



## Europabio's Biotechnology Information Kit

### Genetically Modified Maize

#### 1. Maize, one of the three most important grains in the world

- Home
- Events
- News & Press
- About Biotech
- About EuropaBio
- Contact Us
- Members Section
- Useful Links
- Site Guide

- ▣ Maize is among the few intensively cultivated crops in central European agriculture. After most frequently cultivated crop worldwide. In 1998, the total acreage under maize cultivation was 28.72 million hectares. The annual harvest/crop in 1997 was 584.9 million tons. For 1998 the FAO reports 599.41 million metric tons (source: FAOSTAT database).
- ▣ The United States is the main producer. In 1998/99 the United States exported 47.2 million metric tons about 72% of the maize traded worldwide (65.2 million tons). Eighty percent of the maize is from the United States.

#### \* Main Corn-producing Countries (1999/2000 Proj.)

Country	Area [Million hectares]	Yield [Metric tons per hectare]	Production [Million metric tons]
USA	28.72	8.46	242.86
China	25.30	5.06	128.00
Brazil	12.50	2.72	34.00
Mexico	7.70	2.40	18.50
EU	4.05	8.81	35.68
Argentina	3.10	5.00	15.50
South Africa	3.00	2.67	8.00
World	138.37	4.33	599.41

Source:  
Production Estimates and Crop Assessment Division, FAS, USDA (August 1999)

#### \* 2. The principal uses of the maize harvest

78% of the maize harvest is used as animal feed, in particular for cattle, pigs, and poultry. Human food, e.g. as grain maize or polenta or in processed form such as oil, starch, glucose. An important role is also played by the so-called "extruder products": here maize is processed into products such as chemicals, insecticides, adhesives, paints, solvents, and lacquers.

Maize derivatives are also used in pharmaceutical products such as tablets, in cosmetics products such as chemicals, insecticides, adhesives, paints, solvents, and lacquers.

#### Principal uses of the maize harvest

Application	Share
Animal feed	78%
Human food	13%

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Alcohol as a fuel additive	6%
Starch for industrial applications	3%

Source:  
Arthur D. Little (1997).

### 3. Food products that contain maize

In its processed forms as oil, starch, glucose syrup, dextrose, and flour, maize is an important food product.

Oil	Starch	Glucose syrup / dextrose	Dry-ground
Vegetable oil Margarine Mayonnaise Potato crisps Salad dressings Sauces	pudding powder Milk desserts Gravy sauces Salad mayonnaise Extruder snacks Confectionery Chocolate drinks TV dinners Cake fillings	Sweets Ice cream Confectionery Beverages Fruit-juice beverages Jams and marmalades Fruit preserves Muesli Sugar coatings and toppings	Flour Corn grains Maize meals (e.g. polenta)

Source: Gesprächskreis Grüne Gentechnik (GGG), Genius Biotechnologie GmbH, Dr. H. I.

Important: The Bt maize produced by the Novartis company which was already approved, special labelling regulations apply here (see section 6.4).

### 4. The corn-borer larva

The corn-borer larva is one of the most damaging pests in maize cultivation. Each year in the United States, the maize harvest (42 million tons). This amount would fill the Cheops pyramid - the largest pyramid ever. In some regions in North America and Europe, the larva is responsible for 10% of the harvest. Scarcely has it hatched out of its egg than the corn-borer larva drills into the plant. Today plant-protection agents are used against the larva, at a cost of 20 to 30 million dollars each year in the United States alone. The most common use of spraying agents is ineffective once the corn-borer larva sits in the middle of the stem. In total, the damage incurred in the United States as a result of corn-borer infestation amounts to 50 million dollars each year; in France the damage is estimated to be about 50 million Euro.

### 5. The soil bacterium *Bacillus thuringiensis*

The soil bacterium *Bacillus thuringiensis* (Bt) has a lethal effect on specific insect larvae. When a butterfly larva eats the bacterium, the Bt protein produced by the bacterium is activated. This in turn results in the production of a new protein that leads to the development of a toxic larva, which then starves and perishes.

In agriculture the highly specific effect of the Bt proteins has been used to combat pests. When used as biological spraying agents, they are, for instance, used in vegetable cultivation against the Colorado potato-beetle larva, and in maize-cultivation to combat the corn-borer larva. Spraying agents prepared from Bt proteins are ideal from the ecological viewpoint. They are harmless to humans and animals. A drawback with maize is, as indicated above, that once inside the stem, the plant is protected from the Bt spraying agents.

### 6. Maize that protects itself against the corn-borer larva

Novartis has succeeded in producing a genetically modified form of maize that protects it by producing the Bt protein of *Bacillus thuringiensis* in its leaves, stem, and pollen - when the larva begins to bore its way into the plant, it dies.

In 1997, farmers worldwide were already cultivating genetically modified, corn-borer-resistant million hectares - in 1998 this acreage had grown to 8.3 million hectares equivalent to 3 area for all crops (ISAAA, C. James, 1998). For the first time, in 1998, transgenic Bt maize the European Union with approximately 20,000 hectares in Spain and 2,000 hectares in countries growing transgenic corn in 1998 was six: USA, Canada, Spain, France, Argentina. Bt maize has also been granted a licence for import and further processing by Japan (apart from human food).

**Additional genes in Bt maize**

Europe is virtually self-sufficient in maize, and consequently we import only a small percentage from abroad. GM maize is generally found in imported products that have been manufactured (e.g. 'Jelly Belly' jelly beans). The limited amounts of GM maize that are currently grown in Europe are licensed solely for use in animal fodder.

The development of genetically modified plants often requires so-called marker genes. To identify those plant cells into which the desired gene has been successfully incorporated and transferred, a gene is linked to the target gene (e.g. the gene for the Bt protein). Using these marker genes, the selection has been carried out, the scientist can select those cells that have taken up the genes. In a relatively small proportion of the cells used actually take up the genes.

In addition to the Bt gene, Bt maize contains two marker genes; a herbicide-tolerance gene and an antibiotic resistance gene. Bt maize lines of the most recent generation no longer contain any antibiotic resistance genes. The issues arising from the use of antibiotic-resistance genes such as the ampicillin-resistance gene are discussed in sections 6.3.4 and 7.4.

The herbicide-tolerance gene in Bt maize renders the plant resistant to the herbicide Roundup. There was no selection regarding a high degree of herbicide tolerance - the only aim of the selection was to produce a plant resistant towards insects, which is why this maize cannot be used as a herbicide-tolerant maize variety. A herbicide-tolerant plant has been described above in section 5.1. With the Maisgard (LibertyLink®-tolerant plant) Monsanto has developed a corn-borer-resistant maize and also a herbicide-tolerant Roundup-Ready maize.

**7. Who benefits from the corn-borer-resistant maize?**

After sowing the Bt maize crop, farmers need no longer worry about infestation with the pests. This results in a reduction in the use of plant-protection products as 15% higher than those achieved with the cultivation of conventional maize lines (see section 6.3.4). The built-in protection is independent of the weather and is effective in all parts of the plant. Pesticides no longer have any effect when they are washed off the plants by rain, nor when they are washed off the stem.

Environmental benefits of Bt maize include decreased use of mineral fertilizer, fossil fuel and water. Because Bt maize reduces harvest/crop losses, as much as one fifth (2.5 million hectare maize cultivation could be released to other agricultural uses. Finally, efficient agriculture reduces the costs in the food-production sector.

**Savings made possible by Bt maize that benefit the environment**

Savings of valuable resources	Diminishing harvest losses
<p>At the same harvest yield, the corn-borer resistant maize could result in the following cost savings when compared against conventional maize, e.g. in the United States (estimates):</p> <ul style="list-style-type: none"> <li>■ 2.5 million hectares of land,</li> <li>■ 100,000 tonnes of mineral fertilizers,</li> <li>■ 100 million litres of fossil fuels,</li> </ul>	<p>With the same deployment against conventional maize reduce the harvest losses</p> <ul style="list-style-type: none"> <li>■ 15 million tonnes of extra yield</li> <li>■ 200% of the Canadian yield</li> <li>■ 33% of American export</li> <li>■ This extra yield can be used for animal feed</li> </ul>

■ 20 to 30 million dollars-worth of plant-protection agents.

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Source: Novartis, Gafta.



[Back to Info Kit main page](#)

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