IS AGBIOTECHNOLOGY SUITED TO AGRICULTURAL PRODUCTION IN INDIA?

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The Life Science industry is fond of referring to Agbiotechnology as the 'Evergreen Revolution' in an obvious effort to link it with the Green revolution, which is viewed favourably by most policy makers in developing countries. However there are crucial differences that make the two technologies fully different in their approach to agricultural production.

The Green Revolution was a publicly owned technology, belonging to the people. The research was conducted with public money to fulfil a public need, inadequate food production, and it created public goods to which everyone had access. There were no Intellectual Property Rights (IPR), no patents vested in multinational companies, no proprietary technologies or products. If there was ownership of the GR, it was vested in the farmer. Once the seed reached the farmers, it was theirs; they moved it where they wanted. Therefore despite its faults, the Green Revolution addressed farmers needs and India's food production showed an upward curve.

The Evergreen Revolution is almost the exact opposite. It is a privately owned technology. Six corporations (Monsanto, Syngenta, Bayer Crop Science, Dupont, Dow and BASF Plant Science) control practically the entire research and output in the field of transgenic plants. Processes and products, including research methodologies are patented and the farmer has no control on the means of production. The seed belongs to the company. With the development of the 'terminator' or sterile seed technology, the farmer is just a consumer. The Evergreen Revolution has in its 20 years, not yet produced a crop variety that has any direct connection to hunger and nutritional needs. The most prevalent crops remain corn, soybean, cotton and canola and the dominant traits are herbicide tolerance and insect resistance. Despite its other faults, the Green Revolution was able to put out a number of crop varieties in a short span of time that enabled direct yield increases.
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India, which had adopted the Green Revolution, is set to adopt the Evergreen Revolution too but there is no debate about the path that Agbiotechnology should take in India. There is neither consultation with the public nor any sharing of information with stakeholders. The Department of Biotechnology has promoted research projects randomly in universities and research institutions, without any assessment of farmers' needs and the best way to fulfil them; civil society has been demanding participatory decision making and a consultative process; the media is largely uninformed and political leaders have no say in determining the agenda for Agbiotechnology.

There is little evidence to support the claim that GM technology will feed the world or increase food supply. Hunger is a complex issue. In India we have seen the paradox of overflowing buffer stocks coexisting with endemic hunger. A multi pronged approach may make a dent in hunger; techno-fixes are unlikely to. Safe and meaningful GM technology may make a contribution but other factors will remain overwhelmingly important.

GM Technology and Sustainable Agriculture

Genetic diversity is the basis of agriculture and food security in the long run. Its importance cannot be underestimated. Any technology, which results in a loss of genetic diversity, goes against long-term food security and sustainable agricultural production. It is the diversity of genetic material that enables the stability and viability of farming systems because it enables farmers to plant a wide range of crops and therefore insure against biotic and abiotic stress. It is genetic diversity that can tide through adverse conditions. The genetic erosion begun with the introduction of the high yielding varieties of the Green Revolution will get worse with GM technology. The entry of GM crops along with the aggressive marketing of a few proprietary varieties is going to accelerate genetic erosion further.

Poverty, agricultural intensification and structural changes of the kind dictated by the IMF and World Bank, have already contributed to marginalisation of small farmers and environmental damage. GM crops are likely to exacerbate these problems. They are also likely to worsen the inequalities in agriculture, both between the North and South as also between large and small farmers. This technology threatens to marginalize small farmers further and establish the dominance of corporations. This has serious implications for the self-reliance in agriculture and food production that developing countries have been striving for.

Is the GM Approach the Best Way?

The cynical view that problems in the farmers' fields are not what drives GM research but the margin of profits, gains credibility when we see the approach of the industry to agricultural problems. There is little acknowledgement of the fact that there are likely to be non-GM alternatives that are better adapted and cheaper for solving an agricultural problem.

The much-celebrated Golden Rice is a good example. If the goal was to increase the nutritive quality of rice, is genetic engineering the only way or the most suitable way? Rice diversity in rice growing regions is likely to reveal several varieties that are naturally rich in iron and beta-carotene. Some are already identified. They can be source materials for breeding programs to produce more nutritive rice. The 'black rice' found in parts of Madhya Pradesh is known to local people as a rich source of nutrition. ICRISAT has already presented its Golden Millet, a variety of pearl millet bred from two lines of high nutrition millets obtained from Zambia **(1)**.

The National Center for Genetic Engineering in Thailand has shown a breakthrough in salt tolerant rice, not through genetic engineering but through scanning the genetic diversity in the country's rice gene bank. Faced with the restriction on growing GM crops, scientists in Thailand began to search their own gene banks for salt tolerant strains and found good, well adapted varieties that can be used in breeding programs. Scientists have selected four indigenous rice varieties that can with stand high levels of salt.

Genetic variability can be screened at a fraction of the cost of a genetic engineering program seeking to incorporate traits from some exotic species. Farming communities have a vibrant knowledge of the properties of varieties and land races that are grown in their region. This can be an important clue in tracing and selecting varieties with useful traits that can be used in breeding programs. When no clues are found and conventional breeding fails to provide an answer the GM option can be tried.

Another example of a successful alternative to the GM approach is the breeding of non-gluten rice. A Japanese company Orynova was engaged in breeding non-gluten rice and long before it could report any significant success, another company had already placed a non-GM non-gluten rice on the market **(2)**. There is a lesson here for those who are promoting the view that GM is the only answer to solving problems in agriculture and for national research programs in developing countries that attempt to be trendy by jumping on to the GM bandwagon without evaluating the other strategies in their own systems and their genetic diversity, for leads.

Is the Bt route of disease resistance as in Monsanto's Bt cotton and corn, the only way to introduce disease resistance or are there more effective approaches? Is this strategy, which requires diversion of 20% of the land to maintaining an insect refuge, really a viable approach in developing countries where every inch of arable land is needed to produce food? Can we afford to divert land to maintain this artificially constructed method of introducing disease resistance when other approaches show promise?

Should we not invest in developing bio -control agents, bio pesticides and sophisticated Integrated Pest Management (IPM) techniques? Promising results are coming in from work on bio-intensive IPM systems using biopesticides and closely related synthetic analogues. Spinosad, developed by Dow Agrosciences is a bioinsecticide developed from the fermentation of an actinomycete species. Another agent called azoxystrobin is a reduced risk fungicide and is a synthetic analogue of a natural fungal metabolite, selling well already. Jasmonic acid being investigated for triggering the plant's own defenses against pathogens is showing promising results **(3)**. Experiments in tomato show that the application of jasmonic acid triggered a response causing the plants to produce chemicals that served as a signal to insect predators **(4)**.

Results from a recent study done in China **(5)** provide exciting evidence that genetic diversity is the most sustainable approach to disease resistance. Zhu and his colleagues planted a simple mixture of rice varieties in thousands of farms in Yunnan province, and were able to arrest the development of rice blast, the most significant disease of rice, which is spread by a fungus. The level of rice blast was so hugely reduced that farmers stopped using fungicides. This is a far more sensible and sustainable approach to disease resistance and in any case, more appropriate for India and developing countries.

How Much and What Kind of GM Research?

A question that all developing countries must ask themselves is how much of their research budgets they should invest in GM research. It is an expensive science and its accomplishments are meager so far. In developing countries science administrators and funding agencies are placing unrealistically large amounts of money on biotech research. This is leading to neglect of other branches of research crucially needed for agricultural production, a process that will have a greatly negative impact in the coming years. A poorly framed research proposal with a GM component is more likely to get funded than a sensible, hand on project on good, conventional scientific principles.

And how much of its modest budget should India apportion to GM research when its post harvest losses can go up to as much as 30 % of harvested food due to bad storage, leaky transportation, rodent attacks and inability to reach the market. If increasing the amount of food available is the central aim, surely it would be intelligent to try to save as much of the food that is already produced but which is getting lost/wasted at present. Would it not make more sense to replace the poorly maintained trucks from which grain spills continuously on the roads as it is transported from the field; to build sound, properly ventilated grain warehouses where damp and rodents do not destroy the grain that is stored; to build roads leading out of the village so that farmers can bring their perishable produce to the next available market. This may sound pedestrian, plodding stuff compared to glamorous science but its results are guaranteed unlike the technology fix approach. Money is constrained in developing countries and it needs to be wisely spent on areas where better results can be anticipated.

If the amount of food produced is to be increased, is GM the only route to do it? There are studies, which have shown truly impressive gains in increasing the production of food crops like wheat and rice and vegetables. In most parts of India, the yield potential of the varieties in the field is not fully exploited, due to lack of resources and infrastructure and sometimes lack of proper information. A recent study **(6)** shows that farmers in the state of Bihar in India were able to increase their yields of rice and wheat by 2.5 to 3 *times* through a systems approach to changing farming practices. These impressive yield jumps were the result of educating farmers in managing their resources better and by proper training in simple practices like line sowing rather than broadcasting seed, early nursery raising, reducing seed rate in the nursery and thinner transplantation in the case of rice, as well as reducing the amount of fertilizer and water used. There is clearly a need to invest in inexpensive, common sense training of this kind which increases food production by up to 300%, rather than looking for a GM bandwagon to jump on to.

Another approach, which does not make headlines but shows impressive results in increasing rice production, is the System of Rice Intensification (SRI).This is also a systems approach where the basic strategy is to create soil, water and nutrient conditions for young plants that will accelerate growth **(7)**. Rice yields have been reported to go up to as much as 10, even 12 tons/hectare when average yields in Asia range between 2- 4 tons, depending on soil, water and other conditions. The higher yields are achieved because the plant shows greater root growth, greater tillering and a positive correlation between number of tillers per plant and grains per panicle. Besides Madagascar where it was initially developed, SRI is being tried out in 15 countries including China, Indonesia, Philippines, Cambodia, Sri Lanka and Bangladesh. Everywhere, it is showing substantial increases in rice yields. There is a need to examine low cost strategies of this kind and disseminate them widely.

The Focus of GM Research

The focus of GM research has little relevance to the needs of developing countries or small farmers. The industry's focus is on soybean, corn (yellow corn for animal feed and industrial use, not white corn for food), canola and cotton. The two principal traits it has chosen to focus on are insect resistance and herbicide tolerance. The needs of developing countries are crops like pulses, millets and fodder; and traits like biological nitrogen fixation and enhanced nutritional uptake.

Should India Cultivate GM Rice?

Should India Cultivate GM Rice considering it is a 'high risk' area, being a major center of origin and diversity for rice? A center of origin is from where a particular crop originated a few thousand years ago. Food crops, as we know, are not collected from the forests; they were developed (bred) by a careful process of selection and crossing, by tribal and farming communities from the wild plants found in nature. India is one of the centers where rice originated so lots of rice varieties and the plants related to rice (wild relatives) are also found here. This means that the greatest number of rice and related genes are found in India, particularly in the Jeypore tract of Orissa, and the swathe cutting across Jharkhand and Chattisgarh, as well as in the Northeastern tract.

Centres of origin are considered high-risk areas for GM crops because if the foreign genes contained in the GM variety were to move into the natural gene pool, the results could be potentially catastrophic. Scientists promoting agbiotech argue that rice is a self-pollinating crop and will not accept outside pollen and genes. This is not true. Several studies exist showing cross-pollination happens in rice. Recent reports from China and Latin America are showing that gene flow between GM rice and other rice happens at rates that are high enough to cause concern. Experiments have also found that the herbicide tolerance gene can move to native varieties and create new, difficult to control, weeds **(8)**.

Too little is understood about what happens when foreign genes are abruptly pushed into the genetic material of living organisms like plants. The Precautionary Principle is central to GM work, dictating that when faced with uncertainty, it is better to be cautious and not proceed. Mexico, the country that is the centre of origin and diversity for corn, has a clear-cut policy. It has imposed a ban on not just the cultivation of GM corn, but also research in GM corn. Mexico has taken this position in order to safeguard the natural gene pool of corn, another major staple food of the world. India must not cultivate GM rice until a solid body of research is done under Indian conditions to understand the implications of foreign genes shifting to rice diversity. Agbiotechnology proponents argue collecting this data could take several years. So be it. One cannot rush when the stakes are so high. In any case, several other lines of research are yielding more promising results than the GM route.

Is herbicide tolerant corn appropriate for India?

Roundup Ready corn, a herbicide tolerant maize variety has been given the green signal by the government. This variety which like Bt cotton, belongs to Monsanto, offers no advantages to the farmer with respect to yield, protection against disease, or improvement in the quality of the grain. Monsanto's herbicide tolerant maize is a variety which contains genes that will allow it to tolerate the poisons contained in the herbicide Roundup, which when sprayed, will kill all the other plants, which become weeds in the field. After spraying Roundup in the field, the Roundup Ready variety will be the only vegetation left standing, all other vegetation will die.

Roundup is a herbicide which also belongs to Monsanto which until very recently held the patent on it. This means that the farmer has to buy the package, the Roundup Ready variety and its matched herbicide, Roundup, since one is dependent on the other. Herbicide tolerance is a clever strategy developed for the company, not the farmer. It allows Monsanto to make a double profit, first on the seed and then on the herbicide. Monsanto has succeeded in promoting its herbicide tolerant crops to the extent that globally, herbicide tolerance is the single most prevalent trait in the cultivation of GM crops, the other being insect resistance, that is Bt. At present, of the total acreage of GM crops, over 85 per cent is devoted to herbicide tolerant crops and the remaining to Bt crops.

Herbicide tolerance was developed as a trait in crops to address the problems of agriculture in industrial countries where landholdings run into a few thousand acres and where practically no labour is available for farm operations. With just two to five per cent of the population in farming, agriculture is largely mechanized. Weed control therefore cannot be done by hand. The preferred way of controlling weeds in these countries is by aerial spraying which is a wasteful and ecologically destructive method. The wastefulness makes it expensive, but in the OECD countries where the agriculture subsidy exceeds one billion dollars a day, cost is hardly an issue! In countries like the US and Canada, agricultural fields are large monocultural tracts with little natural vegetation around. Thus aerial spraying of herbicides would essentially fall on the cultivated area and destruction of natural vegetation will not be on the same scale as what could happen in a developing country situation.

In developing countries, agricultural holdings are small and densely packed. Fields growing different crops neighbour one another and agricultural fields are set within or border natural ecosystems with natural biodiversity. So, if fields of other crops and even borders of natural vegetation or the forest edge flanked a field growing Monsanto's Roundup Ready maize, then spraying the Roundup herbicide would affect the neighbouring crops and natural vegetation (which do not have Monsanto's Roundup resistant gene) and destroy them. This kind of GM technology cannot be considered desirable either from the point of view of farmers or the biodiversity.

The herbicide tolerant trait should not be allowed in India or other developing countries for important economic and health reasons. In these countries weeding is a source of many benefits to the rural community. A weed is only a plant that is growing at the wrong place at that time. It is not a useless plant. Weeding provides wage labour to agricultural labour, which is usually the land-less farmer. In addition, women mostly do the weeding, providing them with a direct, and often only, income source. Using the Roundup Ready approach will kill this source of income. So in India, rather than the chemical route of herbicide tolerant plants and the double deal for the company with the proprietary herbicide, the socio-economic interest of the community lies in manual weeding.

Even more importantly, the rural household consumes all the plants that are collected as weeds. Many of these are leafy greens like amaranth (the same plant which is contributing the protein gene for the efforts to make a protein rich GM potato), a rich source of vitamins and minerals. This highly nutritious source of food is available for free and goes into the cooking pot of poor rural families, one of the reasons why rural nutrition is far better than urban nutrition. What the family does not consume serves as fodder for the livestock maintained by the family as an additional source of income. 'Weeds' are also medicinal plants that are used by the rural community for their health and veterinary care needs.

Problems of Regulating GM Technology in Developing Countries

The regulation and implementation of GM crops in India and many developing countries is proving to be difficult. There has been little effort to educate farmers in the practicing principles of the new technology and science administrators tend not to differentiate between the practices required of GM and non- GM crops, adding to the problems of implementation. Illegal plantings of GM crops are known from India and Thailand and are certainly more widespread.

The case of Bt cotton in India **(9)** shows that when it came to the crunch, the Indian regulatory agency the GEAC (Genetic Engineering Approval Committee) collapsed and was not able to perform its mandated duty, that of halting a violation and penalizing the offenders. A few years ago, Bt cotton plantings were detected in 11,000 acres in Gujarat, which had not gone through the regulatory process. A private seed company Navbharat Seeds had sold the illegal Bt cotton variety to farmers in Maharashtra and Gujarat.

The GEAC has failed over a period of years, to take any action against Navbharat's transgressions so the market is awash with seeds of the illegal, unregulated cotton variety. These illegal seeds are now sold openly in all the cotton growing regions in India. So far no action has been taken against any body dealing in the unauthorized seeds.

The fundamental problem of regulation in developing countries is weak public institutions and untrained regulators. The regulatory committees are overwhelmingly bureaucratic and packed with ex officio members rather than people with any technical competence in risk assessment and biosafety. Public regulatory institutions in India therefore lack the capacity to play a strong and independent monitoring role. India should not permit the cultivation of GM crops until a responsible regulatory structure is put in place and oversight and monitoring systems are proven to be alert and competent. Responsible stewardship has to be the basis of technology adoption, at present this is absent.

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