Conclusion
Bt crops are an addition to our GM product arsenal against plant pests. With an increasing population and decreasing arable land, it is necessary to exploit all options with as little compromise to produce more crops. When used side by side with proper agricultural practices, Bt insect resistance technology can bring many benefits to crops, farmers, and consumers alike.

References

Download the Bt Pocket Ks
Pocket Ks are Pockets of Knowledge, packaged information on crop biotechnology products and related issues available at your fingertips. They are produced by the Global Knowledge Center on Crop Biotechnology (http://www.isaaa.org/kc). For more information, please contact the International Service for the Acquisition of Agri-biotech Applications (ISAAA) SEAsiaCenter c/o IRRI, Los Baños, Laguna, 4031 Philippines.

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Safety Aspects of Bt Technology

Effects on Human Health

So how safe is the Bt protein to non-target organisms? The specificity of Bt for its target insects is one of the characteristics that make it an ideal method of biological pest control. In fact, different strains of Bt have specific toxicity to certain target insects. The specificity rests on the fact that the toxicity of the Bt protein is receptor-mediated. This means that for an insect to be affected by the Bt protein, it must have specific receptor sites in its gut where the proteins can bind. Fortunately, humans and majority of beneficial insects do not have these receptors.

Before Bt crops are placed on the market, they must pass very stringent regulatory tests, including those for toxicity and allergenicity.

The U.S. Environmental Protection Agency (US-EPA) has already administered toxicity assessments, and Bt proteins have been already been tested even at relatively higher dosages. According to the Extension Toxicology Network (Extoxnet), a pesticide information project of several universities in the US, “no complaints were made after 18 humans ate one gram of commercial Bt preparation daily for five days, on alternate days. Humans who ate one gram per day for three consecutive days were not poisoned or infected.” Furthermore, the protein was shown to be degraded rapidly by human gastric fluid in vitro (Extoxnet, 1996).

Effects on the Environment

Soil ecosystems and groundwater

The Bt protein is moderately persistent in soil and is classified as immobile, as it does not move, or leach, with groundwater. It does not particularly persist in acidic soil conditions and, when exposed to sunlight, is rapidly destroyed due to UV radiation.

Independent experts have conducted studies to investigate the impact of Bt crops on soil organisms and other insect species that are considered beneficial in agriculture. No adverse effects have been found on non-target soil organisms, even when these organisms were exposed to quantities of Bt far higher than what would actually occur under normal crop-growing conditions. Likewise, research done by the US-EPA revealed no changes in the soil microbiota in fields with Bt plant material or conventional plant material (Donegan, et al., 1995), or between fields of Bt and non-Bt crops (Donegan, et al., 1996).

Animals and insects

On tests conducted on dogs, guinea pigs, rats, fish, frogs, salamanders, and even birds, the Bt protein was found not to have any harmful effects. It is also noteworthy that no toxic effects were found on beneficial or predatory insects, such as honeybees and lady beetles (Extoxnet, 1996).

In 1999, it was reported that pollen from Bt corn had a negative impact on Monarch butterfly larvae. This report raised concerns and questions about the risks of Bt crops on non-target organisms. Recent studies, however, show that Bt corn poses “negligible” threat to Monarch butterflies in the field. A collaborative research effort by scientists in the US and in Canada has produced information to develop a formal risk assessment of the impact of Bt corn on Monarch butterfly populations. They concluded that in most commercial hybrids, Bt expression in pollen is low, and laboratory and field studies show no acute toxic effects at any pollen density that would be encountered in the field.

Advantages of Bt Crops

Improved pest management. Insect-protected Bt crops provide the farmer with season-long protection against several damaging insect pests, and reduce or eliminate the need for insecticide sprays. This eliminates the yield loss that results from less than optimal pest control by applied farm insecticides, and it allows the farmer more time for other farm management duties.

Reduction in insecticide use. A study by the US Department of Agriculture reported that 8.2 million pounds of pesticide active ingredients were eliminated by farmers who planted Bt crops in 1998. Significant reductions have also been reported in China and Argentina, where the use of Bt cotton resulted in a 60-70% reduction in pesticide use.

Greater net return. Lower input costs often contribute to a higher net return compared to conventional crops. Bt cotton farmers in the US earned an incremental $99 million as a result of decreased pesticide costs and/or increased yields. Similarly, Bt cotton farmers in Argentina reported that Bt cotton generated an average incremental benefit of $65.05/ha.

Improved conditions for non-target organisms. Since Bt crops are able to defend themselves against pests, the use of chemical insecticides is significantly reduced, thereby encouraging the proliferation of beneficial organisms. These beneficial organisms can help control other secondary pests, which can often become a problem when predator and parasite populations are reduced by conventional broad-spectrum insecticides.

Less mycotoxin in corn. Aside from being effective against insect pests, Bt crops have lower incidences of opportunistic microbial pathogens, such as the fungus Fusarium. This fungus produces mycotoxins that can be deadly to livestock and also cause cancer in humans.

Insect Resistance Management

Since Bt crops are capable of season long expression of the Bt protein, precautionary steps have to be taken in order to avoid the development of insect resistance. In the US, for example, the EPA usually requires a “buffer zone,” or a structured refuge of non-Bt crops that is planted in close proximity to the Bt crops. Insect resistance management (IRM) is said to be the key to sustainable use of the insecticide in both genetically modified crops and Bt microbial spray formulations.

Current Status of Bt Technology

At the end of 2016, an estimated 23.1 million hectares of land were planted with crops containing the Bt gene. The following table shows the countries that have commercialized Bt crops (with single and stacked genes) and its products, from 1996 to 2016.

<table>
<thead>
<tr>
<th>Bt Crop</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Argentina, Australia, Brazil, Burkina Faso, Canada, China, Colombia, Costa Rica, European Union (EU), India, Japan, Malaysia, Mexico, Myanmar, New Zealand, Pakistan, Paraguay, Philippines, Singapore, South Africa, South Korea, Sudan, Taiwan, United States of America (USA)</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Maize</td>
<td>Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Egypt, EU, Honduras, Indonesia, Japan, Malaysia, Mexico, New Zealand, Panama, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam</td>
</tr>
<tr>
<td>Poplar</td>
<td>China</td>
</tr>
<tr>
<td>Potato</td>
<td>Australia, Canada, Japan, Mexico, New Zealand, Philippines, Russian Federation, South Korea, USA</td>
</tr>
<tr>
<td>Rice</td>
<td>China, Iran</td>
</tr>
<tr>
<td>Soybean</td>
<td>Argentina, Australia, Brazil, Canada, China, Colombia, EU, India, Indonesia, Japan, Mexico, New Zealand, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam</td>
</tr>
<tr>
<td>Tomato</td>
<td>Canada, USA</td>
</tr>
</tbody>
</table>

Source: ISAAA GM Approval Database (http://www.isaaa.org/gmapprovaldatabase/)
For the first 20 years of commercialization (1996-2015), benefits from insect resistant crops are valued at US$98.6 billion, 59% of the global value of biotech crops of US$167.5 billion; and for 2015 alone at US$8.96 billion, 59% of the global value of biotech crops of US$15.1 billion.