GMOs: Need for Appropriate Risk Assessment System

There is an urgeng need for setting up a Biotechnology Commission which would in turn determine the monitoring and policy making machanisms in the field. For, such bodies not only need to have technical expertise, but have to work within a well-developed social perspective.

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When in February 1975 a group of leading molecular biologists from around the world met in Asilomar in California in the US to discuss the new technology of gene splicing or genetic engineering as it is called today – and at the end of the meeting decided on a self-imposed regulation of the new technology, they had no idea of the tempest it would raise less than two decades later. Today, release of genetically engineered or manipulated living organisms (GMOs) in the environment is one of the most debated scientific topics around the world. The US has been its greatest proponent, a significant proportion of the land under cultivation in the US, now uses genetically engineered seeds produced by multinational corporations whose influence in virtually every sector of American economy as well as on the American government is widely recognised. It is believed that worldwide, as of the summer of 2001, genetically engineered crops are being grown on over one hundred million acres of farmland.

In Europe, Asia, Africa, Australia and Latin America, the acceptance of genetically engineered crops is much more circumspect. In India, we have been able to prevent the release of any genetically engineered crop so far in spite of a strong nexus between the concerned departments of the government, specially the department of biotechnology (DBT) and the multinationals (MNCs) like Monsanto who are desirous of controlling Indian agriculture through the sale of their proprietary, genetically engineered seeds. The unique selling point of the MNCs in respect of their genetically engineered seeds has been that these seeds offer substantial immediate as well as long-term economic advantage over the conventional seeds with no concomitant disadvantage, something for which no definitive, clear-cut, transparent and firm evidence has ever been presented to the public.

The fact is that, as of today, no country in the world, has a satisfactory system of assessing the risks associated with the release of genetically engineered plants, microoganisms, animals and marine organisms in the environment. Not only that, in the lax environment around the world in this respect what has actually happened is, to say the least extremely disturbing. Thus, the genetically engineered soyabean in which a gene from Brazil nut had been put in to make its protein more balanced, was found to lead to an allergenic response in Americans allergic to Brazil nut. Fortunately, this soyabean was not marketed. However, it has been established that the soyabean flour that was given as a gift by the US to the Orissa famine victims a while ago, was genetically engineered and it is perfectly possible that it could have been the flour that could not be sold in the US.

Recently, a genetically engineered corn marketed by Aventis was found to lead to serious medical problems in a number of individuals, and a high-power committee in the US recommended its withdrawal from the market which, according to Aventis, would take four years, as the genetically engineered corn had already got into the food chain. The much talked about Monsanto's Bt cotton which is supposed to be resistant to certain natural pests such as bollworm, no longer shows the resistance it did in the beginning – so much so that, as of today, Monsanto itself recommends plantation of 40 per cent refuge in the fifth generation of its Bt cotton crop at the same site.

That the multinationals-sponsored genetically engineered agricultural crops have a strong lobby in corridors of power in the US is exemplified by the following incident. A farmer in Canada recently discovered some of Monsanto's GM-plants growing in his farm. Since he had not ordered any GM seeds, his surmise was that the GM-plants must have come from the neighbouring farm which was growing them deliberately. However, Monsanto, instead of apologising to the farmer, sued him. What was incredible was that the court verdict was in favour of Monsanto. Thus the farmer was asked to pay damages to Monsanto for unwanted infiltration of his land by Monsanto's Bt cotton.

Permitting the marketing of genetically engineered seeds by multinational corporations may spell even greater disaster for a country such as India. Our economy is primarily based on agriculture, with some 70 per cent of our population engaged full-time directly or indirectly, in agriculture or agriculture-based related activity (about 1 per cent in the US and 2 to 3 per cent in Europe). Our farmers are, by and large, unaware of the nuances of the new technologies and buy seeds in trust. We have no place in the country where seeds can be tested quickly and cheaply from the genetic point of view, even though India was the second country in the world to develop its own technology of DNA fingerprinting. Further, MNCs are not the most ethical of organisations in the world today. At a public hearing before the Permanent Peoples Tribunal on Global Corporations and Public Harm (formed in 1979 as the successor to the Bertrand Russell War Crimes Tribunal on Latin America) at Coventry in the UK in March 2000, there was a severe indictment of

four MNCs: Monsanto, Union Carbide, Rio Tinto Zinc, and Freeport McMoRan.

The MNCs can market seeds or agrochemicals such as weedicides in our country under various pretexts, without telling the farmer the whole truth. The farmers can be made to sign all kinds of documents without their knowing what they are signing. Monsanto/Mahyco (in which Monsanto has a 26 per cent stake) in its trials of Bt cotton permitted by the DBT has not always obtained truly informed consent of the farmers, for example, the farmers were never told that after the first or second plantation, there may be need to put in as much as 40 per cent of refuge plantation. In fact, Monsanto started its first trials of Bt cotton in 1998 even before obtaining the formal written permission of the DBT, as it had apparently made sure of that permission! The trials were thus illegally commenced. Not only that, as the trials were done in some 40 places, the permission should have been obtained from the Genetic Engineering Approval Committee (GEAC) before commencing the trials, as per the then prevalent government rules. However, neither Monsanto-Mahyco nor the DBT were taken to task for violating the rules, thus providing one more example of the nexus between MNCs, the government and the bureaucracy in our country as elsewhere.

Problems and Benefits

Genetic engineering technology is one of the most important technologies that has ever been developed. The enormous variety and the variability that we find in the living universe is a consequence of Nature's random, chance-driven genetic engineering and, as one might expect, the results have not always been good for mankind. Thus, in Europe, hybridisation between cultivated sugar beets and wild beets led to the evolution of weed beets which did not provide a usable product and damaged harvesting equipment, leading to a loss of millions of dollars per year to Europe's sugar beet industry. Escape of the African sub-species of honeybee in Brazil led to the evolution of the Africanised honeybeen in the new world that disrupted the Latin American honey industry, caused human deaths and killed livestock. And hybridisation between wild rye and cultivated rye in north-eastern California led to the evolution of weedy rye which has rendered the region unsuitable for cultivation of both wheat and rye. But these examples are exceptions. As a rule, evolution through natural selection without human interference beyond a point, actsas an impediment to perpetuation of harmful products of nature's random genetic engineering.

With the new genetic engineering technologies designed over the last two-and-half decades, we can now achieve a specifically desired result in terms of changing the genetic capabilities of a living organism. And we can today, do so easily and inexpensively. This has already led to an enormous benefit to mankind. Human insulin was just not available till genetically engineered human insulin came into the market a decade or so ago. The only alternative till then was cattle or pig insulin which some people could not tolerate. Some other important and widely used lifesaving drugs produced through genetic engineering that are in the market are interferon, human growth hormone, Factor VIII, TPA, GCSF, erythropoietin and hepatitis B vaccine. In 1997, the market for genetically engineered drugs (including vaccines) was 50 billion dollars; today it could be around 100 billion dollars, and is likely to rise to 500 billion dollars in the next 10 years or so.

The advantage when one markets chemical products such as drugs made through genetic engineering is that if, at any given time, the product is found to be harmful, one can stop manufacturing it. Thus, tryptophan, an essential aminoacid, which was marketed in the US as a food additive for some time, was made by a Japanese company through genetic engineering – that is, using a genetically engineered microorganism. It turned out that this tryptophan had a contaminant which led to a rare disease. As soon as this was established, the production of genetically engineered trytophan was stopped by the Japanese company. Unfortunately, when we release genetically engineered plants, microorganisms, animals or marine organisms in the environment, it would be difficult to recall any of them – specially in the case of plants, microorganisms, and marine organisms. Thus, while the benefit to agriculture through genetically engineered seeds can be dramatic and has the potential of increasing productivity substantially, if a problem arises there is no way that we can recall all the seeds as, by that time, they would have spread widely. It is, for this reason that an appropriate regulation of the release of genetically engineered living organisms into the environment, has been advocated internationally.

The following problems can arise from release or otherwise widespread use of genetically engineered organisms: (1) Introduction or creation of a new or known toxin or allergen. An example would be the Brazil nut-soyabean case mentioned above. (2) Gene flow that could have adverse effects. For example, market genes conferring antibiotic resistance, that are often used in genetic engineering could be transferred to pathogenic microorganisms, thus making them resistant to antibiotics. It has been recently shown that 10-20 per cent genes have been laterally transferred in the last one hundred million years on our planet. (3) Experimental errors. For example, Monsanto once cloned the wrong gene in canola. (4) Competing of the genetically engineered organism with wild or other desirable strains or varieties on account of growth advantage or other advantages. (5) Interference with a desirable symbiotic relationship. For example, Bt crops could destroy useful insects as well as change the microflora of the soil. The deleterious effect of such crops – at least on a laboratory scale – has been demonstrated on monarch butterflies. (6) Dispersal into areas where positive harm could be done. I will deal with this in some detail later on. (7) Changes in surface properties that may affect normal interaction between species in a viable and useful ecosystem. (8) Reproductive interference. (9) A second-site change. Thus, an insertion of the desired gene in the genetically engineered organism could take place not only on the desirable but also at an undesirable place in the host genome, which could have deleterious effects. (10) Increased selective transcription and translation. Transcription and translation are processes in cells which lead to the transmission of information contained in the genetic material, DNA, to proteins. Vast changes in concentrations of precursors following genetic engineering could, in some cases, lead to increased transcription or translation of certain genes, leading to an undesirable imbalance in the cell. (11) Changes in relative concentration of intracellular metabolites. This again could lead to metabolic imbalances as in the case of tryptophan mentioned above. (12) Development of resistance to the trait that is introduced. Development of resistance in insects to the Bt toxin produced in genetically engineered Bt plants, such as Bt cotton, is now widely known requiring, as mentioned above, plantation of refuge non-Bt crops to attract the insects

that are resistant to Bt. (13) Pleitropic effects leading to unexpected undesirable changes, for example, in ecology. In fact, six areas of such effects have been identified: metabolism, tolerance of physical factors, behaviour, factors regulating or releasing populations, demography and life history, and morphology. In GMOs, any one or more of the above could be drastically changed. The above-mentioned six classes of changes could lead to more than 70 identifiable phenotypic changes and more than 30 potential ecological effects. (14) Crossing of country or region boundaries. For example, US transgenic corn has been very recently (in 2001) found to be growing wild in Mexico in a region which is a recognised global centre for corn biodiversity.

Crossing of Region Boundaries by GMOs

Genetically engineered organism can cross national boundaries either unintentionally or as a result of deliberate human decision and effort – exactly as in the case of any other living organism. Some of these transfers can be beneficial, some harmful. Example of beneficial transfers of non-GMO's through history would be the mango in the US and the potato in India. In this context we should take into account the following factors that may put a recipient country at risk in respect of a GMO coming into its territory, either unintentionally or as an act of deliberation that may or may not involve the consent of both the parties (the 'donor' and the 'recipient'): (a) An underdeveloped capacity to identify and assess ecological concerns, as evidenced by insufficient scientific infrastructure to create inventories of biodiversity and assess the ecological and economic importance of biotic holdings. (b) A climatic pattern, soil-composition and social structure that is different from the country of origin of the GMO. For example, where there is a lack of dramatic seasonal change (as in the case of absence of a cold winter), the environment may be at a greater risk of damage due to introduction of new organisms including GMOs. (c) The lack of ability to extrapolate the results of testing for ecological risks, when the original testing was done in different climate. (d) The presence of a variety of crops that are not extensively different from the wild types, in the recipient area. In such places, if the vigour of these near-wild-type crops were artificially increased by gene flow from a GMO, the crops could become ecological problems. (e) The presence of centres of crop origin and genetic diversity in the recipient region. These pools of genetic reserves are critical to the development of new strains to meet the challenges from new diseases, pests, and changing climatic conditions. (f) Lack of adequate quality-control facilities and of resources and personnel to validate the claims in regard to the GMO made by the donor country, and to detect, monitor and analyse any unusual health effects of the GMO. For example, the discovery of the new disease, eosinophilia mylangia that was somehow caused by two batches of L-tryptophan made by genetically engineered bacteria referred to above, was facilitated by the fact that many of the people who died or were crippled, lived in the vicinity of the Mayo Clinic in Rochester in the US, a world centre for the analysis of unusual illnesses. If the L-tryptophan had been marketed in a part of the world that was not so fortunate as to have a facility like the Mayo Clinic, the very fact that there was an epidemic might have gone undetected, the product might not have been withdrawn, and the deaths and crippling might have continued.

The presumptive roots of local and global dispersal that many GMOs, like their microbial, plant or animal relatives, are likely to follow after intentional or unintentional release, are given in the Table. (Examples given in this table are by no means exhaustive.)

What May We Do?

We have thus a very difficult situation on the one hand we have the above-mentioned very considerable risks of releasing a GMO in the environment while, on the other, we have the tremendous potential advantages, specially for the developing world where we have low productivity in the agricultural sector and high incidence of disease in the health sector.

The answer would lie in setting up an appropriate protocol for risk assessment in respect of a GMO if it is intended to be released in the environment. We would then also need a trade-off policy which would balance the residual risks that would always remain no matter how stringent and

Table

Hitchhiking on Human Forms of Transport

Shipping at sea and on large lakes and rivers
- ballast water and sediments, e g, marine larvae, shellfish, fish, arthropods, microbes, molluscs and algae
- on all the surfaces and crevices of boats below water line, e g, marine larvae, shellfish, fish, microbes, sedentary marine organisms, arthropods, molluscs and algae
- on surfaces above water line, e g, bacteria, bacterial and fungal spores and plant seeds

floating oil and gas drilling platforms, e g, a variety of marine organisms
aircraft, e g, live plants, seeds, insects and other terrestrial arthropods
ground transport, e g, live plants, seeds, small mammals, microbes, insects and other terrestrial arthropods, pollen, and soil organisms and seeds when bulk soil, manure or compost is transported *recreational boats*, e g, freshwater fish and invertebrates, algae and microbes
containers used to transport live organisms, e g, plants, fungi, seeds, fish, insects and bait buckets with fish or invertebrates
containers used to transport food including live organisms travelling with frozen foods, seeds within fresh fruits and vegetables and grain crop seeds
transport of crop seeds, cuttings, and nursery stock, e g, microbes and insects
on and in human bodies especially bacteria and viruses
trash/refuse/garbage, e g, microbes and insects
navigation canals allowing active dispersal of mobile organisms, e g, fish
transfer of water between municipalities and regions, for domestic and industrial use and irrigation, e g, microbes, protozoa and viruses.

Natural Routes of Dispersal

Flowing water, e g, microbes, fish, algae, aquatic insects, fish, arthropods and molluscs
subsurface flowing water, e g, soil microbes and invertebrates, and cave organisms
on waterfowl and shorebirds, e g, microbes, small invertebrates and plant seeds
terrestrial vertebrates, especially mammals, e g, seeds, pollen, and small invertebrates
terrestrial and flying insects (flies, bees, ants), e g, pollen, seeds, microbes, and mites
rafting on logs and larger floating 'islands' broken away from shorelines on lakes, rivers, and seas, e g, many kinds of terrestrial organisms
ocean and lake currents, e g, multicellular and unicelloular algae, larger aquatic plants, invertebrate larvae, fish and microbes
atmospheric circulation with subsequent deposition as rain, snow and dry fall, e g, bacterial and fungal cells and spores, pollen and airborne plant seeds
autonomous locomotion, e g, flying, walking and swimming organisms
tornados, cyclones, hurricanes, floods, e g, microbes, seeds, insects and birds

Notes: Presumptive routes of local and global dispersal that many GMOs, like their microbial, plant, or animal relatives, are likely to follow after intentional or unintentional release, and during transport of people and goods. The example given are not exhaustive.

practical the risk assessment procedure is, against the potential and decisive advantages and benefits that may follow the release of the GMO in the environment. It is of course, implied that the process of risk assessment would involve a stepwise controlled release of GMO, before it is finally released freely and publicly, exactly as is done in the case of prescription drugs that have to go through phase I, phase II, phase III, and phase IV trials before they are made available for public use.

We must recognise that, as of today, we do not have a satisfactory risk assessment protocol for GMO, which would take into account all that has been said above, in place anywhere in the world, leave aside India where, over the last few years, we have made a mockery of even the highly unsatisfactory protocol that exists – thanks to vested interests. And we do not have anywhere a same policy in respect of the trade-offs mentioned above.

Relevant Information

What is, however, clear today is that it would be necessary to obtain the following information (as applicable) for risk assessment in respect of the GMO that is intended to be released in the environment for commercial purposes without containment:

(1) Molecular characteristics of the GMO with complete information on the site and sequence of every genetic change that has occurred in the GMO.
(2) Details of the technology, with all steps clearly stated, that was used to effect the above-mentioned genetic changes (intentional or unintentional).
(3) Automated karyotyping and gross chromosomal analysis.
(4) Details of plasmids, transposons or insertion elements introduced.
(5) Properties of the product of the gene(s) considered to be introduced (allerginicity; toxicity: will it lead to resistance to a microorganism or pest?).
(6) Growth characteristics of the GMO (comparison with the starting host organism).
(7) Nutrient, soil, climatic and other requirements of the GMO (comparison with the host or wild type).
(8) The nature of interaction (including symbiotic) with other organisms (comparison as above).
(9) Nutritional and toxicity studies with the organism or its product that may be intended to be used as food.
(10) Dispersal patterns of the GMO where applicable, and comparison with those of the starting organisms.
(11) Gene flows from the GMO under normal ecological conditions.
(12) If the GMO is a plant, the viability of hybrids (comparison as above).
(13) If the GMO is a plant, its biomass productivity.
(14) Gross chemical composition of the GMO.
(15) Details of any structural or surface changes in the GMO.
(16) Impact on ecology in controlled field trials.
(17) Reproductive interference if any.
(18) The manner and mode of the use of the GMO. (When and where will it be grown, harvested and processed? If it is to be grown in a containment facility, what are the chances of its escape?)

As of today, there is no GMO that has been released anywhere in the environment for which we have all the above information. Concurrently with the efforts to obtain the above information on a GMO, one would also need to make a realistic assessment of the benefits that would accrue to the society if the GMO is released in the environment and made publicly available. This would involve an assessment of the claims made by the producer of the GMO in the socio-economic contexts in which it is intended to be released. This assessment would be best done by committee (let us call it Committee 1 for GMOs) consisting of experts in the particular field which the GMO is intended to address, along with appropriate sociologists, economists and policy-makers.

Ideally, the report of this committee should be available before the process of risk assessment actually begins; however, if this is likely to cause undue delay the report should be made available as soon as possible after the beginning of the process of risk assessment.

Coming to risk assessment itself, it should be clear that this would be a highly specialised job. The responsibility of providing data in respect of the parameters mentioned above, should rest with the organisation that is intending to derive commercial benefit from the marketing of the GMO. It would, however, help and make the process credible and transparent if there are reliable contract research organisations, both in the public and the private sector, which would do the kind of studies on GMOs mentioned above. As of today, such organisations are rare anywhere and they certainly do not exist in our country where for example, there is no organisation which would test, on a reliable commercial basis, whether a seed is a Bt seed or not. I have, on several occasions, suggested to the director-generals of CSIR and ICAR to jointly set up commercial organisation in the public sector for this purpose. I would imagine that one of the reasons why this has not been set up (besides that of jurisdiction) would be that the presence of such an organisation might be detrimental to the marketing (authorised or unauthorised) of genetically engineered seeds in the country by the MNCs.

We obviously need another committee (let us call it Committee 2 for the GMOs) that would need to assess all the information that is provided on the above-mentioned 18 points by the organisation that intends to market the GMO. This committee should obviously, again consist of experts who are not only familiar with all the science involved, but also understand the socio-politico-economic implications of the release of the GMO. One of the responsibilities of both the above-mentioned committees should be also to monitor on a continuing basis the performance of the GMO if it is finally permitted to be released in the environment.

In the Indian context, it is specially important that both the above-mentioned committees operate in close collaboration with each other within a framework of total transparency. The commitment of the members of the two committees to fairness and objectivity and to the country and the society must never be in question; in fact, there should be objective proof of this for each individual member. The committees will need, at times, to take courageous decisions. Its members should, therefore, be known for their ability to do so and not to succumb to pressures; in other words, the public credibility of the members must be high. The committees would need to set up a machinery for evaluation on a continuing basis.

Biotechnology Commission

I strongly feel that in view of the potential of biotechnology, including in areas such as genetic engineering, there is a case for the government of India to set up a strong Biotechnology Commission which would then appoint and coordinate the work of the above-mentioned committees. The members of the commission should obviously satisfy the criteria of a

high level of professional competence, social commitment, courage, fairness and objectivity, transparency, administrative ability and public acceptance.

As of today, in our country, the clearance of a GMO has to go through two committees, the RCGM of the DBT and the GEAC of the ministry of environment. I believe that both these committees, with the solitary exception of the decision taken by the GEAC under the chairmanship of the new secretary, environment and forests, at its meeting in August 2001, at which it did not permit Monsanto to immediately release its Bt cotton in India for commercialisation, have suffered from the following flaws: (a) they have been professionally incompetent, inexperienced and unknowledgeable, especially about the world scenario; and (b) they have shown virtually a total lack of social commitment, courage, integrity and transparency.

Thus, taking the much publicised case of Monsanto's Bt cotton as an example, neither RCGM nor the GBAC who dealt with the case, did so in a transparent manner. The minutes of the meetings of these committees should be in public domain but those who have tried to obtain these minutes have never been able to do so openly. The RCGM never went through an adequate and appropriate assessment of Monsanto's performance, which alone would have cautioned the RCGM to handle Monsanto specially carefully. (Did RCGM, for example, look into the past record of Monsanto in respect of the numerous unethical and immoral practices in which it was involved and the fine it has paid to the government in the US in spite of its effective lobby in the corridors of power in the above country?) Then, the RCGM permitted trials initially in 40 one-acre plots, making a total of 40 acres which would come under the purview of GEAC. The RCGM never made the required site visits during the first trials of Bt cotton by Monsanto. There are strong reasons to believe that there was virtually no professional assessment of the results of Monsanto's trials which were never made public. Further, during the trials, neither the RCGM nor the GEAC ensured that Monsanto obtain a truly informed consent of the farmers.

Genetically engineered organisms are like nuclear power; they can play a role, for example, in transforming agriculture. However, they can also do an enormous harm if not regulated. The regulatory system must, therefore, be set up with the utmost care. It is clear that the present system is unsatisfactory. Leaving everything as it is but effecting only a cosmetic change such as having a single-window clearance system, without bringing about a sea change in its structure, will not help. If we wish to use the new genetically engineering technologies to help safeguard both our health and agriculture and the integrity and independence of our country, we will need to change the ship, the crew, and the direction of travel all together. The question is: Will we ever learn lessons from the past and be truly concerned about the future? In 2000, the US courts awarded US $ 145 billion damages against the American tobacco giants. We would surely not want a similar situation to arise in our country in respect of GMOs!

Finally, should we not be also looking at alternatives to GM crops – that is, practices and natural and other non-GM seeds that will give us the same advantages that GMOs claim to offer? To be able to do all this, given the situation mentioned in this article, worldwide and in India, would it not be wise to put a moratorium and the release of any GMO in the environment, for a period of five years or so during which we set our house in order in respect of the required regulatory procedures? EPW

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