ISAAA
INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

EXECUTIVE SUMMARY

Global Review of Commercialized Transgenic Crops: 2002
Feature: Bt Maize

by

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First Harvest of Commercial Bt Maize, Mindanao, Philippines, 2003

Conventional Maize | Bt Maize

Control of Asian Corn Borer in Bt Maize

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GLOBAL GM CROPS IN 2002

Growth in GM Crop Area

- In 2002, the global area of GM crops was 58.7 million hectares or 145 million acres, grown in sixteen countries by 6 million farmers, of whom 5 million were small resource-poor farmers in developing countries. GM crop area has grown 35 fold between 1996 and 2002 – one of the highest rates of adoption of any technology in agriculture. The US was the largest grower of GM crops (68%), followed by Argentina (23%) Canada (6%) and China (4%) with the balance grown by the other 12 countries. Three countries India, Colombia, and Honduras grew GM crops for the first time in 2002.

- The principal GM crops continued to be soybean, maize, cotton and canola. On a global basis 51% of the 72 million hectares of soybean was GM, 20% of the 34 million hectares of cotton, 9% of the 140 million hectares of maize and 12% of the 25 million hectares of canola. Herbicide tolerance continued to be the most dominant trait occupying 75% of the GM global area in 2002, followed by insect resistance (17%) and the stacked genes of herbicide tolerance and insect resistance, occupying 8%.

- In the first seven years of GM crop commercialization, 1996 to 2002, a cumulative total of over 235 million hectares of GM crops were planted globally which met the expectations of millions of small and large farmers in both industrial and developing countries. GM crops delivered significant agronomic, environmental health and social benefits to farmers and to global society, and contributed to a more sustainable agriculture.

- Global GM crop area is expected to continue to grow in 2003.

Value of the Global Transgenic Seed Market in 2002

- The value of the global transgenic seed market is based on the sale price of transgenic seed plus any technology fees that apply. The value in 2002 was $4.0 billion, up from $3.7 billion in 2001.

Global R&D Expenditures in Crop Biotechnology

- Global R&D expenditure in the private and public sectors is $4.4 billion with over 95% of the total in the industrial countries, led by the US. China is the leading investor in R&D crop biotechnology in the developing countries, followed by India.

GM Crops and the Commercial Seed Industry

- GM crops represent approximately 13% of the $30 billion global commercial seed market in 2001.

Feature: Bt Maize

The feature on Bt maize is devoted to:

- assessing the performance to-date of the first generation of Bt maize with the *cry1Ab* gene on a global basis over the last seven years

- evaluating the future potential of *cry1Ab* and other Bt or novel genes that confer resistance to the major caterpillar/moths (Lepidoptera), particularly the economically important stem borer complex

- a preliminary assessment of new genes for the control of the corn rootworm complex (Coleoptera/beetles), an important pest in the Americas which has also been detected in 13 countries in Europe

The principal aim is to present a consolidated set of data that will facilitate a knowledge-based discussion of the potential benefits and risks that Bt maize offers global society. The topics presented include:

- the maize crop and its origins;

- global distribution of maize in developing and industrial countries, by area, production, consumption, imports, and exports as well as projections of future maize demand in 2020;

- definition of the areas sown to hybrids, open pollinated varieties and farmer-saved seed;

- estimates of the number of maize farmers worldwide, by principal country, and average size of maize holdings;

- maize production systems, germplasm development and maize utilization;

- an overview of the insect pests of maize as well as the crop losses they cause, including the cost of control, and an analysis of the $550 million global maize insecticide market and a gains from Bt maize;

- deployment of the *cry1Ab* gene in Bt maize, its global adoption and assessment of benefits;

- a preview of the second generation genes which include the genes *cry3Bb1* and *cry1Fa2,* first commercialized in the US in 2003, and five other gene products that are in development and expected to be launched within the next three years;

- a review of Insect Resistance Management, the potential effect of Bt maize on the environment and the food and safety aspects of Bt maize, including the important topic of mycotoxins and the advantage that Bt maize offers with lower levels of the mycotoxin fumonisin in terms of food and feed safety, particularly in developing countries;

- a brief overview of trade issues as they relate to Bt maize in the USA and the EU;

- concluding with an assessment of the global potential of Bt maize, as a safe and sustainable technology that has the capacity to make a critical contribution to global food and feed security, more specifically to the unprecedented demand for approximately 850 million tons of maize in 2020, 60% of which will be consumed in developing countries which will have the formidable challenge of having to produce most of their maize demands in their own countries with imports supplying only around 10% or less.

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The Maize Crop

Approximately 75 countries in both the industrial and developing world, each grow at least 100,000 hectares of maize; the total of 140 million hectares produces 600 million MT of maize grain per year, valued at $65 billion annually, based on the 2003 international price of $108/MT. Developing countries plant two-thirds of the global maize area, and industrial countries one-third. The top five producers of maize are the US 229 million MT, China 124 m MT, Brazil 35.5 m MT, Mexico 19 m MT and France 16 m MT. Of the top 25 maize countries in the world 8 are industrial and 17 are developing countries including 9 from Africa, 5 from Asia and 3 from Latin America. There are approx. 200 million maize farmers worldwide, 98% of whom farm in developing countries; 75% of maize farmers are in Asia (105 million in China alone), between 15 and 20% in Africa and 5% in Latin America. Two thirds of the maize seed sold globally is hybrid and only 20 % is farmer-saved seed. In fact, hybrids are the predominant seed type in many of the principal developing countries which have a seed distribution system already in place for providing Bt maize to farmers; for example 84% of the 105 million Chinese maize farmers buy hybrid seed, and 81% of all maize seed used in Eastern and Southern Africa is hybrid.

Maize insect pests and the value of crop losses

The lepidopteran pests, particularly the stem borer complex, are a major constraint to increased productivity, and are of economic

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The western corn rootworm shown here searching for pollen on corn silk.

importance in most maize-growing countries throughout the world. Just under half (46%) of the maize area in the 25 key maize-growing countries have medium (40% area infested in temperate areas) to high levels (60% area infested in tropics/subtropics) of infestation with lepidopteran pests. Corn rootworm infests 20 million hectares in the Americas, requiring more insecticide than any other pest in the US, with losses and control measures in the US costing $1 billion per annum. The global losses due to all insect pests is 9%, equivalent to 52 million MT of maize, valued at $5.7 billion annually and consuming insecticide valued at $550 million. Losses associated with lepidopteran pests, that can be controlled by *cry1Ab*, are estimated to cause losses of 4.5%, equivalent to half the total losses from insect pests of maize.

Potential global benefits of Bt maize

Bt maize has proved to be a safe and effective product. Having undergone rigorous testing for food and feed safety, it has provided environmentally friendly and effective control of targeted pests, and the resistance is still durable after seven years of deployment on 43 million hectares. It is the first Bt maize product widely commercialized with proactively implemented, science-based insect resistant management strategies featuring refugia (areas planted to non-Bt maize) combined with high dose technology. Global deployment of the *cry1Ab* gene in Bt maize has the potential to increase maize production by up to 35 million MT valued at $3.7 billion per year; yield gains due to Bt maize are estimated at 5% in the temperate maize growing areas and 10% in the tropical areas, where there are more and overlapping generations of pests leading to higher infestations and losses. From a global perspective the potential for Bt maize in the near to mid-term is substantial. There are several reasons for this:

- Firstly, the *cry1Ab* gene has provided effective control of several of the primary pests of maize, principally the stem borers, and intermediate control for other caterpillar pests including armyworm and earworm. The successful performance of Bt maize *(cry1Ab)* has resulted in its rapid adoption on 43 million hectares in seven countries, since its introduction in 1996.

- Secondly, new Bt products are already being launched including the *cry3Bb1* gene for corn rootworm control in the US in 2003 and the *cry1Fa2* gene that provides effective control of pests controlled by *cry1Ab* with enhanced control of fall armyworm and black cutworm. In addition there are five new Bt and novel gene products that are anticipated for launch in the next three years

that will provide the necessary diversity in modes of action to allow even more effective control of a broader range of the principal insect pests of maize.

- Thirdly, in addition to the significant advantages that Bt maize offers as a pest management tool, the product offers safer feed and food products than conventional maize with lower levels of harmful mycotoxins, an increasingly important attribute as food and feed safety is assigned higher priority. Of the three major staples, maize, wheat and rice, to-date maize is the only one that offers the significant benefits of commercialized biotechnology. Bt maize now offers an increasing range of options to meet the very diverse needs of the environments in which maize is grown.

Farmers assign Bt maize high value because it is a convenient and cost effective technology that allows them to manage risk in an uncertain environment and offers insurance against devastating crop losses in years when pest infestations are unusually high. For example, benefits from using Bt to control corn rootworm in the US alone, where it infests 13 million hectares, are projected at $460 million annually of which farmers would gain two-thirds and technology developers one-third. Producer gains of $289 million would be associated with increased yields, lower production costs and a significant decrease (2,300 MT a.i, or more) in insecticide use, which is currently the highest for any pest in the US. Global deployment of Bt or novel genes to control the principal lepidopteran pests of maize as well as corn rootworm has the potential to substitute up to 40 to 50% of the current 10,700 MT (a.i) of insecticides applied to maize globally, valued at approximately $550 million annually; this has significant environmental implications.

Challenges and Opportunities

The potential yield gains of up to 35 million MT, attainable from the first generation of Bt maize *(cry1Ab)*, with more gains to come from the second generation of Bt maize and novel gene technology, represent a challenge and an opportunity to contribute to feed and food security in 2020, when, for the first time ever, maize demand will exceed the demands for wheat and rice. The challenge is to produce an additional 266 million MT globally to meet an unprecedented global demand totaling approximately 850 million MT of maize by 2020, fuelled by more demand for meat by a more affluent global society. The 35 million MT potential gain from Bt maize amounts to almost a 15% contribution to the additional 266 million MT needed by 2020. Of the additional 266 million tons required globally in 2020, 80%, or 213 million MT, will be required by developing

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countries and the formidable challenge for them is to optimize domestic production to meet most of their own additional needs, with imports expected to continue to provide only around 10%. It is projected that Bt maize has the technological potential to deliver benefits on 40 to 45 million hectares in the near to mid term compared with the 10 million hectares it occupies today. This should be an incentive for major maize consuming developing countries, such as China and Brazil, to approve and adopt Bt maize because of the significant and multiple benefits it offers, including less risks associated with food and feed security. The major constraints are the lack of regulatory capacity in many developing countries, with acceptance, and trade issues being equally important, especially relative to the market influence of the European Union. Bt maize is likely to continue to experience high growth rates in the near-term in the traditional markets of the US, Canada, Argentina, South Africa, Spain, Philippines and Honduras. Subject to regulatory approval and acceptance, Asia offers significant new opportunities particularly in China and in India, Indonesia, and Thailand. Other important markets include Brazil and Mexico in Latin America and Egypt, Kenya, and Nigeria on the African continent.

Acceptance will be the major factor governing approval and adoption in Eastern European countries such as Romania and Hungary, which are EU accession countries. In Western Europe, France, Italy and Germany have much to gain from the technology, but political considerations related to acceptance have continued to result in rejection of the technology except in Spain where Bt maize has been a success, occupying 10% of the national maize area in 2003, having doubled from 5% in 2002.

Bt maize is a proven safe and effective technology that has the potential to deliver benefits on 25 million hectares through hybrid systems in temperate mega-environments, amongst which China offers the most important opportunity. In the tropical environments with a potential of 18 million hectares of Bt maize through hybrid systems, the most important opportunity is in Brazil. Bt maize offers a unique opportunity and an incentive for major maize consuming developing countries to approve and adopt Bt maize and benefit from the multiple and significant benefits it offers in terms of a safer and more affordable food and feed, which can coincidentally make a major contribution to food and feed security and to the alleviation of hunger and malnutrition which claims 24,000 lives a day in the developing countries of Asia, Africa and Latin America.

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