Pesticide applications by and with genetically modified (GM) crops: misregulated pesticide issues

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Global GMO status

175.2 million hectares
- soybean (84.5 M ha)
- maize (57.4 M ha)
- cotton (23.9 M ha)
- canola (8.2 M ha)

The vast majority of GM plants worldwide is represented by first generation GM crops ➔ plant protection strategies

Serious concerns of environmental safety and legal registration status!
„Insect resistant” plants

Insecticide producing plants (Bt plants), considered as “bioformulated” pesticides

**Bt-based bioinsecticide**

**Bt** crop

**application**

- singular
- environmental dosage
  - < 625–1.930-fold

**composition of the active ingredients**

- Cry1Ab (and several related) toxin (protoxin form)
- single modified Cry1Ab toxin (preactivated form)

Cannot be considered as equivalent technologies!
Biopesticide vs. GM plant

**Bacillus thuringiensis**

- bacterial Cry1Ab crystal (bipyramidal)
- crystal structure stabilized by disulfide bond
- solubilization of Cry1Ab molecules by lysis of disulfide bonds (pH 9-12, ME, DTT)
- Cry1Ab protoxin 131 kDa

**MON 810 maize**

- GM maize
- genetically modified plant DNA containing cry1Ab transgene
- expression of cry1Ab transgene in plant
- activated Cry1Ab toxin 63-65 kDa
- preactivated Cry1Ab toxin 91 kDa

Cry1Ab protoxin 131 kDa

activated Cry1Ab toxin 63-65 kDa

preactivated Cry1Ab toxin 91 kDa
Difficulties

- integrated pest management
- registration
- analytical methods
- ecotoxicology studies
"Herbicide tolerant" plants

The most common types (in application) are glyphosate tolerant GM crops
„Herbicide tolerant” plants

glyphosate  
herbicide active ingredient

formulating agents  „inert”
e.g., polyethoxylated tallow amine (POEA)

controversy in pesticide registration: surfactants, adjuvants are assumed to be inert

- Tsui and Chu (2003): POEA, assumed to be biologically inactive, is strongly toxic to species of bacteria, microalgae, protozoa and crustacean
- Marc et al. (2005): POEA is toxic to sea urchin
- Relyea and Jones (2009): POEA has endocrine disruptor effect of glyphosate is synergized by POEA
- Székács et al. (2014): POEA is toxic to Daphnia magna and have cytotoxic effect
- Mesnage et al. (2013, 2014): POEA has cytotoxic effect
Cell lines, cytotoxicity tests, test substances

- **JEG 3**
- **HEPG2**
- **HEK293**

**MTT** (cell proliferation assay)
**ToxiLight test** (necrosis)
**Caspase-Glo 3/7 test** (apoptosis)

- **Glyfos (Cheminova)**
  42% glyphosate IPA salt
  9% polyethoxylated tallow amine (POEA)
- **Medallon Premium (Syngenta)**
  34% glyphosate DA salt
  10-20% alkyl polyglucoside
- **POEA, APG**
- **glyphosate IPA salt (97%)**
Results, Glyfos

A

Mitochondrial respiration inhibition (R.U.)

POEA > Glyfos > glyphosate

B

Adenylate kinase activity (R.U.)

POEA > Glyfos > glyphosate

C

Caspases 3/7 activity (R.U.)

POEA > Glyfos > glyphosate not in every case!
Results, Medallon

Mitochondrial respiration inhibition (R.U.)

A

Adenylate kinase activity (R.U.)

B

Caspases 3/7 activity (R.U.)

APG > Medallon > glyphosate

APG ? Medallon ? glyphosate
Conclusion

• regulation of *Bt* crops and glyphosate-based herbicide are not adequate

• not only POEA, but other adjuvants also exert higher toxic effects than glyphosate
  • authorization should require risk assessment of adjuvants

• *Bt* bioinsecticides do not equal to *Bt* crops

• decrease in mitochondrial respiratory indicated the same trend for the three human cell lines: **glyphosate > Glyfos > POEA**
  **glyphosate > Medallon > APG**

• different sensitivity was detected among cell lines:
  **glyphosate** caused **lower toxicity than POEA**

• difference in cytotoxicity between the two glyphosate-based herbicides