A literature review conducted by the Council for Agricultural Science and Technology concluded that the environment benefits from the use of HT crops. In the US, for example, no-till soybean acreage has increased by 35% since the introduction of HT soybeans. A similar trend is observed in Argentina where soybean fields are 98% planted with HT varieties. The CAST paper entitled “Comparative Environmental Impacts of Biotechnology-derived and Traditional Soybean, Corn, and Cotton Crops” is available at http://www.cast-science.org.

For the first 21 years of commercialization (1996-2016), benefits from herbicide tolerant crops are valued at US$ 89.02 billion, 47.8% of global biotech crop value of US$ 186.1 billion, and for 2016 alone at US$ 8.44 billion or 46.4% of global value of US$ 18.2 billion.

REFERENCES
**Technology Background**

**How do these herbicides work?**
These herbicides target key enzymes in the plant metabolic pathway, which disrupt plant food production and eventually kill it. So how do plants elicit tolerance to herbicides? Some may have acquired the trait through selection or mutation; or more recently, plants may be modified through genetic engineering.

**Why develop HT crops?**
What is new is the ability to create a degree of tolerance to broad-spectrum herbicides - in particular glyphosate and glufosinate - which will control most other green plants. These two herbicides are useful for weed control and have minimal direct impact on animal life, and are not persistent. They are highly effective and among the safest of control and have minimal direct impact on animal life. Unfortunately, they are equally effective against crop plants. Thus, HT crops are developed to have a degree of tolerance to these herbicides.

**How do Glyphosate and Glufosinate HT crops work?**

1. **Glyphosate tolerant crops**
   Glyphosate herbicide kills plants by blocking the EPSPS enzyme, an enzyme involved in the biosynthesis of aromatic amino acids, vitamins and many secondary plant metabolites.

2. **Glufosinate tolerant crops**
   Glufosinate tolerant crops contain a bacterial enzyme involved in the biosynthesis of aromatic amino acids, vitamins and many secondary plant metabolites.

There are several ways by which crops can be modified to be glyphosate-tolerant. One strategy is to incorporate a soil bacterium gene that produces a glyphosate tolerant form of EPSPS. Another way is to incorporate a different soil bacterium gene that produces a glyphosate degrading enzyme.

Other methods by which crops are genetically modified to survive exposure to herbicides including: 1) producing a new protein that detoxifies the herbicide; 2) modifying the herbicide's target protein so that it will not be affected by the herbicide; or 3) producing physical or physiological barriers preventing the entry of the herbicide into the plant. The first two approaches are the most common ways scientists develop herbicide tolerant crops.

**Advantages of Herbicide Tolerant Crops**

- Excellent weed control and hence higher crop yields;
- Flexibility – possible to control weeds later in the plant's growth;
- Reduced numbers of sprays in a season;
- Reduced fuel use (because of less spraying);
- Reduced soil compaction (because of less need to go on the land to spray); 
- Use of low toxicity compounds which do not remain active in the soil; and
- The ability to use no-till or conservation-till systems, with consequent benefits to soil structure and organisms (Felsot, 2000). 

A study conducted by the American Soybean Association (ASA) on tillage frequency on soybean farms showed that significant numbers of farmers adopted the "no-tillage" or "reduced tillage" practice after planting herbicide-tolerant soybean varieties. This simple weed management approach saved over 234 million gallons of fuel and left 247 million tons of irreplaceable topsoil undisturbed.

**Safety Aspects of Herbicide Tolerance Technology**

**Toxicity and Allergenicity**
Government regulatory agencies in several countries have ruled that crops possessing herbicide tolerant conferring proteins do not pose any other environmental and health risks as compared to their non-GM counterparts.

Introduced proteins are assessed for potential toxic and allergenic activity in accordance with guidelines developed by relevant international organizations. They are from sources with no history of allergenicity or toxicity; they do not resemble known toxins or allergens; and they have functions, which are well understood.

**Effects on the Plants**
The expression of these proteins does not damage the plant's growth nor result in poorer agronomic performance compared to parental crops. Except for expression of an additional enzyme for herbicide tolerance or the alteration of an already existing enzyme, no other metabolic changes occur in the plant.

**Persistence or invasiveness of crops**
A major environmental concern associated with herbicide tolerant crops is their potential to create new weeds through outcrossing with wild relatives or simply by persisting in the wild themselves. This potential, however, is assessed prior to introduction and is also monitored after the crop is planted. The current scientific evidence indicates that, in the absence of herbicide applications, GM herbicide-tolerant crops are no more likely to be invasive in agricultural fields or in natural habitats than their non-GM counterparts (Dale et al., 2002).

The herbicide tolerant crops currently in the market show little evidence of enhanced persistence or invasiveness.

**Current Status of Herbicide Tolerance**

From 1996 to 2018, HT crops consistently occupied the largest planting area of biotech crops. In 2018 alone, HT crops occupied 87.5 million hectares or 45% of the 191.7 million hectares of biotech crops planted globally. The most common are the glyphosate and glufosinate tolerant varieties. The following table shows countries that have approved major HT (with single and stacked genes) crops for food, feed, and/or cultivation.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Argentina, Australia, Canada, Japan, Mexico, New Zealand, Philippines, Singapore, South Korea, USA</td>
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<tr>
<td>Argentine Canola</td>
<td>Australia, Canada, Chile, China, EU, Japan, Malaysia, Mexico, New Zealand, Philippines, Singapore, South Africa, South Korea, Taiwan, USA</td>
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<tr>
<td>Carnation</td>
<td>Australia, Colombia, EU, Japan, Malaysia</td>
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<tr>
<td>Chicory</td>
<td>USA</td>
</tr>
<tr>
<td>Cotton</td>
<td>Australia, Argentina, Brazil, China, Colombia, Costa Rica, EU, Japan, Malaysia, Mexico, New Zealand, Paraguay, Philippines, Singapore, South Africa, South Korea, Taiwan, USA</td>
</tr>
<tr>
<td>Tubers</td>
<td>Australia, Brazil, Korea, Singapore, South Korea, Taiwan, China, Colombia, Costa Rica, EU, Japan, Malaysia, Mexico, New Zealand, Paraguay, Philippines, Russia, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam, Zambia</td>
</tr>
<tr>
<td>Creeping bentgrass</td>
<td>USA</td>
</tr>
<tr>
<td>Maize</td>
<td>Argentina, Australia, Brazil, Canada, China, Colombia, Costa Rica, Cuba, EU, Honduras, Indonesia, Iran, Japan, Malaysia, Mexico, New Zealand, Nigeria, Pakistan, Panama, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam, Zambia</td>
</tr>
<tr>
<td>Polish Canola</td>
<td>Canada</td>
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<td>Potato</td>
<td>Australia, Canada, Japan, Mexico, New Zealand, Philippines, South Korea, USA</td>
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<tr>
<td>Rice</td>
<td>Australia, Canada, Colombia, Honduras, Mexico, New Zealand, Philippines, Russian Federation, South Africa, USA</td>
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<td>Soybeans</td>
<td>Argentina, Australia, Bolivia, Brazil, Canada, Chile, China, Colombia, Costa Rica, EU, India, Indonesia, Iran, Japan, Malaysia, Mexico, New Zealand, Nigeria, Paraguay, Philippines, Russian Federation, Singapore, South Africa, South Korea, Switzerland, Taiwan, Thailand, Turkey, USA, Uruguay, Vietnam</td>
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<tr>
<td>Sugar beets</td>
<td>Australia, Canada, China, Colombia, EU, Japan, Mexico, New Zealand, Philippines, Russian Federation, Singapore, South Korea, Taiwan, USA</td>
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<tr>
<td>Tobacco</td>
<td>EU</td>
</tr>
<tr>
<td>Wheat</td>
<td>Australia, Colombia, New Zealand, USA</td>
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