Insecticide Resistance Action Committee

IRM for Biotechnology

Introduction

In 2006, crops expressing insecticidal proteins from *Bacillus thuringiensis* (*Bt*) were grown on 32 million hectares across 17 countries (see Figure 1). This represents nearly 33% of the global cotton area and 14% of the global maize area. This area of crop land protected by *Bt* is rapidly increasing and the types of crops involved is broadening. It is in the interest of industry, in partnership with growers, universities and governments, to preserve the long-term benefits of *Bt* crops by taking proactive resistance management measures that maximize the utility of the technology. IRAC established a Biotech Team in 2006 to provide globally-coordinated resistance management guidance

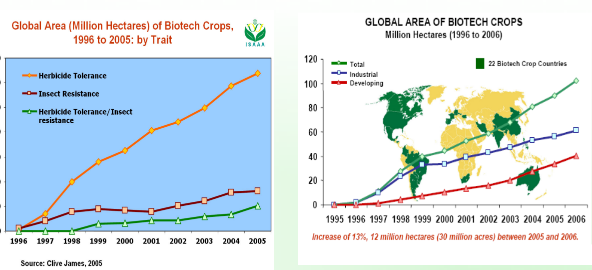

Figure 1. Global area and distribution of biotech crops, including herbicide tolerance and insect resistance traits, since 1996 (International Service for the Acquisition of Agri-Biotech Applications Briefs, 2006/2007)

Roles for IRAC Biotech Team

- Promote sustainable use of Bt crops as part of an integrated pest management system
- Develop local stakeholder groups where needed
  - Growers, registrants, academic experts, government agencies
- Help local groups design locally appropriate resistance management strategies
- Promote grower adherence to resistance management plans
- Provide unified guidance to government authorities
- Develop education toolbox for use by growers, registrants, seed companies, government agencies
- Coordinate resistance monitoring programs, develop local expertise

Resistance risk for *Bt* Crops – Perceptions *vs* Reality

High perceived risk of resistance with Bt crops

- High selection pressure across multiple generations
  - Expression throughout plant, throughout season
  - High levels of mortality
  - Widely grown
  - May be used where not needed (availability of best germplasm, stacks with other traits, preventative rather than curative)
- Perceived lack of diversity in active ingredients
- Complex mode of action (multiple possible resistance mechanisms)
- Resistance to Bt sprayables observed in field (diamondback moth), greenhouse (armyworms), and generated in lab (several species)

Actual risk is much lower

- Few areas where Bt crops have dominated (parts of corn belt, parts of cotton belt)
- Several key pests have broad host range so only a small part of the population is exposed
- Several key pests show long-range dispersal/migration
- Genes conferring resistance have not been found at high levels in field populations
- High levels of resistance tend to be associated with high fitness costs (pink bollworm)
- One Bt protein can have several receptors
- Increasing diversity of actives
- Integration with chemicals extends durability of all

Predictions of resistance in 3 – 5 years by some scientists have failed to materialize

Development of Local Resistance Management Plans Based on Global Principles

Various tools and tactics are available to manage resistance risks. Selection of the most appropriate ones depends on local factors:

Tactic	Strengths and Limitations
High dose to control heterozygotes	Uniform high dose is achieved against several key pests, but is not universal
Structured refuge to supply susceptible insects	Successfully implemented in several countries, but growers see immediate cost and uncertain distant benefit
Alternate hosts (= unstructured/ natural refuge)	Important in many (most?) systems, but can be inconsistent
Rotation of active ingredients	Not possible within a season; few *Bt* choices available across seasons; chemicals and other control tools available
Pyramided active ingredients (stacks)	Can be very effective by controlling resistant insects. Any pair of *Bt*s may be a pyramid against only a subset of targets
Limit availability (acreage cap)	Single case of successful implementation (Ingard cotton in Australia); may be impossible to manage in many systems
Integration with conventional management	Targeted cultural, biological and chemical IPM tools can significantly reduce survival of resistant and susceptible populations

Biological and operational factors

- Target pest spectrum
- Target pest biology
  - Efficacy/dose
  - Host range
  - Dispersal and migration
- Suite of beneficial organisms
- Other crops in the region, on the farm
- Field size, number
- Crop mix
- Crop management practices
  - pesticides, irrigation, fertilization, cultivation, crop rotation etc.
- Availability of pyramided traits
- Availability of stacks with other traits in favored germplasm

Socioeconomics and infrastructure

- Farm size, scale
  - <5ha to >5000 ha
- Profitability
  - Subsistence to corporate
- Farmer education level
- Enforceable Regulations
- Information access
  - Extension services
  - Grower meetings
  - Internet, traditional media
  - Written materials from seed company
  - Seed dealer
- Interested grower organizations
- Intellectual property rights

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