow mainly because of increased plantings of soybean. Should Brazil approve RR soybean then this would result in a significant one-step growth in the most important new and potentially large market for GM soybean globally.

With India growing a GM crop for the first time in 2002 the three most populous countries in Asia – China, India, and Indonesia, with 2.5 billion total people, are all now commercializing GM crops. Two of the three major economies of Latin America

– Argentina and Mexico are officially growing GM crops, plus South Africa on the African continent. In 2002, GM crops were grown in 16 countries with a combined population of 3.2 billion, living on six continents in the North and the South: Asia, Africa and Latin America and North America, Europe and Oceania. Thus, despite the continuing controversy about GM crops, the hectarage and number of farmers growing GM crops have continued to grow every year since their introduction in 1996, and for the first time in 2002, just over half the world's population live in countries where GM crops have been officially approved and grown.

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Introduction

The rapid adoption of transgenic crops during the initial six-year period, 1996 to 2001 reflects the substantial multiple benefits realized by both large and small farmers in industrial and developing countries that have grown transgenic crops commercially. Between 1996 and 2001, a total of sixteen countries, 10 industrial and 6 developing, contributed to more than a thirty fold increase in the global area of transgenic crops from 1.7 million hectares in 1996 to 52.6 million hectares in 2001. The cumulative area of transgenic crops planted during the five-year period 1996 to 2001 total 175 million hectares, equivalent to more than 430 million acres.

Adoption rates for transgenic crops during the period 1996 to 2001 are unprecedented and are the highest for any new technologies by agricultural industry standards. High adoption rates reflect farmer satisfaction with the products that offer substantial benefits ranging from more convenient and flexible crop management, higher productivity and/or net returns per hectare, and social benefits, and a cleaner environment through decreased use of conventional pesticides, which collectively contribute to a more sustainable agriculture. There is a growing body of compelling evidence that clearly demonstrates the improved weed and insect pest control attainable with transgenic herbicide tolerant and insect resistant Bt crops, that also benefit from lower input and production costs; genetically modified (GM) crops offer substantial economic advantages to farmers compared with corresponding conventional crops. The severity of weed and insect pests varies from year to year and hence this will directly impact on pest control costs and economic advantage of GM crops.

Despite the on-going debate on GM crops, particularly in countries of the European Union, millions of large and small farmers in both industrial and developing countries continue to increase their plantings of GM crops in consecutive years because of the significant multiple benefits they offer. This high adoption rate is a strong vote of confidence in GM crops, reflecting farmer satisfaction. Several recent studies in both industrial and developing countries have again confirmed that farmers planting herbicide tolerant and insect resistant Bt crops are more efficient in managing their weed and insect pests. About 5 million farmers grew transgenic crops in 2001 and derived multiple benefits that included significant agronomic, environmental, social and economic advantages. ISAAA's 2001 Global Review predicted that the number of farmers planting GM crops, as well as the global area of GM crops, would continue to grow in 2002, and contribute to a more sustainable global production of food, feed and fiber. Global population exceeded 6 billion in 2000 and is expected to reach approximately 9 billion by 2050, when approximately 90% of the global population will reside in Asia, Africa and Latin America. Today, 815 million people in the developing countries suffer from malnutrition and 1.3 billion are afflicted by poverty. Transgenic crops, often referred to as genetically modified crops (GM), represent promising technologies that can make a vital contribution to global food, feed and fiber security and also make a contribution to the alleviation of poverty.

Global reviews of transgenic crops have been published by the author as ISAAA *Briefs* annually since 1996. This publication, a Preview of the 2002 Annual Review to be published later, provides the latest information on the global status of commercialized transgenic crops. A detailed global data set on the adoption of commercialized transgenic crops is presented for the year 2002 and the changes that have occurred between 2001 and 2002 are highlighted. The global adoption trends during the last seven years from 1996 to 2002 are also illustrated. Given the continuing debate on transgenic crops in Europe, the status of the global economy, particularly the economic situation in Argentina, one of the world leaders in GM crops, some doubted that global area of transgenic crops would continue to grow in 2002. This Preview documents the global database on the adoption and distribution of GM crops in 2002.

Note that the words maize and corn, rapeseed and canola, as well as transgenic and GM crops, are used synonymously in the text, reflecting the usage of these words in different regions of the world. Global figures and hectares planted commercially with transgenic crops have been rounded off to the nearest 100,000 hectares and in some cases this leads to insignificant approximations, and there may be slight variances in some figures, totals, and percentage estimates. It is also important to note that countries in the Southern Hemisphere plant their crops in the last quarter of the calendar year. The transgenic crop areas reported in this publication are planted, not harvested, hectarage in the year stated. Thus, the 2002 information for Argentina, Australia, South Africa and Uruguay is hectares planted in the last quarter of 2002 and harvested in the first quarter of 2003.

Global Area of Transgenic Crops in 2002

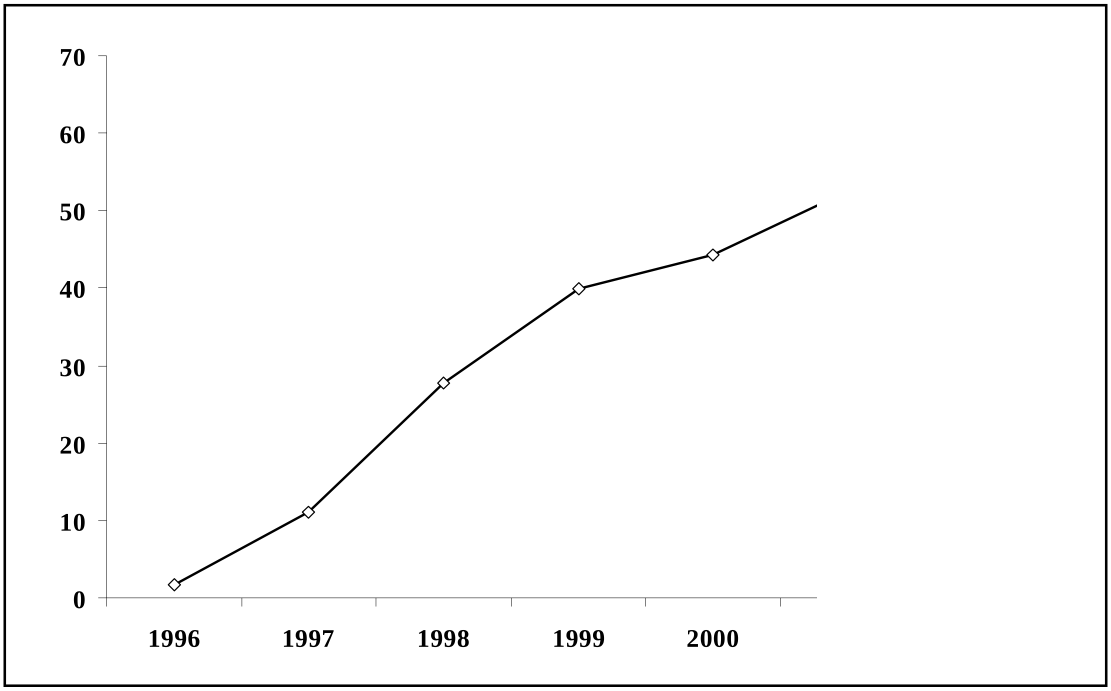
In 2002, the global area of transgenic crops continued to grow for the sixth consecutive year at a sustained rate of growth of more than 10% per year. The estimated global area of transgenic crops for 2002 is 58.7 million hectares or 145 million acres (Table

Table 1. Global Area of Transgenic Crops, 1996 to 2002

	Hectares (million)	**Acres** (million)
1996	1.7	4.3
1997	11.0	27.5
1998	27.8	69.5
1999	39.9	98.6
2000	44.2	109.2
2001	52.6	130.0
2002	58.7	145.0

Increase of 12%, 6.1 Million Hectares or 15.0 Million Acres between 2001 and 2002.
Source: Clive James, 2002.

Figure 1. Global Area of Transgenic Crops, 1996 to 2002 (Million Hectares)



Source: Clive James, 2002.

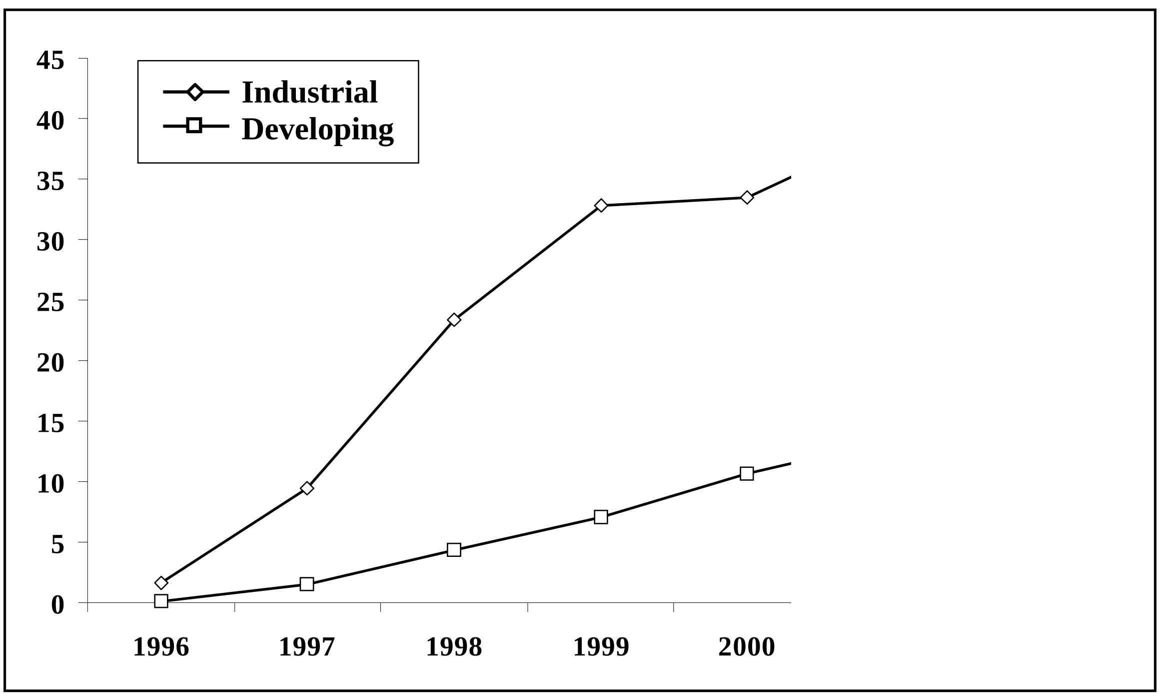
1). It is noteworthy that 2002 is the first year when the global area of transgenic crops has almost reached the milestone of 150 million acres equivalent to almost 60 million hectares. To put this global area of transgenic crops into context, 58.7 million hectares is equivalent to more than 5% of the total land area of China (956 million hectares) or the US (981 million hectares) and almost two and half times the land area of the United Kingdom (24.4 million hectares). The increase in area of transgenic crops between 2001 and 2002 is 12%, equivalent to 6.1 million hectares or 15 million acres.

During the seven-year period 1996 to 2002, the global area of transgenic crops increased by 35 fold, from 1.7 million hectares in 1996 to 58.7 million hectares in 2002 (Figure 1). This high rate of adoption reflects the growing acceptance of transgenic crops by farmers using the technology in both industrial and developing countries. During the seven-year period 1996 – 2002 the number of countries growing transgenic crops more than doubled, increasing from 6 in 1996 to 9 in 1998, to 12 countries in 1999 and to 16 in 2002.

Distribution of Transgenic Crops in Industrial and Developing Countries

Figure 2 shows the relative hectarage of transgenic crops in industrial and developing countries during the period 1996 to 2002. It clearly illustrates that whereas the substantial share of GM crops have been grown in industrial countries, the proportion of transgenic crops grown in developing countries has increased consistently from 14% in 1997, to 16% in 1998, to 18% in 1999, 24% in 2000, 26% in 2001 and 27% in 2002. Thus, in 2002, more than one quarter, 27%, (Table 2) of the global transgenic crop area of 58.7 million hectares, equivalent to 16.0 million hectares, was grown in developing countries where growth continued to be strong between 2001 and 2002, particularly in Argentina, China and South Africa, with India planting 45,000 hectares of Bt cotton for the first time in 2002. Whereas the absolute growth in GM crop area

Figure 2. Global Area of Transgenic Crops, 1996 to 2002: Industrial and Developing Countries (Million Hectares)



Source: Clive James, 2002.

Table 2. Global Area of Transgenic Crops in 2001 and 2002: Industrial and Developing Countries (Million Hectares)

	2001	%	2002	%	+/-	%
Industrial Countries	39.1	74	42.7	73	+ 3.6	+ 9
Developing Countries	13.5	26	16.0	27	+ 2.5	+ 19
Total	**52.6**	**100**	**58.7**	**100**	**+ 61**	**+ 12**

Source: Clive James, 2002.

between 2001 and 2002 was higher in industrial countries (3.6 million hectares), compared with developing countries (2.5 million hectares), the percentage growth was more than twice as high in the developing countries of the South (19%) than in the industrial countries of the North (9%).

Distribution of Transgenic Crops, by Country

In 2002, four countries grew 99% of the global transgenic crop area (Table 3), and all four countries reported growth of GM crops between 2001 and 2002 (Figure 3). It is noteworthy that the top four countries include two industrial countries, USA and Canada, and two developing countries, Argentina and China. Consistent with the pattern since 1996, the USA grew the largest transgenic crop hectarage (66%) in 2002. The USA grew 39.0 million hectares, followed by Argentina with 13.5 million hectares (23%), Canada 3.5 million hectares (6%) and China 2.1 million hectares (4%); China displayed the highest percentage year-on-year growth with a 40% increase in its GM crop area of Bt cotton between 2001 and 2002. China's Bt cotton hectarage of 2.1 million hectares in 2002, equivalent to 51% of the total cotton area of 4.1

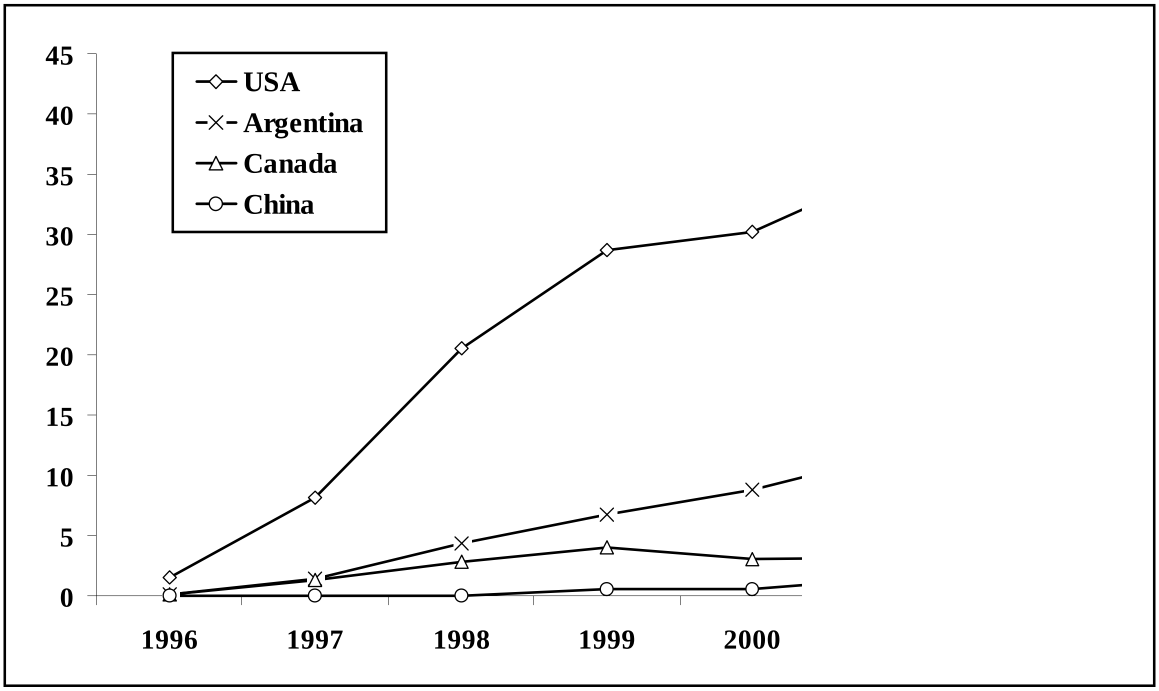
Table 3. Global Area of Transgenic Crops in 2001 and 2002: by Country (Million Hectares)

	2001	%	2002	%	+/-	%
USA	35.7	68	39.0	66	+ 3.3	+ 9
Argentina	11.8	22	13.5	23	+ 1.7	+ 14
Canada	3.2	6	3.5	6	+ 0.3	+ 9
China	1.5	3	2.1	4	+ 0.6	+ 40
South Africa	0.2	<1	0.3	1	+ 0.1	+ 50
Australia	0.2	<1	0.1	<1	- 0.1	- -
India	- -	- -	<0.1	<1	< 0.1	- -
Romania	<0.1	<1	<0.1	<1	< 0.1	- -
Spain	<0.1	<1	<0.1	<1	< 0.1	- -
Uruguay	<0.1	<1	<0.1	<1	< 0.1	- -
Mexico	<0.1	<1	<0.1	<1	< 0.1	- -
Bulgaria	<0.1	<1	<0.1	<1	< 0.1	- -
Indonesia	<0.1	<1	<0.1	<1	< 0.1	- -
Colombia	- -	- -	<0.1	<1	< 0.1	- -
Honduras	- -	- -	<0.1	<1	- -	- -
Germany	<0.1	<1	<0.1	<1	< 0.1	- -
Total	**52.6**	**100**	**58.7**	**100**	**+ 6.1**	**+ 12%**

Source: Clive James, 2002.

million hectares is the first time for the Bt cotton area in China to exceed more than half of the national cotton area. Despite the economic crisis in Argentina the growth rate of GM crops continued to be high (14%) in 2002, equivalent to 1.7 million hectares. Year-on-year growth was the same (9%) for the USA and Canada. In 2002, transgenic crop hectarage also increased in South Africa by over 20% from 0.22 million hectares in 2001 to 0.27 million hectares in 2002. A very severe drought, the worst for decades, decreased all cotton plantings by 50% in Australia and consequently GM cotton hectarage was also down by 50% from 0.2 million hectares in 2001 to 0.1 million

Figure 3. Global Area of Transgenic Crops, 1996 to 2002: by Country (Million Hectares)



Source: Clive James, 2002.

hectares in 2002. Similarly, because of historically low international prices for cotton, total plantings were down by approximately 10% in the US, leading to a decrease in GM cotton hectarage.

The 16 countries that grew transgenic crops in 2002 are listed in descending order of their transgenic crop areas (Table 3). There are 9 developing countries and 5 industrial countries and two from Eastern Europe. In 2002, transgenic crops were grown commercially in all six continents of the world – North America, Latin America, Asia, Oceania, Europe (Eastern and Western), and Africa. Of the top four countries that grew 99% of the global transgenic crop area, the USA grew 66%, Argentina 23%, Canada 6% and China 4%. The other 1% was grown in the remaining 12 countries, with South Africa and Australia being the two countries that grew more than 100,000 hectares or a quarter million acres of transgenic crops.

In the USA there was an estimated net gain of 3.3 million hectares of transgenic crops in 2002; this came about as a result of significant increases in the area of transgenic corn and soybean, a modest increase in canola, and a decrease in the area of transgenic cotton which was associated with the general decrease of approximately 500,000 hectares in the national area planted to cotton in 2002 compared with 2001. The decrease in cotton plantings in the US was attributed to low international prices of cotton, making the crop less profitable than soybean and corn, both of which increased in total plantings at the expense of cotton. In Argentina, despite the severe economic crisis a gain of 1.7 million hectares was reported for 2002 due to a significant growth in transgenic soybean and a modest increase in corn.

For Canada, a net gain of 0.3 million hectares was estimated with gains in both soybean and canola with the GM corn area remaining the same as 2001. For China, the area planted to Bt cotton increased by a significant 0.6 million hectares from 1.5 million hectares in 2001 to 2.1 million hectares in 2002.

A significant increase was reported for South Africa, where the combined area of transgenic corn and cotton and soybean is expected to be approximately 275,000 hectares. In Australia, a severe drought in 2002 led to only 125,000 hectares of transgenic cotton being planted in 2002 compared with 200,000 hectares in 2001. Romania tripled its area of GM soybean to 45,000 hectares in 2002, and Spain doubled its area of Bt maize to 25,000 hectares in 2002. Elsewhere in Europe, Germany continues to grow a small area of Bt corn and Bulgaria grows a small area of herbicide tolerant corn. Mexico has a small area of GM soybean and Bt cotton, Uruguay grows about 20,000 hectares of herbicide tolerant soybean and about 2,700 farmers continue to grow Bt cotton in South Sulawesi, Indonesia. In 2002, there was a significant increase in the total number of countries growing GM crops with three new countries joining the expanding global group of countries that are growing GM crops. Notably, India the largest cotton growing country in the world (8.7 million hectares) approved Bt cotton in May 2002; 54,000 farmers planted 45,000 hectares of Bt cotton during the Kharif season in India in 2002.

Colombia in Latin America also approved the planting for the first time of about 2,000 hectares of pre-commercial Bt cotton in 2002 in anticipation of full commercial approval for 2003. Also for the first time in 2002, Honduras became the first country in Central America to grow a GM crop with a pre-commercial introductory area of approximately 500 hectares of Bt corn, pending commercialization expected in 2003.

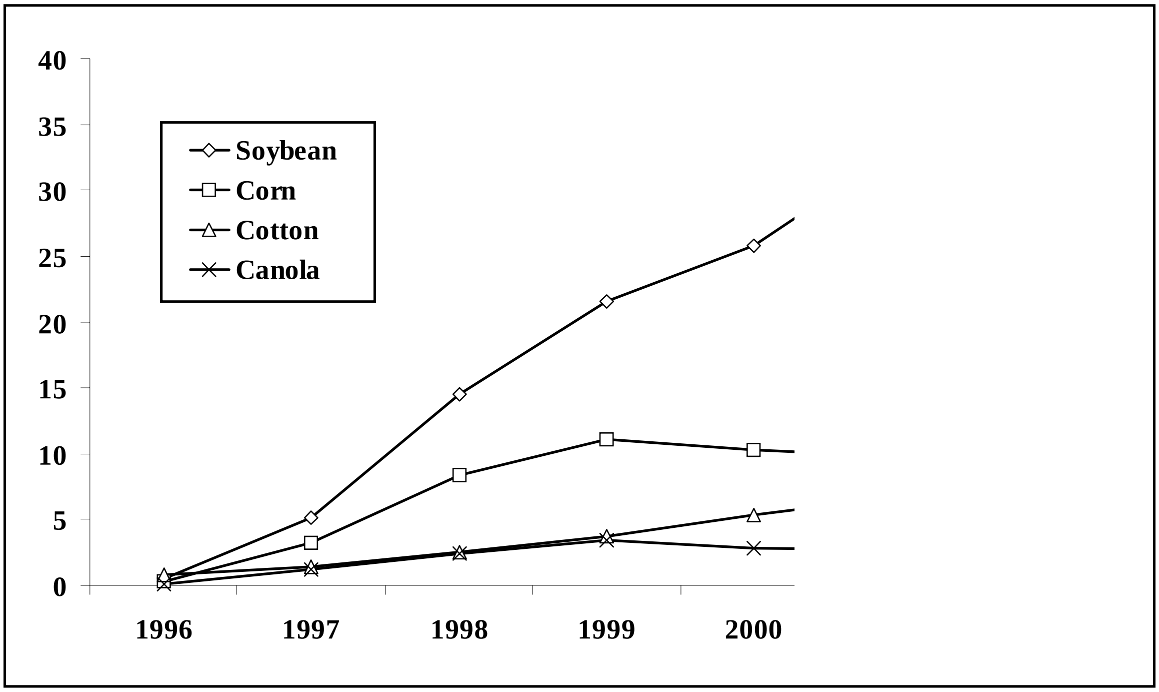
The country portfolios of deployed GM crops continued to diversify in 2002. Of particular interest was the approval of Bollgard® II for use in Australia in September 2002. It is expected that 3,000 to 5,000 hectares will be planted in 2002/03, with a plan for it to replace the single gene construct, INGARD®, entirely in 2004/05. Unlike the single construct INGARD®, which was limited to 30% of the area, Bollgard® II is not subject to the 30% restriction, and eventually will probably occupy 70% or more of the cotton area in Australia. Approval of Bollgard® II is pending in the US and is expected to be cleared imminently for introduction in the US in 2003. It is likely that Bollgard® I will be phased out of commercial production in the US after Bollgard® II becomes available. Bollgard® II is an important new element in the insect resistant management strategy for cotton insect pests; in conjunction with refugia, it provides an additional important tool for facilitating the implementation of IPM, and for optimizing the durability of Bt genes and the multiple and significant benefits they offer.

Distribution of Transgenic Crops, by Crop

The distribution of the global transgenic crop area for the four major crops is illustrated in Figure 4 for the period 1996 to 2002. It clearly shows the dominance of transgenic soybean occupying 62% of the global area of transgenic crops in 2002; the entire transgenic soybean hectarage is herbicide tolerant. Transgenic soybean retained its position in 2002 as the transgenic crop occupying the largest area. Globally, transgenic soybean occupied 36.5 million hectares in 2002, with transgenic corn in second place at 12.4 million hectares, transgenic cotton in third place at 6.8 million hectares, and canola at 3.0 million hectares (Table 4).

In 2002, the global hectarage of herbicide tolerant soybean is estimated to have increased by 3.2 million hectares, equivalent to a 10% increase. Gains of approximately 1.2 million hectares of transgenic soybean were reported for the USA in 2002 with 75% to 79% of the national soybean area of 29.5 million hectares planted to RR® soybean. Argentina reported a gain of 1.7 million hectares of GM soybean with

Figure 4. Global Area of Transgenic Crops, 1996 to 2002: by Crop (Million Hectares)



Source: Clive James, 2002.

Table 4. Global Area of Transgenic Crops in 2001 and 2002: by Crop (Million Hectares)

Crop	2001	%	2002	%	+/-	%
Soybean	33.3	63	36.5	62	+ 3.2	+ 10
Maize	9.8	19	12.4	21	+ 2.6	+ 27
Cotton	6.8	13	6.8	12	0.0	- -
Canola	2.7	5	3.0	5	+ 0.3	+ 11
Squash	<0.1	<1	<0.1	<1	(- -)	- -
Papaya	<0.1	<1	<0.1	<1	(- -)	- -
Total	**52.6**	**100**	**58.7**	**100**	**+ 6.1**	**+ 19**

Source: Clive James, 2002.

adoption rates estimated at 99% of the 12.8 million hectares of soybeans grown in 2002; this is a remarkable achievement given the state of the economy in Argentina.

Whereas transgenic corn area decreased globally by about 500,000 hectares in 2001, it increased by a substantial 2.6 million hectares globally in 2002 with most of the increase occurring in the US (Table 4). Increases in transgenic corn were also reported for Argentina, South Africa and Spain. In South Africa, Bt yellow maize used for feed increased from 160,000 hectares (14%) of the crop in 2001 to 175,000 hectares, equivalent to 20% of the yellow maize crop in 2002. Notably, Bt white maize, used for food, first introduced in 2001 on 6,000 hectares equivalent to 0.3 % of the total white maize area, increased ten fold to 58,000 hectares, equivalent to 3 % of the 2002 white maize crop of 2.1 million hectares.

The area planted to cotton in the USA in 2002 was approximately 10% less than in 2001 and the GM cotton area was also down by approximately the same percentage. The combined decrease in GM cotton in the US and Australia of just over 0.6 million hectares was offset by an equal increase of Bt cotton in China and other countries resulting in the same GM cotton hectarage for 2001 and 2002.

The global area of transgenic canola in 2002 is estimated to have increased by 0.3 million hectares, from 2.7 million hectares in 2001 to an estimated 3.0 million hectares in 2002 with the increase equally shared between Canada and the US. In Canada 2.59 million hectares of the total of 4 million hectares of canola in 2002 was GM herbicide tolerant, with an additional 20% of mutagenic herbicide tolerant canola leaving only 16% of conventional canola.

Distribution of Transgenic Crops, by Trait

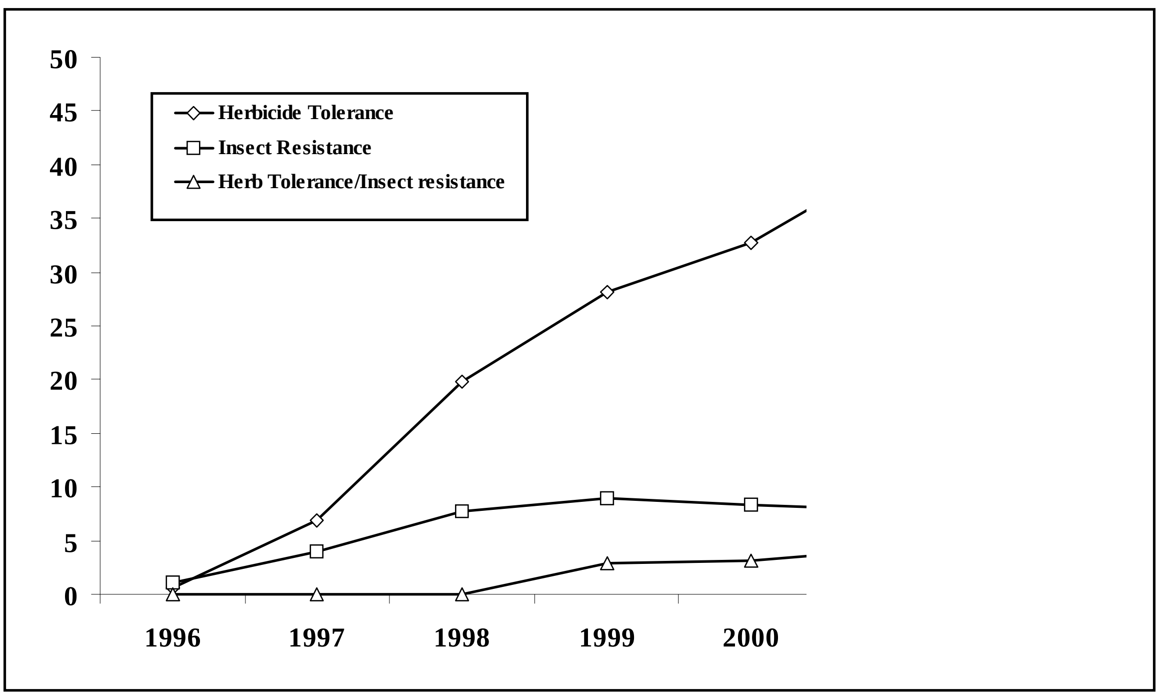
During the seven-year period 1996 to 2002, herbicide tolerance has consistently been the dominant trait with insect resistance being second (Figure 5). In 2002, herbicide tolerance, deployed in soybean, corn and cotton, occupied 75% of the 58.7 million hectares (Table 5), with 10.1 million hectares planted to Bt crops equivalent to 17%, and stacked genes for herbicide tolerance and insect resistance deployed in both cotton and corn occupying 8% of the global transgenic area in 2002. It is noteworthy

Table 5. Global Area of Transgenic Crops in 2001 and 2002: by Trait (Million Hectares)

Trait	2001	%	2002	%	+/-	%
Herbicide tolerance	40.6	77	44.2	75	+ 3.6	+ 9
Insect resistance (Bt)	7.8	15	10.1	17	+ 2.3	+ 29
Bt/Herbicide tolerance	4.2	8	4.4	8	+ 0.2	+ 5
Virus resistance/Other	<0.1	<1	<0.1	<1	< 0.1	- -
Global Totals	**52.6**	**100**	**58.7**	**100**	**+ 6.1**	**+ 12**

Source: Clive James, 2002.

Figure 5. Global Area of Transgenic Crops, 1996 to 2002: by Trait (Million Hectares)



Source: Clive James, 2002.

that the area of herbicide tolerant crops increased significantly by 9% (3.6 million hectares) whereas the Bt crops increased at a much higher rate of 29% (2.3 million hectares) between 2001 and 2002. This increase in Bt crops reflects the significant increase in Bt corn in 2002, most of which occurred in the US, following higher infestation levels of European corn borer in 2001 compared with 2000. However, increases in Bt corn hectarage also occurred in Argentina and South Africa. The largest increase in GM corn in 2002 was in the single Bt gene. The stacked genes of Bt/herbicide tolerance, in both corn and cotton at 4.4 million hectares in 2002, gained 0.2 million hectares equivalent to a 5 % increase over 2001.

Dominant Transgenic Crops in 2002

Herbicide tolerant soybean continued to be the dominant transgenic crop grown commercially in seven countries in 2002 – USA, Argentina, Canada, Mexico, Romania, Uruguay and South Africa (Table 6). Globally, herbicide tolerant soybean occupied 36.5 million hectares, representing 62% of the global transgenic crop area of 58.7 million hectares for all crops. The second most dominant crop was Bt maize, which occupied 7.7 million hectares, equivalent to 13% of global transgenic area and planted in seven countries – USA, Canada, Argentina, South Africa, Spain, Honduras and Germany. The third most dominant crop was herbicide tolerant canola, which occupied 3.0 million hectares, equivalent to 5% of global transgenic area and planted in two countries, Canada and the USA. The other five crops listed in Table 6 all occupy 4% each of global transgenic crop area and include, in descending order of area: herbicide tolerant maize on 2.5 million hectares (4%); Bt cotton on 2.4 million hectares (4%); herbicide tolerant cotton on 2.2 million hectares (4%); Bt/herbicide tolerant cotton on 2.2 million hectares (4%); and Bt/herbicide tolerant maize on 2.2 million hectares (4%).

Global Adoption of Transgenic Soybean, Corn, Cotton and Canola

One useful way to portray a global perspective of the status of transgenic crops is to characterize the global adoption rates of the four principal crops – soybean, cotton, canola and corn – in which transgenic technology is utilized (Table 7 and Figure 6).

Table 6. Dominant Transgenic Crops, 2002

Crop	Million Hectares	% Transgenic
Herbicide tolerant Soybean	36.5	62
Bt Maize	7.7	13
Herbicide tolerant Canola	3.0	5
Herbicide tolerant Maize	2.5	4
Bt Cotton	2.4	4
Herbicide tolerant Cotton	2.2	4
Bt/Herbicide tolerant Cotton	2.2	4
Bt/Herbicide tolerant Maize	2.2	4
Total	**58.7**	**100**

Source: Clive James, 2002.

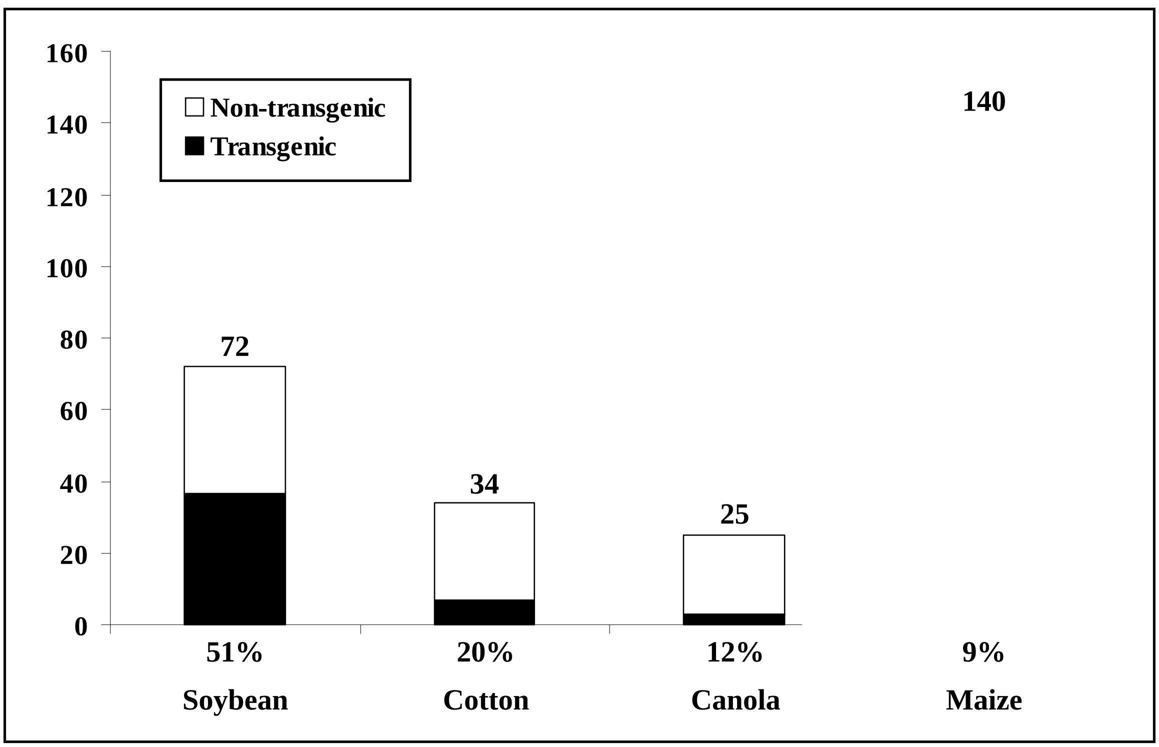
Table 7. Transgenic Crop Area as % of Global Area of Principal Crops, 2002 (Million Hectares)

Crop	Global Area	Transgenic Crop Area	Transgenic Area as % of Global Area
Soybean	72	36.5	51
Cotton	34	6.8	20
Canola	25	3.0	12
Maize	140	12.4	9
Total	**271**	**58.7**	

Source: Clive James, 2002.

The data indicate that in 2002, 51% of the 72 million hectares of soybean planted globally were transgenic - up from 46 % in 2001. Of the 34 million hectares of cotton, 20% or 6.8 million hectares were planted to transgenic cotton in 2002. The area planted to transgenic canola, expressed on percentage basis, increased from 11% in 2001 to 12 % or 3.0 million hectares of the 25 million hectares of canola planted globally in 2002. Similarly, of the 140 million hectares of maize planted in 2002, 9% was planted to GM maize up significantly from 7% in 2001. If the global areas (conventional and transgenic) of these four crops are aggregated, the total area is 271 million hectares, of which almost 22%, were GM - up from 19% in 2001. It is noteworthy that two-thirds of these 271 million hectares are in the developing countries where yields are lower, constraints are greater, and the need for improved production of food, feed, and fiber crops is the greatest.

Figure 6. Global Adoption Rates (%) for Principal Transgenic Crops (Million Hectares)



Source: Clive James, 2002.

The Future

The experience of the past is often the best guide for the future. The experience of the first seven years, 1996 to 2002, during which a cumulative total of over 235 million hectares (over 580 million acres) of transgenic crops were planted globally in 19 countries, has confirmed that the early promise of biotechnology has been fulfilled. GM crops deliver substantial agronomic, environmental, economic and social benefits to farmers and, increasingly, to society at large. GM crops have met the expectations of large and small farmers planting transgenic crops in both industrial and developing countries.

The most compelling case for biotechnology, and more specifically GM crops, are their capability to contribute to: increasing crop productivity and thus contribute to global food, feed and fiber security; conserving biodiversity, as a land saving technology capable of higher productivity; more efficient use of external inputs and thus a more sustainable agriculture and environment; increasing stability of production to lessen the suffering during famines due to abiotic and biotic stresses; to the improvement of economic and social benefits and the alleviation of abject poverty in developing countries. It is critical that a combination of conventional and biotechnology applications be adopted as the technology component of a global food, feed and fiber security strategy that also addresses other critical issues including population control and improved food, feed and fiber distribution. Adoption of such a strategy will allow society to continue to benefit from the vital contribution that plant breeding offers the global population. GM crops offer the following important contributions:

- **Increase crop productivity and contribute to global food, feed and fiber security.**
  GM crops can contribute to continued annual increments in productivity achieved through genetic gains, which can also generate healthier and more nutritious food/feed products. For example, in 2001 the eight GM crops deployed in the US increased crop production by 1.7 billion kgs. and herbicide tolerant soybean in Argentina yielded 10% more than conventional soybean. Bt cotton in China increased seed cotton production by 514,000 metric tons.

- **Conserving biodiversity, through the use of GM crops as a land saving technology.**
  Capability for increasing crop productivity per unit of land makes GM crops a land saving technology which, combined with conventional technology, will increase the probability that crop production can be confined to the current 1.5 billion hectares of global cultivable land where sustainable agriculture can be practiced. This will help ensure the conservation of the fragile ecosystems and environments, the in-situ centers of biodiversity, the wild life and the forests for future generations. Thirteen million hectares of forest, which are havens of biodiversity and provide watershed control, are lost every year in the developing countries to agricultural and industrial expansion.

- **More efficient use of external inputs and a more sustainable environment.**
  GM crops allow more efficient use of external inputs. To-date the use of GM crop protection applications as alternates for some conventional pesticide applications, using herbicide tolerance and/or Bt genes in soybean corn, cotton, and canola have resulted in substantial savings in conventional pesticides. In the US in 2001, herbicide tolerant and Bt crops reduced conventional pesticide use by 20.7 million kgs. of active ingredient (a.i.) with positive implications for the environment. Similarly, in China in 2001, insecticide application on cotton was reduced by 78,000 tons of formulated product due to the deployment of 1.5 million hectares of Bt cotton. The potential global saving of insecticides through optimizing deployment of Bt cotton alone is estimated at 33,000 metric tons (a.i) of the 81,200 tons (a.i.) applied globally on cotton in 2001. Biotechnology applications in the R&D pipeline may offer significant savings in fertilizer usage by increasing the efficiency of fertilizer use on crops which in turn will reduce the additional fertilizer needs and modulate fertilizer run-off into watersheds, aquifers and coastal waters.

- **Increasing stability of crop production to lessen suffering during famines caused by abiotic and biotic stresses.**
  The annals of history confirm that famines often result from instability

of yield due to drought, unfavorable weather patterns, pest infestations and disease epidemics. Biotechnology offers the best promise for reducing the variability in yield due to both abiotic and biotic stresses, especially a complex trait such as drought tolerance; drought is a pervasive constraint that applies to at least one third of the 1.5 billion hectares of global cultivable land.

- **Economic and social benefits and alleviation of poverty.**
  Economic benefits from GM crops are substantial and apply to both small farmers in developing countries and large farmers in industrial countries. Farmers, not the developers of the technology, are the major beneficiaries from GM crops. In the US in 2001, the net economic gain to producers of GM crops was estimated at $1.5 billion. In China the economic gain for resource-poor Bt cotton farmers was $500/hectare equivalent to a national benefit of $750 million in 2001. Of the 5 million GM farmers globally in 2001, over 75% were small resource-poor cotton farmers mainly in China, as well as several thousand in the Makhathini Flats in South Africa. These resource-poor farmers derived significant economic benefits from Bt cotton, supporting the 2001 UNDP Human Development Report thesis that biotechnology can contribute to the alleviation of poverty. In terms of social benefits, GM crops significantly increase income and save time, which is particularly valuable for small resource-poor farmers in developing countries. In China, the increased income allows poor farm families to spend more on food and increase nutritional standards. In South Africa, where 50% of the cotton farmers are women, cultivation of Bt cotton allows them more time to care for children, the sick, and/or generate additional income from other activities.

The opportunities and constraints associated with public acceptance of transgenic crops continue to be important challenges facing the global community. Because of our thrice-daily dependency on food, agriculture touches the life of every individual in the global community of over 6 billion people. Unlike industrial countries, such as the US and countries of the European Union, with few exceptions, all developing countries are net importers rather than exporters of food, and where a high percentage of the population employed in agriculture are either small resource-poor farmers practicing subsistence farming or the rural landless who are dependent on agriculture for survival; 70% of the world's 1.3 billion poorest people are rural people, the majority of them resource-poor farmers and their families. Agricultural employment, as a percentage of total employment, was 80% in the developing countries in 1950, and is still projected to be 50% in 2010 when the population of the developing countries will be approximately 6 billion, equivalent to the global population of today. Improved food, feed and fiber crops derived from appropriate conventional and biotechnology applications for small resource-poor farmers are vital for increasing productivity and income to provide access to food in the rural areas where the majority of the poverty, hunger and malnutrition exists. Crops are not only the principal source of food but are the livelihood of farmers and agricultural workers. Increased crop productivity provides more employment and acts as the engine of economic growth in the rural communities. Producing more food, feed and fiber on small resource-poor subsistence farms, where most of it is consumed, has the significant advantage that the inevitable infrastructure constraints associated with transport can, to a large extent, be circumvented in that the produce is largely consumed at the same locations where it is produced.

Global society must seek equitable solutions that meet the different needs of people and nations and respect differing opinions re GM crops. Implementing an equitable policy is a challenge in a world where globalization, a web of international protocols and international trade are all impacting on the ability of sovereign nations in the developing world to access and utilize biotechnology and GM crops in their national food, feed and fiber security strategies, to meet domestic and export needs. This does not imply that biotechnology and GM crops are panaceas. Biotechnology, like any other technology, has strengths and weaknesses and needs to be managed responsibly and effectively as one tool in a toolbox of options. Biotechnology represents one essential link in a long and complex chain that must be in place to develop and deliver more productive crops, which are urgently required by small resource-poor farmers in developing countries. This will require the political will, goodwill and unfailing support of both the public and private sectors in the industrial and developing countries to work together in harmony, as pledged during the recent World Summit on Sustainable Development held in Johannesburg, August 2002.

From a technology viewpoint the annual $4.4 billion investment in R&D in crop biotechnology, $4.22 million of which is invested by the industrial countries, represents a substantial investment which has delivered a new generation of safe and effective new products that have already had substantial impact on agriculture. The growing R&D investments in crop biotechnology by developing countries, notably by China and also by India, are seminal initiatives that other developing countries should carefully note. Special interest groups that are supporting on-going moratoria and requiring more demanding regulations are slowing the registration of products, which in turn will probably delay, by a few years, the planned delivery of quality traits that can deliver direct benefits to consumers. However, the current focus by industry on developing products will continue to generate a flow of new products, whilst striving to maintain longer-term R&D investments. Nutritionally-enhanced food products such as increased beta-carotene-containing rice and canola and enhanced animal feed products like increased lysine-containing corn continue to move forward, as do other nutritional enhancements in oil content, increases in protein content, and other nutritional properties.

New input trait products from industry include the dual Bt gene, Bollgard® II cotton product, approved in Australia in 2002, and expected to be available in the US in 2003, with another dual Bt gene cotton becoming available in 2004 as well as an insect resistant cotton with a novel Bt gene. A new trait in corn for the North American market, for corn root worm control, will probably be available in the US in 2003. Over the next few years the availability of the corn root worm trait should contribute to significant growth in GM corn acreage in the US, where approximately 18% of the corn hectarage of 31million hectares, currently treated with insecticides for corn root worm, is likely to benefit rapidly from the technology. There is a significant overlap between areas infested with European corn borer and corn root worm, and therefore some of the new products will have stacked traits for the control of these two insect pests, and other secondary pests. The global GM corn area with insect resistance and herbicide tolerance traits, as well as the stacked traits, is likely to increase significantly in the near term. This expansion of GM corn in the global hectarage of 140 million hectares will occur mainly in established GM country markets such as the US, Canada, South Africa and Argentina. GM corn will also be grown in new countries like the Philippines which plans to introduce Bt yellow corn for the first time in 2003 for the control of Asian corn borer, and Honduras that grew pre-commercial Bt corn in 2002.

Bt cotton is also expected to increase significantly in 2003 and beyond as large established markets in countries like China and Australia continue to expand modestly, with significant new growth in India. Preliminary results from early harvests in India for Kharif 2002 suggest that Bt cotton is yielding 20 to 30% more than conventional cotton with a saving of at least half the number of insecticide sprays (a saving of 3 to 6 sprays) and that economic gains are in line with expectations. Modest growth in Bt cotton is also expected in new GM countries like Colombia that grew pre-commercial Bt cotton in 2002, and over the next few years there are likely to be more developing countries adopting the technology.

Despite the high rate of adoption in the US and market saturation in Argentina, herbicide tolerant soybean hectarage is likely to continue to grow on an absolute area basis in both countries and possibly modest growth in some new markets. Should Brazil approve RR soybean then this would result in a significant one-step growth in the most important new and potentially large market for GM soybean globally.

Canola will probably feature in new markets such as Australia. Growth in GM canola will be modest, because the percentage of GM canola in Canada, which is by far the largest market, has plateaued at about 65% with a significant area (20%) in mutagenic herbicide tolerant canola, leaving only 16% conventional canola in Canada.

In the near term there is likely to be more balanced growth in GM crop area between the industrial and developing countries with the latter continuing to increase global share versus industrial countries. Countries in Eastern Europe are also likely to participate, which will feature the reintroduction of GM potatoes that performed extremely well in North America. Taking all factors into account, the outlook for the near term points to continued growth in the global hectarage of GM crops and the number of farmers. The global proportion of small farmers from developing countries growing GM crops is expected to increase as countries like India increase their GM hectarage of Bt cotton and approve other advanced products like GM mustard that are already under consideration. The increasing number and global share of resource–poor farmers growing and benefiting from GM crops has important implications because of the resulting economic, environmental and social benefits that contribute to the developmental goals of food, feed and fiber security and the alleviation of poverty.

In 2000 the market value of GM crops was $3.0 billion, increasing to $3.8 billion in 2001, when it represented over 12% of the $31 billion global crop protection market and 13% of the $30 billion global commercial seed market. In 2002 the global market value of GM crops is estimated to be approximately $4.25 billion. The market value of the global transgenic crop market is based on the sale price of transgenic seed plus any technology fees that apply. The global value of the GM crop market is projected at approximately $5 billion for 2005.

There is cause for cautious optimism that the global area and the number of farmers planting GM crops will again continue to grow in 2003, particularly in the six principal countries that grow GM crops - USA, Argentina, Canada, China, South Africa and Australia. Amongst the other ten countries growing transgenic crops in 2002, India is expected to increase its Bt cotton significantly and one or more new countries will also grow GM crops for the first time in 2003; Philippines approved Bt corn as its first commercial GM crop in early December 2002 with the first plantings expected in early 2003.

With India growing a GM crop for the first time in 2002 the three most populous countries in Asia – China, India, and Indonesia, with 2.5 billion people, are all now commercializing GM crops. Two of the three major economies of Latin America – Argentina and Mexico are officially growing GM crops, plus South Africa on the African continent. In 2002 GM crops were grown in 16 countries with a combined population of 3.2 billion, living on six continents in the North and the South: Asia, Africa and Latin America and North America, Europe and Oceania. Thus, despite the continuing controversy about GM crops, the hectarage and number of farmers growing GM crops have continued to increase every year since their introduction in 1996, and for the first time in 2002, just over half the world's population live in countries where GM crops are officially approved and grown.

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