# Transitions in Agbiotech: Economics of Strategy and Policy

EDITED BY
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*Proceedings of NE-165 Conference*
*June 24-25, 1999*
*Washington, D.C.*

*Including papers presented at the:*

*International Consortium on Agricultural Biotechnology Research Conference*
*June 17-19, 1999*
*Rome Tor Vergata, Italy*

PART FIVE: Developing Countries

## 24. Will Biotechnology Lead to More Sustainable Agriculture?

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Chapter 24

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## Introduction

Technological changes in agriculture over the last few decades have been subject to criticism: damage to the environment, pollution, removal of certain natural resources faster than they can renew themselves, soil deterioration, loss of biodiversity and degradation of landscape, etc. It is often agreed that the model of agricultural development should place more emphasis on sustainability which has become the password even if sustainability is subject to widely differing interpretations and requirements. But at the same time, agriculture is developing rapidly as a result of many different factors: globalization, trade liberalization, society's demands, applications of technical and scientific advances, etc. Will the resulting changes lead to greater sustainability? This article deals with the controversial subject of biotech applications and genetic engineering, in particular.

The widely adopted definition of sustainable development is the one used in the Brundtland report: "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED 1987). Although this definition seems to be generally accepted, it is relatively vague and can be made to mean a variety of different things, depending on who is using it. The need to reconcile ecological and economic factors is often emphasized as well as the necessity of avoiding irreversible deterioration of the environment. For the purpose of this article, we will use a broader definition which will also include socioeconomic factors. Sustainable agriculture will therefore be defined as follows (Bonny 1994):

– environmentally sound, preserving resources and maintaining production potential,
– profitable for farmers and workable on a long-term basis,
– providing food quality and sufficiency for all people,
– socially acceptable,
– socially equitable, between different countries and within each country.

Is biotechnology heading in this direction? This is the question that we will look at here. Basically, biotechnology is at the center of a controversy and is seen, by some, as a means for more sustainable development and, by others, as just the opposite. The purpose of this article is to examine its potential and its limits, the way in which biotech could contribute to sustainability and the contrary. We will look at the potential impact of genetic engineering in agriculture on each of the different aspects of sustainability: effects on the environment, economic viability, sufficiency and food quality, social acceptability and equity.

## Will Biotechnology Lead to a Form of Agriculture That Will Preserve Both *The Environment and Resources?*

### *Potential Positive Effects of Biotechnology*

· ***A New Type of Agriculture Relying More on the Potential of Living Matter.*** Biotechnology could contribute to the development of a new type of agriculture that would rely more on biological processes and the potential of living matter and less on chemical applications. The agricultural development model which evolved in the 20th century and particularly after the 2nd World War relied mainly on three types of technical innovations: (i) mechanization with tractors and other machines, replacing human and animal muscle power; (ii) use of chemicals and, particularly, fertilizers and pesticides made from synthetic chemicals; (iii) the selection of new high-yielding breeds and varieties. Although genetic improvement has been used for a long time, it was mainly mass selection done by farmers on the basis of individual phenotypic characteristics. In the 20th century, more scientific methods based on the laws of heredity were developed in State Research Centers and through private seed breeders, resulting in the marketing of high-yielding breeds and varieties.

One of the major causes of environmental damage has been the application of these innovations sometimes without the proper control and with disregard for their secondary effects because the emphasis was put on increasing production. This has also led to the replacement of essentially homegrown farm inputs with external industrially-produced inputs because of farm specialization. The result is a reduction of complementarity between different activities, which, in the past, permitted by-products from one activity to be used as raw material for others.

Biotechnology is opening numerous possibilities to more fully develop the potential locked within living matter (INRA 1998). Indeed, living matter is now better understood, and man has acquired a much greater intervention capacity through knowledge of the mechanisms which govern and regulate different functions and as a result of the development of different methods used to modify the functions in the desired way (Bonny 1998d). Following are several examples of improving the potential of living matter while limiting the use of chemicals:

- Use of bacteria or plants, genetically modified to produce different pharmaceutical or other products instead of obtaining them through chemical synthesis (this has already been put into use and should develop).
- Development of plants resistant to insects, nematodes, fungi, viruses and bacterial disease. This could make it possible to avoid the use of some pesticides.
- Improvement of plant-microorganism symbiosis (present in legumes as well as in other plants such as filaos or Casuarinaceae in tropical countries) and plant-mycorhiza associations which could lead to improved plant growth and/or increased yield without additional inputs.

- Understanding of the processes by which plants assimilate nitrates could lead to more efficient use of nitrogen.
- Modification of the composition of certain produce should make it easier to process and less costly in energy and chemical additives after harvesting. Research is being done to modify the lignin content (or the type of lignin) of certain trees used to manufacture pulp so that the process will consume less energy and pollute less.
- Finally, bread, beer and cheese have been made for centuries using traditional biotechnology methods, that is, natural microorganisms. These methods could be improved through genetic modification of these microorganisms in order to facilitate certain forms of processing, to more efficiently resist bacteriophages (viruses which destroy bacteria) or even to produce molecules which would inhibit undesirable germs, greatly reducing losses.

These examples show that better use of the potential of living matter could lead to a new agriculture that would require less chemical inputs per final produce unit and which could therefore better preserve the environment and resources provided that the transformation used have obviously been tested for safety.

· ***Less Chemical Treatments as a Result of Pest-resistant Plants.*** In 1998, the most common transgenic plants, including both those already cultivated and those being tested in field trials, were varieties tolerant to herbicides and, in particular, glyphosate, sometimes glufosinate or even oxynils. Does a variety that is made tolerant to an herbicide that is grown with it require less herbicide treatments than a conventional variety which is weeded using normal methods, in terms of the quantity of herbicide used, the number of treatments, and the toxicity of the products used? Precise and adequately documented data for different crops and differing agroclimatic conditions are only partially available at this time. However, the initial results seem to indicate that, effectively, less herbicide treatments are necessary for tolerant transgenic plants (James, 1998; Gianessi, 1999; and data from Monsanto). As regards transgenic plants resistant to insects, nematodes and bacterial or viral diseases, there are two cases: either the crops were treated beforehand and, in this case, the specific pesticides are no longer used, or the crops were not treated and the yield of the transgenic crops should be higher.

We can therefore assume that the overall amount of certain total weed-killers to which transgenic plants have become tolerant should increase (glyphosate, in particular). On the other hand, use of other herbicides should decrease a little; this is also the case for certain pesticides as well. However, this implies that the disappearance of one pest does not encourage the development of another, and that, in general, new solutions will prove to be sufficiently enduring. In addition it is necessary to take into account not only the amount of pesticides used, but also their degree of toxicity.

· ***A Potential Protection of Some Natural Resources.*** It may result from the improvement of agricultural yield and production efficiency as promised by biotechnology which may lead to saving fragile soils, forests and land for other uses. With the development of plants resistant to herbicides or to certain crop pests or disease-carrying agents, production losses could be reduced, particularly where effective widely-used treatments are lacking. This reduction in losses could be very advantageous because they are considerable at this time (Oerke, Dehne et al. 1994). They could also be reduced through better conservation of plants after they are harvested, an area where transgenesis could provide faster and easier solutions than those resulting from traditional means of selection. Finally, on a long-term basis, the development of varieties resistant to drought or to a certain soil salinity and which remain sufficiently productive, could also lead to increased yields. This is also true if scientists succeed in mastering certain processes which govern photosynthesis in the future.

The improvement of yield capacities is perceived as useless and even harmful by some consumers during the present period of overproduction in developed countries. Nevertheless, it is also possible to use it to produce the same quantity with less chemicals or natural resources (land, water, etc.) and to decrease production costs while limiting pollution. In addition food increase is needed for the coming years and decades. But the increase of yields would be more advantageous in countries where production is insufficient and where part of the population suffers from malnutrition, provided that the additional foodstuff obtained can reach the malnourished, which unfortunately cannot be taken for granted. Basically, present malnutrition problems are not the result of insufficient overall agricultural production, but stem instead from wars or factors of insecurity, on one hand, and, on the other hand from low income levels of part of the population which cannot afford to buy available food. Their nutrition level could only be improved if those among them who grow food crops could produce more and if the economic situation of the others improves, a complex process that does generally not depend on only one technical innovation…

Increased yield results in increased production without using new land for planting crops. This means that deforestation and additional erosion may be avoided. As a matter of fact, clearing is generally done at the expense of forest land, on sloping terrain or on fragile soil, all of which are subject to erosion. By preserving this land, the biodiversity found in these uncultivated spaces is also protected. This could be very advantageous for regions where the quantity of arable land per person is very limited, like in Asia. But yield increase will still have to effectively discourage the clearing of new land…

· ***A Contribution to Maintaining Biodiversity***. Biodiversity can be evaluated at different levels: (i) genetic diversity (within a species), (ii) the diversity of the number of animal and plant species (within a zone), (iii) the diversity of ecosystems present in a region, (iv) the diversity of landscapes. The potential contribution of biotechnology can concern the different levels. For example it enables a better knowledge of genetic diversity, its importance and its scope, using biomolecular methods rather than traditional ones to take a closer look at the distance which separates species or different varieties of the same species. Genetic engineering can provide us with the tools to recognize the value of genes present in different species which could be used to confer certain properties through transgenesis. The preservation of biodiversity has a better chance of being taken into consideration if its value is recognized! In addition a better protection of the specific and ecological diversity is made possible through better yields (see above).

· ***A Potential to Clean up Pollution***. Finally, biotechnology could be used for bioremediation: processes have been developed to treat polluted soil, water and waste (OECD 1996). This could be very advantageous both in developed countries and developing countries where serious contamination problems exist.

### *Potential Negative Effects of Biotechnology*

In contrast to its potential positive effects on the environment and natural resources, other repercussions of biotechnology could be more negative. We cannot make a definitive evaluation at this time. We can only list the risks (Kahn 1996 ; Ho et al. 1997 ; Snow, Moran Palma 1997):

- Over-artificialization of nature with, in particular, the transgression of species barriers and the possibility of unexpected effects due to the insertion of new genes in an organism's genome. Many unknowns exist and it is not yet exactly known where the transgenes insert themselves.
- Uncontrolled flow of genes transferred to other nearby crops of the same family or to wild plants which cross with the transgenic plant (Mikkelsen et al. 1997: Chèvre 1997). It is feared that the volunteer seedlings of transgenic plants tolerant to an herbicide could be difficult to eliminate or to control in certain crop rotations. Work is being done to evaluate these flows but since this phenomenon could eventually concern different types of plants, it could become difficult to manage.
- Increased use of herbicides such as glyphosate with the development of different crops which are tolerant to it could increase the risk of weeds resistant to this herbicide whereas none exist at present. This would be regrettable since this total weed-killer herbicide is considered to be one of the least toxic which explains the importance of preserving its effectiveness.
- Increasing large-scale use of Bt proteins with the development of different transgenic plants resistant to a certain insect could also increase the risk of the selection of resistant insects. In these varieties (cotton, corn, potatoes, etc.), the Bt gene of the *Bacillus thuringiensis* bacterium is generally inserted, coding specific endotoxins which are not harmful to man and other animals. Multiplication of the use of Bt could make it eventually impossible to use these proteins whereas they are of great value and can be used in different forms, particularly in biological spray control used in organic farming.
- The effects of insect-resistant transgenic plants on auxiliary fauna need also more in-depth analysis.
- Certain forms of biotech such as in vitro vegetative propagation could lead to a decrease of biodiversity and to a greater susceptibility to disease if they are not managed carefully enough. On the other hand, it is sometimes feared that genetic engineering greatly reduces the number of species proposed to farmers as a result of the tendency to concentrate on crops which represent the biggest markets. Is enough attention given to improving land varieties which correspond to relatively unprofitable markets?

- The introduction of transgenic plants is sometimes compared to that of a new species in certain environments. This has sometimes led to a plague due to the lack of natural enemies to the species introduced which can then proliferate (Paoletti, Pimentel 1996).

These specific environmental risks can be studied, case by case, at least in the beginning. But there are others that are much more difficult to evaluate today because they are relatively unknown or have not yet manifested themselves. It is extremely difficult to detect an unknown phenomenon precisely because references and means of detection are missing…

*Last but not least*, the increase of knowledge in this area can be used in many ways, including even the development of biological warfare (Biofutur 1998). Extremely deadly wars could certainly be fought without sophisticated weapons, but the question of the possibly dangerous applications of certain new techniques should be examined in order to control and prevent them, an extremely difficult undertaking.

## Will Biotechnology Enhance Economic Viability in Agriculture?

### *A Possible Positive Contribution in this Area…*

Biotech may contribute to economic viability in agriculture through a **reduction in production costs due to fewer losses or higher yields.** In the United States, transgenic crops such as soybean and corn rapidly improved between 1996 and 1998, testifying to their advantage for farmers and a better gross margin. But will this continue since the respective prices of seed and inputs can be changed quickly? Agricultural development over the last few decades reveals three interrelated phenomena affecting price trends in constant prices in France: a drop in the price of agricultural products (divided by 2.2 between 1960 and 1997), a much more moderate drop in the cost of inputs and a near stagnation of consumer prices of food products (related to changes in the type of products consumed, among other things). Analyses using the method of surplus accounting show that agricultural productivity gains often benefited the customers, particularly the sector of trade and distribution or those buying exports, rather than the farmers themselves, at least before 1993 (however productivity gains in 1994-96 mainly benefited farmers) (Dechambre 1994 ; INSEE 1998, p. 25-27). It can be hypothesized that the same phenomena that occurred previously for other innovations will be observed in the future for transgenic plants: economic gains for farmers will probably be temporary as a result of the relative drop in agricultural prices; the increased gross margin resulting from innovation will be eroded little by little. But their use is just about unavoidable in order to remain in the profession (Cochrane 1958).

Another advantage of transgenic crops is seen as attractive by farmers: **production diversification**. Biotech could actually give agriculture the opportunity to produce new products using transgenic plants, e.g.:

– pharmaceutical molecules or vaccines,
– nutraceuticals or functional food or pharmafood (foods containing supplements or compounds that are thought to deliver a specific health benefit),
– different substances used in agricultural or food production such as vanilla, pyrethrum, alkaloids, very strong sweeteners, etc.,
– agricultural produce whose composition has been modified to adapt to certain chemical and energy uses such as rapeseed which is enriched with fatty acids,
– transgenic animals such as pigs might eventually produce organs for human transplants (in this case, the purpose of transgenesis is to prevent the transplanted organ from being rejected).

But are these new prospects significant? Certain ones such as pharmaceutical molecules would certainly be limited in quantity; others such as new products for chemistry or energy could require large volumes. Nevertheless, different conditions would be required before vegetalochemistry could partially replace petrochemistry over the next few years or decades. For example, a substantial rise in the price of oil and/or a decrease in the cost of raw agricultural materials due to more efficient processing would be a prerequisite. Since energy or chemical raw materials from agriculture would be bought at a low price, it is not certain that this would contribute to keeping a large number of farms in existence. Farmers would certainly earn more by gearing themselves towards products or services with a high added value provided that they would get back a substantial part of the added value. This implies that they themselves would be responsible for the processing and/or sales, or that they would maintain some control over the sector. This does not seem to be the case for GMO produce, at least in the beginning.

### *…But with the Risk of Greater Dependence of Farmers on Industrial Firms*

For several decades now, farmers have bought more and more inputs from industry, including a large proportion of seeds, but with variations depending on the crops. What changes would result from the introduction of transgenic plants? GMO seeds are more expensive in order to pay for the long R&D phase and all of the work and investments made by industry before putting them on the market. But industrial firms establish seed prices so that the farmer has a better gross margin (with the gain in yield or the elimination of another input) to incite him to use them. Is technical crop management (control of weeds or other pests) easier? This must be examined for each case and over a sufficiently long period of time.

By using transgenic seeds, **farmers will be more dependent on agro-industry**. So, if a farmer uses a plant that has been made tolerant to a certain herbicide, he has to use this type of herbicide and the brand sold by the firm which contributed to the development of the tolerant seed. He has also to follow the instructions to the letter (more carefully than with non-transgenic plants) if he wants to avoid legal as well as technical difficulties. If a farmer grows a transgenic plant with a modified composition (e.g. rapeseed enriched with a specific fatty acid), he will probably do so under contract with a company that will provide him with seed, treatment products, specifications to be respected for the crop and that will then buy up what he has produced. Even though contracts have existed for a long time in a large part of the agricultural sector, they are rarely to the advantage of those who work the land themselves. Will it be different today when farmers have unions to represent them and better defend their interests? In any case, agriculture runs the risk of becoming less and less "peasant" and more and more industrialized, despite the fact that genetic engineering offers the possibility of a new type of agriculture that could more fully develop the potential locked within living matter processes.

Another way that farmers could be dependent on industry is through **the development of patents**. Because of the high cost of R&D in genetic engineering, firms have demanded that the products developed be protected by a patent as is the case for other industrial innovations, and not only by Plant Variety Rights. The largest industrial firms therefore may appropriate a large part of germplasm for their own use; this may impede the development of new varieties by other firms or by public research centers.

Finally, huge **concentration, merger, acquisition and buyout movements** involving agro-chemical and seed companies particularly active in the field of biotechnology have been observed over the last few years. Tomorrow, what will be the consequences of this concentration of the possession of genetic resources in the hands of only a few?

In addition some consumers are more wary of **techniques used in agriculture.** This could lead sometimes to costly regulations and standards in all farming sectors. This could also lead people to avoid certain food products, seriously affecting the concerned areas of production. The controversy surrounding GMOs is creating an atmosphere of suspicion which could crystallize around one or another food product on the occasion of an even relatively innocuous event.

## Will Biotechnology Increase Sufficiency and Improve the Quality of Food for Everyone?

### *Biotech Supporters Emphasize their Potential Contributions in this Domain...*

- ***An Increase in Agricultural Production***. It could be obtained:

– **by decreasing losses due to certain crop pests**, particularly through the introduction of resistant genes (see above). As for fungus or virus control, in vitro vegetative propagation has also made it possible to regenerate a variety containing a virus and to obtain virus-free cultivars. Better conservation after harvest is also a key factor and is presently being looked into: some results have already been obtained.

– **by increasing tolerance to salt, drought and certain metals.** Yield is frequently limited by a lack of precipitation. Moreover, water resources are more and more difficult to come by and a source of conflict between different users, and irrigation can result in an increase in soil salinity. Better plant tolerance to these limiting factors would be very advantageous but this work is only in the experimental stages.

– **by enabling the production of new types of foods or of nutrition supplements**, particularly proteins: for example, the development of varieties enriched in lacking essential amino acids, the development of aquaculture, the growth of proteins from unicellular organisms, etc.

Scientists feel that it is possible to influence different factors which affect plant yield: for example, the increase in the harvest index and the effectiveness of certain phases of photosynthesis. The reduction in losses which are enormous should, in itself, lead to an increase in production: Oerke and Dehne (1997) estimate that for the period 1991-93, losses due to rice pests amounted to 51% of the possible production if there had been no losses, 34% for wheat and 38% for corn. It can therefore be deduced that the introduction of new pest-resistant varieties could increase food supply provided that they are enduring (however, it seems impossible to completely eliminate all the losses).

· ***An Improvement in Produce Quality.*** Different characteristics of quality can be or could be modified through transgenesis, particularly composition:

– modification of the fatty acid content of oilseed crops according to their final use,
– increase in the content of different vitamins or certain micronutriments,
– improvement of the capacity of products to undergo certain forms of processing after harvesting,
– decrease in the quantity of nitrates present in edible plant parts,
– reinforcement of organoleptic quality, etc.

Different results have already been obtained and rapeseed enriched with certain fatty acids is already marketed in Canada. For some, and the processing industry, in particular, biotechnology offers a valuable improvement in quality. But, on the contrary, those opposed to genetic engineering see this as an alteration or even the disappearance of quality as a result of the use of "genetic manipulation" which transgresses the natural barriers between species...

***…But Others are Skeptical of the Claim that Biotechnology Can Improve the Food Situation***, particularly for those who need it the most.

· ***At the Quantitative Level.*** Research in genetic engineering is generally done by big private firms with an eye to financially solvent markets. Thus, 92% of the field trials of transgenic plants during the period from 1986-1995 were carried out in developed countries with only 8% in less developed countries (LDCs) and particularly in Argentina and China (James, Krattiger, 1996). The percentage of trials carried out in Africa was only 0.7% and 1.7% for less developed countries in Asia (including China), for the same period. Admittedly, biotech research is done within the framework of the International Agricultural Research Centers, by research organizations in some less developed countries, and by research institutes in developed countries involved in cooperation such as IRD or CIRAD in France (IRD: scientific Research Institute for Development; CIRAD: International Center of Agricultural Research for Development). Different international organizations of the United Nations devote attention to this as well. Thus a certain amount of research in this area is directed towards the less developed countries, but it is often confronted with a lack of resources. Anderson, Pardey and Roseboom (1994) determined that during the period from 1981-1985, agricultural research expenses per agricultural worker were $3.10 in 1980 purchasing power parity (PPP) in sub-Saharan Africa (37 countries) as opposed to $213.50 1980 PPP in the 18 most developed countries in the world. Moreover, resources allotted to agricultural research in the poorest countries have often diminished over these last few years (Pardey, Alston 1995). Therefore, **one of the major risks of biotechnology is that it is not sufficiently geared towards the needs of those who need its potential contribution the most** and that they can take only little advantage of it. In addition food security implies that there is sufficient income to buy food: certain populations could even lose income sources with the development of biotech in the Northern countries leading to production which would be in competition with their exports (see below).

· ***At the Qualitative Level.*** Does genetic engineering create toxic, food and health risks? Some consumers – a large proportion in some countries – fear that there are risks of toxicity related to the nature of products whose synthesis is controlled by the new gene, to the modification of plant metabolism due to the transgene or even to the modified metabolism of herbicides to which the plant has been made tolerant. One must also look at the potential food risks related to new compounds which are possibly present in the transgenic plant and at the risk of allergy due to products synthesized by the transferred gene. Others mention the risk of developing resistance to antibiotics from marker genes which code this characteristic and are present in some transgenic plants. These toxic and food risks, of which Western consumers are very aware, have undergone and are undergoing numerous tests before they can be approved for marketing (Kahn 1996; CNRS 1997; OCL 1997). Thus it should be possible to control these risks. But what about other risks, particularly those of an economic nature?

## Will Biotechnology Lead to a Socially Acceptable Form of Agriculture?

In some western countries, particularly in Europe, the present industrialized agricultural model is subject to criticisms as a result of environmental damage, recent food safety problems, food quality sometimes deemed inadequate, insufficient control over quantities produced, etc. (see Bonny 1998c, for example). In this context, what could be the effect of introducing GMOs? May this not make Western consumers more wary of food and agricultural production techniques? In fact, certain consumers express doubts about modern farming techniques deemed to be too artificial and to pollute too much, and towards food products considered to be *"tasteless, pumped up with water and full of pesticides, antibiotics and hormones"*. In 1996, the mad cow crisis crystallized these questions and doubts. In this climate, consumers are not very enthusiastic about the prospects of foods made from GMOs. A poll taken by SOFRES (a French polling institute) in February 1998 at the request of UIPP (professional Union of the Crop Protection Industry), on a sample of 1003 people, representative of the French population, indicated that:

- 69% are against growing transgenic plants (32% totally against, 37% somewhat against),
- 26% are in favor (4% totally in favor, 2% somewhat in favor),
- 5% didn't know.

The last Eurobarometer poll of the European Commission taken at the end of 1996 and concerning opinions about biotechnology, led to a more in-depth analysis of variations of opinions as a result of different factors (Eurobaromètre 1997). Although certain medical applications of genetic engineering, particularly disease diagnostic tests and the production of medicines or vaccines, are considered useful and morally acceptable, applications in the area of food production are less well viewed. The use of genetic engineering may contribute to the growing suspicions of many consumers. On the contrary, it contributes to the revival of interest in other forms of agricultural production such as organic farming. One of the indirect effects of the development of GMOs in agriculture could be its contribution to the development of the organic food market, at least on a short-term basis. But this area will probably remain limited because a high proportion of consumers seek out cheap and easily prepared foods. Genetic engineering is often perceived by some consumers as an over-exaggerated artificialization of agricultural production. Thus, over half of the French respondents (54%) in the Eurobarometer poll said they pretty much agreed with the statement, *"One should only use traditional growing methods"* (16% chose not to give their opinion). The people polled felt, however, that certain developments in genetic engineering were manifestly positive in contrast to others which were qualified as negative or ambivalent. Moreover, the probability of actually developing "positive" applications is considered more likely than that of applications that were poorly viewed. Opinion could therefore be influenced by actual developments and consequences of genetic engineering. This is what has come out of the poll taken by the ACNielsen Institute in late June - early July 1998, of 1000 panelists from their Homescan-consumer panel (the sample was certainly slightly biased) (Le Corroller 1998). It seems that 75% of the participants said they would probably buy transgenic food products if they could be assured that there were no health risks, and 72% if they were informed that the nutritional value would be increased (Table 1).

TABLE 1 Likelihood of Consumers to Buy Transgenic Foods According to Certain Advantages Presented (ACNielsen poll, 1998) (in % of answers for each proposal)

| **Will buy transgenic foods** | **yes for sure** | **yes probably** | **maybe** | **no probably not** | **no surely not** |
|---|---|---|---|---|---|
| - if they are guaranteed that there is no health risk | 11 | 22 | 43 | 15 | 9 |
| - if they are informed that the nutritional value is increased | 10 | 21 | 41 | 17 | 11 |
| - if they are informed that they taste better | 7 | 20 | 41 | 20 | 12 |
| - if they are informed that they are less expensive | 9 | 19 | 35 | 24 | 13 |

The reserved attitude of European consumers towards genetic engineering applications can be explained by many reasons other than cultural factors that we will not go into here. First of all, the advantage of genetically modified foods, compared to those already existing, often seems to them very small and even negative due to fears concerning the different risks. Secondly, biotechnology is part of the trend to industrialize agriculture and even reinforces it, whereas this trend is seen as being rather negative by a proportion of the consumers. Finally, the controversy surrounding this subject and the hesitations and even reversals of authorization decisions have contributed to confirming these doubts. Moreover, refusing GMOs often seems to stem from the crystallization of concern over the overall socio-economic evolution: concentration and increasing power of firms, growing social inequalities, furtherance of the marketability of all sectors – now the genes, etc. Genetic engineering seems sometimes playing the role of a scapegoat…

## Biotechnology and Equity.
## Will Biotechnology Strengthen or Weaken Disparities?

Wide disparities between development levels throughout the world are a factor which make the present system unsustainable. Biotech is presented by its promoters as being indispensable to feed humankind in the 21st century while preserving the environment and resources and, therefore, an essential tool to development. An open letter signed by fifty scientific and political leaders from thirty LDCs and former communist countries was published in October 1998 under the aegis of the Monsanto Company to call for biotech development. They write:

> "As we stand on the edge of a new millennium, we dream of a tomorrow without hunger. To achieve that dream, we must overcome many hurdles, including poverty, distribution, water supply, soil erosion and crop disease. Biotechnology alone cannot address all of these hurdles, but it is an important tool in our hands today. We know advances in biotechnology must be tested and safe, but they should not be unduly delayed. In the next century, we need food that is more plentiful and more affordable than it is today. With more productivity needed from less tillable land, we need new ways to yield more from what is left. To strengthen our economies, we need to grow our own food as independently as we can. Agricultural biotechnology can help play a major role in realizing the hope we all share. This science can help make a dramatic difference in millions of lives. (…) Let the harvest begin."

The technical potential of biotechnology is certainly notable but its economic repercussions in the LDCs or for deprived populations could be a mixed blessing, at least on a short-term basis, as the following risks illustrate:

· **At the present time, biotechnology, developed largely through private investments, is particularly geared towards the markets of rich countries.** Its first impact would be the increase of production for the big international agro-exporters. In 1998, virtually all of the 30 million hectares of transgenic plants were grown in three major agro-exporting countries: the USA, Argentina and Canada (James 1998). Agricultural exports from agro-exporting countries would probably increase, particularly if they produce more at a lower cost. This could lead to a drop in world agricultural prices, or at least prevent their increase if market strains arise. Urban populations and particularly retailers, middle-men and wholesalers would be at an advantage in the LDCs. But what about local producers and small farmers? Competition of imported products, often at a low price, could discourage local production which would not really contribute to food security. Admittedly farmers could find work in the cities but not all of them, which could create difficult situations. Even if emerging countries can afford large agricultural imports, strong dependence on these (especially on food products) is generally considered undesirable. Security in this area requires a certain degree of self-sufficiency in addition to several types of exchanges. It would be **important that biotechnology increase production first in areas where food is lacking** instead of increasing competition due to agricultural imports from developed countries and, therefore, discouraging local production in some LDCs.

· **Loss of markets and income sources** if Northern countries produce different substances through biotechnical means that are presently extracted from produce bought from LDCs. For example, the production of different types of fatty acids by transgenic rapeseed could create stiff competition for palm and coconut oil exports from different countries. Thaumatine (an intense sweetener) or natural vanilla flavorings obtained through genetic engineering could possibly put an end to the harvest or production of these crops in certain Southern countries (Leisinger 1995, Galhardi 1996). The impact of biotechnology in this area depends on different factors and particularly on the possibilities of diversifying production in the Southern countries and on their situation: are they net importers or exporters of agricultural products? Do they have a high or low technological potential? Are they capable or not of exporting other types of products?

· **Difficulty of access** to technological advances which are aggravated by the fact that high R&D costs has opened the way for legal protection through patents, possibly hindering their use in the poorest countries.

· **The piracy of genetic resources in Southern countries.** Specific and genetic biodiversity are much greater in Southern countries. Using traditional medicinal plants from local pharmacopoeia, industrial firms can extract valuable active ingredients that they protect with a patent and then market in the form of medicine. In the same way, valuable local plants could be genetically transformed in developed countries and protected by a patent. This could prevent other research using the same germplasm and deprive Southern farmers who produce these same products for export of their markets. Different members of LDCs and NGOs (non-governmental organizations) denounce the fact that the Southern countries that discovered the value of certain plants (eliminating the need for pharma-ceutical and agro-chemical companies to screen thousands of molecules) and who genetically improved them using traditional methods over thousands of years in the case of plants which benefited from selection by local populations, are the ones who reap the least benefits from them. Admittedly, Article 19 of the Rio Convention on Biological Diversity in 1992 stipulates that LDCs should receive payment for their genetic resources, but its actual acceptance and application have met with some obstacles (Sauvain, 1997). However, certain people feel that the Southern countries should not be under too many illusions about the source of wealth represented by genetic resources (Macilwain, 1998). In the area of pharmaceutics, modern recombinant chemistry techniques reduce the need for bioprospection; and so does the development of gene banks to find genes that could be transferred to plants.

· **Dependency of farmers on big firms.** The big agro-chemical, processing and distribution firms play an increasingly important role in agricultural production. This could develop according to their economic interests more than to those of small farmers, especially in countries where these farmers have little political power and are poorly represented.

· **Indifference to other essential improvement factors.** Since biotechnology provides an extraordinary tool for understanding the intimate workings of living matter and much hope has been placed in it, it could eat up a major part of investments and resources. This could result in the neglect of other essential factors involved in food security such as the use of other types of knowledge or techniques and particularly those dealing with the operation of local social and agro-systems, integrated production techniques, etc. The crucial role of other essential development factors such as security, the absence of war, the presence of infrastructures for research, training, information, transportation, etc., should not be underestimated nor should the importance of social, cultural and economic factors (Griffon, Weber 1996).

**Would it, therefore, really be possible for the most deprived populations to take advantage from the potential contributions of genetic engineering even though they are the ones who need them the most?**

## Conclusion

Biotechnology or, more exactly, genetic engineering, is presently at the center of a controversy. It is presented by some as being indispensable to feed humankind in the 21st century while preserving the environment and resources and, therefore, is considered to be an essential factor for sustainable development. This is often used as a decisive argument to legitimize it in the face of suspicions. On the other hand, its opponents point out the different risks and don't trust it. They go as far as challenging it or demanding a moratorium until more is known about its effects. This article attempts to examine the contributions of biotechnology to the different aspects of sustainable agriculture.

As a result of the present state of its advancement, available knowledge and data, it is not possible of course to give a definitive point of view. We have attempted to lay out the anticipated benefits and the possible risks in relation to sustainable agriculture. This leads to give an outline of further more detailed studies needed. It is indisputable that biotechnology offers considerable potential, foremost as a tool to understanding the functioning of living matter, greatly increasing the possibilities of intervention and, thus, opening up important application prospects (Bonny 1998a, 1998b). It can also provide interesting technical solutions to problems that are difficult to solve without it. But it can involve certain risks, including indirect ones, as well.

The potential of biotechnology seems substantial but it is double-edged as well. Everything depends on how it is used and, especially, on the objectives set for biotechnology and for its applications, and the way in which they are and will be used and regulated. So this is not a case of technological determinism but, on the contrary, the possibility for those involved to play an important role, even if the mastery of man over nature is far from being complete and if some of those involved carry more weight than others. On one hand, scientific and technical uncertainties exist. Since it is in its beginning stages, biotechnology requires a great deal of research and could give rise to unexpected developments and consequences. On the other hand, the trends and the type of applications developed depend, in large part, on the strategies of those involved and particularly on the industrial firms that occupy an important position in relation to research into this field.

Some of the major risks are indirect, for example, that of over-privileging this trend. Since the contribution of molecular biology to the knowledge of how living matter functions is considerable, this type of approach tends to become highly dominant in agricultural research, particularly because so much is expected of it. It therefore runs the risk of eating up a large part of the resources and investments, diverting them from other approaches which are necessary as well.

There is also the risk of making people believe that the solution to food problems is simply technical and that it is only necessary to produce more and increase yields. As of now, given the technical context and the knowledge acquired in the 1990's, it seems technically possible to feed the eight billion people expected for 2025 (Bender, Smith 1997; Bonny 1997). The food problem, at least for now, is not the lack of world-wide agricultural production, but mainly local shortages and insufficient income to buy available products. Food insecurity is generally the result of wars, of the unequal distribution of land and wealth and of the disorganization of certain economic and institutional structures. However, certain basic problems should not be overlooked by avoiding them just because a technology is considered or presented as being miraculous and working wonders.

So perhaps the concern about different forms of technical progress that we find in developed countries indirectly expresses the fear of certain excesses resulting from rampant liberalism. If certain people greatly benefit from it, wouldn't it be possible that the situation of others will worsen? Moreover, food is an area that is highly charged with symbols in every culture. The idea that "we are what we eat" is an important principle in the relation to food, explaining the mistrust of certain foods when they become the object of concern or anxiety (Giachetti 1996).

Genetic engineering represents high economic and financial issues in agriculture and even more so because of the highly competitive economic climate today: competition among firms that have invested in this sector, competition between agro-exporting countries on international markets, competition within each country between agricultural producers and, finally, competition of end consumer product markets between downstream agro-food firms as well as between major distributors to increase their share of the market. This situation of extremely stiff competition strongly influences trends in biotechnology and genetic engineering and, as a result, its potential impact. This can actually become a risk factor by leading to a course of action without careful consideration, even if these firms, which are particularly careful about their public image, take the necessary precautions to enhance it or at least to avoid damage to it.

At this time, the majority of investments in the area of transgenic plants come from private firms. These companies will probably favor developments concerning financially solvent demands as a result of the need for return on investment. Thus, one of the major risks of biotech is that it is not sufficiently suited to the demands of those who need it the most. Generally speaking, it would be preferable to use technology so that it would reduce the exclusion of certain populations instead of making their situation worse. It actually often increases the gap between those who possess it or have access to it and those who don't. Wouldn't the real challenge and advantage of biotechnology in agriculture be not only that it doesn't involve any particular environmental risks, but, above all, **that is better oriented towards the needs of the poorest and most undernourished populations**, and particularly that it leads to **an increase in production first where it is the most needed**? If biotechnology could lead to an improvement of the nutrition level of everyone in the XXIst century while preserving natural resources, this would be an essential contribution to a model for sustainable development. But will this ever go beyond the stage of wishful thinking and is the mobilization necessary to achieve this goal in action? This brings us back to the debate surrounding objectives and guidelines set for research and its applications, and also reminds us of a danger of certain trends that are often extolled today: the increasing privatization of research and its growing submission to the solvent demand.

Thus the potential of biotechnology to contribute to sustainable agriculture seems significant if its risks can be managed. But this will depend on the **objectives set for its applications and on the regulations for biotech product authorization and marketing**. How can this done so that it is not uniquely a function of the economic war that is often prevalent today?

## Endnote

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