Ecological Effects of Transgenic Crops

Peter C. Ellsworth, Ph.D.
IPM Specialist, University of Arizona
&
Steve Naranjo, Ph.D.
Research Scientist, USDA-ARS, WCRL
Disclosure

• Those engaged in the dialog on biotechnology should fully disclose their relationships and opinions “up front” so that audiences can consider the context.

• Partial support for my research comes from companies with interests in biotechnology.

• The balance of support comes from state and federal sources of competitively available public funds.
Disclosure (continued)

- Biotechnology and its products are neither inherently good nor bad.

- The specific process and each of its products should be scientifically and independently evaluated.
Science or Emotion?

Proponents and opponents of biotechnology have made ample use of both.
However, emotion tends to rule in the court of public opinion.
Public Opinion

• “Unintended consequences: pelicans nearly wiped out by DDT, massive radiation leaked at Chernobyl, now butterflies killed by genetically modified corn…”

Full page back cover of “blue” magazine; Patagonia, 2001
Public Opinion

• “... The list of environmental damage caused by inadequately tested technologies is long. With genetic engineering unleashed on the world the list may grow much, much longer. We don’t yet know all the impacts and dangers of genetic engineering. Shouldn’t we find out the risks before we turn genetically modified organisms loose on the world, or eat them in our food?”
Public Opinion

“Our species, as yet unable to see the whole, or to know how it works, now stands poised...

...with an X-Acto blade to cheat the outcome: to solve the puzzle by reshaping its pieces to our own devising.”

From
www.patagonia.com/enviroaction;
Patagonia, 2001
Powerful Imagery

Mad Cow Disease
Powerful Imagery

Bikini Atoll

Ellsworth/UA
Powerful Imagery

Asbestos
Powerful Imagery

Brown Pelican & DDT
Powerful Imagery

Thalidomide Babies
Powerful Imagery

“And we now have a solid modern history of stuff that’s come out of labs that should have stayed there.”

Patagonia, 2002
So What Is The Story?

- Monarch Butterfly, symbol of nature and “wildness” in North America.
Incredible Annual Migration!
Monarchs Feed on Milkweed
Bt Corn Sheds Pollen

- Some of which may fall on milkweed plants that serve as hosts for Monarchs.

- Bt corn pollen may contain some quantity of the Bt endotoxin.
Monarchs Are Killed?

- Scientists have shown that larvae are killed when fed milkweed “dusted” with Bt corn pollen.

- But how realistic was this study?
PNAS: Temporal & Spatial Distribution of Monarchs...

- Per plant densities of larvae, similar among habitats (i.e., ag. vs. non-ag. lands)
- For upper Midwest, most Monarchs are, in fact, produced on agricultural lands!
- Regardless of Bt corn, other agricultural practices like foliar insecticide use and weed control could have large impacts on populations of Monarchs

*From Oberhauser et al., 2001*
PNAS: Corn Pollen Deposits on Milkweed...

- Average 171 pollen grains per sq. cm. in corn fields
- Average 14 pollen grains per sq. cm. 6 ft outside of the corn field
- One rain removes 54-86% of the pollen
- Youngest leaves, the preferred food, have 50-70% lower pollen density than older leaves

*From Pleasants et al., 2001*
### PNAS: Toxicity of Bt Proteins & Corn Pollen

<table>
<thead>
<tr>
<th>Bt Toxin</th>
<th>1st instars on diet</th>
<th>1st instars on pollen on discs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cry1F</td>
<td>Non-Toxic</td>
<td>Non-Toxic</td>
</tr>
<tr>
<td>Cry9C</td>
<td>Non-Toxic</td>
<td>Non-Toxic</td>
</tr>
<tr>
<td>Cry1Ac</td>
<td>Toxic</td>
<td>Non-Toxic</td>
</tr>
<tr>
<td>Cry1Ab</td>
<td>Toxic</td>
<td>Toxic (Event 176 only)</td>
</tr>
</tbody>
</table>

*From Helmich et al., 2001*
PNAS: Field Mortality of Monarchs...

- 50% of Monarch larvae died in the first 24 hrs
  - NONE related to proximity to Bt corn

- But slower growth of Black Swallowtails likely related to pollen exposure
  - for Event 176 (Novartis) only

From Zanger et al., 2001
**PNAS: Field Impact of Cry1Ab (3 events)...**

<table>
<thead>
<tr>
<th>Exposure Density &amp; Duration</th>
<th>Cry1Ab Event 176</th>
<th>Cry1Ab Bt11</th>
<th>Cry1Ab Mon810</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 gr. / sq. cm.</td>
<td>Weight loss (-18%)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>67 gr. / sq. cm.</td>
<td>Weight loss (42%) &amp; mortality (40%)</td>
<td>NOE</td>
<td>--</td>
</tr>
<tr>
<td>97 gr. / sq. cm.</td>
<td></td>
<td>NOE</td>
<td>--</td>
</tr>
<tr>
<td>500+ gr. / sq. cm.</td>
<td></td>
<td>NOE</td>
<td>--</td>
</tr>
<tr>
<td>In-field feeding for 14-22 d</td>
<td></td>
<td>NOE</td>
<td>NOE</td>
</tr>
</tbody>
</table>

Compared to lambda-cyhalothrin which killed most Monarch larvae

*From Stanley-Horn et al., 2001*
PNAS: A Risk Assessment...

\[
\text{Hazard} = \text{Acute toxic effects of pollen} \\
\times \\
\text{Exposure} = \text{Probability of larvae being exposed to toxic levels in and around corn fields} \\
\downarrow \\
\text{Risk} = \text{“This two year study suggests that the impact of Bt corn pollen from current commercial hybrids on Monarch Butterfly populations is negligible.”}
\]

From Sears et al., 2001
Non-Target Organisms (NTO)

- Search for unintended consequences of technology (e.g., Bt cotton) on biodiversity.

- Through direct effects, i.e., toxic effects on non-target species,

- Or through indirect effects, i.e., through non-target species feeding on intoxicated hosts.