**GMOs Crops**

Today:
- The biotechnology behind insect-resistant Bt crops.
- The biotechnology allowing herbicide-resistant (HT) crops.
- Gene modifications can improve the nutritional value of crops.

*HT = herbicide tolerant (Roundup Ready)*

*Bt = insect resistant (Bacillus thuringiensis bacteria toxin)*

---

**Adoption of genetically engineered crops in the U.S.**

Data for each crop category include varieties with both HT and Bt (stacked) traits. Source: USDA, Economic Research Service.

---

**Bacillus thuringiensis (Bt)**

Produces proteins (Cry, for Crystalline) that are toxic to insects.

1. Spore
2. Cry
3. Bt toxin
4. Insect Control

https://www.youtube.com/watch?v=3aLj1WmzL98
Watch from start to 3:35

---

**Insect Control**

Strains of the soil bacterium Bacillus thuringiensis produce over 200 different Bt toxins. Each toxin is harmful to different insects. Most notably, Bt toxins are insecticidal to the larvae of moths and butterflies, beetles, cotton bollworms but are viewed as harmless to other forms of life.

---

**How to engineer a plant so that it makes Bt?**
Creation of transgenic plants is simplified, many cell types can be used to regenerate.

Cotton fiber is harvested from a “boll” that serves as a protective cover around cotton seeds.

The bollworm is the larval stage of a moth. Feeds on cotton plants.

Impact on Arizona Cotton: A success story

- In 1990, > 6.8 insecticide treatment sprays were made against PBW; still, > 5% yield loss.
- Since 1996 when Bt cotton was introduced, no insecticide treatment for PBW control, AND
- Since 1997, only 0.5 sprays have been made against PBW over all cotton acreage (Bt and non-Bt); i.e., an area wide reduction of PBW has occurred
- The net reduction in insecticide use has resulted in large savings to farmers.

Bollgard (Bt) Cotton vs. PBW (moth=pink bollworm)

Four Sites, Two Dates of inspection:

<table>
<thead>
<tr>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-Sep</td>
<td>12-Oct</td>
<td>19-Sep</td>
<td>12-Oct</td>
</tr>
<tr>
<td>19-Sep</td>
<td>12-Oct</td>
<td>19-Sep</td>
<td>12-Oct</td>
</tr>
<tr>
<td>19-Sep</td>
<td>12-Oct</td>
<td>19-Sep</td>
<td>12-Oct</td>
</tr>
<tr>
<td>19-Sep</td>
<td>12-Oct</td>
<td>19-Sep</td>
<td>12-Oct</td>
</tr>
</tbody>
</table>

Infested Bolls (%)

Effects on Non-Target Organisms (Arizona study)

- Over 370 arthropod species have been tracked in 2 years of field studies using multiple methodologies.
- No differences seen in environment and species communities in vicinity of Bollgard (Bt) cotton fields.
- Conventional cotton areas show greater disturbance of non-target organisms due to harsh insecticide sprays.

Proponents: a better strategy than using insecticides on conventional cotton.

Biodiversity Concerns

Monarch Butterfly, symbol of nature and “wildness” in North America.

- The reports of Bt effects on Monarch butterflies have fueled much emotional debate on the use of biotech crops.
STUDENT RESEARCH
Why should GMO crops be banned?

Arguments
Against

1. Evidence lacking it increases yields
2. Ecosystem effects overlooked
3. Genetic contamination, loss of diversity
5. Development of Additional Bt-type proteins.
6. Refuges.
Can biotechnology address food deficiencies?

Prevalence of Vitamin A deficiency (World Health Organization)

How to make rice that contains β-carotene?
1. psy (phytoene synthase, desaturase) from daffodil
2. crtI (carotene desaturase) from a soil bacterium
3. Lycopene isomerase still present in rice genome.

Golden Rice!

Genetically Engineered Animals

How Oxitec GM mosquitoes work

Conventional Soybean Crop
Roundup Ready Soybean Crop Treated with Glyphosate
Do GM Mosquitoes work in the field?

Suppression of a Field Population of *Aedes aegypti* in Brazil by Sustained Release of Transgenic Male Mosquitoes

- Damian D. Concolino
- Andrew K. Mckinney
- Luis Saldanha
- Manuel Luaces
- Cristo F. Carvalho
- Luke Farley
- Kyle Ribeiro
- Vinicius L. Costa

Published: July 2, 2015 - https://dx.doi.org/10.1371/journal.pmed.1002064
Do GM Mosquitoes work in the field?

From journal report: Reduction was ~95% (92.2%-97.5%) in treated areas. “We conclude that sustained release of OX513A males may be an effective and widely useful method for suppression of the key dengue vector Ae. aegypti.”

Wrapping Up......

Our objectives this week:

Mechanisms of:
• Insect-resistant Bt crops.
• Herbicide-resistant crops.
• Improving the nutritional value of crops.
• GM approaches to mosquito control.
• field trial for GM mosquito control.