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**Ten reasons why biotechnology will not ensure food security, protect the environment
and reduce poverty in the developing world**

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Biotechnology companies often claim that genetically modified organisms (GMOs) -- specifically genetically altered seeds -- are essential scientific breakthroughs needed to feed the world, protect the environment, and reduce poverty in developing countries. The Consultative Group on International Agricultural Research (CGIAR) and its constellation of international centers around the world charged with research to enhance food security in the developing world echo this view, which rests on two critical assumptions. The first is that hunger is due to a gap between food production and human population density or growth rate. The second is that genetic engineering is the only or best way to increase agricultural production and thus meet future food needs.

Our objective is to challenge the notion of biotechnology as a magic bullet solution to all of agriculture's ills, by clarifying misconceptions concerning these underlying assumptions.

1. There is no relationship between the prevalence of hunger in a given country and its population. For every densely populated and hungry nation like Bangladesh or Haiti, there is a sparsely populated and hungry nation like Brazil and Indonesia. The world today produces more food per inhabitant than ever before. Enough is available to provide 4.3 pounds every person everyday: 2.5 pounds of grain, beans and nuts, about a pound of meat, milk and eggs and another of fruits and vegetables. The real causes of hunger are poverty, inequality and lack of access. Too many people are too poor to buy the food that is available (but often poorly distributed) or lack the land and resources to grow it themselves (Lappe, Collins and Rosset 1998).

2. Most innovations in agricultural biotechnology have been profit-driven rather than need-driven. The real thrust of the genetic engineering industry is not to make third world agriculture more productive, but rather to generate profits (Busch et al 1990). This is illustrated by reviewing the principle technologies on the market today: a) herbicide resistant crops such as Monsanto's "Roundup Ready" soybeans, seeds that are tolerant to Monsanto's herbicide Roundup, and b) "Bt" crops which are engineered to produce their own insecticide. In the first instance, the goal is to win a greater herbicide market-share for a proprietary product and in the second to boost seed sales at the cost of damaging the usefulness of a key pest management product (the *Bacillus thuringiensis* based microbial insecticide) relied upon by many farmers, including most organic farmers, as a powerful alternative to insecticides. These technologies respond to the need of biotechnology companies to intensify farmers' dependence upon seeds protected by so-called "intellectual property rights," which conflict directly with the age-old rights of farmers to reproduce, share or store seeds (Hobbelink 1991). Whenever possible corporations will require farmers

to buy company's brand of inputs and will forbid farmers from keeping or selling seed. By controlling germplasm from seed to sale, and by forcing farmers to pay inflated prices for seed-chemical packages, companies are determined to extract the most profit from their investment (Krimsky and Wrubel 1996).

3. The integration of the seed and chemical industries appears destined to accelerate increases in per acre expenditures for seeds plus chemicals, delivering significantly lower returns to growers. Companies developing herbicide tolerant crops are trying to shift as much per acre cost as possible from the herbicide onto the seed via seed costs and/or technology charges. Increasingly price reductions for herbicides will be limited to growers purchasing technology packages. In Illinois, the adoption of herbicide resistant crops makes for the most expensive soybean seed-plus-weed management system in modern history - between \$40.00 and \$60.00 per acre depending on rates, weed pressure, etc. Three years ago, the average seed-plus-weed control costs on Illinois farms was \$26 per acre, and represented 23% of variable costs; today they represent 35-40% (Benbrook 1999). Many farmers are willing to pay for the simplicity and robustness of the new weed management system, but such advantages may be short-lived as ecological problems arise.

4. Recent experimental trials have shown that genetically engineered seeds do not increase the yield of crops. A recent study by the USDA Economic Research Service shows that in 1998 yields were not significantly different in engineered versus non-engineered crops in 12 of 18 crop/region combinations. In the six crop/region combinations where Bt crops or HRCs fared better, they exhibited increased yields between 5-30%. Glyphosphate tolerant cotton showed no significant yield increase in either region where it was surveyed. This was confirmed in another study examining more than 8,000 field trials, where it was found that Roundup Ready soybean seeds produced fewer bushels of soybeans than similar conventionally bred varieties (USDA 1999).

5. Many scientists claim that the ingestion of genetically engineered food is harmless. Recent evidence however shows that there are potential risks of eating such foods as the new proteins produced in such foods could: act themselves as allergens or toxins, alter the metabolism of the food producing plant or animal, causing it to produce new allergens or toxins, or reduce its nutritional quality or value as in the case of herbicide resistant soybeans that contained less isoflavones, an important phytoestrogen present in soybeans, believed to protect women from a number of cancers. At present there is a situation in many developing countries importing soybean and corn from USA, Argentina and Brasil, in which genetically engineered foods are beginning to flood the markets, and no one can predict all their health effects on consumers, most unaware that they are eating such food. Because genetically engineered food remains unlabeled, consumers cannot discriminate between GE and non-GE food, and should serious health problems arise, it will be extremely difficult to trace them to their source. Lack of labeling also helps to shield the corporations that could be potentially responsible from liability (Lappe and Bailey, 1998).

6. Transgenic plants which produce their own insecticides closely follow the pesticide paradigm, which is itself rapidly failing due to pest resistance to insecticides. Instead of the failed "one pest-one chemical" model, genetic engineering emphasizes a "one pest-one gene" approach, shown over and over again in laboratory trials to fail, as pest species

rapidly adapt and develop resistance to the insecticide present in the plant (Alstad and Andow 1995). Not only will the new varieties fail over the short-to-medium term, despite so-called voluntary resistance management schemes (Mallet and Porter 1992), but in the process may render useless the natural pesticide "Bt," which is relied upon by organic farmers and others desiring to reduce chemical dependence. Bt crops violate the basic and widely accepted principle of "integrated pest management" (IPM), which is that reliance on any single pest management technology tends to trigger shifts in pest species or the evolution of resistance through one or more mechanisms (NRC 1996). In general the greater the selection pressure across time and space, the quicker and more profound the pests evolutionary response. An obvious reason for adopting this principle is that it reduces pest exposure to pesticides, retarding the evolution of resistance. But when the product is engineered into the plant itself, pest exposure leaps from minimal and occasional to massive and continuous exposure, dramatically accelerating resistance (Gould 1994). Bt will rapidly become useless, both as a feature of the new seeds and as an old standby sprayed when needed by farmers that want out of the pesticide treadmill (Pimentel et al 1989).

7. The global fight for market share markets is leading companies to massively deploy transgenic crops around the world (more than 30 million hectares in 1998) without proper advance testing of short- or long-term impacts on human health and ecosystems. In the U.S., private sector pressure led the White House to decree "no substantial difference" between altered and normal seeds, thus evading normal FDA and EPA testing.

Confidential documents made public in an on-going class action lawsuit have revealed that the FDA's own scientists do not agree with this determination.

One reason is that many scientists are concerned that the large scale use of transgenic crops poses a series of environmental risks that threaten the sustainability of agriculture (Goldberg, 1992; Paoletti and Pimentel 1996; Snow and Moran 1997; Rissler and Mellon 1996; Kendall et al 1997 and Royal Society 1998):

a. The trend to create broad international markets for single products, is simplifying cropping systems and creating genetic uniformity in rural landscapes. History has shown that a huge area planted to a single crop variety is very vulnerable to new matching strains of pathogens or insect pests. Furthermore, the widespread use of homogeneous transgenic varieties will unavoidably lead to "genetic erosion," as the local varieties used by thousands of farmers in the developing world are replaced by the new seeds (Robinson 1996).

b. The use of herbicide resistant crops undermine the possibilities of crop diversification thus reducing agrobiodiversity in time and space (Altieri 1994).

c. the potential transfer through gene flow of genes from herbicide resistant crops to wild or semidomesticated relatives can lead to the creation of superweeds (Lutman 1999).

d. There is potential for herbicide resistant varieties to become serious weeds in other crops (Duke 1996, Holt and Le baron 1990).

e. Massive use of Bt crops affects non-target organisms and ecological processes. Recent evidence shows that the Bt toxin can affect beneficial insect predators that feed on insect pests present on Bt crops (Hilbeck et al 1998), and that windblown pollen from Bt crops found on natural vegetation surrounding transgenic fields can kill non-target insects such as the monarch butterfly (Losey et al 1999). Moreover, Bt toxin present in crop foliage plowed under after harvest can adhere to soil colloids for up to 3 months, negatively affecting the soil invertebrate populations that break down organic matter and play other ecological roles (Donnegan et al 1995 and Palm et al 1996).

f. There is potential for vector recombination to generate new virulent strains of viruses, especially in transgenic plants engineered for viral resistance with viral genes. In plants containing coat protein genes, there is a possibility that such genes will be taken up by unrelated viruses infecting the plant. In such situations, the foreign gene changes the coat structure of the viruses and may confer properties such as changed method of transmission between plants. The second potential risk is that recombination between RNA virus and a viral RNA inside the transgenic crop could produce a new pathogen leading to more severe disease problems. Some researchers have shown that recombination occurs in transgenic plants and that under certain conditions it produces a new viral strain with altered host range (Steinbrecher 1996).

Ecological theory predicts that the large-scale landscape homogenization with transgenic crops will exacerbate the ecological problems already associated with monoculture agriculture. Unquestioned expansion of this technology into developing countries may not be wise or desirable. There is strength in the agricultural diversity of many of these countries, and it should not be inhibited or reduced by extensive monoculture, especially when consequences of doing so results in serious social and environmental problems (Altieri 1996).

Although the ecological risks issue has received some discussion in government, international, and scientific circles, discussions have often been pursued from a narrow perspective that has downplayed the seriousness of the risks (Kendall et al. 1997; Royal Society 1998). In fact methods for risk assessment of transgenic crops are not well developed (Kjellsson and Simmsen 1994) and there is justifiable concern that current field biosafety tests tell little about potential environmental risks associated with commercial-scale production of transgenic crops. A main concern is that international pressures to gain markets and profits is resulting in companies releasing transgenic crops too fast, without proper consideration for the long-term impacts on people or the ecosystem .

8. There are many unanswered ecological questions regarding the impact of transgenic crops. Many environmental groups have argued for the creation of suitable regulation to mediate the testing and release of transgenic crops to offset environmental risks and

demand a much better assessment and understanding of ecological issues associated with genetic engineering.

This is crucial as many results emerging from the environmental performance of released transgenic crops suggest that in the development of "resistant crops", not only is there a need to test direct effects on the target insect or weed, but the indirect effects on the plant (i.e. growth, nutrient content, metabolic changes), soil, and non-target organisms.

Unfortunately, funds for research on environmental risk assessment are very limited. For example, the USDA spends only 1% of the funds allocated to biotechnology research on risk assessment, about \$1-2 million per year.

Given the current level of deployment of genetically engineered plants, such resources are not enough to even discover the "tip of the iceberg".

It is a tragedy-in-the-making that so many millions of hectares have been planted without proper biosafety standards. Worldwide, such acreage expanded considerably in 1998 with transgenic cotton reaching 6.3 million acres, transgenic corn: 20.8 million acres and soybean: 36.3 million acres, helped along by marketing and distribution agreements entered into by corporations and marketers (i.e. Ciba Seeds with Growmark and Mycogen Plant Sciences with Cargill), in the absence of regulations in many developing countries. Genetic pollution, unlike oil spills, cannot be controlled by throwing a boom

9. As the private sector has exerted more and more dominance in advancing new biotechnologies, the public sector has had to invest a growing share of its scarce resources in enhancing biotechnological capacities in public institutions including the CGIAR and in evaluating and responding to the challenges posed by incorporating private sector technologies into existing farming systems. Such funds would be much better used to expand support for ecologically based agricultural research, as all the biological problems that biotechnology aims at can be solved using agroecological approaches.

The dramatic effects of rotations and intercropping on crop health and productivity, as well as of the use of biological control agents on pest regulation have been confirmed repeatedly by scientific research. The problem is that research at public institutions increasingly reflects the interests of private funders at the expense of public good research such as biological control, organic production systems and general agroecological techniques . Civil society must request for more research on alternatives to biotechnology by universities and other public organizations (Krimsky and Wrubel 1996). There is also an urgent need to challenge the patent system and intellectual property rights intrinsic to the WTO which not only provide multinational corporations with the right to seize and patent genetic resources, but that will also accelerate the rate at which market forces already encourage monocultural cropping with genetically uniform transgenic varieties. Based on history and ecological theory, it is not difficult to predict the negative impacts of such environmental simplification on the health of modern agriculture (Altieri 1996).

10. Although there may be some useful applications of biotechnology (i.e.

the breeding drought resistant varieties or crops resistant to weed competition) much of the needed food can be produced by small farmers located throughout the world using agroecological technologies (Uphoff and Altieri 1999). In fact, new rural development approaches and low-input technologies spearheaded by farmers and NGOs around the world are already making a significant contribution to food security at the household, national and regional levels in Africa, Asia and Latin America (Pretty 1995). Yield increases are being achieved by using technological approaches, based on agroecological principles that emphasize diversity, synergy, recycling and integration; and social processes that emphasize community participation and empowerment (Rosset 1999). When such features are optimized, yield enhancement and stability of production are achieved, as well as a series of ecological services such conservation of biodiversity, soil and water restoration and conservation, improved natural pest regulation mechanisms, etc (Altieri et al 1998). These results are a breakthrough for achieving food security and environmental preservation in the developing world, but their potential and further spread depends on investments, policies, institutional support and attitude changes on the part of policy makers and the scientific community, especially the CGIAR who should devote much of its efforts to assist the 320 million poor farmers living in marginal environments. Failure to promote such people-centered agricultural research and development due to diversion of funds and expertise to biotechnology, will forego a historical opportunity to raise agricultural productivity in economically viable, environmentally benign and socially uplifting ways.

REFERENCES

Alstad, D.N. and D.A. Andow (1995) Managing the Evolution of Insect Resistance to Transgenic Plants. *Science* 268, 1894-1896.

Altieri, M.A. (1994) *Biodiversity and Pest Management in Agroecosystems*. Haworth Press, New York.

Altieri, M.A. (1996) *Agroecology: the science of sustainable agriculture*.

Westview Press, Boulder.

Altieri, M.A., P.Rosset and L.A. Thrupp. 1998. The potential of agroecology to combat hunger in the developing world. 2020 Brief 55. International Food policy research Institute. Washington DC.

Benbrook, C. 1999 *World food system challenges and opportunities: GMOs, biodiversity and lessons from America's heartland* (unpub. manuscript).

Busch, L., W.B. Lacey, J. Burkhardt and L. Lacey (1990) *Plants, Power and Profit*. Basil Blackwell, Oxford.

Casper, R. and J Landsmann (1992) The biosafety results of field tests of genetically modified plants and microorganisms. Proceedings of the Second International Symposium Goslar, Germany, p. 296.

Donnegan, K.K., C.J. Palm, V.J. Fieland, L.A. Porteous, L.M. Ganis, D.L.

Scheller and R.J. Seidler (1995) Changes in levels, species, and DNA fingerprints of soil micro organisms associated with cotton expressing the *Bacillus thuringiensis* var. *Kurstaki* endotoxin. *Applied Soil Ecology* 2, 111-124.

Duke, S.O. (1996) *Herbicide resistant crops: agricultural, environmental, economic, regulatory, and technical aspects*, p. 420. Lewis Publishers, Boca Raton.

Goldberg, R.J. (1992). Environmental Concerns with the Development of Herbicide-Tolerant Plants. *Weed Technology* 6, 647-652.

Gould, F. (1994) Potential and Problems with High- Dose Strategies for Pesticidal Engineered Crops. *Biocontrol Science and Technology* 4, 451-461.

Hilbeck, A., M. Baumgartner, P.M. Fried, and F. Bigler (1998) Effects of transgenic *Bacillus thuringiensis* corn fed prey on mortality and development time of immature *Chrysoperla carnea* Neuroptera:Chrysopidae). *Environmental Entomology* 27, 460-487.

Hobbelink, H. (1991) *Biotechnology and the future of world agriculture*. Zed Books, Ltd., London. p. 159.

Holt, J.S. and H.M. Le Baron (1990) Significance and distribution of herbicide resistance. *Weed Technol.* 4, 141-149.

James, C. (1997). *Global Status of Transgenic Crops in 1997*. International Service for the Acquisition of Agri-Biotech Application. p. 30. ISSA Briefs, Ithaca.

Kendall, H.W., R. Beachy, T. Eismer, F. Gould, R. Herdt, P.H. Ravon, J Schell and M.S. Swaminathan (1997) *Bioengineering of crops*. Report of the World Bank Panel on Transgenic Crops, World Bank, Washington, D.C. p. 30.

Kennedy, G.G. and M.E. Whalon (1995) Managing Pest Resistance to *Bacillus thuringiensis* Endotoxins: constraints and incentives to implementation. *Journal of Economic Entomology* 88, 454-460.

Kjellsson, G and V. Simonsen (1994) *Methods for risk assessment of transgenic plants*, p. 214. Birkhauser Verlag, Basil.

Krimsky, S. and R.P. Wrubel (1996) *Agricultural Biotechnology and the Environment: science, policy and social issues*. University of Illinois Press, Urbana.

- Lappe, F.M., J. Collins and P. Rosset (1998). *World Hunger: twelve myths*, p. 270. Grove Press, NY.
- Lappe, M and B. Bailey 1998. *Against the grain: biotechnology and the corporate takeover of food*. Common Courage Press, Monroe, Maine.
- Liu, Y.B., B.E. Tabashnik, T.J. Dennehy, A.L. Patin, and A.C. Bartlett (1999) Development time and resistance to Bt crops. *Nature* 400, 519.
- Losey, J.J.E., L.S. Rayor and M.E. Carter (1999) Transgenic pollen harms monarch larvae. *Nature* 399, 214.
- Lutman, P.J.W. (ed.) (1999) *Gene flow and agriculture: relevance for transgenic crops*. British Crop Protection Council Symposium Proceedings No. 72. Staffordshire, England.
- Mallet, J. and P. Porter (1992) Preventing insect adaptations to insect resistant crops: are seed mixtures or refugia the best strategy? *Proc. R. Soc. London Ser. B. Biol. Sci.* 250. 165-169 National Research Council (1996) *Ecologically Based Pest Management*. National Academy of Sciences, Washington DC.
- Palm, C.J., D.L. Schaller, K.K. Donegan and R.J. Seidler (1996) Persistence in Soil of Transgenic Plant Produced *Bacillus thuringiensis* var. *Kustaki* (-endotoxin. *Canadian Journal of Microbiology* (in press).
- Paoletti, M.G. and D. Pimentel (1996) Genetic Engineering in Agriculture and the Environment: assessing risks and benefits. *BioScience* 46, 665-671.
- Pimentel, D., M.S. Hunter, J.A. LaGro, R.A. Efroymson, J.C. Landers, F.T. Mervis, C.A. McCarthy and A.E. Boyd (1989) Benefits and Risks of genetic Engineering in Agriculture. *BioScience* 39, 606-614.
- Pretty, J. *Regenerating agriculture: Policies and practices for sustainability and self-reliance*. Earthscan., London.
- Rissler, J. and M. Mellon (1996) *The Ecological Risks of Engineered Crops*. MIT Press, Cambridge.
- Robinson, R.A. (1996) *Return to Resistance: breeding crops to reduce pesticide resistance*. AgAccess, Davis.
- Rosset, P. 1999 *The multiple functions and benefits of small farm agriculture in the context of global trade negotiations*. Institute for Food and Development Policy, Food First Policy Brief No.4.
- Royal Society (1998) *Genetically modified plants for food use*. Statement 2/98, p. 16. London.

Snow, A.A. and P. Moran (1997) Commercialization of transgenic plants: potential ecological risks. *BioScience* 47, 86-96.

Steinbrecher, R.A. (1996) From Green to Gene Revolution: the environmental risks of genetically engineered crops. *The Ecologist* 26, 273-282.

United States Department of Agriculture (1999) Genetically Engineered Crops for Pest Management. USDA Economic Research Service, Washington, DC.

Uphoff, N and Altieri, M.A. 1999 Alternatives to conventional modern agriculture for meeting world food needs in the next century. Report of a Bellagio Conference. Cornell International Institute for Food, Agriculture and Development. Ithaca, NY.

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