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Socio-Economic and Ethical Implications of Various Agricultural Biotechnology Interventions

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Biotechnology is the application of biological methods or processes to produce useful products. The ancient Egyptians were credited with the invention of fermenting beer by using yeast. Indians have been making curds by using biological cultures for centuries. Several conventional biotechnology processes and approaches are in use in India. Some of them are mentioned below:

1. Fermentation or conversion of substrates into desired products by biological processes.
2. Downstream processing for recovery of metabolites.
3. Use of microbes or enzymes for producing value added products.
4. Sera, vaccines and diagnostics produced by conventional methods.

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5. Reproduction, artificial insemination and embryo transfer technology for animal breeding.
6. Methods for fish spawning induction.
7. Plant cell or tissue culture.
8. Biofertilizers.
9. Biopesticides.
10. Shelf life improvement.
11. Industrial waste treatment.
12. Plant breeding based on marker aided selection.
13. Vermi culture

Farmers have been selecting and sowing the seeds from plants with beneficial characters, such as higher yield, better nutrition and resistance to diseases and pests etc.

Unknowingly, they have been modifying the genetic make up of plants and animals, albeit slowly. The power of these practices was enhanced dramatically in the twentieth century by breakthroughs in basic science of genetics, leading eventually to modern hybrid seed varieties for important food crops such as maize and by mid century, to high yielding "Green Revolution "seed varieties for wheat and rice.

In 1973, scientists began engineering recombinations of DNA molecules by moving specific genes carrying desired traits from a source organism into the DNA of a living target organism. This genetic engineering technique, which is commonly referred as genetic modification (GM), seemed to promise not only greater range and speed for genetic modification processes but also greater control over the outcomes.

However, it took more than two decades to develop and commercialize GM crops during the mid-nineties of twentieth century. Due to the 'permissive' policies followed by United States, Canada and Argentina, the GIVE varieties of corn, cotton, soybean etc., spread rapidly in these countries. But in Europe, where 'green' parties are strong and where a ' mad cow disease' crisis in 1996 sensitized the media to food safety issues, the GM crop revolution encountered strong social resistance. European Governments are following 'precautionary' policies and have imposed separate labeling requirements on GM foods since 1997. These divergent policies toward GM technologies in the developed countries have now created a complicated problem of policy choice in the developing world. Caught between the bulls and bears of GM crops, scientists in the developing countries are engaged in the task of maximizing the benefits from GM crops while keeping the risks down to the acceptable levels.

The Green Revolution technologies were universally accepted without much protest or opposition. The plant breeding methods that were used to evolve high yielding varieties and hybrids were considered 'natural' as there was no transfer of genes across species. But the genetic engineering techniques employed in GM crops also involve transfer of genes between species and sometimes, even from plants to animals and the *vice versa.* Such a transfer of genes between unrelated species might appear' unnatural' and 'immoral' to the conditioned psyche of people in the developing countries. Besides the perceived risks of GM crops affecting the health of humans and animals, these 'moral' or 'ethical' concerns about some techniques of modern biotechnology such as cloning and genetic engineering are contributing to the mounting opposition to GM crops and modern biotechnology. But the eventual acceptance of these technologies would depend upon the objective merits and demerits of these technologies rather than on the subjective feelings, which may subside as more and more such breakthroughs occur. But, at the moment, the socio-economic and ethical concerns about the new agricultural biotechnology interventions may be limiting their acceptance by the producers and consumers.

1. *Cost-Benefit Analysis of Biotechnologies*

There are not many studies that attempted a systematic economic analysis of different biotechnology innovations. However some rough estimates and *ex ante* economic analyses are available. An attempt is made to collect and present these estimates to give an indication of their economic viability.

(*A*) *Vermicompost*

Vermi composting is an effective process of recycling farm residues by using earthworms to increase humus content in the soil. Earthworms can convert about 1000 tonnes of moist organic wastes into 300 tonnes of rich dry vermi compost. In 45 to 60 days one Kg of earthworms can produce roughly 10 kg of vermi-castings. The economics of a commercial vermi compost unit are summarized in Table 12.1.

Table 12.1 Economics of a Vermiculture Unit in $^1/_2$ acre site

Non-Recurring Expenses	Rs.
1. Construction cost of sheds (180 x 6 x 5ft)	60,000
2. Cost of sprinkler system - 1 HP motor and water tank of 250 litres capacity	1,60,000
3. Borewell, pipes, Pump + 5 HP motor	1,60,000
4. Electrically operated cutting machine including motor	15,000
5. Cost of planks, spades, Bamboos etc	10,000
6. Compost storage shed of 1500 s. ft	60,000
7. Weighing machine, motor cycle, Telephone etc	30,000
Total	**4,95,000**

Table 12.1 *Contd..*

Recurring Expenses	Rs.
1. Salary of a manager and a salesman @ Rs 5000/pm	60, 000
2. 4 labourers to fill 5 trucks daily (annual wages)	96,000
3. Electricity & water charges	18,000
4. Cost of Vermi castings for 20 beds @Rs.5/Kg (for 2500 kgs)	12,500
5. Empty gunnies	24,000
6. Watering charges (Per year)	1,10,000
7. Cost of 100 tonnes of FYM @ Rs. 500/ ton	50,000
8. . Other miscellaneous charges	18,000
Total recurring Expenses	**3,88,500**
9. Interest and Depreciation charges on non-recurring items @ 25%	1,23,750
Total Costs	**5,12,250**
Revenue from 300 tonnes of Vermi compost @Rs 2/Kg	**6,00,000**
Benefit-Cost Ratio = 6,00,000 : 5,12,250 = 1.17.: 1.00	

Source : Raw Data drawn from Venkataratnam.L and G. Purushottam reported in Mediplorama, 2000

A commercial scale vermi composting unit can give a return of 17 per cent on the investment.

(*B*) *Biofertilizers*

Biofertilizers are microbial inoculants and they enhance crop production through improvement in nutrient supplies and their availability to crops. The potential benefits from using *Rhizobium* inoculation for some legume crops were estimated by Wani and Rao (1996) with the assumption that inoculation would increase yield by 10 per cent to 50 per cent of the area under the crop (Table 12.2).

Table 12.2 : Potential benefits from using *Rhizobium* inoculation for selected legumes in India

Crop	Area (million ha)	Avg. Yield (Kg/ha)	Increased Yield (million tonnes)	Price per tonne US $	Economic Benefits (million US $)
Chick Pea	6.46	673	0.22	206.0	45.32
Pigeon Pea	3.63	663	0.12	235.0	28.24
Groundnut	8.35	1060	0.44	264.7	116.47
Moong bean	3.54	482	0.06	235.3	14.12
Black gram	3.61	521	0.09	233.5	21.18
Lentil	1.17	662	0.04	206.0	8.24
Soybean	3.63	856	0.15	200.0	30.00
Total			**1.12**		**263.57**

Note: 1 US $ = Rs. 48.00

Source : Wani, S.P. and J.V.D.K. Kumar Rao, 1996

Wani and Rao also estimated the potential benefits from using N_2-fixing bacterial fertilizers for some selected cereal crops in India (Table 12.3). These estimates were based on the assumption that inoculation would increase yield by 10 per cent for sorghum and pearl millet, 15 per cent for rice, wheat and maize on 50 per cent of the area shown.

Table 12.3 : Potential Benefits from N_2 -fixing bacterial fertilizers for selected cereal crops in India

Crop	Area (million ha)	Avg. Yield (Kg/ha)	Increased Yield (million tonnes)	Price per tonne US $	Economic Benefits (million US S)
Sorghum	12.9	900	0.58	88.2	51.2
Pearl Millet	9.5	530	0.25	88.2	22.0
Rice	42.0	1880	5.67	105.9	600.5
Wheat	24.9	2370	4.43	111.8	495.3
Maize	5.9	670	0.30	91.2	27.4
Total			**11.23**		**1196.4**

Note: 1 US $ = Rs. 48.00

Source : Wani, S.P. and J.V.D.K. Kumar Rao, 1996

Although these potential benefits of biofertilizers in legumes and cereals appear to be very high, they will be realized only when the use of biofertilizers in these crops picks up and reaches 50 per cent of the area under these crops and the expected yield response of 10 to 15 per cent materializes.

Another important biofertilizer is blue green algae. It is recommended for use in rice crop. An estimate of its economic viability is presented in Table 12.4.

Table 12.4 ; Economics of Blue Green Algae Project (For a unit with production capacity of 50000 packets of 100 gms each)

A	**Project Cost**	**Rs. Lakhs**
1.	Factory shed/building	54.50
2.	Plant & Machinery	10.00
3.	Fees for Technical know-how	10.00
4.	Miscellaneous fixed assets	1.67
5.	Preliminary and pre-operative expenses	13.33
6.	Provision for contingencies	7.95
7.	Margin money for working capital	6.66
	Total	104.11
B.	**Viability Indicators**	
1.	Internal Rate of Return	29%
2.	Cash Break Even Point	41.94% (in first year)
3.	Debt Service Coverage Ratio	1: 1.29
4.	Pay Back Period	7 years

Source : Technology Profiles circulated at Entrepreneurs' Meet on Biotechnology, Hyderabad, 1999

(C) Bio-Agents

Bio-agents like *Trichogramma, Chrysopa, Coccinellids, Baculo viruses* etc., are being multiplied and supplied to the farmers for the control of pests. This is a highly capital-intensive activity requiring huge investments. The project economics of a bio-agents production facility are presented in Table 12.5.

Table 12.5 : Project Economics of a Bio-agents Production Facility

Project Cost	Rs. in Lakhs
1. Land and Site Development	5.00
2. Building	24.00
3. Plant & Machinery	8.50
4. Miscellaneous fixed assets	8.00
5. Technical know-how fees	16.00
6. Pre-operative expenses	6.00
7. Margin money for working capital	1.50
8. Contingency/escalation costs	4.00
Total	**73.00**
9. Operating Cost	125.00
10. Turn Over	
(i) *Heliothis NPV*	84.00
(ii) *Spodoptera NPV*	84.00
(iii) *Trichogramma NPV*	84.00
(iv) *Trichoderma*	2.00
Total	254.00
11. Performance Indicators	
(i) Break Even Capacity	40 tonnes
(ii) Payback Period	3 years
(iii) Internal Rate of Return	35%

Source : Technology Profiles circulated at Entrepreneurs' Meet on Bio-Technology, Hyderabad, 1999

(D) *Biopesticides and Plant origin Insecticides*

Several biopesticides are in use today. Biopesticide products are based on natural agents such as microorganisms and fatty compounds. They are toxic to targeted pests and do not harm humans, animals, fish, birds and beneficial insects.. One of the most common microorganisms used in biologically based pesticides is the *Bacillus thuringiensis* or Bt, bacterium. Several of the proteins produced by the Bt bacteria are lethal to individual species of insects. The European corn borer, one of the most prevalent pests, costs the United States $ 1.2 billion in crop damage each year. The bio-pesticides which are quite effective against this pest can cause a considerable saving even if they succeed in preventing 25 per cent of the losses.

As the interest on organic fanning and integrated pest management is growing, plant origin insecticides like neem and tobacco formulations are gaining the acceptance of the farmers. During the last few years, there has been a marked increase in the use of neem formulations containing *Azadirachtin* as active ingredient both in India and abroad. In view of the growing demand, researchers are selecting superior trees (upto 0.8% *Azadirachtin* concentration) and propagating them through vegetative or tissue culture. A tissue culture protocol for large scale micro-propagation of neem was developed and standardised with the help of which a multiplication ratio of 1:10 in two and half months time was achieved. Farmers are planting these tissue culture neem clones in degraded lands with a hope to reap profits.

The economics of Neemgold 1500 ppm, a product of SPIC Ltd., Chennai are presented below in Table 12.6.

Table 12.6 : Economics of Neemgold (1500 ppm *per litre*)

		Rs. in lakhs
1.	Manufacturing cost	101.55
2.	Market expenses	24.00
3.	Sales Commission	20.00
4.	Royalty	2.00
5.	Excise duty and sales tax	6.15
	Total Cost	**153.70**
	Expected price	200.00
	Net profit	**46.30**

Source: Technology Profiles circulated at Entrepreneurs'. Meet on Biotechnology, Hyd, 1999.

(*E*) *Micro-propagation of Plants*

Micro-propagation technology offers genetically identical plants popularly called as clones. The plants produced through tissue culture are free of diseases, pests and nematodes. Many companies are successfully producing tissue culture plants. The economics of a tissue culture project which can produce 3 million tissue culture plants per annum are presented below in table 12.7. This project requires a water supply of 25,000 litres per day and a power of 125 HP.

Table 12.7 : Project Economics of a Tissue Culture Laboratory

A.	**Project Cost**	**Rs. in lakhs**
1.	Land & Site Development	8.00
2.	Factory Shed/Building	45.00
3.	Plant & Machinery	75.00
4.	Other Fixed Assets	
	(i) Green House	15.00
	(ii) Electrical	15.00
	(iii) Furniture S Fixtures	3.00
5.	Know-how fee	25.00
6.	Pre-operative Expenses	20.00
7.	Margin Money for Working Capital	8.00
8.	Contingencies and Location	10.00
	Total	**224.00**

Table 12.7 *Contd..*

B.	**Operative Cost**	**Rs. in lakhs**
1.	Consumables	10.00
2.	Salary & Wages	*16.00*
3.	Administrative Costs	9.00
4.	Selling Expenses	4.00
5.	Market Expenses	6.00
6.	Power & Fuel	15.00
	Total	**60.00**
C.	**Economics**	
1.	Cost of Production/plant at 80% capacity	3.75
2.	Average Selling Price/Plant	5.00
3.	Profit Margin/Plant	1.25
4.	Interna! Rate of Return	25%
5.	Payback Period	5 years

Source: Technology Profiles circulated at Entrepreneurs' Meet on Biotechnology, Hyderabad, 1999

(*F*) *Genetic Engineering*

Genetically modified plants are created by the process of genetic engineering that allows scientists to move genetic material between organisms with the aim of changing their characteristics. In the absence of solid data on the impacts of modern biotechnology, some ex-ante evaluations are presented below.

Evenson (1994) evaluated the efforts to introduce insect resistance and disease resistance into rice under the Rice Biotechnology Programme of the Rockfeller Foundation, which was initiated in 1985. His estimates of the effects or benefits of Rice Biotechnology Programmes are presented in Table 12.8.

Table 12.8 : Estimates of Effects or Benefits of the Rice Biotechnology Programmes

Traitor Benefit	Time to Production		Area (million ha.)	Yield Increase (%)	Quantity (m. tonnes)	Value (Billion Rs.)
	Optimistic	Conservative				
Multiple Insect Resistance	12	21	37	30	41	8.0
Multiple Disease Resistance	15	22	50	15	27	5.4
Total Annual Benefit						13.4

Source : Evenson, R.E., 1994

As can be seen, the estimated annual benefit ofusing insect-resistant and disease-resistant transgenic rice plants in farmers' fields is 13.4 billion dollars. The benefits are expected to start around the year 2012 (the mid-point between optimistic and conservative estimates). The Rockfeller Foundation's investment in the rice biotechnology programme between 1985 to 2012 would be approximately 0.3 billion dollars. The total financial support for rice biotechnology programmes from all other sources upto 2012 have been estimated to be about 2.4 billion dollars. Thus projected annual benefit, starting from the year 2012. would be approximately five times (13.4 / 2.7) larger than the total estimated support by Rockfeller Foundation and other sources between 1985 and 2012. A different way of calculating the annual benefit / cost ratio after the year 2012 is to divide $13.4 billion (total annual benefit) by $0.15 billion (estimated annual investment after the year 2012), which gives 90 as the benefit / cost ratio.

(G) *Pricing of Biotech Seeds*

Let us assume that the 'Bollguard' cotton that Mahyco (Maharashtra Hybrid Seed Company) - Monsanto Research Foundation is presently testing in the farmers' fields passes through all stages of testing successfully and gets permission for commercial marketing. We further assume that it gives a 10% higher yield than the best ruling hybrid in all the irrigated cotton tracts, besides saving the cost of plant protection by Rs.1000 per hectare. The comparative economics are worked out and presented in Table 12.9.

Table 12.9 : A Hypothetical Example of Benefits and Pricing of 'Bollguard' Cotton

Pricing	Ruling Hybrid (Rs)	Bollguard(Rs)
Cost of seed (Rs/ha)	1500	-
Total cost of cultivation other than cost of seed (Rs/ha)	15000	14000
Total returns (Rs/ha)27000	29700	
Farmers' profit before paying for seed (Rs/ha)	12000	15700
Farmers' profit after paying for seed (Rs/ha)	10500	
Value addition due to Bollguard	-	3700

Source: Rao K.P.C. , 2000

Given these hypothetical figures, the question arises as to at what level will Bollguard seeds, sufficient for planting one hectare, be priced? We can visualise several alternative scenarios.

1. The company may price them at Rs. 5200, thereby expropriating all value-addition due to their innovation,,

2. The company may price them at Rs. 2500, if it figures out that the additional cost of research and development can be recovered by charging an additional price of Rs. 1000 per hectare over the present ruling price.

3. The company may price them at Rs. 3350, so that the value-addition due to new seeds is evenly shared between the company and the farmers who use the seeds.

Many skeptics think that the company may opt for scenario (i). In their perception, the company will fully exploit its monopoly to corner all benefits of innovation. But in reality, the company may not opt for this scenario because farmers will have no interest in using the new seeds if they do not get any benefit out of their usage. This will seriously constrain the demand for new seeds. Those who have experience with public sector agencies would wish that the company would opt for scenario (ii). But any company, which has taken risks and has invested money on an innovation, would not price its seeds merely on cost-recovery basis. The company may, instead, follow a middle path and opt for scenario (iii). It would enthuse the farmers to try the new seeds, as they will share about one-half of the benefit value-added by them. At the same time, the company will reap good returns on its investment, expand its sales and would have interest in further investing in the development of new bio-technology products.

But this scenario will last only for a short while. In the long run, as the new seeds are adopted by more and more farmers, the supply of cotton in the market would increase markedly, causing a fall in the price of cotton (may be not in absolute terms, but in real terms). That is the point when consumers will be getting their share of the benefit. But if cotton price falls, the value-addition due to innovation decreases and the company have to reduce its price. Thus, the new technology benefits all: the company, the seed growers, the farmers, and the consumers who use cotton-based products.

While the companies may come out with several new biotechnological products, all may not find acceptance with the farmers. For instance, the Roundup Ready (herbicide resistance) seeds of different crops may have very limited acceptance in India, because the use of herbicides itself is quite restricted in the country.

As more and more biotechnologies are released, their economic viability will be assessed based on micro-level data. *Ex-Poste* studies will grow in number, although *ex-ante* studies also have their relevance in case of emerging technologies. In any case, farmers will only adopt those biotechnologies, which are expected or believed to give a reasonable rate of return on the investments.

II. CONCERNS ABOUT BIOTECHNOLOGY

The environmentalists, who are critical of biotechnology, have been raising several social, religious, ethical and biosafety issues, some of which are summarized below:

1. Ethical

(i) Should we alter the genetic structure of the entire living kingdom in the name of utility and profit?

(ii) Is there something sacred about life or should life forms, including humans, be viewed simply as commodities in the new bio-technological market place?

(iii) Do biotechnologists feel that they are masters of nature? Is this an illusion constructed on scientific arrogance and conventional economics ignoring the complexity of ecological processes?

(iv) Will some countries be plundered for their genetic resources?

2. Biosafety

(v) Is it possible to minimize ethical concerns and reduce environmental risks while keeping the benefits?

(vi) What will consumers be told about the new food products obtained through biotechnology (Right of the consumer to know)?

(vii) Will food from modified crops be safe?

(viii) Will food from modified plants have a different nutritional quality from that of the food it replaces?

(ix) Will modified plants transfer their introduced genes into wild relatives growing nearby?

(x) Could the planting of a restricted number of cultivars lead to a reduction in biodiversity and an increase in susceptibility to diseases?

3. Social

(xi) How will the structure of farming (particularly in developing countries) be affected by biotechnology?

(xii) How will patent laws affect the rights of traditional breeders? (For example, the right to save seed from one year to the next)

(xiii) What share of public resources (both financial and human) will be diverted to biotechnology research?

4. Economic Competition

(xiv) Is the genetic make up of all living things a common heritage of all or it can be appropriated by some Corporations and thus become a private property of a few?

(xv) Who gave individual companies the right to monopolise over, entire group of organisms?

In view of the above concerns expressed by the skeptics of biotechnology, the role of the Government as the Regulatory Body attains importance. Some of the regulatory issues to be addressed by the Government are:

Regulatory Issues

1. Do current regulations give sufficient protection to farmers, consumers, those who have invested in research and those engaged in research?
2. Is there sufficient international legislation to ensure environmental protection?

3. Do current regulations compromise the competitiveness of biotechnology companies by being excessively restrictive?
4. Labelling of genetically modified crops
5. Financial investment by the government and industries in biotechnology.
6. Need to ensure transfer of technology to farmers and access to seeds.

III. *EQUITY ISSUES*

Another debate that is taking place in the country is about the class of farmers that would benefit from the new biotechnology innovations. Some argue that only the rich farmers would benefit from the innovation because poor farmers will not have the ability to invest, nor the ability to take risk with a new technology. Some others argue that; since the biotechnology innovations can be cost-saving, they would benefit the small farmers also. While these conflicting views are being voiced, the first group of analysts is apprehensive that the income distribution will worsen, and the second group of analysts expects that it would improve.

The experience of Green Revolution was that the rich farmers could reap the early gains from the new technologies. But subsequently, institutional mechanisms like custom hiring of tractors, water purchase from tube wells etc., made the new technologies accessible even to the resource-poor farmers and they also shared the benefits of technology, albeit, a little later. A similar trend may appear in case of biotechnology products as well. It is also established that whenever technology benefits the farmers, the demand for labour as well, as the wage rates paid to them also increase. The secondary effects of technology contributed to the improvement of vertical income distribution. But, the Green Revolution technologies were noted to have increased the horizontal income inequalities between irrigated and rainfed areas. Will the same experience be repeated with biotechnological innovations?

Has biotechnology something to offer to people living in the ill-endowed regions? So far, biotechnology innovations have concentrated largely on insect-resistance and herbicide-tolerance. Ill-endowed regions like dry lands, saline-alkaline soils, degraded lands etc., would need tolerance to abiotic stresses to be built into seeds. The famous Dr. Anand Chakravarthy case relates to the invention of a microorganism that could eat up oil spills. Although there are no indications to that effect as yet, we may, by the same token, imagine microorganisms that can convert saline-alkaline soils into fertile fields. It may be mentioned that a Calcutta-based scientist recently claimed to have introduced successfully a salt-tolerant gene from the wild rice grown on the seacoast into cultivated varieties of rice. This success may be the first step in the evolution of high yielding rice varieties with the salt tolerance built into them. If such innovations materialize, biotechnology can reduce even horizontal income inequalities by aiding the development of backward regions and areas.

IV. RELIGIOUS BELIEFS AND DIETARY RESTRICTIONS

As modern biotechnology involves transfer of genes across species and even from plants to animals and the *vice versa,* certain religious sentiments and dietary restrictions of the people may come in the way of adoption of some biotechnologies, even when they can yield high pay-offs to investments. Transfer of any animal genes to plants may cause an alarm to the strict vegetarians. Transfer of any genes from cows or pigs to plants or other animals may cause resentment among Hindus and Muslims respectively while consuming the modified food substances. But, vaccines or insulin developed from animal tissues are being accepted for medicinal purposes by the vegetarians. Going by this example, there may not be any opposition to GM foods on religious grounds. However, the mischief that, fundamentalist forces of any hue or shade can play through orchestrated campaigns should not be underestimated. Time and experience can only tell whether or not the religious sentiments and dietary restrictions can hinder the acceptance of GM foods. The only way to blunt such campaigns is by way of education and informed discussions that an introduction of a single gene from somewhere would not alter the taste or composition of the food substances.

V *BUILDING PUBLIC AWARENESS AND DEBATE*

In a democratic society, awareness campaigns and debates are necessary to appreciate the intentions and purpose of biotechnologists. Modern biotechnology has opened up the possibilities to reduce pollution and to improve the health and nutrition of human-beings. Even now, the functional literates constitute a small minority in the country. For centuries, people have lived with religious beliefs and superstitions. To make them appreciate the scientific inventions and discoveries, skillful campaigns are necessary.

Experiences with Green Revolution

Over the last 54 years after independence, some headway was made in this regard. When Mashuri variety of rice was introduced, there was an apprehension that its consumption causes knee-joint pain. But after a decade, consumers have given it the top preference for consumption. How the initial objection was overcome ? Just by education and experience. Consumers also believed that food grown with chemical fertilizers does not have the same nutritive value as that grown with organic manures. But, later this resistance was overcome. Of course, now the issue has completed a full circle with the quality experts and rich consumers preferring organically grown food that does not have any residues of pesticides. The farmers and consumers may also accept GM foods in the same way as long as it is proved that they do not have any deleterious effects on health and nutrition of humans, animals and plants. The reduction in pesticide use should lead to a lower level of residues and to a positive preference of GM foods, if lasting resistance to pests and disease can be built into plant varieties through modern biotechnology.

Social scientists, who should contribute to the debate and public awareness of GM foods, have to adopt as neutral a stance as possible. Like any other section of the society, some of them may tend to sweep aside the risks in order to accelerate the materialization of benefits to the public, while some others may exaggerate the risks and downplay the benefits of modern biotechnology. Despite such extreme positions taken by some individual social scientists, the overwhelming majority of social scientists are expected to take a dispassionate and objective view of this contentious issue,

Better Chances of Acceptance of GM foods

In less developed countries like India, people still spend a considerable part of their income on food (about 30 to 50 per cent). In the developed countries of Europe, food expenditures are below 10 per cent of the total expenditures. If the genetic engineering technologies can reduce the unit cost of food substances by 10 per cent, it may not mean much to European consumers, but the same can improve the access to food in case of consumers of developing countries, particularly in case of those below the poverty line. Poor people are known to take greater risks for survival and development than the rich. In view of these well-known facts, the GM foods may be accepted better in developing countries, if it is proved that they have both cost-reducing and health-enhancing properties. Notwithstanding these stylized facts, a proper assessment of safety of GM foods is absolutely necessary. Both the testing processes and science-based debates should be as transparent and impartial as possible.

Infrastructure for Biosafety Tests

Farmers' Organizations, Consumer Associations and Non-governmental Organizations should also be involved with the implementation of effective biosafety protocols. Presently, we are relying on toxicology institutes for this purpose. We need separate institutions to look at toxicology and biosafety aspects of agricultural products. We have developed such protocols for drugs and to some minor extent for industrial pesticides and chemicals but nothing at all for biological products. Today, the drug industry in developed countries produce 60000 to 80000 new molecules every month that go through 30 different tests. They are screened cell-based and each of them costs about 20 to 30 million dollars to buy. If the Indian Council of Agricultural Research (ICAR) or State Agricultural Universities buy those Cell-screening Systems, large numbers can be screened very quickly, instead of using animal systems and then wait for an extended period of time to get the final results. India also lacks a smooth and fast protocol for field trials- of transgenic plants before they can be released commercially. Similarly, we don't have adequate standards for animal biotechnology.

After strengthening infrastructure and protocols for a speedy and comprehensive assessment of biosafety, the results are to be shared widely with the stakeholders. Of course, there is one problem in case of biotechnological innovations. With the strengthening of intellectual property rights (IPRs) as required by the World Trade Agreement (WTA), there is a lot of awareness and interest in patenting the products and processes rather than in publishing the results. Of course, disclosure *is* a pre-condition *for* grant of any forms of IPRs. But the lure of commercial exploitation of new products and processes may delay the availability of results to the; common public. Not withstanding this limitation, there is a continuous need to publicize the results as early as possible to clear the misconceptions and prejudices of the public built on rumour and ignorance.

Dissenting voices of Environmentalists

Some self-styled environmentalists have seen violence in the green, blue and white revolutions ushered in the past few decades. But it is these revolutions that have averted a 'red' revolution by increasing the physical food availability faster than the population growth and'by making it economically accessible to the vulnerable sections of population through the reduction in the real costs of food articles. It is an irony that scientists responsible for green, blue and white revolutions are remembered and admired much less than these self-styled champions of peoples' interests. Two centuries of slavery and the resultant scourges of poverty, illiteracy, inequality and dependency have provided fertile grounds for sowing the seeds of doubt by these professional agitators to reap the benefits of fame and recognition. This is not to ignore or to sweep aside the problems of resource and environmental degradation that have assumed alarming proportions because of wrong priorities and deferred investments. In fact, considerable resources should be allocated to rejuvenate the basic resources and environment to their past glory. But in this effort, we should use all the advances in science and technology to keep up the increased and diversified supplies of food and other articles while simultaneously restoring resources to the pink of their health. In a resource - scarce country like India, we can ill afford to ignore the cutting edge technologies that are advancing by leaps and bounds in other parts of -the world.

Fear of the Multi-National Corporations

For a Nation fed on the slogans of socialism and public sector, private sector and profit are not decent words. But we have long realized that the public sector failed us and that the egalitarian society was only a dream that was never achieved. The new economic policies of liberalization, privatization and globalization are getting a fair trial. In spite of some problems caused by the World Trade Agreement, the country is learning to face, negotiate and grapple with the issues related to international trade. The entry of multi-national corporations either by themselves or in partnership with local firms is a fact that we should reckon with. History is replete with examples that the social returns from technologies are much higher than the private returns expropriated by any form of private organization. Of course, monopolies resulting from mergers and acquisitions are a cause of concern. We should try to increase competition in the game of invention by investing heavily in the public sector laboratories and in training and encouraging the promising scientific workers in the field of Biotechnology. Strengthening of Intellectual Property Rights would motivate and aid the processes of technology generation. While emphasizing on the need for adequate testing of biotechnology outputs, we should not develop a prejudiced view against the private companies or, for that matter, multinational companies. The government should ensure that the free choices of producers and consumers would prevail. Safe products of biotechnology research, if found to be having the potential to increase output and to reduce cost and pollution should be welcomed irrespective of the source of their origin.

VI. KEY MESSAGES

Some key messages that should find a place in the public awareness campaigns for scientists, policy makers, NGOs, extension workers, farmers and consumers may be summarized as follows:

1. Science and technology have unlimited potential to solve the problems plaguing our society.
2. Human societies have always opposed new discoveries due to the fear of unknown.
3. Nothing should be pre-judged based on prejudice or fear.
4. Technologies that perform well will eventually be accepted by the society.
5. Adequate and comprehensive testing of new products is necessary.
6. Stakeholders have a right to know all the pros and cons of a new technology.
7. Healthy debate leads to a resolution of conflicting perceptions and to the emergence of a consensus.
8. Social and moral concerns may limit the acceptance of new technologies.
9. Objective facts will eventually score over subjective beliefs.

10. Social returns from technologies are much higher than private benefits.
11. Priority setting in research can lead to a better focusing on the needs of the poor.
12. All sections of society will eventually benefit from new technologies, although they may be received by a particular section in the first instance.
13. A liberal and democratic society is the best bet for informed discussion and rational choices.
14. Regulatory bodies should carry out their jobs in a strict, impartial and transparent manner.
15. *Ex-Ante* and *Ex-Poste* evaluations of new technologies are needed for rational decisions.
16. Competition and rewards are necessary to support inventive activity.
17. Competitiveness has to be improved along with quality of products.
18. By developing legal and institutional safeguards, conflicts in the interests of different sections can be resolved.
19. Socio-cultural development of have-nots is as much important as their economic empowerment.
20. Widespread validation is needed for adoption and adaptation of technologies by the farmers.

VI. STRATEGIES TO REACH TARGET GROUPS

In a differentiated and multi-layered society like India, a combination of strategies is required to take the messages to all sections of the population. Some of them are :

1. Wide spread testing and validation of research results is required to evolve technologies relevant for different sections of the farmers.

2. Demonstrations of proven technologies are necessary to convince the farmers.
3. Awareness campaigns about new but proven methods through mass media are necessary to develop interest in them.
4. Subsidizing organic inputs and promotion of environment-friendly methods of production will help in early adoption of new technologies.
5. Training and skill development can have high pay-offs in the long run.
6. Producers / consumers associations and clubs to discuss and debate about new technologies.
7. Farmers can be involved in research initiatives in a partnership or participatory mode.
8. Contractual arrangements between companies and farmers to ensure supply of quality inputs and processing facilities.
9. Non-governmental organizations to complement the efforts of governmental agencies in public awareness campaigns and debates.

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