Miscellaneous topics

AGRICULTURAL BIOTECHNOLOGY FOR DEVELOPING COUNTRIES

Terri Raney, Food and Agriculture Organisation, Rome, Italy

"An evergreen revolution can be achieved only if we ... mobilize the best in both traditional wisdom and frontier science. Among the frontier technologies relevant to the nest stage in our agricultural revolution, the foremost is biotechnology ...." MS Swaminathan (2004)

Abstract

The Food and Agriculture Organization of the United Nations, in "The State of Food and Agriculture 2003-04", examines the potential of agricultural biotechnology to address the current and future needs of the world's poor and food insecure. Critics of biotechnology claim that technology is not the answer to the problems of poverty and hunger. They argue - correctly - that the world produces enough food to provide everyone with an adequate diet and that what is required is more equitable access by the poor. They extrapolate from these sensible observations to the mistaken conclusion that technological innovation is unimportant or even counter-productive in the fight against poverty and hunger (GRAIN, 2004) . This paper summarizes the findings of The State of Food and Agriculture and argues that technological innovation in agriculture, based on the best of modern science, is a necessary condition for sustainable economic growth and poverty alleviation. Biotechnology is not a panacea, but it is an essential part of the solution. This paper briefly reviews the range of biotechnology applications that can address problems of the poor. It also describes the role of technological innovation in promoting agricultural and economic growth and examines the key differences between the Green Revolution and the Gene Revolution. These differences - private sector dominance and safety and regulatory concerns - influence both the technologies being developed and their capacity to reach the poor. The economic evidence on the experience of developing countries so far with GM crops is reviewed, followed by policy recommendations to enhance the likelihood that the Gene Revolution will meet the needs of the poor

What is biotechnology?

Biotechnology encompasses a range of research tools that enable scientists to understand and manipulate the genetic make-up of plants, animals and other living organisms. In agriculture, this includes genomics, marker-assisted selection, genetic engineering and many other tools that complement each other and conventional breeding approaches.

Biotechnology allows researchers to characterize plants and animals at the genomic level, so the specific gene responsible for a desirable trait can be targeted in breeding and conservation programmes. Conventional breeding, in contrast, must rely on the physical appearance of a specimen, which is often an imperfect guide to its value in breeding. By integrating biotechnology into their agricultural research programmes, developing countries can speed up breeding programmes and tackle challenges that are not tractable with conventional methods. An example is the use of micropropagation techniques to generate disease-free planting materials for clonally propagated species like potato and banana that many subsistence farmers rely on.

Biotechnology is also used in diagnosing plant and animal diseases before the host is badly damaged, while treatment is still possible. By distinguishing vaccinated animals from infected ones, biotechnology can facilitate vaccination programmes without disrupting trade. Biotechnology, including genetic engineering, has also been instrumental in developing vaccines that can prevent devastating outbreaks of livestock diseases like Rinderpest.

Most of the controversies surrounding biotechnology focus on transgenic crops and other GMOs produced through genetic engineering. Genetic engineering is both a more precise extension of breeding tools that have been used for decades and a radical departure from conventional methods. It is the ability of genetic engineering to move genes across species barriers that gives it its tremendous power and that makes it so controversial. Genetic engineering can meet some challenges that other biotechnologies cannot address, but in many cases it is used to complement other research approaches.

Can technological innovation help the poor?

The Green Revolution taught us that technological innovation - higher yielding seeds and the inputs required to make them grow - can bring enormous benefits to poor people through enhanced efficiency, higher incomes and lower food prices. Modern varieties of wheat, rice and maize were made available to millions of poor farmers in the developing world during the Green Revolution, first in Asia and Latin America but also in Africa, although later and to a lesser degree. By raising agricultural productivity, the Green Revolution lifted farm incomes and reduced food prices, making food more affordable for the poor. This virtuous cycle of rising productivity, improving living standards and sustainable economic growth has lifted millions of people out of poverty (Evenson and Gollin, 2003).

Critics of the Green Revolution claim that larger farmers in favourable agro-ecological zones benefited most from the new technologies, and that the resulting intensification of agriculture caused irreparable environmental harm. Several recent reviews have surveyed hundreds of Green Revolution economic impact studies conducted over the last 30 years in all parts of the world (Alston et al., 2000; Evenson and Gollin, 2003). Although these studies were carried out using a variety of different methods, they showed considerable consistency. The average social rate of return to public investments in agricultural research is in the region of 40-50 percent, supporting the assertion that agricultural research is a very good investment. Studies of the economy-wide impacts of Green Revolution technologies have shown that crop productivity gains quickly translate into higher demand and prices for land, labour and non-agricultural goods and services (Hayami et al., 1978; Hazell and Haggblade, 1993; Delgado et al., 1998; and Fan et al., 1998). Although larger farmers in the more favourable areas benefited first, smaller farmers in less favourable environments and landless labourers benefited through these second-round effects. Finally, perhaps the most important benefit of the Green Revolution for the poor was through shifting the food supply function, increasing output and reducing real food prices, because as argued by Alston et al. (1995), "*only the poor go hungry*".

The environmental record of the Green Revolution is more controversial. Critics argue that the Green Revolution high-yielding varieties required the use of irrigation and fertilizers to perform, and that they were often sold "bundled" with chemical insecticides that gave rise to pest resistance and pollution. Most scientists concede that insecticides were over-used, especially in the early years of the Green Revolution, but many dispute the environmental evidence regarding irrigation and fertiliser use, and argue that claims of environmental harm ignore the counter-factual problem: What would have happened to the environment without the Green Revolution? The central argument is that the Green Revolution technologies have allowed global cereal production to double since the 1960s on essentially the same amount of land. By reducing the need to expand cultivated area, the Green Revolution saved large tracts of virgin land from the plow (Borlaug, in FAO, 2004). The global population has doubled since the beginning of the Green Revolution but the proportion of the world's population that lives with chronic hunger has fallen by half, to 17 percent. Although the number of undernourished people remains stubbornly high, without the yield gains made possible by the Green Revolution, many more people would be hungry and much more land would be under cultivation.

Private sector dominance

The Gene Revolution offers the technical potential to further enhance the gains made in the Green Revolution. But there are some important differences between the Green and Gene Revolution paradigms that must be considered. The technologies that produced the Green Revolution were produced by public sector researchers at the national and international levels. These technologies were developed and disseminated freely as public goods, based on an explicit strategy for international technology transfer. Most biotechnology research, in contrast, is done by the private multinational sector. The resulting technologies are held under exclusive patents and are distributed on a commercial basis. This paradigm shift has important implications for the kind of research that is being done, the products that are being developed and their accessibility by poor farmers (Pingali and Traxler, 2003).

Intellectual property rights protection - through patents or other means - provide necessary incentives for technology developers and have greatly stimulated the growth of private agricultural research. As a result, however, developing countries are facing increasing transactions costs in access to and use of technologies. Existing public sector international networks for sharing technologies across countries and thereby maximizing spillover benefits are becoming increasingly threatened. The urgent need today is for a system of technology flows which preserves the incentives for private sector innovation while at the same time meeting the needs of poor farmers in the developing world.

The dominance of the private sector in biotechnology research is clear from a comparison of public and private research expenditures. The world's top ten transnational bioscience corporations spend about US$3 billion per year on agricultural biotechnology research and development. The CGIAR system has a total crop improvement budget of one-tenth that amount - about $300 million - and only about one-tenth of that is devoted to biotechnology. Among developing countries, the three largest national agricultural research programmes (Brazil, China and India) have total budgets of less than $500 million each, of which about 5 to10 percent goes to biotechnology research (Byerlee and Fischer, 2001). China is the only developing country that has developed transgenic crop technologies independently of the international private sector. India and Brazil might develop this capacity, but very few other developing countries will be able to. Some of the CGIAR centres are working with national research systems and the private sector to develop transgenic crops for developing countries, but these programmes are small and poorly funded.

Private sector biotechnology research is naturally focused on developing technologies suitable for the major commercial agricultural input markets in the temperate-zone production environments of North America and Europe. Some farmers in developing countries have been able to take advantage of "spillover" benefits from private sector research aimed at farmers in the developed world. These farmers are located primarily in temperate production zones in South America, South Africa and China. Transgenic crop research and development is being carried out on more than 40 crops world-wide and dozens of innovations are being studied by both the public sector and private sector. But there is clear evidence that the problems of the poor are being neglected. Barring a few initiatives here and there, there are no major public sector or private sector programmes to tackle the critical problems of the poor or targeting crops and animals that they rely on. This includes the crops that provide the bulk of their food supply and livelihoods - rice and wheat - but also a variety of "orphan crops" like sorghum, pearl millet, pigeon pea, chickpea and groundnut that are largely neglected in conventional or biotechnology research programmes. Traits of particular interest to the poor include resistance to production stresses like drought, salinity, disease and pests, as well as nutritional enhancement. Concerted international efforts, including public/private partnerships, are required to ensure that the technology needs of the poor are addressed and that barriers to access are overcome.

Safety and regulatory issues

A further difference between the Green Revolution and the Gene Revolution lies in the health and safety concerns and the regulatory requirements surrounding GMOs. Many developing countries lack the necessary capacity to formulate and implement their own regulatory procedures. *The State of Food and Agriculture* reviews the scientific concerns and evidence associated with transgenic crops and summarizes the international scientific consensus, where it exists.

Food safety concerns and evidence

The transgenic crops that are currently being grown commercially and the foods derived from them have been evaluated by the national food safety authorities of several countries using procedures consistent with internationally agreed principles (ICSU, 2003). These foods have been judged safe to eat and the methods used to evaluate their safety have been deemed appropriate (FAO/WHO 2000). To date, no verifiable untoward toxic or nutritionally deleterious effects resulting from the consumption of foods derived from GM crops have been discovered anywhere in the world (ICSU, 2003). Scientists acknowledge that little is known about the potential long-term safety effects of foods derived from transgenic crops (or any foods) and they recommend continued monitoring. Scientists agree that foods derived from emerging, more complex genetic transformations may require additional food safety procedures.

The safety of any whole food is very difficult to determine scientifically due to the natural variation in the foods themselves and the complexity and diversity of human diets and metabolism. Thus, the safety of conventional foods is usually established on the basis of a history of safe use. Risk analysis of foods derived from GMs is conducted using principles similar to those used for food additives: i.e. differences from the conventional food are identified and those differences are tested. If no harmful effects are found, the food is deemed to be as safe as its conventional counterpart. The concept of '*substantial equivalence*' is the cornerstone of this approach which is endorsed by the FAO/WHO Codex Alimentarius Commission. Substantial equivalence is only one step in the risk analysis process, not the conclusion (i.e. a product is substantially equivalent to its conventional counterpart except for the identified differences which are then tested). Some critics argue that risk analysis based on the concept of substantial equivalence is not sufficient for GM foods because complex, unexpected differences arising from genetic modification may be missed.

Main food safety concerns regarding GM crops

The main food safety concerns regarding GM crops and foods derived from them are:

- Allergens and toxins: Gene technology - like traditional breeding - may increase or decrease levels of naturally occurring proteins, toxins or other harmful compounds in foods. Traditionally developed foods are not generally tested for these substances although they often occur naturally and can be affected by traditional breeding. The use of genes from known allergenic sources in transformation experiments is discouraged and if a transformed product is found to pose an increased risk of allergenicity it should be discontinued. The GM foods currently on the market have been tested for increased levels of known allergens and toxins and none have been found (ICSU). Scientists agree that these standard tests should be continuously evaluated and improved and that caution should be exercised when assessing all new foods, including those derived from transgenic crops (ICSU, GM Science Review Panel).

- Antibiotic resistance: antibiotic resistance is a food safety concern because many first generation GM crops were created using antibiotic resistant marker genes. If these genes could be transferred from a food product into the cells of the body or to bacteria in the gastrointestinal tract this could lead to the development of antibiotic resistant strains of bacteria, with adverse health consequences. Although scientists believe the probability of transfer is extremely low (GM Science Review Panel). The use of antibiotic resistance genes has been discouraged by an FAO and WHO expert panel (2000) and other bodies. Researchers have developed methods to eliminate antibiotic resistance markers from genetically engineered plants.

- Other unintentional changes: unintentional changes in food composition can occur during genetic improvement by traditional breeding and/or gene technology. Chemical analysis is used to test GM products for changes in known nutrients and toxicants in a targeted way. Scientists acknowledge that more extensive genetic modifications involving multiple transgenes may increase the likelihood of other unintended effects and may require additional testing (ICSU, GM Science Review Panel).

- Potential health benefits of transgenic foods: Scientists generally agree that genetic engineering can offer direct and indirect health benefits to consumers (ICSU). Direct benefits can come from improving the nutritional quality of foods (e.g. golden rice), reducing the presence of toxic compounds (e.g. cassava with less cyanide) and by reducing allergens in certain foods (e.g. peanuts and wheat). However, there is a need to demonstrate that nutritionally significant levels of vitamins and other nutrients are genetically expressed and nutritionally available in new foods and that there are no unintended effects (ICSU). Indirect health benefits can come from reduced pesticide use, lower occurrence of mycotoxins (caused by insect or disease damage), increased availability of affordable food and the removal of toxic compounds from soil. These direct and indirect benefits need to be better documented (ICSU, GM Science Review Panel).

GM crops, environmental concerns and evidence so far:

There is less scientific agreement regarding the potential environmental impacts of transgenic crops. Scientists generally agree on the types of hazards that exist, but they disagree on their likelihood and potential consequences. Thus far, none of the major environmental hazards potentially associated with transgenic crops have developed in commercial fields (ICSU). Scientists agree that transgenic crops must be evaluated on a case-by-case basis taking into consideration the crop, the trait and the agro-ecosystem in which it is to be released.

- Gene flow: the spread of transgenes to related crops (conventional, organic or landraces) or wild relatives. Scientists agree this can happen when transgenic crops are grown in proximity to related plants, but they disagree on whether gene flow in and of itself constitutes a problem. Transgenes will only persist and spread in these circumstances if they convey a competitive advantage on the recipient plant. This is not likely to be the case for herbicide tolerance because this trait is only advantageous in the presence of the herbicide. Insect and disease resistance could provide an advantage, however. Even if transgenes spread and persist in related plants, gene flow is not necessarily a problem unless it causes 'harm' (ecological or economic). While no evidence of ecological harm resulting from transgene flow has yet been documented, controversy surrounds the question of transgene flow to landraces, both regarding whether this has actually occurred and whether it would constitute 'harm' (ICSU). Economic harm could arise if the presence of transgenic material makes a product ineligible for a particular status like 'organic'. Coexistence of transgenic and non-transgenic agriculture then becomes an issue. Coexistence has been managed for years with conventional crops (e.g. low-erucic acid canola for food use vs high-erucic acid rapeseed for industrial use). The feasibility of coexistence between organic and GM crops will depend on the allowable tolerance level for adventitious GM material. Agronomic and marketing practices can minimize the likelihood of adventitious GM material being found in organic crops, but a zero tolerance level is probably not attainable.

Table 1: Transgenic crop adoption by country, 2003

Country	Area under transgenic cultivation	% of the world area under transgenic cultivation
USA	42.8 m ha	63 %
Argentina	13.9 m ha	20 %
Canada	4.4 m ha	7 %
Brazil	3.0 m ha	4 %
China	2.8 m ha	4 %
South Africa	0.4 m ha	1%
Others*	0.3 m ha	<1%

* Others: Australia, Bulgaria, Colombia, Germany, Honduras, India, Indonesia, Mexico, Philippines, Romania, Spain and Uruguay. (Source: James, 2003)

Table 2: Transgenic crops adoption by crop, 2003

Crop	Area under cultivation by transgenic crop	% of totals area under transgenic cultivation
Soybean	41.4 m ha	61 %
Maize	15.5 m ha	23 %
Cotton	7.2 m ha	11 %
Canola	3.6 m ha	5 %
Others*	0.2 m ha	<1%

* Others: squash and papaya (Source: James, 2003)

Table 3: Transgenic crops adoption by trait, 2003

Trait	Area under cultivation by trait	% of the total area under transgenic cultivation
Herbicide tolerance	49.7 m ha	(73 %)
Insect resistance (Bt)	12.2 m ha	(18 %)
Stacked HT and Bt	5.8 m ha	(9 %)
Other (virus resistance) 0.1 m ha	(<1 %)	

(Source: James, 2003)

● Direct harm to non-target organisms: insect resistant crops could harm non-target insects and other organisms, potentially disrupting food chains and soil microbial communities. In the famous monarch butterfly case, pollen from some Bt maize plants was found to harm monarch caterpillars when force-fed under laboratory conditions (Losey et al., 1999). Follow-up studies found this to be highly unlikely in field conditions for all Bt maize varieties except one which was subsequently removed from the market (Connor et al., 2003). Bt maize has also been found to be less harmful to non-target insects than maize produced using conventional pesticides.

Table 4: Farm-level performance advantages of Bt over conventional cotton

	Argentina	China	India	Mexico	South Africa
Yield, kg/ha (percent)	531 (33%)	523 (19%)	699 (80%)	165 (11%)	237 (65%)
Chemicals, $/ha(percent)	-$18 (-47%)	-$230 (-67%)	-$30 (n/a)	-$106 (-77%)	-$26 (-58%)
Seeds, $/ha (percent)	$87 (+530%)	$32 (95%)	n/a	$58 (165%)	$14 (89%)
Profits, $/ha (percent)	$23 (31%)	$470 (340%)	n/a	$295 (12%)	$65 (299%)

(Source: FAO, 2004)

Table 5: Economic benefits from Bt cotton adoption in the United States

- Total economic benefits: US$ 230 million (annual average 1998-2000)
- Distribution of benefits:

o	US farmers	$105 million	(46 %)
o	Consumers	$ 45 million	(19 %)
o	Seed industry	$ 80 million	(35 %)
o	Other farmers	-$15 million	(-<1 %)

(Source: FAO, 2004)

● Bt resistant pests: Insect pests develop resistance to conventional pesticides over multiple generations as those pests not killed by the pesticide survive and breed, passing resistance to their progeny. Insect resistant Bt crops may lead to the emergence of pests that are resistant to Bt. Scientists generally agree that this is possible, and crop management strategies (refugia) are recommended to avoid or delay that occurrence. Newer generations of insect resistant crops contain two Bt genes rather than one, significantly reducing the likelihood of resistance developing. Scientists disagree about how effective refugia will be in delaying the emergence of resistant pests and how significant the consequences would be. Some argue this would not be a serious problem because farmers would substitute different pesticides if Bt became ineffective, as they have historically done with conventional pesticides. Others argue that losing Bt as an effective pesticide would be a serious problem, particularly for organic growers. So far, no evidence of Bt resistance has been observed in the field.

● Indirect environmental effects: Some transgenic crops are changing cropping practices in ways that may indirectly affect the environment either positively or negatively. Negative effects have not been observed in commercial production, although experimental results have shown the potential for harm. The result seems to be a matter of management practices rather than the technology per se. The main indirect environmental concerns and the evidence and debates surrounding them are summarised in the report. The main ones include the following:

- Herbicide tolerant (HT) crops are associated with decreased use of the most highly toxic herbicides, but an overall increase in herbicide use of lower toxicity. Replacing more toxic herbicides with less toxic ones is generally acknowledged as an environmental benefit. The overall increase in herbicide use could, however, have indirect negative effects by reducing the presence of weeds in farmers' fields and thus harming the farmland birds and other organisms that feed on weeds. The Farm-Scale Evaluations sponsored by the Royal Society evaluated this concern for herbicide tolerant maize, sugar beet and rapeseed in the UK. They found HT maize to be associated with an increase in the prevalence of farmland birds, but the other two crops were associated with declines. They concluded that management practices - not the HT crops themselves - were the key factor in determining whether the impact on farmland birds was positive or negative.
- Herbicide tolerant crops are associated with the adoption of low-till or no-till cropping practices which reduce soil erosion and the disruption of soil structure and microbial communities.
- Insect resistant Bt crops have been associated with a reduction in the use of conventional pesticides that are generally considered to be more harmful to non-target species than the Bt crops. This point is controversial: some argue that the appropriate point of comparison is not with conventional pesticides but with alternative production systems such as organic or IPM.

Table 6: Economic benefits from herbicide tolerant Round-up Ready soybeans in Argentina and the US

- Total economic benefits: US$ 1.2 billion (2001)
- Distribution of benefits:
  - o US + Arg farmers $445 million (15 %)
  - o Consumers $652 million (53 %)
  - o Seed industry $421 million (34 %)
  - o Other farmers -$291 million (-2 %)

(Source: FAO, 2004)

The scientific evidence on transgenic crops is still emerging. In the countries where transgenic crops are being grown commercially, there have been no verifiable reports of them causing any significant health or environmental harm, and some benefits have been observed. However, the lack of negative impacts so far does not mean they cannot occur and scientists agree that our understanding of ecological and food safety processes is incomplete. FAO supports a science-based evaluation system that would objectively determine the benefits and risks of each individual GMO. This calls for a cautious case-by-case approach to address legitimate concerns for the biosafety of each product or process. The scientific consensus documents reviewed for The State of Food and Agriculture agree that there is not enough scientific evidence of actual or potential harm to justify a moratorium on research, field trials or the controlled release of GM crops into the environment.

Economic impacts of GM crops in developing countries

Transgenic crops were grown on 67.7 million hectares of land in 2003, in a total of 18 countries (James, 2003). Ninety-nine percent of the global area planted in transgenic crops in 2003 was accounted for by just six countries, four crops and two traits. These same crops and traits are the subject of most of the transgenic crop research underway in both developed and developing countries and public and private sectors.

Some transgenic crops, especially insect resistant cotton, are yielding significant economic gains to small farmers as well as important social and environmental benefits through the changing use of agricultural chemicals. Estimated farm-level benefits vary widely from country to country and year to year, depending primarily on pest pressures, seed prices and the availability of effective alternative pest-control measures. Prices for Bt cotton seed tend to be higher than for conventional seed, but are more than compensated by higher effective yields and lower pesticide costs. Reduced chemical pesticide use helps farmers and their families avoid the health and environmental dangers associated with pesticides.

With the exception of China, all transgenic crops commercialized to date have been developed and distributed by private companies. The evidence suggests that, despite fears of corporate control of the sector, farmers and consumers so far are reaping a larger share of the economic benefits of transgenic crops than the companies that develop and market them. The evidence also suggests that small farmers are just as likely as large farmers to benefit from the adoption of transgenic cotton. Farmers in other countries, however, where transgenic cotton is not grown have experienced small economic losses as a result of lower cotton prices.

It must be considered that this economic evidence is based on only two or three years of data for a relatively small number of farmers in just a few countries. The short-term farm-level gains may not be sustained over time as larger numbers of farmers adopt the technologies. More evidence is required to determine what the level and distribution of benefits from transgenic crops will be in the longer run.

Conclusions and recommendations for bringing the Gene Revolution to the poor

Biotechnology - including genetic engineering - can benefit the poor when appropriate innovations are developed and when poor farmers in poor countries have access to them on profitable terms. So far these conditions are only being met in a few developing countries.

Biotechnology should be part of an integrated and comprehensive agricultural research and development programme that gives priority to the problems of the poor. Biotechnology can complement but not substitute for research in other areas like plant breeding, integrated pest and nutrient management and livestock breeding, feeding and disease management systems.

The public sector - developing and developed countries, donors, and the international research centres - should direct more resources to agricultural research, including biotechnology. Public sector research is necessary to address the public goods that the private sector would naturally overlook and to provide competition in technology markets.

Governments should provide incentives, institutions and an enabling environment for public and private sector agricultural biotechnology research, development and deployment. Public-private partnerships and other innovative strategies to mobilize research and technology delivery for the poor should be encouraged.

Regulatory procedures for GMOs should be strengthened and rationalised to ensure that the environment and public health are protected and that the process is transparent, predictable and science-based. Appropriate regulation is essential to command the trust of both consumers and producers, but duplicative or obstructionist regulation is costly and should be avoided. GMOs should be evaluated on a case-by-case basis, commensurate with the level of risk.

Capacity building for agricultural research and regulatory issues related to biotechnology should be a priority for the international community. FAO has proposed a major new programme to ensure that developing countries have the knowledge and skills necessary to make their own decisions about the use of biotechnology.

End Notes

[1] The author is Senior Economist and Editor of *The State of Food and Agriculture*, Agricultural and Development Economics Division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy.

[2] *The State of Food and Agriculture* is the annual flagship publication of the Food and Agriculture Organization of the United Nations. FAO, the UN's specialized agency on agriculture, was founded in 1945 with the mandate to raise levels of nutrition, improve agricultural productivity, better the lives of rural populations and contribute to the growth of the world economy. With 185 Member states, FAO works in four main areas: providing information, sharing policy expertise, bringing knowledge to the field, and providing a forum for inter-governmental debate.

[3] GRAIN sent an open letter of protest about *The State of Food and Agriculture* report on biotechnology to the Director-General of the FAO, available in the list of references. The Director-General's reply is available at: http://www.fao.org/newsroom/en/news/2004/46429. A second NGO letter in support of the report is available at: http://www.internationalconsumers.org/faoletter.htm and a supporting letter from a group of independent scientists and economists is available at: http://www.economia.uniroma2.it/conferenze/icabr2004/open_letter.

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