Non-target Environmental Risk Assessment Methodologies for GMOs

GMO Guidelines Project

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Part I

Assessing effects on biodiversity:

Necessity for and how to do species assessments

Biodiversity

How to assess the potential adverse effects of a GMO on Biodiversity?

Two General Strategies:

1. “Biodiversity” strategy **Use at end**

Advantages
- Direct
- Potentially complete
- Seems comprehensive

Disadvantages
- “Biodiversity” hard to define and measure
- Must be done on large areas in the field
- Cannot assess risks early in GMO testing

Two General Strategies:

1. "Biodiversity" strategy **Use at end**
2. Species strategy **Use at start**

Advantages
- Can be done in lab or field
- Can be used for early assessment
- Methodologies are readily available

Disadvantages
- Species not case- specific
- Species are poor indicators
- Endpoints sometimes not appropriate
- Easy to use bad methods

Conclusion:

It is necessary to use a species-based approach to assess potential risks of GMOs on biodiversity.

A biodiversity approach can supplement this if needed.

Goal for First Session:

How to design the species-approach to limit two of its disadvantages:

Case-specificity
Species are poor indicators

And be consistent with the aspirations of the Cartagena Biosafety Protocol to the Convention on Biological Diversity

Points of Consistency (Cartagena Protocol)

Risk assessment must be **science**-based (Annex 3)

Risk assessment must consider the **transgene**, the **organism**, and the **environment** into which the proposed release would occur (Annex 3)

A **precautionary approach** is fundamental to the Cartagena Protocol (CBD, Article 10.6 Decision Procedure, Article 11.8)

Limitations of the Main Alternative Model Ecotoxicology Model

- Universal indicator species
- Extrapolation-species

Endpoint:

- Acute toxicity
- Extrapolation-endpoint

Methodology:

- Dose-response
- Not case-by-case
- No empirical or theoretical basis
- Continual release
- Inaccurate for chronic exposure
- Not a single chemical

Andow and Hilbeck 2004 BioScience

Species-specific Risk Assessment

Step 1. Functional Classification
Step 2. List species and prioritize them
Step 3. Assess exposure
Step 4. Identify potential adverse effects
Step 5. Identify risks and conduct lab experiments
Step 6. Retest risks in the field as needed

Step 1. Functional Classification

- Requires no information about the transgenic plant except the crop species being considered
- This step is case specific in that it is tailored to the crop agro-ecosystem that is being analyzed
- Simplifies complexity consistent with ecological theory

Maize monoculture (USA)

>600 non-target species

Rice monoculture (Japan)

>800 non-target species

(including endangered species)

Too many to assess all species

Non-target Effects

- Natural Enemies
- Non-target Herbivores
- Pollinators
- Birds and Mammals
- Soils
- Species of conservation or cultural concern

Endangerment of species

Hundreds of possible species effects

Step 1. Functional Classification

A. Specify possible functional groups
B. Choose functional groups to continue, if possible, based on scientific concerns

A. Specify functional groups

Anthropocentric:

- (1) pests/ potential pest
- (2) natural enemies (predators, parasitoids, parasites)
- (3) plant pathogens
- (4) weeds
- (5) rare or endangered species
- (6) species used to generate income
- (7) species of social or cultural value

Ecological:

- (1) herbivory
- (2) secondary consumption
- (3) pollination
- (4) seed dispersal
- (5) decomposition of crop residues
- (6) plant disease
- (7) plant competitors
- (8) soil ecosystem functions
- (9) detritivory-soil organisms
- (10) species with unknown ecological function

B. Choose functional groups

Brazil – Bt cotton

Anthropocentric:

- (1) pests/ potential pest
- (2) natural enemies (predators, parasitoids, parasites)
- (3) plant pathogens
- (4) weeds
- (5) rare or endangered species
- (6) species used to generate income
- (7) species of social or cultural value

Ecological:

- (1) herbivory
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- (6) plant disease
- (7) plant competitors
- (8) soil ecosystem functions
- (9) detritivory-soil organisms
- (10) species with unknown ecological function

B. Choose functional groups

Vietnam – Bt cotton

Anthropocentric:

- (1) pests/ potential pest
- (2) natural enemies (predators, parasitoids, parasites)
- (3) plant pathogens
- (4) weeds
- (5) rare or endangered species
- (6) species used to generate income
- (7) species of social or cultural value

Ecological:

- (1) herbivory
- (2) secondary consumption
- (3) pollination
- (4) seed dispersal
- (5) decomposition of crop residues
- (6) plant disease
- (7) plant competitors
- (8) soil ecosystem functions
- (9) detritivory-soil organisms
- (10) species with unknown ecological function

B. Choose functional groups

For today

Anthropocentric:

- (1) pests/ potential pest
- (2) natural enemies (predators, parasitoids, parasites)
- (3) plant pathogens
- (4) weeds
- (5) rare or endangered species
- (6) species used to generate income
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Ecological:

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- (8) soil ecosystem functions
- (9) detritivory-soil organisms
- (10) species with unknown ecological function

Step 2. List and prioritize species

- Requires no information about the transgenic plant except the crop species being considered
- This step is case specific in that it is tailored to the crop agro-ecosystem that is being analyzed

Step 2. List and prioritize species

A. List species
B. Rank criteria in “species selection” matrix
C. Prioritize the species
D. Select species for further assessment

A. List species

- Identify variation in production regions (for cotton in Brazil: Northeast, Midwest, and Meridian regions)
- Use species lists from each region (keep them separate)
- Consult experts familiar with cropping system in Brazil

B. Rank criteria

- Requires input from experts
- Maximum potential exposure
  - Geographic distribution
  - Habitat specialization
  - Prevalence
  - Abundance
  - Phenology
  - Linkage
  - Association
- Significance
  - In specified function
  - Other significance (other functions)

Species Selection Matrix, part a

DESCRIPTION OF THE PREDATOR SPECIES

Feeding guild	Species or species group	Order and family	Life cycle stage with predator function	Main prey
General predator	crab spiders	Arachnida: Thomisidae	all	
General predator	wolf spiders	Arachnida: Lycosidae	all	
Predator of mites	predatory mites (*Amblesius, Eusieus*)	Acarina: Phytoseiidae	all	mites

Species Selection Matrix, part b

Predator species	Analysis of maximum potential exposure				
	geographic distribution	habitat special-ization	Prevalence: proportion of suitable habitat occupied		
			Meridi-an	Mid-West	North-East
crab spiders	1	3	high	high	high
wolf spiders	1	3		high	
Predatory mites (*Amblesius, Eusieus*)	1	3	medium	medium	medium

Species Selection Matrix, part c

Candidate species	Assessment of maximum potential exposure				
	Abundance in cotton			Phenology	
	Meridia-n	Mid-West	North-East	Proportion of cotton growing season when present	Life cycle stages on cotton
crab spiders	medium/ low	medium /low	medium /low	early, mid	all
wolf spiders		high		all	all
predatory mites (*Amblesius, Eusieus*)	medium	medium	medium	all	all

Species Selection Matrix, part e

Candidate species	Maximum potential significance			
	biological control in cotton	**biological control in other crops**	**food for other natural enemies**	**biological control in natural areas**
crab spiders				?
wolf spiders	1	1		?
predatory mites (*Amblesius, Eusieus*)				?

C. Prioritize the species

This is what we will ask you to do today

- Combine scores in the “maximum exposure” criteria
- Combine scores in the “significance” criteria
- Combine these two summary scores to obtain a final rank (1 is high)
- Recommend that <10% of species have rank = 1

Species Selection Matrix, part f

Predator species	**RANKING**				
	maximum potential exposure			**signifi-cance**	**OVERALL RANK**
	Mmeridian	**Mid-west**	**North east**		
crab spiders	3	3	3	3	3
wolf spiders				1	**1?**
predatory mites (*Amblesius, Eusieus*)	2 (1 if mites as prey alone)				3

D. Select species

- Pragmatic decision
  - Can add more if needed
  - Can reduce number as needed
- Recommend that several species from each function be retained, because later steps will eliminate some of these

Uncertainty and Precaution

- Fill in unknowns with highest reasonable rank, noting the uncertainty (this is a worst case scenario)
- Prioritize the species with and without this worst case assumption
- Examine resulting rankings. If the worst case scenario makes the species into a Rank 1 species, then it will be important to collect data to reduce uncertainty.

Ranking

- 1= Highest preliminary risk
- 2= Intermediate preliminary risk
- 3= Low preliminary risk