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# BIOTECHNOLOGY AND THIRD WORLD ENVIRONMENT
## Threat or Solution? (1)

A lot of sense and nonsense has been said and written on what biotechnology will do for society. Most striking is the range of contradictory perspectives, ranging anywhere from biotechnology as the ultimate solution to virtually all serious problems mankind is facing today, to being the last, decisive step towards the creation of a "brave new world" where life itself can be engineered to suit the interest of the big industrial brother.

Talking about biotechnology and the Third World is an even more speculative and tricky exercise. Although R & D in biotechnology is probably growing faster than in any other technology, to a large extent the results still have yet to be brought to the marketplace. This is true in the industrialzed countries, but even more so in the developing world. Nevertheless, some assessment of how and to what extent biotechnology will affect markets, economies and people is possible, drawing on past experiences with new technologies. To do so, we feel it is important to stress a few points that might serve as some fundamental guidelines for understanding the "biorevolution" and how counter-action can be pursued.

Below, we discuss four points that undergird the "biorevolution" as we see it. We then briefly describe some of the likely impacts of the new biotechnologies on Third World economies. This is followed by a discussion on the impact of biotechnology on three different areas of environmental concerns: the use of agrochemicals, the impact of genetic diversity and the deliberate release of genetically engineered organisms.

### Biotechnology and Development: Four Undercurrents

#### *1. "Technology is a tool, not a solution"*

This statement is perhaps nowhere more true than with respect to biotechnology. In principle, biotechnology has the potential to help solve some of the major problems that societies across the globe are facing today. It especially has the potential to provide solutions for those who need them most: the poor, the hungry and the marginalized.

In agriculture, biotechnology could be used to design crops that are better suited to small farmers' circumstances, crops that need less external inputs and grow better on the worst soils. But it could also be used to the opposite. It depends on who sets the priorities for research, who is involved in deciding what the problem is, and in which directions the solutions should go.

In that sense, biotechnology itself is no solution, as some tend to describe it. It is rather a tool, a very powerful tool that can be used in several ways. And since choices are involved in orienting this new technology, it is a highly political affair.

A lot of the problems that Third World peoples are now struggling with are, themselves as well, more of a political and socio-economic nature than a strictly technical one. Perhaps the best example from the past is the "Green Revolution" that, indeed, offered for some countries technical fixes in the sense that national food production rose. But, on the other hand, it did so at a tremendous social and economic cost to such an extent that many people doubt whether the Green Revolution had been of any substantial benefit to the Tird World at all.

*2. "Biotechnology as such is nothing new"*

Techniques using life forms and living processes have been common practice for centuries. Farmers domesticating and improving their crops and animals through genetic selection, people brewing their wine and beer or fermenting cheese with the help of micro-organisms ...: they were all practicing biotechnology, often without knowing about genes and microbes. They were playing around with biological processes in order to get something out of nature that would suit their needs better.

What is new about the "new biotechnologies" is the extent to which this "playing around" can be controlled. Modern biotechnology basically grew out of the integration of diverse scientific disciplines such as genetics, molecular biology, biochemistry, enzymology, etc. The integration of these fields made the fine-tuning and industrial scale-up of techniques such as gene transfer (recombinant DNA), tissue, culture, enzyme immobilization, etc. possible.

This resulted in a quantum leap forward in the extent to which the manipulation of biological processes and the overcoming of sexual barriers are possible. Perhaps the clearest example of this is the breaking down of natural reproductive frontiers, making it possible to cross species that normally would never cross.

*3. "Bio-business is private business"*

Biotechnology was born within the walls of universities and public research institutions in the North. Commercial interest grew when the aforementioned integration of scientific disciplines started offering a potential of profitable markets.

Among the first to realize this were the university professors themselves. This resulted in the setting-up of small biotechnology firms, often located at the university campus and led by ambitious university professors, to further develop and commercialize some of the research results. At the beginning of the 1980s in the U.S.A., an authentic proliferation of such firms was taking place, particularly with the support of venture capital and stock market enthusiasts. While some were gambling that these firms would become the leading edge in the commercialisation of biotechnology, a parallel and much more profound development was already until then consisting of many small, often family-based firms, was subject to a tremendous concentration process within just one decade. The deciding factors in this process, as pointed out by several authors (2), were on one hand technical and on the other legal. Hybridization techniques became possible for an increasing number of crops. Hybrids provide a high return for the company as the farmer has to buy new seeds each year. At the same time, most industrialised countries adapted patent-like legislation for crop varieties, which guaranteed royalties and market control for the breeding companies.

Moving into biotechnology, is the next – and perhaps qualitatively the most important – step in this restructuring process. Currently, virtually every major pesticide and pharmaceutical producer is heavily investing in biotechnology. While the companies had successfully moved into new areas, the actual integration of all these areas in the laboratory and in the final market place proved to be difficult. After all, the production of a pesticide is technically-speaking something quite different from the breeding of a new crop variety. Biotechnology now makes this integration increasingly possible ... and profitable. If, for example, a company has successfully developed (and patented) a technique to tissue culture a certain plant, then this technique can in principle be used by all divisions of the same company. The plant breeding division will use it to identify germplasm more quickly and breed it into new varieties. The pesticides division will use the tissues to screen the impact of the pesticides, while the pharmaceutical division might find ways to use the technique to screen for useful drug substances, or even produce them directly in fermentation tanks. The advantages for the company as a whole are obvious.

But the integration does not stop in the laboratory. It moves on to the marketplace. The most striking example of this being the matching of seeds and herbicides, as we describe in detail further on. But first we look briefly at some of the likely impacts of biotechnology on the Third World economies.

## The Third World: Winning In Or Losing Out?

As stated in the beginning of this article, whether a new technology will have a positive or negative impact on society depends on the direction of the research and on the socio-economic context in which it is introduced. Unlike the highly criticized "Green Revolution", which was mainly developed and promoted with public funds and by public institutions, the new biotechnology is almost completely in the hands of private industry. Not surprisingly, this results in a research focus that emphasizes the interests of industrialised countries in general and of their TNCs in particular.

### *Export Product Substitution*

What this can mean for developing countries is already becoming clear in the sugar sector. Sugar prices on the world market have fallen 59 % since 1975, and are expected to drop further because of the increasing use of other sweeteners by the food industry. By the end of the 1980s, more than 10 % of all sugar consumption in the world will be replaced by the biotechnologically engineered high fructose syrups from corn, potatoes and cassava. In the U.S.A. alone, sugar consumption per person has dropped to 50 % of the sweetener market, high fructose corn syrup has risen to 40 %, and the remaining 10 % is occupied by other artificial substances (3).

What all these developments will signify for over 50 million workers in sugar production and processing, most of them in the Third World, we can only fear. It is clear that developing nations are losing a very important export market with dramatic consequences especially for the nations which are largely dependent on sugar exports. Income from sugar exports to the U.S. from the Carribbean, for example, shrank from US-$ 686 million in 1981 to US-$ 250 million in 1985.

Developments in the Philippines provide a typical example of what the global sugar crisis can mean for millions of small farmers and plantations workers. The Philippines saw their sugar export earnings drop from US-$ 624 million in 1980 to US-$ 246 million in 1984. Marketing problems forced the government to reduce production from 2.4 to 1.6 million tons annually. Large sugar plantations are now massively changing to other crops that are often less labour intensive, resulting in half a million farm workers losing their jobs. This switch can hardly be made by the small sugarcane farmers due to the investments required. So, the result is a neglect of land and further impoverishment. The standard of living in the Philippines, where a large part of the population derives its income from agriculture, has gone down about one fifth in the last four years (4).

Sugar is by no means the only crop that is being replaced by biotechnologically produced substitutes. The Anglo-Dutch TNC Unilever and other corporations are using biotechnology to modify palm oil to the extent that it can replace the more expensive cocoa butter. The Swiss-based TNC Nestle is carrying out research to produce cocoa back home in their laboratories through biotechnology. If this research results in marketable products, this will leave poor African countries like Ghana, the Cameroon and the Ivory Coast without important sources of export income. Again, it will be the small farmers who will be hurt most because of this shift, as over half of the world's cocoa output is produced on small landholdings (5). Several other crops like natural pyrethrins, vanilla, plants useful to the pharmaceutical industry, etc., are on the verge of being replaced by tissue culture substitutes produced in Northern factories.

*Overproduction*

Apart from substitution, biotechnology poses another threat to developing countries: overproduction. In the vegetable oils and fat sector, also traditionally a market for developing countries, the new biotechnology trends are expected to be dramatic. Unilever already produces, through biotechnology, one million completely identical oilpalms a year, and it is estimated that oil palm in the future could satisfy the entire world vegetable oil demand, thus making other vegetable oil crops obsolete. This will seriously affect the developing countries that heavily depend on crops like cocoa and coconut for their export earnings. The consequences for the environment, and especially for genetic diversity are hard to evaluate, but it is logically feared that biotechnology will contribute to genetic erosion through the production and cultivation of millions of tissue culture clones.

Looking at yields, plantation crops are probably the most extreme example of the impact that biotechnology will have in the near future. Biotechnology, however, is also expected to boost yields of major food crops, but probably to a lesser extent. It is very likely that the increase of food production with the help of biotechnology will be concentrated in the industrialized world, as virtually all biogenetic research is being carried out in the North in function of its own farming conditions. The U.S. Office for Technology Assessment (OTA) calculates that with the help of biotechnology, the total production of corn, soybean and wheat in the U.S. will haverisen by 21 %, 68 % and 35 % respectively by the year 2000 (6). This will undoubtedly result in an increased overproduction of these crops and, consequently, greater pressure to dump these surpluses on Third World markets.

In summary, we think that in this context, where the new technology is almost entirely in the hands of a few multinational corporations – beyond the scope of any form of democratic decision-making process –, biotechnology will not necessarily bring the often promised solutions to the Third World, nor resolve many of today's environmental problems. If priorities of research are not redefined, and if the developing countries themselves do not get a voice in the orientation of the techniques towards their own needs, it is quite likely that biotechnology will lead to increased concentration within the agro-industrial sector, fewer possibilities for defining national policies in developing countries, and greater constraints against the participation of the Third World in international decision-making. This will ultimately result in even stronger dependency of developing countries on the industrialized centres in the North. As with the Green Revolution, the ones who pay the final tab are likely to be, once again, the small farmers.

### The Impact on the Environment: Some Concerns (7)

*The pesticide bias*

Perhaps one of the most exiting and promising possibilities of agricultural biotechnology is to decrease the need for chemical inputs in crop production. Virtually every article on this question starts off by saying that biotechnology has unlimited possibilities in this direction. This euphoria about the possible impact of biotechnology and agriculture is easy to unterstand. Biotechnology, at least in theory, *can* provide the tools for increased pest resistance in crops and for the reduction of dependence on chemical nitrogen fertilizers. Although the work is not as easy as it might seem, it is possible to transfer the genes responsible for pest resistance to crop plants.

The breeding of pest resistance into crops has always been a painstaking and expensive job and certainly has not received the attention that it deserves. The U.S. Office of Technology Assessment (OTA) stated that in the past decades less resistance-breeding was done because of the availability of cheap pesticides (8). The main focus of plant breeding has always been to increase yields. Private breeding programmes especially lack emphasis on pest resistance breeding, according to OTA (9). In many ways, chemical pesticides were used to compensate for the lack of genetic resistance that might have been bred into crops. Increased emphasis on monocropping, based on a few very vulnerable varieties, has likewise served to encourage a world agricultural system that needs enormous amounts of pesticides (worth about US-$ 13 billion in 1983) but still loses 20 to 50 % of the harvest to pests (10).

Will biotechnology reverse this trend toward increased crop vulnerability and associated increased pesticide use? It might and it might not – it depends on who sets the priorities for research. At this moment it appears that biotechnology will be used to reinforce this trend. A major research focus of today is the breeding of herbicide resistant crops with the help of biotechnology. One problem that limits the use of herbicides is the fact that many herbicides not only attack the weeds that they are supposed to kill, but also harm the crop that they are supposed to protect. This limits the amount of herbicide the farmer can use, and the amount industry can sell.

Early efforts to reduce the damage that herbicides can cause to crops were undertaken by Ciba-Geigy. Ciba, which had already bought up several seed companies in the 1970s, developed a chemical "coat" for seeds to protect them against the herbicides produced by the same company. This "herbishield" was wrapped around Ciba-Geigy seeds, thus providing the company with a double profit: the farmer buys the Ciba-Geigy seeds packaged with the Ciba-Geigy herbicides.

With the help of biotechnology this process is now being further sophisticated. Research is being done to genetically alter crops so that they may resist higher doses of herbicides. Again, the seeds and herbicides are linked by the company that produces them. Ciba-Geigy works to get Ciba-Geigy seeds tolerant to Ciba-Geigy herbicides (atrazine-based, among others). Rhone-Poulec trys to produce sunflower seeds resistant to its bromoxinyl-based herbicide, and so on.

In Table 2, *some* of the current research activities on herbicide resistance are listed. Some surveys list over 40 TNC research programmes to develop herbicide resistance, and even these are far from complete. In fact, virtually all large pesticide producers have major research programmes on herbicide resistance (11). The research is either being done in-house, or through contracts with small biotechnology companies. Herbicide resistant crops are expected to be massively marketed by the end of the decade. The total annual value of those varieties is estimated to rise from virtually zero today to US-$ 2.1 billion by the year 2000 (12).

From the TNC perspective, it is not hard to understand this heavy research emphasis on herbicide resistance. The use of herbicide resistant crops will substantially increase the total global herbicide market, and thus the total revenues of

*Table 2: Research on Herbicide Resistance by Selected Companies*

| RESEARCH BY | UNDER CONTRACT FOR | RESISTANCE TO | CROP |
|---|---|---|---|
| ARCO (PCRI) | Heinz | Atrazine | Tomato |
| Advanced Genetic Sc. | | Experimental | Potato |
| Allelix | | Atrazine | Rapeseed |
| Biotechnica Intl. | | Atrazine | Soybean |
| Calgene | | Phenmedipham | |
| Calgene | | Glyphosate | Cotton, corn |
| Calgene | Campbell's | Glyphosate | Tomato |
| Calgene | Coker's Seed Co. | Glyphosate | Tobacco |
| Calgene | DeKalb-Pfizer | Glyphosate | Corn |
| Calgene | Kemira-Oy | Glyphosate | Rapeseed |
| Calgene | Nestlé | Atrazine | Soybean |
| Calgene | Phytogen | Glyphosate | Cotton |
| Calgene | Rhône-Poulenc | Bromoxynil | Sunflower |
| Calgene | U.S. Forest Service | Glyphosate | Loblolly |
| Cornell Univ. | | Triazines | Corn |
| Du Pont | | Sulfometuron | |
| Du Pont | | Chlorosulfuron | Tobacco |
| Harvard Univ. | | Atrazine | Soybean |
| Intern'l Paper | | | Douglas fir |
| Louisiana State Univ | | Glyphosate | |
| Michigan State Univ. | | Atrazine | Soybean |
| Mobay (Bayer) | | Metribuzin | Soybean |
| Molecular Genetics | Amercian Cyanamid | Imidazolinone | Corn |
| Monsanto | | Glyphosate | |
| Phyto-Dynamics | | Trifluralin | Corn |
| Phyto-Dynamics | American Cyanamid | 'Prowl' | Corn |
| Phyto-Dynamics | Eli Lilly | 'Treflan' | Corn |
| Phyto-Dynamics | Lubrizol | | Oil-seeds |
| Phyto-Dynamics | Monsanto | Glyphosate | Corn |
| Phytogen | Kemira-Oy | Several | Several |
| Pioneer Hi-Bred | American Cyanamid | Several | Corn. |
| Rhône-Poulenc | | Bromoxynil | Sunflower |
| Rutgers Univ. | | Triazines | |
| Shell | | Atrazine | Soybean |
| U.S. Forest Service | | Glypho. & Hexazinone | Jack pine |
| USDA-ARS | | Metribuzin | Soybean |
| Univ. of Alabama | | Atrazine | |
| Univ. of Cal.-Davis | | Sulfometuron | Sunflower |
| Univ. of Guelph | | Atrazine | Rapeseed |

Source: Adapted from H. Hobbelink, "New Hope or False Promise? Biotechnology and Third World Agriculture", ICDA, Brussels, 1987. And: J. Kloppenburg, "First the Seed", Cambridge University Press, Cambridge 1988.

the TNCs involved. But there is yet another reason, which emerges when the costs of developing seeds and pesticides are compared. A draft report recently issued by the European Parliament puts it this way: *"From the point of view of the industry, herbicide-resistant varities are, above all, developed for economic reasons, since the development costs of a new herbicide are up to 20 times higher than those for a new variety."* (13) It is simply cheaper to adapt a crop to a herbicide than develop a new herbicide. With both sectors often in the hands of the same TNC, the company can choose. And the choice does not appear to be a very difficult one.

From an environmental perspective, however, it is difficult to understand why scarce human and financial resources are devoted to make crops resistant to pesticides rather than to pests. Apart from the direct damaging impact on the environment of increased herbicide use, there are also important side effects. Research shows that the increased use of any herbicide might make some crops more susceptible to certain diseases and insect pests by altering the plants physiology. When corn was treated with the recommended dosages of the popular herbicide 2,4-D, it became infested with three times as many corn-leaf aphids. The corn became also more susceptible to European corn borers, corn smut disease and Southern corn leaf blight. Herbicide resistant crop lines could end up requiring more insecticides and fungicides as well, thus aggravating environmental problems (14).

*Genetic uniformity*

An often forgotten environmental problem in agriculture is increasing genetic uniformity of crops. Especially in the industrialized countries, agricultural crops now have an extremely narrow genetic base because of the wide-spread use of just a few highly productive varieties. But also in developing countries, "genetic erosion" is advancing at an incredible speed. A narrow genetic base means vulnerability, and vulnerability often means crop disasters and increased use of chemicals. Biotechnology, again, offers powerful techniques for quicker germplasm identification, better storage of genetic resources and the speeding up of plant breeding. In this way, biotechnology could substantially broaden the genetic base for plant breeding and thus have the effect of increasing genetic diversity in our crops.

However, biotechnology also poses serious risks to genetic diversity. In particular, a technique called tissue culture could have a disastrous impact on genetic diversity if used widely and indiscriminately. Tissue culture is used to reproduce plants from single cells or tissues, thus making genetically exact copies of the "mother plants". Unilever, an Anglo-Dutch TNC heavily involved in vegetable oil and fat production, uses this technique to rapidly multiply (in test tubes) the best yielding oilpalms for its plantations in developing countries. The company already produces a million of such cloned oilpalm plantlets a year and estimates that this will result in a 30 % yield increase. The danger is that all these idencital plants will destroy completely what is left of the genetic diversity of oilpalm, as they will quickly replace traditional varieties with a broader genetic base. This will increase vulnerability of, in this case, the oilpalm crop. Tissue culture is already being used in a wide array of crops and is certain to increase considerably in the near future.

Additionally, it is estimated that clonally propagated crops are six times more vulnerable to pests than their seed bred counterparts (15). The wide use of cloned crops will undoubtedly lead to the increased use of pesticides.

*The release of engineered organisms into the environment*

The release of genetically altered organisms (especially micro-organisms) into the environment is already causing considerable debate worldwide. In agriculture, micro-organisms are altered to combat pests and diseases (so called "biological pesticides"), induce crop resistance to frost, fix nitrogen in the soil, etc. Many experiments are at the stage of being field-tested, and pressure increasing to allow for such experiments to take place.

While industry officials claim that so many precautions have been taken that environmental risks of the release of such organisms are virtually zero, biologists and ecologists point out that we know almost nothing about the possible performance of such alien organisms in nature.In today's agricultural environment there are at least 160 species of bacteria, 250 kinds of viruses, 800 species of insects and 2000 species of weeds. Some scientists estimate that as many as 80 % of our soil microbes have yet to be cultured and as many as 90 % don't have names. Of those that are named, our understanding of their behaviour in a given eco-system is limited. How organisms such as these establish themselves, why some species multiply in nature and other don't, are still largely mysteries (16).

Recently, Advanced Genetic Sciences, a U.S.-based biotechnology company, was allowed to field-test modified bacteria. It took the company several years of legal battles to obtain the green light from the U.S. Environment Protection Agency (EPA). The engineered bacteria, designed to prevent frost damage on crops, were sprayed on a strawberry field in California and the test was seen as a historical breakthrough. With the field test taking place, some very important questions still remain unanswered. What will be the impact of these nowcomers into the ecosystem, how will they affect other micro-organisms, what happens if the engineered bacteria exchange their genetic material with other living matter (as sometimes happens in nature)? There is some evidence that the anti-frost bacteria also make some insects resistant to freezing, which could hurt crops if the insects are pests.

Monsanto is now testing other engineered bacteria in its laboratories. The new bacteria are meant to combat such major soil insects as the black cutworm, a corn pest that causes $ 10 to $ 50 million in damage each year. Several companies are working on this new generation of "biological pesticides". They are presented as a safe alternative to the present agro-chemicals. The word suggests that they will not harm the environment, but again not much is known about their wider impact on the ecosystem. One scientist remarked ironically that *"there might come a time where we are longing back to those friendly chemicals, that do not move around, mutate and reproduce".*

It becomes increasingly clear that for the development of a biotechnology that helps resolve some of our major environmental problems rather then cause them, clear guidelines are necessary. The release of engineered micro-organisms into the environment should be carefully regulated and institutional systems need to be set up to do this. We need to know much more about the possible consequences of such releases, before going ahead with them.

At the moment, the setting up of such guidelines is being extensively discussed in many industrialized nations. Companies are already complaining that existing procedures to release engineered organisms into the environment are too rigorous and cost too much money and time. This has lead several companies to move their testing field to areas where such rules do not exist: the Third World.

A grand example is Argentina: here, not only did a Northern (U.S.A.) biotech company carry out a large-scale field experiment without authorization, but the trial backfired as the test product spread to other animals and people. The Philadelphia-based company called Wistar Institute carried out this experimental release of its genetically engineered rabies vaccine on 20 cattle in Argentina. Neither American nor Argentine authorities, nor the local farm personnel, were informed of the test. Months later, the Argentine government found out and angrily had the inoculated cattle slaughtered. It turns out that both the non-inoculated test cattle and the farm personnel handling the animals were contaminated by the genetically engineered virus. In this case, laws were violated and contamination — multiplication and spontaneous transfer of the engineered virus — clearly occured.

Another example of using the Third World as easy grounds for unckecked release experiments of engineered micro-organisms is the unpleasant story of rice-blast research at the International Rice Research Institute in the Philippines. IRRI "accepted" to carry out research on a genetically modified version of the rice-blast virus, responsible for heavy damage to rice crops in many parts of Asia but, curiously, not so much in the Philippines.

Foreign as it is to the Philippines, IRRI imported from abroad a number of samples of highly virulent strains of the virus from several sources, including the U.S. chemical firm Du Pont who is doing research on it as well ... Intense work has been going on behind the walls of this international institution to use genetic engineering to breed new strains and test them on rice varieties. If some type of secret immunity was to be found in using an international institute for such testing, it did not work. An NGO forum of scientists has loudly denounced the experiment as *"once again using the developong countries as guinea pigs for imperialist research"* and made stringent demands on the Aquino government to establish correct quarantine measures and regulatory protocol, both for national and IRRI-led research.

Whether official regulatory frameworks are the answer or not, one thing is clear: given the biological risks at stake, given our lack of understanding of interactions in the environment and given the behaviour of different interest groups, particularly private industry, some form of control is absolutely necessary. If nothing is done, the environmental damage, particularly in the Third World, could be irreversible.

## NOTES


(1) The first selection of this article is largely derived from H. Hobbelink & R. Vellve, "Biotechnology & Third World Agriculture", ICDA contribution to RIS Research Programme, Aug. 1988, New Delhi, India.

(2) See, for example: J.Kloppenburg: "First the Seed", Cambridge University Press, 1988, and M. Kenney: "Biotechnology: The Industry-University Complex", Yale University Press, 1987.

(3) French Embassy in the U.S.A.: "Biotechnologies", Numero Special, Washington D.C., May 1986.

(4) Bijlman et al.: "The Impact of Biotechnology on Living and Working Conditions in Western Europe and the Third World", University of Amsterdam, April 1986.

(5) Rural Advancement Fund International, "RAFI-Communique", Pittsboro NC, May 1987.

(6) Office of Technology Assessment, "Technology, Public Policy and the Changing Structure of American Agriculture", OTA, Washington D.C., March 1986.

(7) This section uses material from: H. Hobbelink, "Agricultural Biotechnology and the Environment, Opportunities and Concerns", in: "Industry and Environment", Vol 10, No. 4, UNEP, Paris, Oct/Nov/Dec 1987.

(8) OTA, "Pest Management Strategies in Crop Protection", Vol. 1, Washington D.C., 1979.

(9) OTA, quoted in J. Doyle, "Altered Harvest", Viking Press, New York, 1985, p. 190.

(10) FAO, quoted in F. Wengemayer: "Biotechnik für die Landwirtschaft aus der Sicht der Industrie". In: "Entwicklung + Ländlicher Raum", Vol. 20, No. 5/85.

(11) For example, out of the 10 largest pesticide producers at least 7 have a research programme or contract on herbicide resistance.

(12) Estimate from L. Teweless & Co, quoted in RAFI/ICDA "1986 Seeds Campaign", Pittsboro/Brussels 1986 (unpublished).

(13) European Parliament, Commission on Agriculture, Fisheries and Food: "Draft Report on the effects of the use of biotechnology", Brussels, September 1986 (Doc. PE 107.429/rev.).

(14) D. Pimentel: "Down on the Farm: Genetic Engineering Meets Ecology", in: "Technology Review", 24 January 1987.

(15) G. Conway, ed.: "Pesticide Resistance and World Food Production", qutoed by Pat Mooney: "Impact on the Farm", in: UNCSTD, ATAS Bulletin, Vol. 1, No. 1, New York, Nov. 1984 p. 46.

(16) D. Russell, "Rush to Market", in: "Amicus Journal", New York, Winter 1987.


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