

TEN REASONS WHY BIOTECHNOLOGY WILL NOT ENSURE FOOD SECURITY, PROTECT THE ENVIRONMENT AND REDUCE POVERTY IN THE DEVELOPING WORLD

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Advocates of biotechnology affirm that the application of genetic engineering to develop transgenic crops will increase world agricultural productivity, enhance food security, and move agriculture away from a dependence on chemical inputs helping to reduce environmental problems. This paper challenges such assertions by first demystifying the Malthusian view that hunger is due to a gap between food production and human population growth. Second, we expose the fact that current bio-engineered crops are not designed to increase yields or for poor small farmers, so that they may not benefit from them. In addition, transgenic crops pose serious environmental risks, continuously underplayed by the biotechnology industry. Finally, it is concluded that there are many other agro-ecological alternatives that can solve the agricultural problems that biotechnology aims at solving, but in a much more socially equitable manner and in a more environmentally harmonious way.

Key words: biotechnology; transgenic crops; developing countries; Malthusian view; environmental risks.

Biotecnology 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

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food per inhabitant than ever before. Enough food is available to provide 4.3 pounds for 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 to food and land. 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 & 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: (1) herbicide resistant crops, such as Monsanto's "Roundup Ready" soybeans, seeds that are tolerant to Monsanto's herbicide Roundup, and (2) "Bt" (*Bacillus thuringiensis*) 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 a 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 & 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 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 fee rates, weed pressure, and so on. 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 United States Department of Agriculture (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 herbicide tolerant crops (HTCs) fared better, they exhibited increased yields between 5-30%. Glyphosate 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: (1) act themselves as allergens or toxins; (2) alter the metabolism

of the food producing plant or animal, causing it to produce new allergens or toxins; or (3) reduce its nutritional quality or value. In the case of (3), herbicide resistant soybeans can contain less isoflavones, an important phytoestrogen present in soybeans, believed to protect women from a number of cancers. At present, developing countries are importing soybean and corn from the United States, Argentina, and Brazil. Genetically engineered foods are beginning to flood the markets in the importing countries, yet no one can predict all their health effects on consumers, who are unaware that they are eating such food. Because genetically engineered food remains unlabeled, consumers cannot discriminate between genetically engineered (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 & 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 & Andow, 1995). Not only will the new varieties fail over the short-to-medium term, despite so-called voluntary resistance management schemes (Mallet & Porter, 1992), but in the process may render useless the natural Bt-pesticide 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). *Bacillus thuringiensis* 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 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 United States, private sector pressure led the White House to decree "no substantial difference" between altered and normal seeds, thus evading normal Food and Drug Administration (FDA) and Environmental Protection Agency (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 & Pimentel, 1996; Snow & Moran, 1997; Rissler & Mellon, 1996; Kendall *et al.*, 1997; Royal Society, 1998). These risk areas are as follows:

- 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).

- The use of herbicide resistant crops undermines the possibilities of crop diversification, thus, reducing agrobiodiversity in time and space (Altieri, 1994).
- 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).
- There is potential for herbicide resistant varieties to become serious weeds in other crops (Duke 1996; Holt & Le Baron, 1990).
- 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). In addition, 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; Palm *et al.* 1996).
- 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 & 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. Plant growth, nutrient content, metabolic changes, and effects on the soil and non-target organisms should all be examined. 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 reaching 20.8 million acres, and transgenic soybean 36.3 million acres. This expansion has been 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), and in the absence of regulations in many developing countries. Genetic pollution, unlike oil spills, cannot be controlled by throwing a boom around it.

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 & Wrubel, 1996). There is also an urgent need to challenge the patent system and intellectual property rights intrinsic to the World Trade Organization (WTO) which not only provide multinational corporations with the right to seize and patent genetic resources, but 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. Much of the needed food can be produced by small farmers located throughout the world using agroecological technologies (Uphoff & Altieri, 1999). In fact, new rural development approaches and low-input technologies spearheaded by farmers and non-governmental organizations (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, and so on (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 the 320 million poor

farmers living in marginal environments. Failure to promote such people-centered agricultural research and development due to the diversion of funds and expertise towards biotechnology will forego an historical opportunity to raise agricultural productivity in economically viable, environmentally benign, and socially uplifting ways.

References

- Alstad, D.N. and Andow, D.A. (1995). Managing the evolution of insect resistance to transgenic plants. Science, 268, 1894-1896.
- Altieri, M.A. (1994). Biodiversity and pest management in agroecosystems. New York: Haworth Press.
- Altieri, M.A. (1996). Agroecology: the science of sustainable agriculture. Boulder CO: Westview Press.
- Altieri, M.A., Rosset, P., and Thrupp, L.A. (1998). The potential of agroecology to combat hunger in the developing world (2020 Brief No.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. Unpublished manuscript.
- Busch, L., Lacey, W.B., Burkhardt, J., and Lacey, L. (1990). Plants, power and profit. Oxford, England: Basil Blackwell.
- Casper, R. and Landsmann, J. (1992). The biosafety results of field tests of genetically modified plants and microorganisms. P.K. Landers (ed.), Proceedings of the Second International Symposium Goslar, pp. 89-97, Germany.
- Donnegan, K.K., Palm, C.J., Fieland, V.J., Porteous, L.A., Ganis, L.M., Scheller, D.L. and Seidler, R.J. (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. Boca Raton: Lewis Publishers.
- 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., Baumgartner, M., Fried, P.M., and Bigler, F. (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. London: Zed Books, Ltd.
- Holt, J.S. and Le Baron, H.M. (1990). Significance and distribution of herbicide resistance. Weed Technology, 4, 141-149.
- James, C. (1997). Global status of transgenic crops in 1997 (ISAAA Briefs No. 5.). Ithaca, NY: International Service for the Acquisition of Agri-Biotech Application (ISAAA). Available on the World Wide Web: <http://www.isaaa.org/frbrief5.htm>.
- Kendall, H.W., Beachy, R., Eismer, T., Gould, F., Herdt, R., Ravon, P.H., Schell, J. and Swaminathan, M.S. (1997). Bioengineering of crops (Report of the World Bank Panel on Transgenic Crops, pp.1-30). Washington DC: World Bank.
- Kennedy, G.G. and Whalon, M.E. (1995). Managing pest resistance to *Bacillus thuringiensis* endotoxins: constraints and incentives to implementation. Journal of Economic Entomology, 88, 454-460.
- Kjellsson, G. and Simonsen, V. (1994). Methods for risk assessment of transgenic plants. Basel, Germany: Birkhauser Verlag.
- Krimsky, S. and Wrubel, R.P. (1996). agricultural biotechnology and the environment: science, policy and social issues. Urbana, IL: University of Illinois Press.
- Lappe, F.M., Collins, J., and Rosset, P. (1998). World hunger: twelve myths. New York: Grove Press.
- Lappe, M and Bailey, B. (1998). Against the grain: biotechnology and the corporate takeover of food. Monroe, Maine: Common Courage Press.
- Liu, Y.B., Tabashnik, B.E., Dennehy, T.J., Patin, A.L., and Bartlett A.C. (1999). Development time and resistance to Bt crops. Nature, 400, 519.
- Losey, J.J.E., Rayor, L.S. and Carter, M.E. (1999). Transgenic pollen harms monarch larvae. Nature, 399, 214.
- Lutman, P.J.W. (1999). (Ed.). Gene flow and agriculture: relevance for transgenic crops. British Crop Protection Council Symposium Proceedings, 72, 43-64.
- Mallet, J. and Porter, P. (1992). Preventing insect adaptations to insect resistant crops: are seed mixtures or refugia the best strategy? Proceedings of the Royal Society of London Series B Biology Science, 250, 165-169.

- National Research Council (NRC). (1996). Ecologically based pest management. Washington DC: National Academy of Sciences.
- Palm, C.J., Schaller, D.L., Donegan, K.K. and Seidler, R.J. (1996). Persistence in soil of transgenic plant produced bacillus thuringiensis var. kustaki-endotoxin. Canadian Journal of Microbiology, *42*, 1258-1262.
- Paoletti, M.G. and Pimentel, D. (1996). Genetic engineering in agriculture and the environment: assessing risks and benefits. BioScience, *46*, 665-671.
- Pimentel, D., Hunter, M.S., LaGro, J.A., Efroymson, R.A., Landers, J.C., Mervis, F.T. McCarthy, C.A. and Boyd, A.E. (1989). Benefits and risks of genetic engineering in agriculture. BioScience, *39*, 606-614.
- Pretty, J. (1995). Regenerating agriculture: Policies and practices for sustainability and self-reliance. London: Earthscan.
- Rissler, J. and Mellon, M. (1996). The ecological risks of engineered crops. Cambridge, MA: MIT Press.
- Robinson, R.A. (1996). Return to resistance: breeding crops to reduce pesticide resistance. Davis, CA: AgAccess.
- Rosset, P. (1999). The multiple functions and benefits of small farm agriculture in the context of global trade negotiations, (IFDP Food First Policy Brief No. 4). Washington DC: Institute for Food and Development Policy.
- Royal Society. (1998, February). Genetically modified plants for food use. Statement 2/98. London: Royal Society.
- Snow, A.A. and Moran, P. (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 (USDA). (1999). Genetically engineered crops for pest management. Washington DC: USDA Economic Research Service.
- 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). Ithaca, NY: Cornell International Institute for Food, Agriculture and Development.