




**GMO ECOLOGY & RISK
ASSESSMENT**

Problems in facilitating research on environmental effects of GM-crops


Recent experiences

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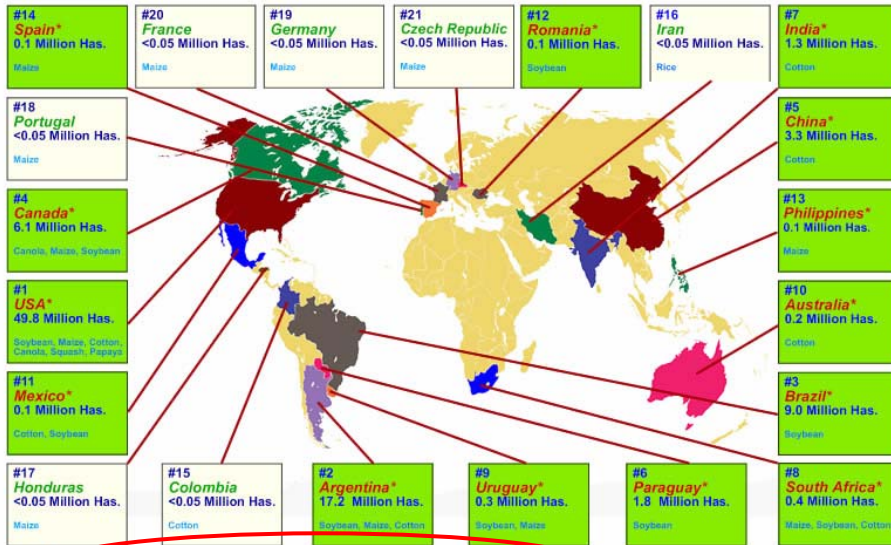


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The research that is NOT conducted!
The questions that are NOT answered!



21 Biotech Crop Countries and Mega-Countries*, 2005



* 14 biotech mega-countries growing 50,000 hectares, or more, of biotech crops.

Source: Clive James, 2005

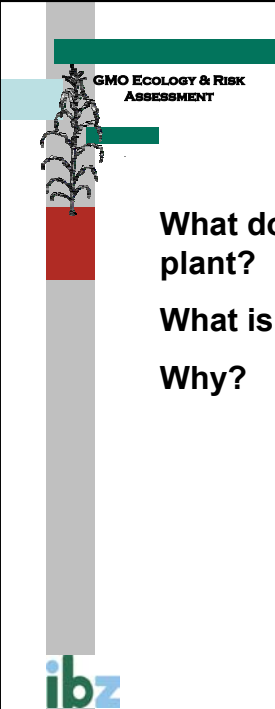
Current Campaign - *We know enough about Bt- and HR GM plants....*

The arguments:

- GM crops grown since more than 10 years in more than 20 countries
- Nothing happened – ‘the technology’ is safe
- All adverse events reported are ‘externalities’ and not due to the technology
- Good governance and practices will take care of the problems

..... to conclude they are safe, therefore:

- No more research on risks and environmental implications of Bt- and HR plants are necessary
- Shortcut ,de‘regulation of new Bt- and HR plants
- No monitoring necessary



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What do we typically know when releasing a GM plant?

What is typically tested?

Why?

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Dissent: interpretation of regulations and data requirements

Narrow vs. broad risk assessment

,trait-based' risk analysis

Narrow interpretation= **current logic** (e.g. of EFSA):

Declaration of **substantial equivalence** allows exclusive

focus on ,trait' = Transgene product


→ no transgene product → no risk!

→ if transgene product → focus on isolated t-product

Ignores: Effects of herbicides with HR crops

Unexpected effects (epigenetics, etc.)

Broad interpretation: Indirect GM effects including, e.g. herbicides with HR plants



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Focus on trait = e.g. transgene product means applying ,pesticide model' (ecotoxicological testing)

Strategy: Expose single species (of standard set) to single chemicals in a hierarchical tiered system

- Tests commence with simple inexpensive range-finding tests on single species
- Measure acute toxicological response to a chemical stressor
- Proceed to more expensive higher tiered tests (incl. some chronic toxicity tests), only if first tier experiments yield results of concern

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Standard non-target organisms tested according ,pesticide paradigm‘

Water fleas (*Daphnia magna*) – acute, 48 hrs static renewal with pollen

Springtail (*Folsomia candida*) – chronic, 28 days, yeast + test material

Earthworm (*Eisenia foetida*) – 14 days, soil + test material

Honey bee (*Apis mellifera*) – acute, 45 minutes, undigested pollen + water

Predatory/parasitoids insects

Hippodamia convergens - adults tested, bitrophic

Nasonia vitripennis – adults tested; pupal parasitoid of house flies,
minor ecological relevance, bitrophic

***Chrysoperla carnea* – larvae, bitrophic, coated meal-moth eggs, ca. 1 week**

Testmaterial used:

- Lyophilized leaf protein as dietary test material
- Microbially produced, activated Bt-toxin

Test duration:

- short time, acute

Test endpoints: toxicological parameters

Table 1: Some standardized guidelines for ecotoxicological testing of pesticides and GMOs (OECD 1998)¹

Testorganisms	Test method	Duration	OECD Guideline No
Water fleas (<i>Daphnia</i> spp.)	Acute immobilization Acute toxicity	24 - 96 hours	202
Fish spp. (e.g. rainbow trout)	Acute toxicity	24 - 96 hours	203
Fish spp.	toxicity of juvenile life stages	4 - 12 weeks	210
Compost worm (<i>Eisenia foetida</i>)	Acute toxicity	7 - 14 days	207
Bobwhite quail and mallards duck	Acute toxicity	14 - 21 days (few days treatment)	205
Honey bees	Acute toxicity (oral)	4 - 24 hours	New (1998) 213
	Acute toxicity (contact)		214

¹ <http://ecb.jr.it/testing-methods/>
<http://www.oecd.org/dataoecd/9/11/33663321.pdf>


This is not sufficient!

GM plants and their novel transgene products resemble plants rather than chemicals!

,Scientifically sound' testing must account for that!

Sounds trivial but really is not:

Since late 90ies.....'an undeliverable message'



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**So, what is the current status of spread
and impact of transgenes and transgene
products?**

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CONCLUSIONS:

- We cannot control their spread and occurrence
- Globally most powerful force: HUMANS (trade and food aid) complemented locally by gene flow


But what are the consequences??



What happens when transgenes spread unknowingly and introgress unnoticed into wild and weedy relatives and/or into other cultivars of the crop (100% of all current cases)?

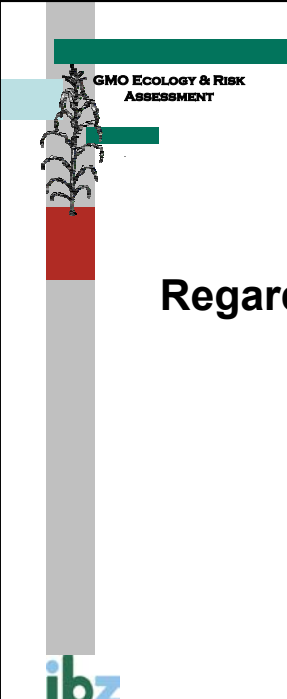

- Will they remain stable or will they split?
- What is inheritance pattern?
- Are transgenes taken up equally by every cultivar: from landraces to open-pollinating varieties to high-yielding hybrids?
- What will they do in a new genomic context?

We wanted to investigate that using Bt- and HR oilseed rape and Bt-maize




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***Rejected! ,Insufficient new and
relevant information will be
generated‘***

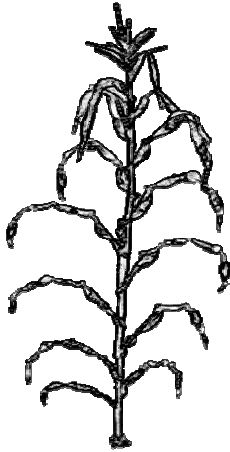


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Regarding transgene products....



For example: insecticidal Bt-plants



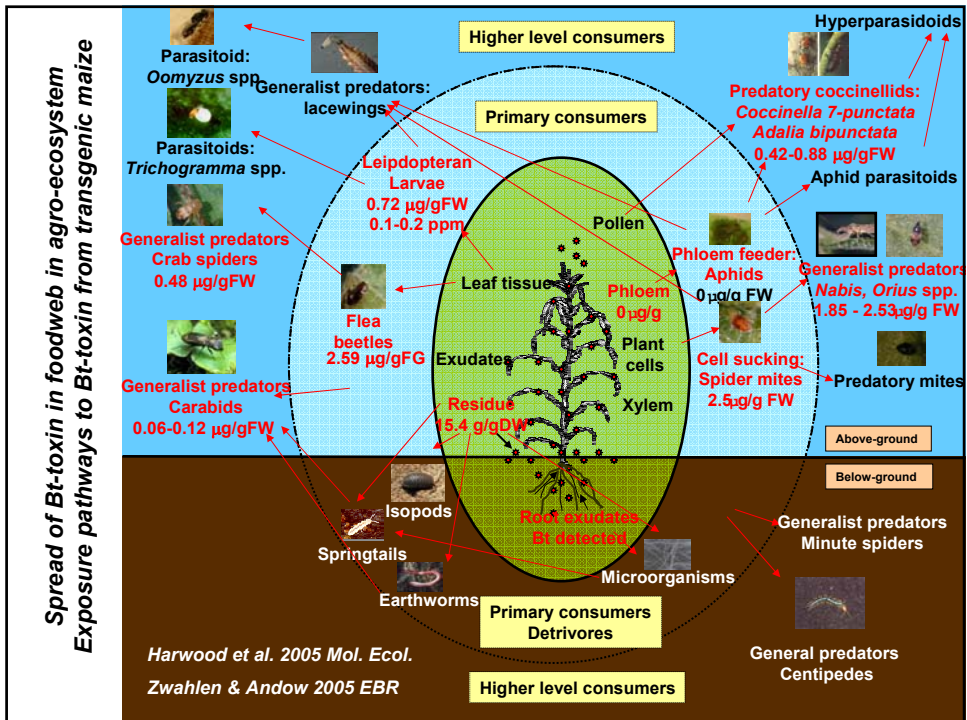
Constitutive Bt-expression

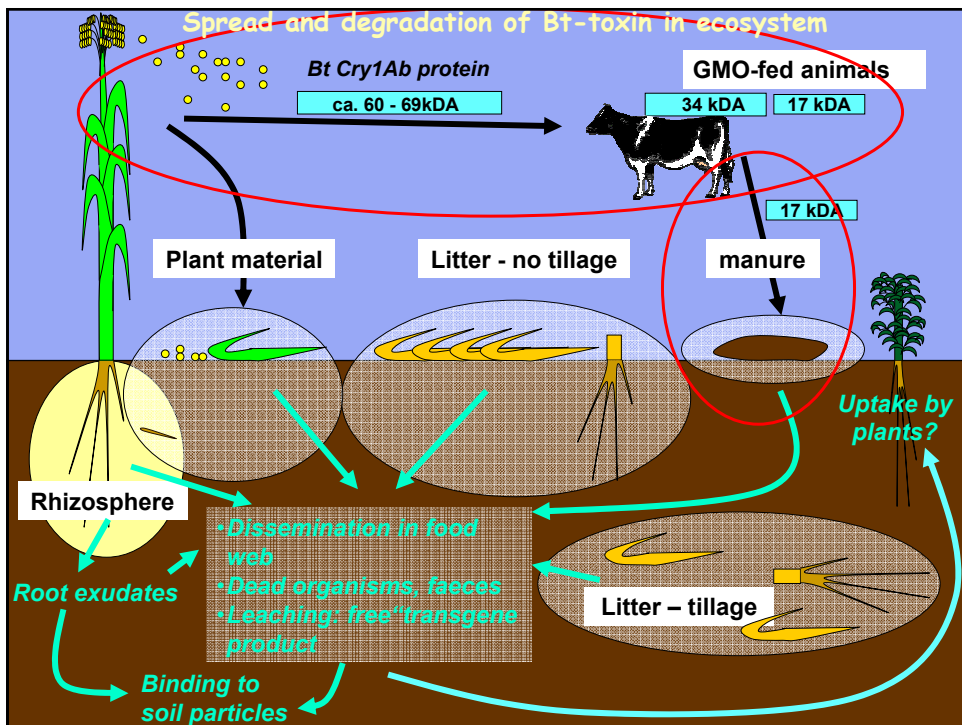
- all plant parts
- most plant fluids, except perhaps phloem/xylem
- season-long

Molecular weights of expressed transgene product (=Bt-toxin) 65, 69 and 91 kDa

Other fragments <50, 40 kDa due to in-plant processing

→ Unclear bioactivity





What happens when the transgene products spread unknowingly in the food chain?

- Will they remain in the same molecular state?
- What Bt-molecules are synthesized in Bt-plants anyway?
- What is the biochemical cycle of the transgene products and their metabolites when entering the ecosystem (via multiple pathways through animals and their excretions)? Do they remain bioactive? If yes, against what organisms?

Investigation proposed with Bt-maize and conduct feeding studies with sheep, pigs and insects

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Rejected! ,Unclear what additional relevant information would add'

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Observed effects in our lab

studies:

- Adverse effects on ladybird larvae and green lacewing larvae (tri-trophic and bi-trophic)
- No adverse effects on some bug predators
- Preference of spider mites for Bt-egg plants and preference of predatory spiders for non-Bt fed spider mites





Various test systems available

Green Lacewing – *Chrysoperla carnea*




























**Multi-Million-Dollar-Question:
Does Bt affect the Green Lacewing?**

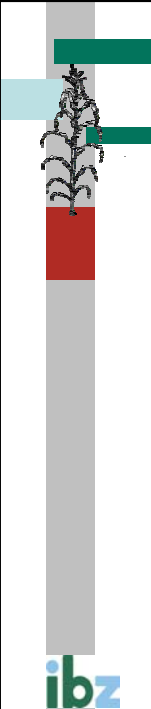


Feeding habit: Inject enzymes in prey, liquefied prey contents are sucked and ingested.

Prey: Larvae eat many other insects incl. fellow chrysopids. Preference for aphids if present. Optimal prey are small lepidoptera eggs.

Ecotox testing approach: 'Bi-trophic' feeding studies

Bi-trophic experiments								
	Treatments/control							
1a	+Bt/-Bt – continual development					Total		
	Mortality:	=	↑	↑	↑	↑		
1b	+Bt/-Bt – continual development							
	Mortality:	=	↑	↑	↑	↑		
1c	Negative control							
	Mortality:	=	=	=	=	=		
2a	+Bt/-Bt – arrested development		All test insects die					
	Time to death:	=	---	---	---	---		
2b	+Bt/-Bt – arrested dev. Followed by recovery							
	Mortality:	=	=	=	---	---		
3	+Bt/-Bt			Exposure still needs to be demonstrated				
	Mortality:	=	=	---	---	---		
Duration of Bt-Exposure		Artificial lacewing diet w/wo Bt toxin		Untreated meal moth eggs		Water drops w/wo Bt toxin		Coated meal moth eggs w/wo Bt toxin



Who controls research programs?


Who drives the development of testing systems?

An evolving network consisting of:

- EFSA members (control EU research projects, sit on research decision making bodies, serve in competent authorities, advise decision makers (politicians, policy makers, etc.))
- Industry
- Advocacy scientists

Philosophy: Biosafety as 'Enabling technology'

A right to repeat mistakes and to NOT learn






















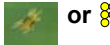









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Thank you!!

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Tri-trophic experiments

	Treatments/control					
1	+Bt/-Bt-maize – S.I.			 + 		Total
	Mortality:	0	↑	↑	↑	↑
2	+Bt/-Bt-diet – S.I.					
	Mortality:	0	↑	↑	↑	↑
3a	+Bt/-Bt-maize – S.I.			 or 		
	Mortality:	0	↑	↑	↑	↑
3b	+Bt/-Bt-maize – aphids					
	Mortality:	0	0	0	0	0
3c	+Bt/-Bt-maize – mites			 or 		
	Mortality:	0	0	0	---	---
4?	+Bt/-Bt-maize – S.I.					
	Mortality:	0	0	---	---	---
Duration of Bt-Exposure	 Untreated meal moth eggs	 <i>Spodoptera littoralis</i>	 Aphids	 Spider mites		