Lilian Ceballos

Assessment of Bt plants for bees in the field

Lilian Ceballos. Apimondia 2009. Montpellier, september 2009.

GM Plants

First commercial release in 1996

Areas under cultivation: 125 MHa

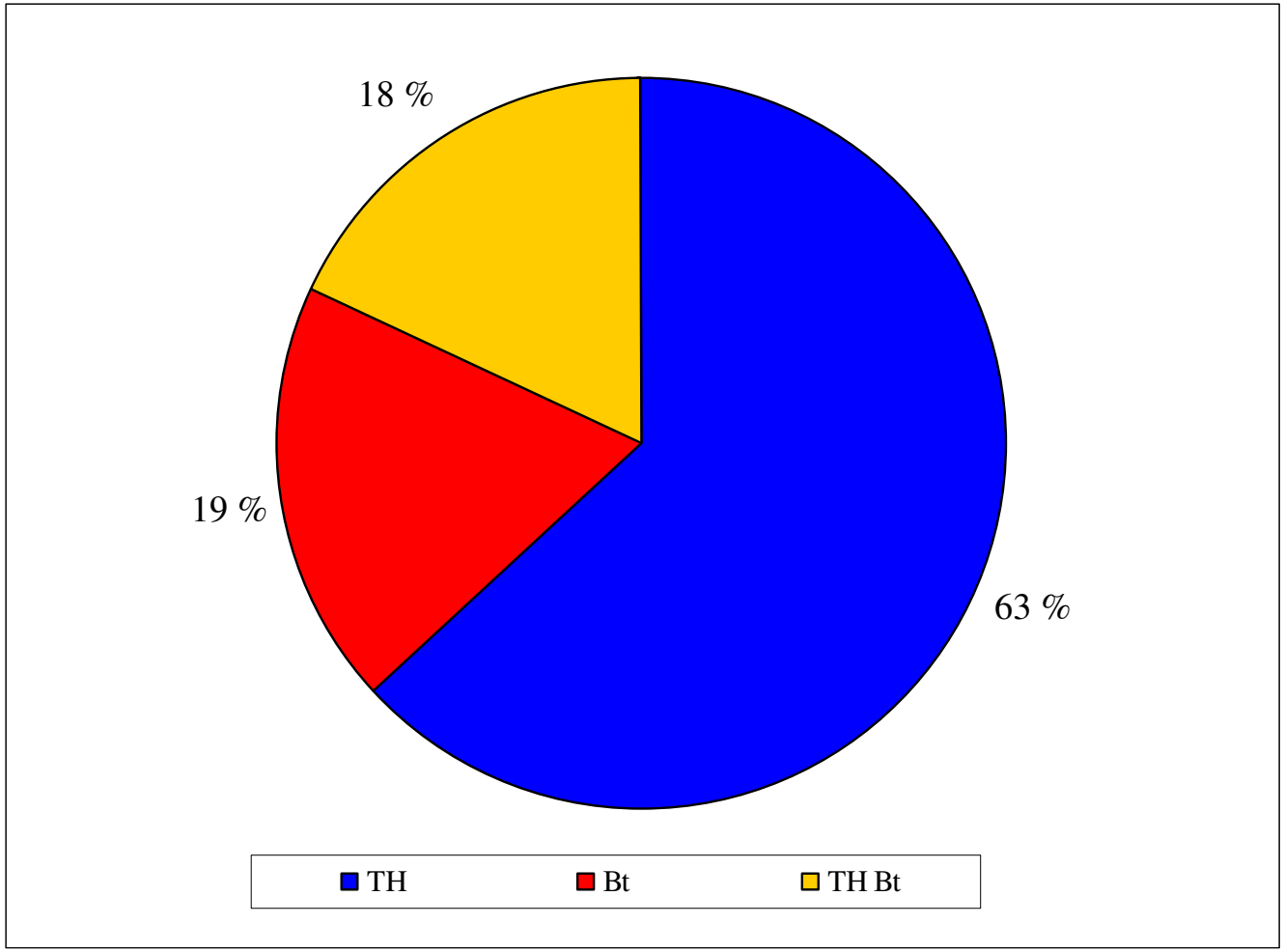
25 countries over the world

USA, Argentina, Brasil & Canada = 85,5% AUC

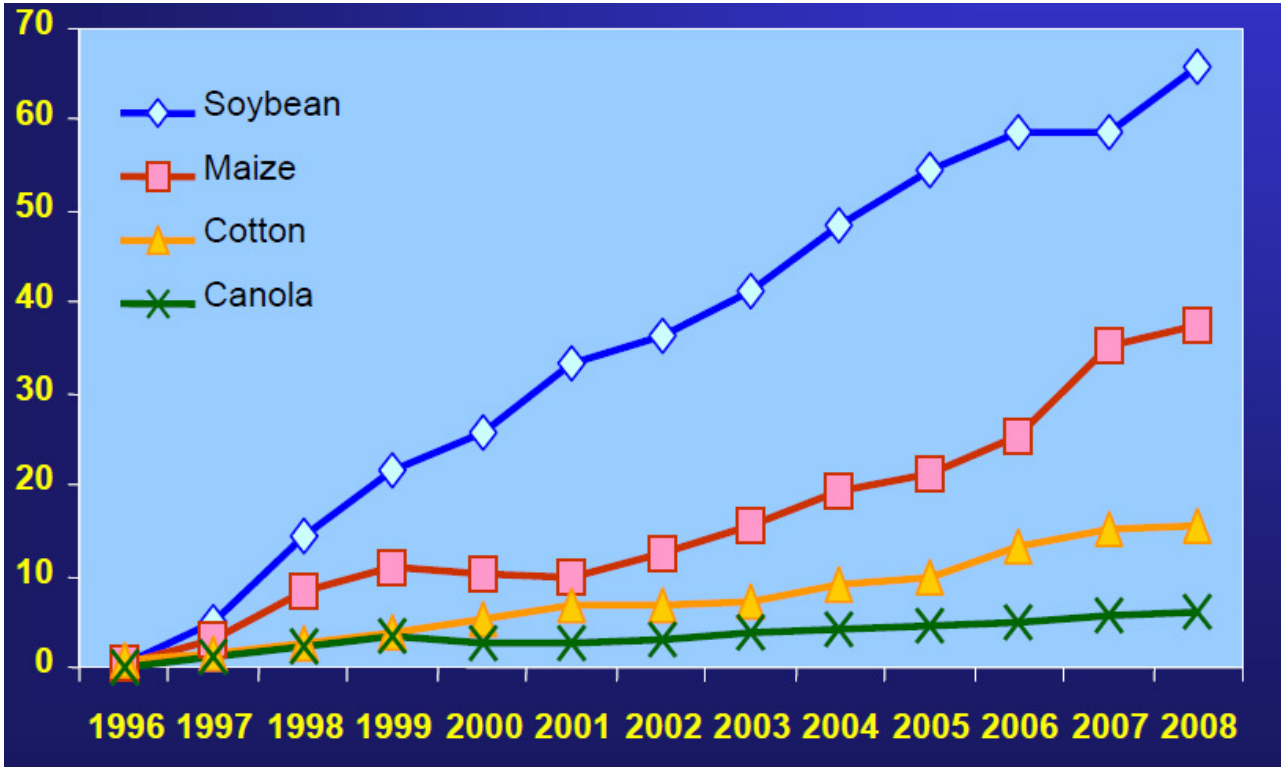
USA (62.5 millions ha), Argentina (21.0), Brasil (15.8), India (7.6), Canada (7.6), China (3.8), Paraguay (2.7), and South Africa (1.8).

ISAAA 2008

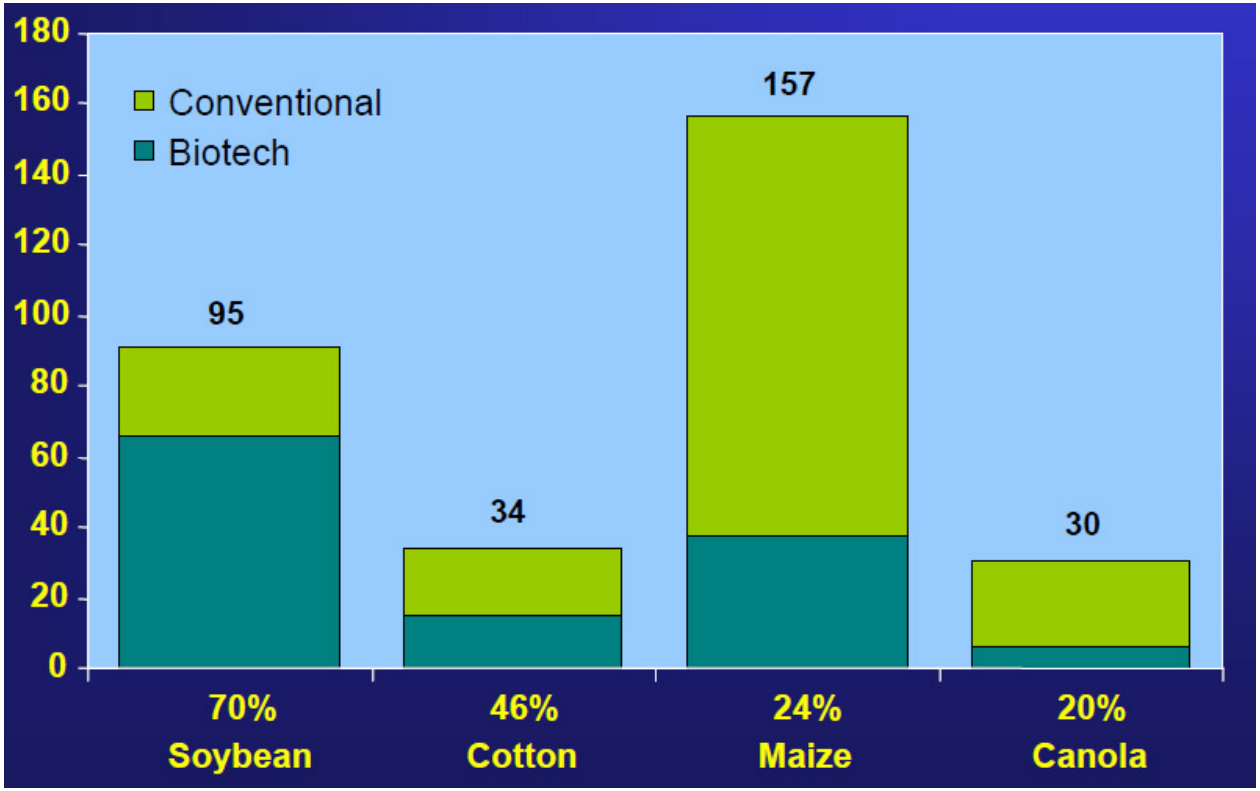
Statistics (ISAAA 2008)



Statistics (ISAAA 2008)



Statistics (ISAAA 2008)



Structure and diversity of insecticidal Bt toxins

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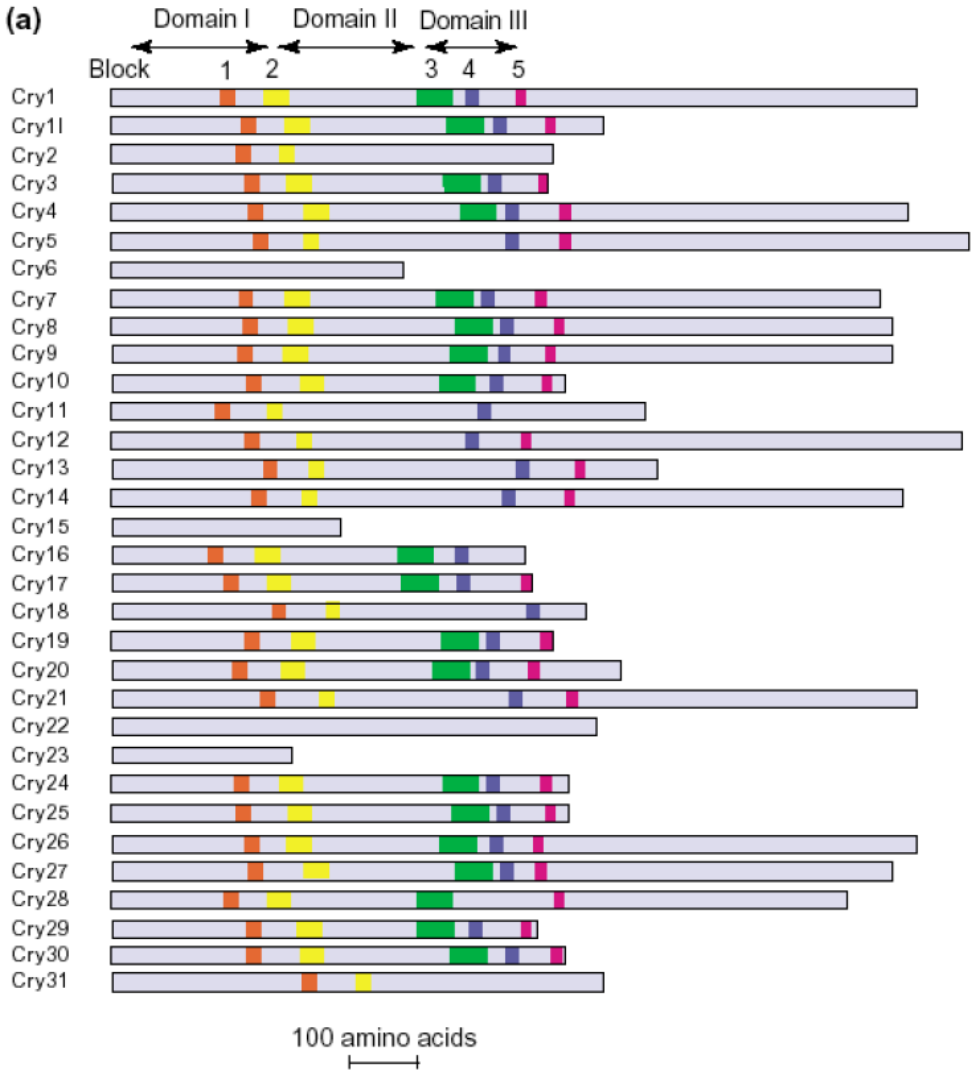
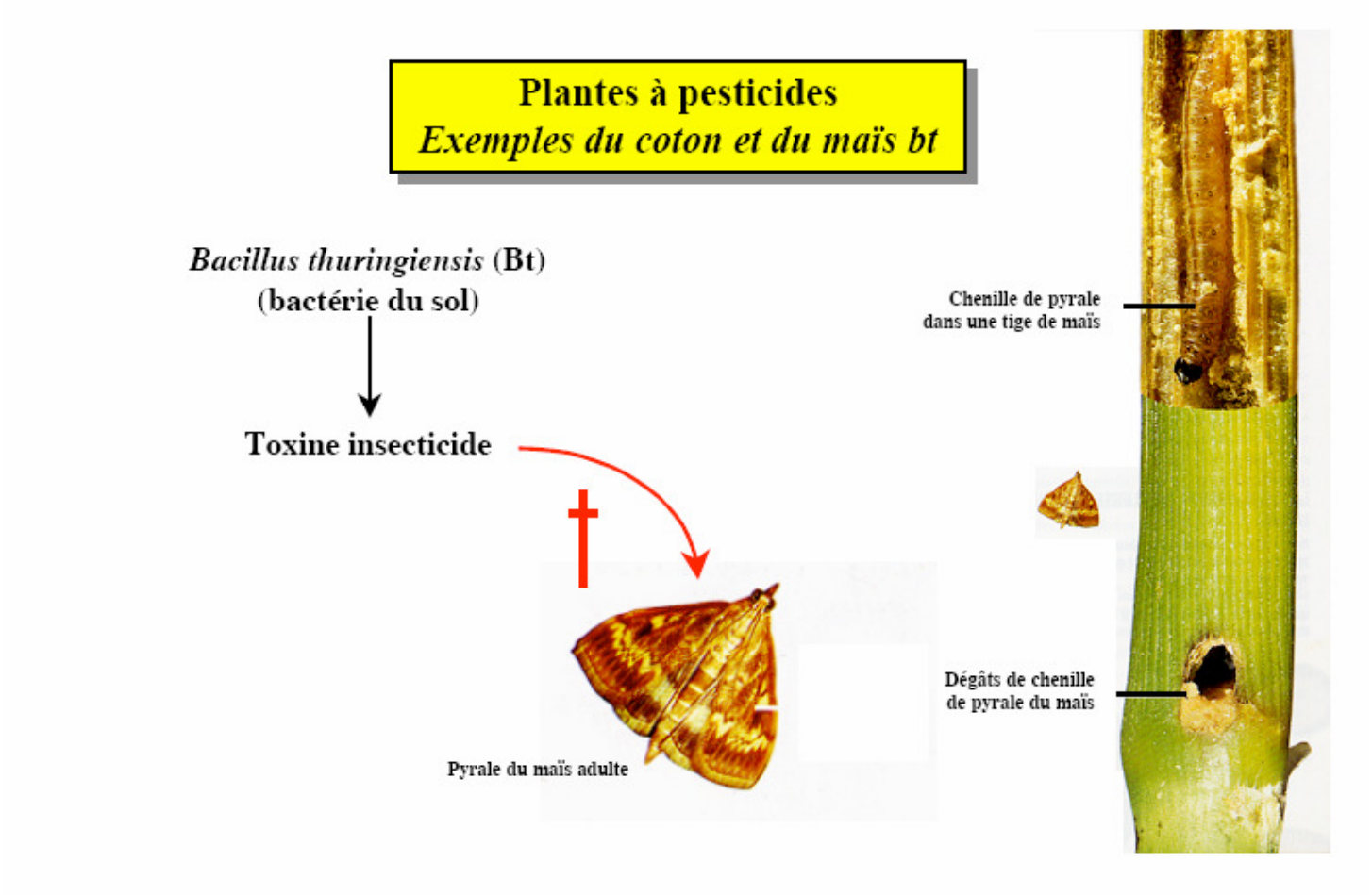
Structural diversity of bacterial protoxins



Specificity of protoxins:

- Cry1: Lepidopterans (butterflies)
- Cry2: Dipterans (flies, mosquitoes)
- Cry3: Coleopterans (CCR)
- Cry4: Dipterans (flies, mosquitoes)

Insecticidal GMP



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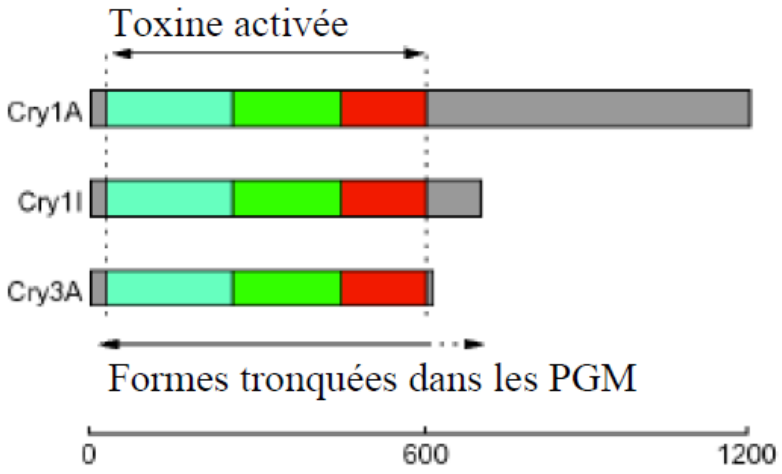
Mode of action of protoxins on targeted insects

1- Solubilisation des Protoxines dans l'intestin de l'insecte :
- Lepidoptera, Diptera: pH alcalin
- Coleoptera: pH neutre

2- Spécificité de la Protéolyse :
- Lepidoptera, Diptera: Protéase à Serine
- Coleoptera: Protéase à Cysteine, aspartate

3- Liaison au Récepteurs :
- Domaine I: "Qualité" du Pore



Activation of protoxins in 3 steps => specificity

Mode of action of Bt toxins

Bacterial Genes

Recombined Genes (truncated)

Protoxins (inactives)

Toxins (actives)

Ingested by larvae (Guts)

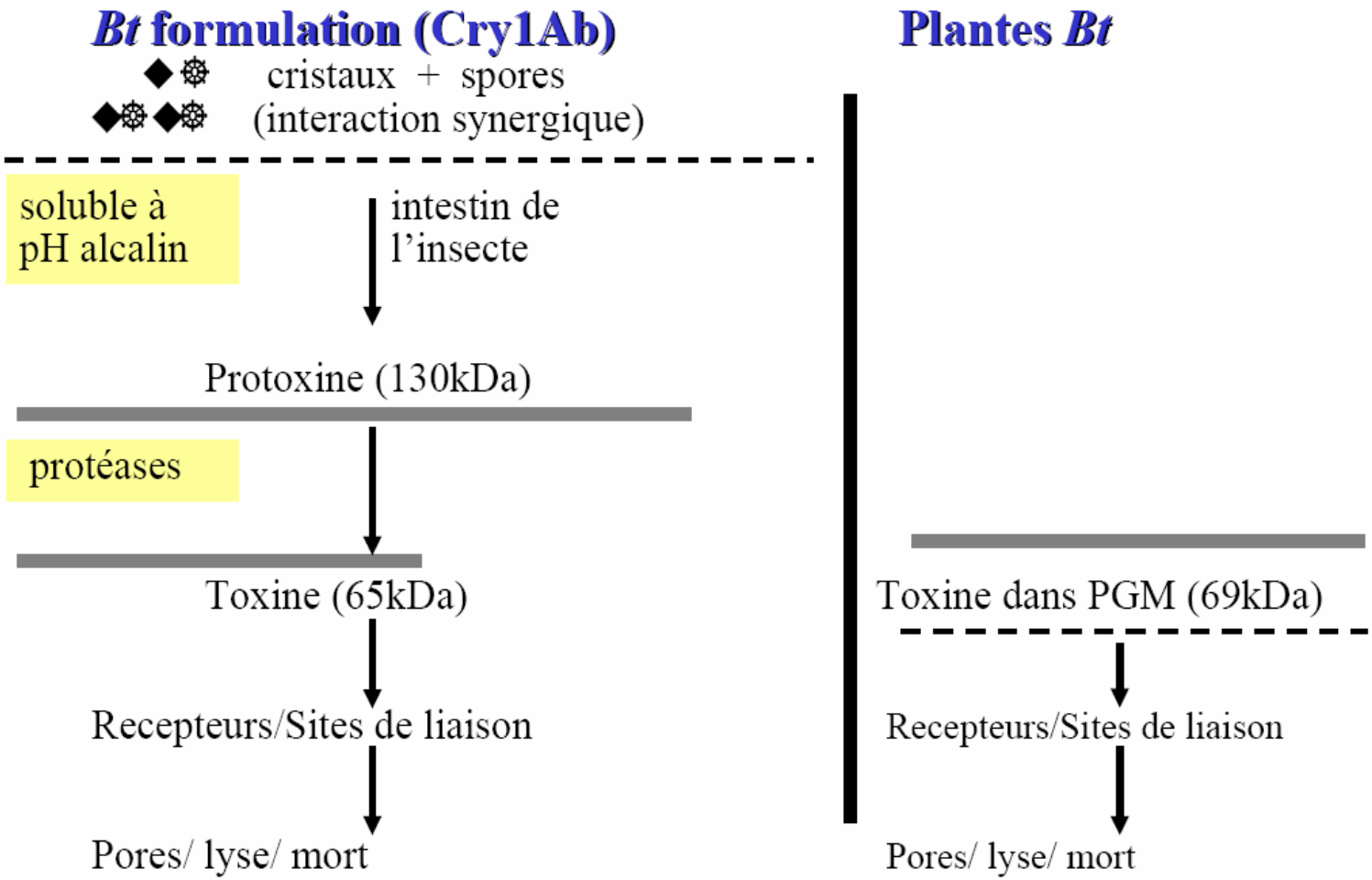
- **Solubilization** (Cry1Ab : pH>10,5)
- **Activation** of toxins by cleavage
- **Linkage to receptors**

- **Solubilized**
- **Actives** (no cleavage required)
- **Linkage to receptors**

Pores, efflux of K+, starvation, death

Structural differences between *Bt* sprays and *Bt* plants

(D'après Hilbeck 2002)



Laboratory assessment of Bt plants

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Proteins Cry and bees

CryIIIB	Larval Survival Weight of pupae	Arpaia 1996
Cry1Ac	Mortality	Sims 1995
Cry1Ba	Longevity and food intake	Malone et al. 1999
Cry1Ba	First flight and duration of flight activity	Malone et al. 2001
Cry1Ab	Larval mortality and protein concentration in haemolymph	Hanley et al. 2003)

Bt plants, nurses and larvae (Babendreïer et al. 2005)

Development of hypopharyngial glands (HG):

Exposition for 10 days to Bt pollen, Bt toxin or SBTI (0.1-1%), 250 individuals/treatment

No measurable impact on HG growth, but detection of Bt toxin, not SBTI in HG

⇒ Need for long term environmental studies

Behavioural effects

- **Goal:** assess the effects of Cry1Ab (3 and 5000 ppb) on adults bees.
- **No lethal effects but** altered food intake and learning
- Reaction to olfactive conditionning, even in the absence of reward (instead of searching new food sources)
- Response also affected by imidacloprid (Decourtye et al. 2004).

(Ramirez-Romero et al. 2008)

Behavioural effects

Does Bt plants (Cry1Ab) alter bees' foraging efficiency in the field?

- The mechanism of Bt-induced mortality, mediated by an effect on gut integrity, does not explain the behavioural modifications.

=> Bt toxins could cause non-lethal effects hidden by mortality (1, 2).

1: Hilbeck and Schmidt 2006; 2: Schmidt et al. 2008

Behavioural effects

- If Bt toxins present various modes of action, many non-targeted organisms would thus be exposed to Bt toxicity.

- Angelika Hilbeck: « Experiments simulating bee's real world experience are still lacking. We should look at the combination of Bt toxin AND imidacloprid, and not Bt toxin OR imidacloprid, in a fashion that simulate their exposition in the fields ».

Environmental assessment of Bt plants on non-targeted insects

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Effects of Bt maize and Bt cotton on non-targeted insects (Marvier et al. Science 2007)

Abundance (42 exp)	Areas treated (USDA 2005)	Sprayed with insecticides	No insecticides
Maize Cry1Ab	**23%**	↑	↓
Maize Cry3Bb	**23%**	↑	↓
Cotton Cry1Ac	**71%**	↑	↓

Effects of Bt maize and Bt cotton on non-targeted insects (Marvier et al. 2007)

Culture	Abundance ↓	Abundance ↑
Maize Cry1Ab (corn earworm)	**Hymenopterans > Collembolans > Neuropterans > Dipterans > Spiders > Thysanopteres > Hemipterans**	**Coleopterans**
Maize Cry3Bb (corn rootworm)	**Hymenopterans > Coleoptereans > Collembolans > Orthopterans**	**Spiders > Acarina > Hemipterans**
Cotton Cry1Ac (cotton lepidopteran pests)	**Lepidopterans > Coleopterans > Hemipterans > Spiders > Hymenopterans**	**Neuropterans**