GREENPEACE Briefing

Environmental and health impacts of GMOs: the evidence

April 2008

Effects on biodiversity

The environmental effects of genetically engineered crops designed to resist insect pests and herbicides are well documented. They are as follows.

Insect-resistant crops kill specific pests known to threaten the crop. In addition to their intended deadly effects, they are also:

- Toxic to 'non-target' organisms, such as butterflies. Long-term exposure to pollen from GM maize that expresses the Bacillus thuringiensis (Bt) toxin has been found to cause adverse effects on the behaviour[1] and survival[2] of the monarch butterfly, the best-known of all North American butterflies. Effects on European butterflies are virtually unknown, as few studies have been conducted. Those few do, however, suggest cause for concern that European butterflies would suffer as a result of insect-resistant GM crop being planted.[3, 4, 5, 6]
- Toxic to other, beneficial insects. Genetically engineered Bt crops adversely affect[7] insects that are important in the natural control of maize pests, such as green lacewings.[8, 9, 10, 11] In the EU (as elsewhere), environmental risk assessment for Bt crops considers direct acute toxicity alone, and not effects on organisms higher up the food chain. These effects can be important. The toxic effects of Bt crops on lacewings were via the prey that they ate. The 'single-tier' risk assessment approach has been widely criticised, with scientists suggesting that the effects of Bt crops need to be studied at multiple levels of the food web.[12, 13, 14, 15]
- A threat to soil ecosystems. Many Bt crops secrete the toxin from the root into the soil[16]. Residues left in the field contain the active Bt toxin.[17, 18, 19] The long-term, cumulative effects of growing Bt maize have not been considered in a European context, even though this is required under EU law (Directive 2001/18).[20]

GM maize MON810 is intended to prevent the need for three applications of insecticide. Yet this and other Bt maize varieties continuously release a toxin into the environment in quantities 3-5,000 times higher than sprays used for non-GM farming.

In addition to the above, risk assessments to date have failed to foresee at least two other impacts of Bt maize:

- Agricultural wastes from Bt maize have been identified entering water courses, where the Bt toxin might be toxic to certain insects.[21] This demonstrates the complexity of interactions in the natural environment and underlines the shortcomings of the risk assessment.
- Bt maize is more susceptible to a plant lice (aphid) than conventional maize, caused by changes in sap chemistry. These changes have not been described in a single application to market Bt maize but have important ecological implications. This demonstrates that plant-insect interactions are too complex to be assessed by the risk assessment.

Herbicide tolerant (HT) crops are associated with:

- Toxic effects of herbicides on ecosystems. Roundup, the herbicide sold by Monsanto in conjunction with its Roundup Ready GM crops, has been shown to be a potential endocrine disrupter, i.e., could interfere with hormones.[22] It is also toxic to frog larvae(tadpoles).[23]
- Increased weed tolerance to herbicide. Evolution of weed resistance to Roundup is now a serious problem in the US and other places where Roundup Ready crops are grown on a large scale.[24, 25, 26, 27] Increasing amounts of herbicide have to be used to control these weeds[28], or else additional herbicides have to be used to supplement Roundup.[29]
- Loss of weeds and other biodiversity. A UK government study found there were 24 % fewer butterflies in the margins of GM oil-seed rape (canola) fields, because there were fewer weed flowers (and hence nectar) for them to feed on.[30] In addition, there were fewer seeds for birds from oil-seed rape and sugar beet.[31, 32, 33] HT maize only compared favourably (in terms of impacts on biodiversity) to maize treated with the herbicide atrazine, which is now banned in the EU.
- Reduction in soil bacteria. The use of herbicides on GM soy leads to reduced amounts of beneficial nitrogen-fixing bacteria.[34, 35]

Effects on health

Independent studies on the wholesomeness of GM crops for either animals or humans are severely lacking from scientific literature.[36, 37, 38, 39]

Sir David King, the UK government's former chief scientist, was forced in December 2007 to admit he had been mistaken to claim that improved crop yields in Africa were due to GM plants. They weren't. The project he described used a sophisticated pest control and crop management technique that involved neither GMOs nor pesticides.

Almost all GMOs commercialised in the world either produce or tolerate pesticides. Yet while pesticides are tested over two-year periods prior to approval in Europe, the longest safety tests for GMOs are 90 days, including pesticide-producing GM plants.

We simply do not know if GM crops are safe for animal or human consumption, because long-term studies have seldom been performed. This is reflected by the ongoing controversy surrounding their safety assessment. The dispute over the pesticide-producing Bt maize MON863, for example, arose from concerns expressed by independent scientists[40] over observed differences in animal feed trials. Rather than admitting uncertainty concerning the food safety of MON863 and carrying out further research, EFSA[41] and the biotechnology[42] industry have used their efforts to try to refute the significance of these findings.

It is ungrounded and misleading to argue that GMOs must be harmless to health on the grounds that people living in the US have been consuming them for 10 years and no visible damage has been observed. There has not been a study on this specific matter.

What is not in doubt is that GM crops have the potential to cause allergenic reactions, more so than conventional breeding.[43, 44] During a long-term field trial in Australia, for example, GM peas were found to cause allergenic reactions in mice.[45] Eating the GM peas also made the mice more sensitive to other food allergies.

References

1 Prasifka, P.L., Hellmich, R.L., Prasifka, J.R. & Lewis, L.C. 2007. Effects of Cry1Ab-expressing corn anthers on the movement of monarch butterfly larvae. Environ Entomolology 36:228-33

2 Dively, G.P., Rose, R., Sears, M.K., Hellmich, R.L. Stanley-Horn, D.E. Calvin, D.D. Russo, J.M. & Anderson, P.L.. 2004. Effects on monarch butterfly larvae (Lepidoptera: Danaidae) after continuous exposure to Cry1Ab expressing corn during anthesis. Environmental Entomology 33: 1116-1125.

3 Lang, A. & Vojtech, E. 2006. The effects of pollen consumption of transgenic Bt maize on the common swallowtail, *Papilio machaon* L. (Lepidoptera, Papilionidae). Basic and Applied Ecology 7: 296—306.

4 Darvas, B., Lauber, E., Polga´r, L. A., Peregovits, L., Ronkay, L., Juracsek, J., et al. (2004). Non-target effects of DK-440-BTY (Yieldgard) Bt-corn. First Hungarian–Taiwanese entomological symposium, 11–12 October 2004, Budapest Hungarian National History Museum (p. 5).

5 Felke, V.M. & Langenbruch, G.A. 2003. Wirkung von Bt-Mais-Pollen auf Raupen des Tagpfauenauges im Laborversuch (Effect of Bt-maize-pollen on caterpillars of *Inachis io* in a laboratory assay). Gesunde Pflanzen, 55: 1-7.

6 Felke, M., Lorenz, N. & Langenbruch, G-A. 2002. Laboratory studies on the effects of pollen from Bt-maize on larvae of some butterfly species. Journal of Applied Entomology 126: 320–325.

7 Obrist, L.B., Dutton, A., Romeis, J. & Bigler, F. 2006. Biological activity of Cry1Ab toxin expressed by Bt maize following ingestion by herbivorous arthropods and exposure of the predator *Chrysoperla carnea*. BioControl 51: 31-48.

8 Andow, D.A. and A. Hilbeck. 2004. Science-based risk assessment for non-target effects of transgenic crops. Bioscience 54: 637-649.

9 Obrist, L.B., Dutton, A., Romeis, J. & Bigler, F. 2006. Biological activity of Cry1Ab toxin expressed by Bt maize following ingestion by herbivorous arthropods and exposure of the predator *Chrysoperla carnea*. BioControl 51: 31-48.

10 Harwood, J.D., Wallin, W.G. & Obrycki, J.J. 2005. Uptake of Bt endotoxins by non-target herbivores and higher order arthropod predators: molecular evidence from a transgenic corn agroecosystem. Molecular Ecology 14: 2815-2823.

11 Lövei, G.L. & Arpaia, S. 2005.The impact of transgenic plants on natural enemies: a critical review of laboratory studies. *Entomologia Experimentalis et Applicata* **114**: 1–14, 2005.

12 Andow, D.A. & Zwahlen, C. 2006. Assessing environmental risks of transgenic plants. Ecology Letters 9: 196-214.

13 Snow, A. A., Andow, D.A., Gepts, P., Hallerman, E. M., Power, A., Tiedje, J. M. & Wolfenbarger, L.L. 2005. Genetically engineered organisms and the environment: current status and recommendations. Ecological Applications, 15: 377–404.

14 Andow, D.A. & A. Hilbeck. 2004. Science-based risk assessment for non-target effects of transgenic crops. *Bioscience*, 54: 637-649.

15 Knols, B.G.J. and M. Dicke. 2003. Bt crop assessment in the Netherlands. Nature *Biotechnology* 21: 973-974.

16 Saxena, D., Flores, S. & Stotzky, G. 2002. Bt toxin is released in root exudates from 12 transgenic corn hybrids representing three transformation events. Soil Biology and Biochemistry 34: 133-137.

17 Flores, S., Saxena, D & Stotzky, G. 2005. Transgenic Bt plants decompose less in soil than non-Bt plants. Soil Biology and Biochemistry 37: 1073-1082.

18 Stotzky, G. 2004. Persistence and biological activity in soil of the insecticidal proteins from *Bacillus thuringiensis*, especially from transgenic plants. Plant and Soil 266: 77-89.

19 Zwahlen, C. Hilbeck, A. Gugerli, P. & Nentwig, W. 2003. Degradation of the Cry1Ab protein within transgenic *Bacillus thuringiensis* corn tissue in the field. Molecular Ecology 12: 765-775.

20 Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms, see Recital 19, Recital 20 and Annex II : "*A general principle for environmental risk assessment is also that an analysis of the .cumulative long-term effects relevant to the release and the placing on the market is to be carried out. Cumulative long-term effects. refers to the accumulated effects of consents on human health and the environment, including inter alia flora and fauna, soil fertility, oil degradation of organic material, the feed/ food chain, biological diversity, animal health and resistance problems in relation to antibiotics*".

21 Rosi-Marshall, E.J., Tank, J.L., Royer, T.V., Whiles, M.R., Evans-White, M., Chambers, C., Griffiths, N.A., Pokelsek, J. & Stephen, M.L. 2007. Toxins in transgenic crop byproducts may affect headwater stream ecosystems. Proceedings National Academy Sciences 41: 16204–16208

22 Richard, S., Moslemi, S., Sipahutar, H., Benachour, N. & Seralini, G-E. 2005. Differential effects of glyphosate and Roundup on human placental cells and aromatase. Environmental Health Perspectives 113: 716–720.

23 Relyea, R.A. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecological Applications 15: 618-627. Relyea, R.A. 2005. The lethal impact of roundup on aquatic terrestrial amphibians. Ecological Applications, 15: 1118–1124. Relyea, R.A., Schoeppner, N.M. & Hoverman, J.T. 2005. Pesticides and amphibians: the importance of community context. Ecological Applications, 15: 1125–1134.

24 Roy, B.A. 2004. Rounding up the costs and benefits of herbicide use. Proceedings of the National Academy of Sciences 101: 13974-13975.

25 Baucom, R.S. & Mauricio, R. 2004. Fitness costs and benefits of novel herbicide tolerance in a noxious weed. Proceedings of the National Academy of Sciences 101: 13386–13390.

26 Vitta, J.I., Tuesca, D. & Puricelli, E. 2004. Widespread use of glyphosate tolerant soybean and weed community richness in Argentina. Agriculture, Ecosystems and Environment 103: 621–624.

27 Nandula, V.K., Reddy, K.N., Duke, S.O. & Poston, D.H. 2005. Glyphosate-resistant weeds: current status and future outlook. Outlooks on Pest Management August 2005: 183-187.

28 Duke, S.O. 2005. Taking stock of herbicide-resistant crops ten years after introduction. Pest Management Science 61: 211–218.

29 http://farmindustrynews.com/mag/farming_saving_glyphosate/index.html

30 Roy, D. B., Bohan, D. A., Haughton, A. J., Hill, M. O., Osborne, J. L., Clark, S. J., Perry, J. N., Rothery, P., Scott, R. J., Brooks, D. R., Champion, G. T., Hawes, C., Heard, M. S. & Firbank, L. G. 2003. Invertebrates and vegetation of field margins adjacent to crops subject to contrasting herbicide regimes in the Farm Scale Evaluations of genetically modified herbicide-tolerant crops. The Royal Society Philosophical Transactions B. 358: 1879–1898

31 Heard, M.S. et al. 2003. Weeds in fields with contrasting conventional and genetically modified herbicide-tolerant crops. I. Effects on abundance and diversity Philosophical Transactions of the Royal Society London B 358: 1819–1832.

32 Firbank, L.G. et al. 2006. Effects of genetically modified herbicide-tolerant cropping systems on weed seedbanks in two years of following crops. Biology Letters 2: 140-143

33 Bohan, D.A. et al. 2005. Effects on weed and invertebrate abundance and diversity of herbicide management in genetically modified herbicide-tolerant winter-sown oilseed rape. Journal Proceedings of the Royal Society B: Biological Sciences. 272, DOI 10.1098/rspb.2004.3049.

34 King, C.A., Purcell, L.C. & Vories, E.D. 2001. Plant growth and nitrogenase activity of glyphosate-tolerant soybean in response to foliar glyphosate applications. Agronomy Journal 93: 179–186.

35 Zablotowicz, R.M. & Reddy, K.N. 2004. Impact of glyphosate on the *Bradyrhizobium japonicum* symbiosis with glyphosate-resistant transgenic soybean: a minireview. Journal of Environmental Quality 33: 825–831.

36 Vain, P. 2007. Trends in GM crop, food and feed safety literature. Nature Biotechnology Correspondence 25: 624-626.

37 Domingo, J.L. 2007. Toxicity studies of genetically modified plants: a review of the published literature. Critical Reviews in Food Science and Nutrition, 47:8, 721 – 733

38 Pryme, I.F. & Lembcke, R. 2003. In vivo studies on possible health consequences of genetically modified food and feed —with particular regard to ingredients consisting of genetically modified plant materials. Nutrition and Health 17: 1-8.

39 Brown, P., Wilson, K.A.., Jonker, Y. & Nickson, T.E. 2003. Glyphosate Tolerant Canola Meal Is Equivalent to the Parental Line in Diets Fed to Rainbow Trout. Journal of Agricultural Food and Chemistry, 51: 4268-4272.

40 Séralini, G.E., Cellier, D., de Vendomois, J.,S., 2007. New analysis of a rat feeding study with a genetically modified maize reveals signs of hepatorenal toxicity. Archives of Environmental Contamination & Toxicolcology, 52, 596-602.

41 EFSA, 2007. EFSA review of statistical analyses conducted for the assessment of the MON 863 90-day rat feeding study.
http://www.efsa.europa.eu/en/science/scientific_reports/statistical_analyses_MON863.html

42 Doull, J., Gaylor, D., Greim, H.A., Lovell, D.P., Lynch, B. & Munro I.C. 2007. Report of an Expert Panel on the reanalysis by Seralini et al. (2007) of a 90-day study conducted by Monsanto in support of the safety of a genetically modified corn variety (MON 863). Food and Chemical Toxicology 45: 2073–2085

43 Bernstein, J.A. et al. 2003. Clinical and laboratory investigation of allergy to genetically modified foods. Environmental Health Perspectives 111:1114–1121.

44 Freese, W. & Schubert, D. 2004. Safety testing and regulation of genetically engineered foods. Biotechnology and Genetic Engineering Reviews, 21: 229-324.

45 Prescott, V.E., Campbell, P.M., Moore, A., Mattes, J., Rothenberg, M.E., Foster, P.S., Higgins, T.J.V. & Hogan, S.P. 2005. Transgenic expression of bean alpha-amylase inhibitor in peas results in altered structure and immunogenicity. Journal of Agricultural & Food Chemistry 53: 9023- 9030