

The Appropriateness of New Biotechnologies in the Crop Sector for Food Production and Agriculture in Developing Countries

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ABSTRACT

In March 2000, the United Nations Food and Agriculture Organization (FAO) established an electronic forum on the role and implications of biotechnology in food and agriculture, with special emphasis on developing countries. The Forum is open to everybody and it operates a series of moderated e-mail conferences, each lasting roughly 2 months. A website to support the Forum has also been established (<http://www.fao.org/biotech/forum.htm>). Five conferences were held in the year 2000. The first four dealt with the appropriateness of new biotechnologies in the crop, forestry, animal and fishery sectors respectively for developing countries. Before each conference begins, a document is sent by e-mail to Forum members providing, in easily understandable language, some background to the conference and, after the conference is finished, a document summarising the discussions is written and sent to Forum members. Here, a brief overview of the first conference of the Forum is given and, for illustration purposes, some discussions from the first conference, on the appropriateness of new biotechnologies in the crop sector for food production and agriculture in developing countries, are summarised.

Keywords: developing countries, food production, genetically modified crops

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RESUMEN

Las nuevas biotecnologías y su aplicación en el sector agrícola de los países en vías de desarrollo para la producción de alimentos y el manejo de los cultivos. En marzo del 2000, la Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO, del inglés United Nations Food and Agriculture Organization) creó un foro electrónico de discusiones sobre las funciones y las implicaciones de la biotecnología en la alimentación y la agricultura, con énfasis particular en la situación de los países en vías de desarrollo. El foro está abierto a la participación de todos y funciona a través de una serie de conferencias moderadas que se envían por correo electrónico y que tienen una duración aproximada de dos meses. También se creó un sitio web para apoyar el foro (<http://www.fao.org/biotech/forum.htm>). En el año 2000 se celebraron cinco conferencias. Las primeras cuatro abordaron la conveniencia de aplicar las nuevas biotecnologías a la agricultura, la silvicultura, la salud animal y la pesca, respectivamente, en los países en vías de desarrollo. Antes de la celebración de cada conferencia, se le envía un documento a los miembros del foro por correo electrónico, en el cual se ofrece información básica sobre la conferencia en un lenguaje claro. Después de terminada la conferencia, se redacta un documento que resume las discusiones y se le envía también a todos los miembros del foro. En ese documento, se resumen los principales aspectos de la primera conferencia del foro y algunas discusiones de la primera conferencia —con fines ilustrativos—, acerca de la conveniencia de aplicar las nuevas biotecnologías al sector agrícola para la producción de alimentos en los países en vías de desarrollo.

Palabras claves: cultivos modificados genéticamente, países en vías de desarrollo, producción de alimentos

Introduction

Three major kinds of currently available biotechnologies could potentially be used for the crop sector for food production and agriculture in developing countries: a) biotechnologies based on molecular markers b) genetically modified crops c) micropropagation.

All three kinds of biotechnologies were discussed in the conference. However, the emphasis was overwhelmingly on genetically modified (GM) crops. In some topics of discussion there exist strongly opposing points of view, reflecting the polarisation that exists regarding some elements of the debate on agricultural biotechnology.

Here, some of the main factors that were discussed in the conference and that participants considered to have direct importance for the appropriateness of the biotechnologies in developing countries, are described. In order to provide references to specific messages, we have included the participant's surname and the date posted (day/month).

The Biotechnologies and the Intellectual Property Rights

The existence and impact of intellectual property rights (IPR) over biotechnological products (e.g. plant varieties) and processes (e.g. techniques used in generating plant varieties) was probably the topic which attracted most discussion throughout the whole 2-month long conference. The fact that a small number of powerful multinational corporations (MNCs) from developed countries had built up extensive patent portfolios meant that there was often a strong socio-political aspect to the discussion. Considerable differences of opinion were expressed about both the need for and consequences of IPR in the crop sector.

Some participants felt that IPR over biological materials were inherently wrong while others felt they were necessary. Berruyer (28/3 and 14/4) suggested it would be better if it was not possible to patent genes. Kumar (18/4) stated that the new seeds patented were devel-

An overview of the first conference of the FAO Electronic Forum on Biotechnology in Food and Agriculture. The full summary document, including other main arguments or recurring themes from the conference, as well as access to the individual messages can be found on the Forum website at <http://www.fao.org/biotech/logs/C1/sum.htm>

oped from existing genetic material, often from developing countries, in a process involving very small (or no) genetic modification and so the patenting process converted something which was the "common heritage of mankind" into private property. She also argued that the process ignored the input over many generations from farmers in building up the base genetic material. Lettington (18/4) argued that enforcing IPR in developing countries created a net loss for humanity due to the lack of access to information.

On the other side, it was argued that farmers have always the choice as to whether or not to buy improved varieties from MNCs and that "those [companies] that invest in developing a product or technology should get paid for their creativity, capital risk-taking and simple hard work" (Laing, 17/4), a view that was also supported by Halos (4/4). Halos (17/5) suggested, in addition, that patenting genes did not mean that the major economic benefit went to the patent holder, but that many diverse groups, including farmers and consumers, also benefited from the GM varieties developed. Roberts (22/5) emphasised that business will only invest where it expects to make a profit and that in order for industry to invest in these technologies they should expect some financial return. Ashton (19/5) disagreed with this argument, maintaining that the nature of capitalism is that the developer bears the risk and nobody owes a return to the risk-taker.

The consequences of IPR were seen as being quite substantial. The point was made that the existence of strong IPR, and the fact that they are often owned by MNCs, would lead to (increased) dependence by developing country farmers on technologies owned by MNCs and developed countries. This was clearly expressed by Hongladarom (3/4) who indicated that "the fear [of biotechnology that has been aired in Thailand] does not so much concern the potential risks of the genetically modified crops as does the possibility that after a while farmers may have to rely exclusively on the technologies owned by these corporations". Berruyer (28/3) also made the same point saying "the problem with biotechnologies is not the tool, but who has the tool". Lettington (18/4) indicated that such dependency relationships were already being built up in East Africa. Salzman (24/3) feared that farmers in developing countries would be at the mercy of MNCs regarding pricing, seed supplies and the types of seeds provided. Reel (6/4) regretted the change by farmers from seed saving towards increased expense and dependence on outside seed resources. Schenkel (4/4), on the other hand, said that he did not see why farmers would become more dependent if the seeds were adapted to their needs.

Another consequence that was much discussed was that patents could be granted to companies from developed countries over genetic material from developing countries. Reel (6/4) provided information on specific examples, such as the yellow bean (Mexico) and basmati rice (India). Carneiro (13/4) pointed out that the recognition of IPR by developing countries opened up the possibility for developing countries to patent biotechnology products or processes either on their own or in joint projects. Munsanje (27/3), however, argued that developing countries lacked the financial resources required to "bioprospect" the large pool of biodiversity in their specific regions and to take economic and social advantage

of their resources. Kumar (18/4) gave a concrete example of the problems raised by IPR, writing that each year in her country, Sri Lanka, many new tea and rice varieties are developed by national research institutes but they are never patented because the effective protection of a single variety in the major countries of the world would cost \$ 75,000 – 100,000. She noted, however, that there was nothing to prevent a private company patenting these varieties in the West and that government institutes would not be able to find the funds (maybe \$ 500,000 in the United States) needed to contest a patent. Ashton (19/5) said that measures to prevent "bio-piracy" were needed and that certain developments, such as the sale of some national seed banks in Africa to corporate interests, should be viewed with great concern.

The impact of IPR on plant breeding research in developing countries was also discussed. Carneiro (13/4) wrote that biotechnology research in developing countries was traditionally based on the transfer of technology but, following the adoption of IPR in developing countries, this approach was obsolete and therefore new products and processes specific for agriculture in developing countries had to be generated. Berruyer (14/4) argued that if patenting of genes was not allowed, then technology transfer would still be possible. Berruyer (14/4) also noted the difficulties of this new situation as developing countries now had to discover and develop the use of new genes, which is the most expensive part of the transgenic process, and, in addition, this had to be done in the context of competition from MNCs.

Some participants maintained that, in the light of this situation, MNCs had to take special consideration of developing countries. Fauquet/Taylor (26/5) proposed that MNCs should offer relevant technologies within their portfolios for use in developing country crops that do not represent a market to them in the near future. Olivares (12/5) proposed that, to encourage such measures, science policy in developed countries should support public science with the idea that the biotechnology products or processes obtained could be transferred free of charge to developing countries.

Others, instead, maintained that a new IPR system was needed. Munsanje (27/3) argued that IPR should be enhanced in developing countries in order to protect their products before they were exploited and patented. Lettington (18/4) argued that the whole current IPR system was developed in the North to serve a series of very particular purposes and that developing countries should develop their own parallel patenting system which would, for example, ensure that the holder of a patent on a traditional variety would compensate and recognise the developers of the variety. Kumar (25/4) supported this view but felt that developed countries would strongly oppose the establishment of such a system.

Resources for Biotechnologies in Developing Countries

It was argued that funds in developing countries are scarce and that often one of the first items in national budgets to be cut is "research and development", making it very difficult for the countries themselves to develop biotechnology products that are suited to their own national needs (Nwalozie, 23/3; Halos, 23/3; Lettington, 24/3; Kuta, 30/3). Schenkel (22/5) emphasised that today the production of GM crops is still "very, very expensive".

Kiggundu (19/5) noted that third world governments typically do not have the finances to support conventional plant breeding activities and that, in this context, the availability of GM crops would be a breakthrough. However, Schenkel (22/5) argued that when there were insufficient resources to sustain conventional breeding, a country should not spend money on GM activities – a viewpoint strongly supported by Khan (22/5). Wingfield (13/4) noted that using biotechnologies in developing countries can be too expensive, especially when equipment has to be imported, and indicated that there was a definite niche available for people to develop procedures to apply biotechnology using locally available material.

Despite the lack of resources in many developing countries, Rebai (9/5) urged that, given the importance of agricultural biotechnology for food security, all developing countries “should keep trying to stay in the biotechnology train as drivers and not as spectators, as active makers and not passive consumers”. Schenkel (22/5) also argued that the lack of resources should not mean that biotechnology would be exploited only by developed countries and that there was an obligation on developed countries to make biotechnology available to developing countries.

The Impact of Biotechnologies on Human Health

There was much discussion regarding whether GM crops, in particular those producing toxins of the soil bacterium *Bacillus thuringiensis* (*Bt*), hereafter referred to as *Bt* crops, could be harmful or allergenic (i.e. inducing allergies) when eaten by humans. Almost all contributions were from participants in developed countries. Large differences of opinion were expressed on this subject. Some participants maintained that they were at least as safe as non-GM food products while others argued that they were potentially highly allergenic. Some messages went into detail regarding testing procedures for allergenicity and, in some cases, links to websites providing further information were included.

Crystal proteins from *Bt* are toxins that kill insects feeding on the plant by binding to and creating pores in their midgut membranes. Both Reel (7/4) and Salzman (10/4) argued that there was no evidence that ingestion by humans of plants producing the toxin was safe. Roberts (10/4) stated that, based on the concept of “substantial equivalence”, edible GM crops were tested in comparison with their non-modified counterparts and that, in general, no relevant differences in food quality were found and that neither the GM nor the non-GM plants were guaranteed to be “completely safe”. Reel (3/4) pointed out that human testing, that might normally be carried out for a new food additive, was not required for GM foods and that testing them on animals (such as mice) was insufficient. Roberts (12/4) counter-argued that the digestive systems of humans were fundamentally different from those of insects and that results of testing with animals could be treated with confidence because of their close relationship to humans.

Berruyer (12/4) and Berruyer and Bucchini (in a joint message of 17/4) then provided more technical details regarding the working of the toxins, describing how most proteins, including *Bt* toxins, are denatured (i.e. the specific activity is destroyed) by the acidity of the human stomach. Bucchini, in the joint message (17/4), concluded

that it is unlikely that the toxin endangers human health but urged caution. He argued (19/4) that there are no direct methods to assess the potential allergenicity of proteins from sources that are not known to produce food allergy. Berruyer, in the joint message (17/4), suggested that the risk of an allergic reaction that endangers human life is low and quite difficult to measure. De Kochko (13/4) argued that *Bt* had been used for years in organic farming and that “any product, absolutely any product and not only *Bt* toxin, can be allergenic for someone in particular. *Bt* toxin has not been shown to be more allergenic... than chocolate or peanut butter!!!”

Some specific concerns were expressed about Cry9C, one of the *Bt* toxins, which is heat- and digestion-resistant (Bucchini, 17/4; Berruyer/Bucchini, 17/4). The gene producing the toxin has been transferred to GM corn which has been under consideration for use as human food in the United States. Lin (18/4) argued that the fact that it had so far only been approved for animal feed and industrial uses (and not for human consumption) suggested that the regulatory system in the United States works.

Another specific product that was discussed was a transgenic soybean crop, developed as a potential animal feed, containing a gene transferred from the Brazil nut species that expresses a high-methionine protein. A study published in 1996 revealed that the protein was allergenic and Reel (7/4) suggested that this finding was a cause for concern regarding the cultivation of GM crops. Wingfield (10/4), on the other hand, argued that this showed that science works since the results were the consequence of efficient testing of the crop before release and that, from the results of the trials, the crops were found to be unacceptable and were not then used commercially.

The Environmental Impact of Biotechnologies

As specified in the Background Document to the conference, of the 39.9 million hectares planted with transgenic crops in 1999, 28.1 million (i.e. 71%) were modified for tolerance to a specific herbicide, 8.9 million (22%) were *Bt* crops while 2.9 million (7%) were planted with crops having both herbicide tolerance and insect resistance. Most of the messages posted concerning the environmental impact of new biotechnologies dealt with *Bt* crops.

Pesticide-resistant GM crops

Some participants expressed the fear that large-scale planting of *Bt* crops would accelerate the development of *Bt* resistance among pests. Geiger (24/3 and 4/4) was one of these, adding that in tropical areas, with several generations of pests per year, this would happen quickly. Reel (29/3) maintained that major companies in the field of agricultural biotechnology were aware that resistance was inevitable and were thus already developing successors to *Bt* crops. Geiger (4/4) said that the loss of *Bt* as an insecticide would be a major loss for farmers and for society. Smith (27/3) counter-argued that the selection pressure on insects to develop resistance would not be any greater than with the use of chemical pesticides.

Another potential concern with *Bt* crops (Lettington, 28/3; Srinivasan, 3/4) was raised by a study published in the scientific journal *Nature* on 2 December 1999 which indicated that the *Bt* toxin exudes from the roots of *Bt*

corn and that it might therefore have negative consequences on soil ecosystems. Lin (4/4) emphasised that the authors could not indicate how the soil communities might be affected. Halos (17/5) suggested that these results from the laboratory were not supported by field experiments.

The positive impact on the environment of finding alternatives to the current large-scale usage of chemical insecticides was also discussed. Halos (24/3) wrote that corn farmers in the Philippines admit to using a lot of pesticides and that, until the possibility of *Bt* corn arose, they saw no alternative. Srinivasan (3/4) reported from a FAO press release that global insecticide sales amounted to about \$12 billion in 1995; that more insecticides were used on cotton than on any other crop and that over two-thirds of the global cotton area treated with insecticides was in India, China and Pakistan. He argued that the introduction of *Bt* cotton in these countries would be expected to reduce insecticide applications and their adverse environmental implications. Several other participants also said they expected that *Bt* crops would lead to reduced insecticide use (e.g. Halos, 23/3; Açıkgöz, 24/3; Smith, 27/3; Berruyer, 28/3; Bartsch, 31/3). However, there seemed to be disagreement about whether the *Bt* crops grown so far had in fact resulted in such reductions. Lettington (3/4) cited a study on soybean crops where pesticide use was higher, while Smith (27/3) quoted from an American newspaper article indicating reductions in insecticide sales following use of *Bt* corn.

Lettington (28/3) noted that both chemical insecticides and *Bt* crops had some problems, such as development of resistance by the insects, and proposed that integrated pest management (IPM), although more time-consuming, might be preferable to GM crops. Halos (27/3) described the situation in the Philippines where corn farms tend to be no bigger than one hectare and, since farmers often have other jobs, she argued that they find IPM too time-consuming.

Herbicide-tolerant GM crops

There was much less discussion about herbicide-tolerant crops than *Bt* crops. Schestibratov (9/5) argued that GM crops resistant to non-selective herbicides (i.e. that kill almost all plants that are sprayed) meant that fewer and less-expensive herbicides could be used. Srinivasan (3/4) suggested that growing them resulted in an increased use of herbicides. The potential spread of herbicide resistance to other plant species was a cause for concern. Kumar (31/3) said that the development of a fast-growing herbicide-tolerant weed could have very serious implications in a small developing country. Berruyer (28/3) suggested that such GM crops should be forbidden in areas containing related wild species.

Impact on biodiversity

It was suggested that biotechnology could have a positive impact on biodiversity in the environment, by increasing the amount of food produced per unit of land area and thus reducing the need to use forest or natural habitats for additional food production in the future (e.g. Paiva, 3/4; Wingfield, 6/4; Roberts, 12/4).

Regarding within crop species diversity, Laing (17/4) indicated that the increasing loss of diverse germplasm was a cause for concern. He said that the availability of improved varieties, often developed using new biotech-

nologies and producing higher yields, resulted in small-scale farmers neglecting their traditional varieties. Yibrah (25/5) predicted also that the use of GM crops, coming from a narrow genetic base, would lead to genetic erosion.

The Biotechnologies and the Biosafety Regulations

It was suggested that the application and monitoring of biosafety regulations would be more difficult in developing than in developed countries. Thus, Kumar (31/3) wrote that "developing countries possess limited scientific infrastructure and expertise and do not have the wherewithal to monitor such experiments or their products. Furthermore they are ill equipped to deal with any environmental disasters emanating from these products." Sivaramakrishnan (14/4) argued that even in a country with a strong biosafety system in force, such as India, the monitoring process would not be very easy. Yibrah (25/5) maintained that the lack of finances would make it extremely difficult to assess or monitor GM crops. Ashton (19/5) said there had been insufficient consideration given to the ability of developing countries to cope with potential negative consequences and that those promoting the use of GM crops would not accept the risks which, in his country, would instead be borne by the farmers, retailers and consumers of South Africa. Lettington (28/3) emphasised the need for capacity building in developing countries in the area of biosafety.

The Biotechnologies and the Reduction of Hunger in Developing Countries

As indicated in the Background Document, the global population is increasing, the amount of land available is finite and more food per hectare is needed in the future, to avoid growing crops on land currently devoted to functions other than food production. Some participants felt therefore that biotechnology was an important element in this process (e.g. Lin, 30/3 and 31/3; Paiva, 3/4; Fauquet/Taylor, 26/5) and that it would help to maintain or increase food security in developing countries (Schenkel, 16/5; Alexandratos, 16/5; Halos, 17/5).

Others argued that social and political factors were of greatest importance (e.g. Lohberger, 31/3; Lettington, 3/4; Reel, 3/4), which could be seen by the fact that, even today, when sufficient food is produced globally, there is still hunger and poverty in many developing countries (Yibrah, 25/5). Some messages went a step further and suggested that, in some cases, pro-biotechnology parties argued that biotechnology could reduce world hunger for public relations purposes (Lettington, 3/4; Yibrah, 25/5).

Lin (31/3) and McGuire (31/3) emphasised that biotechnology alone could not solve the problem of world hunger but that it could contribute to solving it. McGuire also pointed out that "it is unrealistic (and unreasonable) to expect Southern agricultural scientists to become political activists as well, especially in charged settings". Reel (6/4) agreed that biotechnology researchers tended to be reluctant about getting involved in the politics and economics of their field, but argued that economic imperatives governed the benefits of their research.

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