Ecological Effects of Transgenic Crops: Non-target Effects in \textit{Bt} Cotton

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Pest Complex - Western U.S. Cotton

Key Pests

- Pectinophora gossypiella
- Bemisia tabaci
- Lygus hesperus

Sporadic and Minor Pests

- Cotton bollworm
- Tobacco budworm
- Armyworms
- Loopers
- Cotton leafperforator
- Saltmarsh caterpillar
- Cutworms
- Fleahoppers
- Plant bugs
- Stink bugs
- Cotton aphid
- Thrips
- Spider mites
Insecticide Use Patterns
Arizona Cotton

Ellsworth and Jones 2000
Selective Insecticide Use

Arizona Cotton

% Acreage treated

Bt cotton • Pyriproxyfen • Buprofezin


Select varieties based on resistance to cotton pests.
Natural Enemy Complex - Western U.S.

Parasitoids
30+ species
- Hypoeter
- Copidosoma
- Microplitis
- Lysiphlebus
- Chelonus
- Lespesia
- Eretmocerus
- Encarsia
- Anaphes
- Leiophron

Predators
50+ species
- Geocoris
- Orius
- Nabis
- Zelus
- Collops
- Hippodamia
- Drapetis
- Chrysoperla
- Labidura
- Misumenops
Natural Enemies – *Pectinophora gossypiella*

**Predators**

≈23 species described
9 species (immunological ID)

**Parasitoids**

4 native species described (rare)
16 exotic species introduced
(0 established)
Non-Target Effects
(Arthropods)

Function

Abundance  Diversity
General Methods

Non-target abundance/diversity

- Replicated experimental studies at MAC
- Treatments:
  - Bt cotton / conventional cotton
  - Unsprayed for any pest
  - Insecticides for all pests as needed
- Sampling by sweep nets, beat buckets, whole plants, pitfall traps
- ANOVA, EstimatorS V. 5 (Colwell) for diversity analyses
Natural Enemy Abundance
Natural Enemy Abundance
No Insecticides

Cum. arthropod-days (50 sweeps)

1999
- Misum: 0.98
- Collops: 0.37
- Geocoris: 0.40
- Orius: 0.34
- Nabis: 0.03
- Zelus: 0.08
- Chrysop: 0.24
- Drapetis: 0.28
- Hymen: 0.57

2000
- Misum: 0.70
- Collops: 0.23
- Geocoris: 0.89
- Orius: 0.18
- Nabis: 0.66
- Zelus: 0.16
- Chrysop: 0.16
- Drapetis: 0.39
- Hymen: 0.51

Bt cotton
Non-Bt
Natural Enemy Abundance

No Insecticides

Cum. arthropod-days (50 sweeps)

1999

P = 0.18

2000

P = 0.29

Bt cotton

Non-Bt
Natural Enemy Abundance

Insecticides as Needed (e.g. 1999)

Cultivar

Insecticides

Cum arthropod-days (50 sweeps)

<table>
<thead>
<tr>
<th></th>
<th>29 Jun</th>
<th>8 Aug</th>
<th>17 Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt cotton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Bt</td>
<td></td>
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</table>

$P = 0.92$

<table>
<thead>
<tr>
<th></th>
<th>29 Jun</th>
<th>8 Aug</th>
<th>17 Sep</th>
</tr>
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<tbody>
<tr>
<td>Unsprayed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprayed</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

$P = 0.001$
Arthropod Community Structure
Community Structure – Pitfall Traps
(Bt vs. Non-Bt)

Diversity
(Fisher’s alpha)

Evenness
(Shannon)

1999 2000
0 5 10 15 20

Evenness
(Shannon)

1999 2000
0.0 0.2 0.4 0.6 0.8

Bt vs. Non-Bt
Non-Bt Bt cotton

70 68
57 57

*
**Community Structure – Pitfall Traps**
*(Sprayed vs. Unsprayed)*

### Diversity
(Fisher's alpha)

<table>
<thead>
<tr>
<th>Year</th>
<th>Unspray</th>
<th>Spray</th>
</tr>
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<tbody>
<tr>
<td>1999</td>
<td>69</td>
<td>68</td>
</tr>
<tr>
<td>2000</td>
<td>74</td>
<td>40</td>
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### Evenness
(Shannon)

<table>
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<tr>
<th>Year</th>
<th>Unspray</th>
<th>Spray</th>
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</thead>
<tbody>
<tr>
<td>1999</td>
<td>*</td>
<td></td>
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<tr>
<td>2000</td>
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</tbody>
</table>
Natural Enemy Function
Methods
Natural Enemy Function

- Replicated experimental studies at MAC
- No insecticides
- Estimate rates of predation and parasitism

- Sentinel pink bollworm egg masses (20 per plot)
- Life tables for whitefly nymphs (50 per plot)
Natural Enemy Function
Predation on Pink Bollworm Eggs

19 July 2001

1 August 2001

30 August 2001

Proportion eaten

Bt cotton
Non Bt
Natural Enemy Function

Mortality of Whitefly Nymphs

12 July 2001

Predation Parasitism

Marginal rate of mortality

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

Bt cotton
Non Bt

20 August 2001

Predation Parasitism

Marginal rate of mortality

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Conservation Biological Control
An Example

Whitefly IPM in Cotton

- Natural Enemies
- Bt Cotton
- IGRs
Impact of Conservation

![Graph showing Impact of Conservation with data points for 1997.]
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