From Lab to Field: Understanding the Social Implications of Genetically Modified Crop Technology in India

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Abstract:

The paper traces the underlying ideologies, forces and factors that have set GM crops in motion throughout the world, especially in developing nations like India. It looks at the debate between the opponents and proponents of Genetically Modified (GM) Crops with special reference to the Indian scenario. However, no monolithic praising or condemning ofGM crops has been resorted to. It describes both the versions- Pro- and Anti- of GM crops. The paper briefly identifies the public health risk and implication of GM crops. Moreover, it briefly Towards the end, the paper gropes to explore whether thereis any meeting ground or balance possible between the two versions.

"... walk on the legs of innovation and solidarity and work with one hand for food production and with the other for environment."

Keyword: *Genetic Engineering crops*

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Introduction:

Alteration of genomes in different organisms including animals and plants, has been taking place for centuries so as to produce specific, selective and desirable characteristics and modifications. The genetic changes in agriculture are often directed towards increasing produce, food quality and resistance to pests and diseases. In past these modifications in agriculture set-ups were done in traditional ways. However, the advancements in science, especially in the field of biotechnology and biochemistry, the whole process gets sophisticated through which prolific knowledge about genes and genetic engineering is applied to get the desired traits in agricultural and food produce.

Background:

The modern process of genetic engineering can trim and isolate a single gene with a specific and desirable trait and the same gene can be transferred from on crop species to another (Bruce & Bruce, 2014). Moreover, the technology also enables to transfer gene/s from other organisms like rat into any plant species like brinjal. The whole process is quite different from the traditional modes of genetic transfer where hundreds and thousands of genes get transferred from one species to another in not so controlled manner as it is done in the modern processes of genetic engineering (Bruce & Bruce, 2014; Tiedje et al,1989). This modern process dates back to the early 1970s when GM technology was experimented *in vitro* settings. Its application has greatly been developed and extended with high end sophistication into the field of agriculture, medicine, environment and food production (Pental, 2003). The manufacturing industry and research & development in the sector have been witnessing huge revolutionary transformations which has motivated multinational corporations to make huge investments in the GM technology (Oliver, 2014; Robert, 1999*).*

Genetic Engineering and Crops:

The genetic modification technology involves the identification of a particular gene in a species linked to a specific trait or characteristic which is desired and to be transferred to another organism. In other words, GM crops are developed by taking genes from organisms like bacteria, virus, etc and inserting these genes into the genome of crops, so that new traits, like pest & drought resistance, are developed in the engineered crop (Maghari & Ardekani, 2011; Bawa & Anilakumar, 2013). For instance, in Bt Cotton and Bt Brinjal, genes from an organism, *Bacillus thuringiensis* is inserted into natural cotton or brinjal genome; the genes of that organism express in the engineered crops seeds and, henceforth, the new desirable traits are developed. Moreover, the nature of the technology is such that the developers use 'terminator/ suicide genes' in the GM crops that makes it non- renewable, i.e. the seeds that are produced by GM crops after one season are sterile. In short, the GM crop-seeds are viable for only one season. This 'terminator technology' is to prevent the patent infringements of the agribusiness corporations who are involved in the propagation of GM crops in the world (Dalazen & Merotto Junior, 2016). The genetic engineering has been variedly used in plants

and crops to produce whole plants and their food products that are used in everyday life across human societies. The technology has greatly been used in plants, vegetables and many other crops and end products including tomatoes, soya, maize, rice, yeasts, cotton, brinjal, and different types of protein, oil, beverage and flour. Especially, in case of end-products derived out of GM crops it is being argued that these foods or edibles are refined to such extent that these do not contain any genetic material or modified protein from other organisms. In fact, as argued, these products cannot be distinguished from those produced in traditional manners (Robert, 1999). However, the foods and other products derived from genetic modifications is generally defined as a food which is, or which is made from, a genetically modified organism" and which contains genes or protein material due to this biotechnological alteration.

GMCs as a panacea for Global Food Crisis and Hunger- A Debate:

Since 1992 Rio earth summit majority of nations around the globe fortified their positions that biotechnology could improve food security, health care and environment (Bender, 2001). On the similar lines, the agri-business corporations proposed the developments in biotechnology like GM technology as an ultimate solution to eradicate hunger and global food crisis. In the present context, the argument that the adoption of GM crops into agriculture for solving the global hunger and food crisis has got caught into an intense political and public debate throughout the world. The three reactions to this debate are revolving around ‘‘acceptance’’, ‘‘rejection’’ and ‘‘precaution’’ with respect to the adoption of GM crops. Theproponents who accept or are favoring the adoption of GM crops see it as a panacea for the global hunger and food crisis. It is argued that the population across the globe in increasing rapidly and making sure to supply adequate food and nutrition this growing population is regarded by the proponents of GM crops to be a bigger and crucial challenge for future. GM foods are deemed to promise to meet this need in a number of ways by developing high nutritive quality, crop-resistance to pest and diseases; tolerance to herbicide, adverse climate, water-scarcity and salinity. In other words, the three-trait technology proposed by the agri-biotechnologist and agri-business corporation specifically focuses on controlling rampant use of harmful chemicals; increasing quantity, quality and storage life of crops and prevent farm and crops from climatic adversities.

The proponents of GM crops heavily rely on this three-trait technology by emphasizing that the overwhelming damage to farm and crops from insect pests results in huge financial losses that inturn greatly impacts the local populations and regional economies of many nations whose priority sectors are agribusiness. Moreover, the uncontrolled use of chemicals in the form of pesticides or fertilizers contaminates the food and other edible products and also its potential hazard to environment and water sources is not scalable (Maji, Dwivedi, Singh, Kishor & Gond, 2020). The GM technology offers to greatly reduce the cost of growing crops or brining these to market. It is projected that through these genomic innovations there is drastic reduction in the use of chemicals to protect crops from pests and diseases, and that it

also facilitates their early introduction into markets, which is claimed to be benefitting farmers extensively (Pental, 2003). Moreover, it is also projected to reduce impact on environment by reducing high and rampant use of chemicals in agriculture sector. On similar lines, the GM technology makes it possible to introduce climate-specific traits in crops like anti-drought, anti-saline or anti-freeze gene in plant genomes that is claimed to enable crops to tolerate extremes of heat, saline or cold condition across diverse agricultural zones (Chandra & Pental, 2003). These innovations are believed to be ready to revolutionize agri-food industry by allowing agricultural activities in region which were inhospitable or unsuited for plants and crops. Additionally, it is also possible to enrich nutritive value of exiting food crops like rice or other grains by introducing specific genes into the plants genome that greatly enriches its protein, vitamin and mineral composition. In collaboration with pro-GM lobby corporations, many non-profit agencies, like Rockefeller Foundation, have sponsored similar GM research and lab activities. Moreover, the level of acceptance or adoption of the GM crops across nation could assessed from the following fact that the majority production of GM crops at global level is heavily controlled by agri-business corporations with huge increase in GM production across previous two decades. The transgenic processes have transformed the agriculture sector in such countries (Maghari & Ardekani, 2011). As claimed by the proponents of the genetically engineered varieties in agriculture, the adoption of the new biotechnology many milestones have been achieved (Thamarajakshi, 2001; Pental, 2003; Whitman, 2000).

Between 'Claimed Benefits' and 'Apparent Risks'- A brief:

The opponents of the adoption of GM crops vehemently focus on the bio-safety and impact of the genetically engineered varieties on human health, environment and natural biodiversity. They generally take either a ''rejectionist'' approach or a ''precautionary'' approach. The former group of the opponent so GM crops completely ''rejects'' the new biotechnology of the engineered crops and strongly advocates for the adoption of traditional and conventional varieties and practices in agriculture to increase the production and productivity. A somewhat moderate group, the precautionary group advocates for the strict testing of GM crops before their environmental release (Ando & Khanna, 2000), and thereafter, infallible regulation and monitoring. The European approach to GM crops could accurately be identified with the ''rejectionist'' ideology while the precautionary approach towards the GM crop adoption is being shown by the developing nations like India. Nonetheless, the two approaches, more-or-less, equally consider bio-safety an important aspect that needs serious attention in the whole GM driven innovations. Since they have an adverse impact on environment, health and biodiversity as evidence across the globe is emerging.

The fact that GM technology embeds specific genetic material into diverse genomes for desired traits it must also be noted that these engineered genomes remain active in the biosphere which may pose threat to national biodiversity and may incite unwanted genetic

modifications. Precisely for this reason we have lobbies and critics across the globe against transgenic agri-technologies who either vehemently reject this technology altogether or sensitize stakeholders to follow a precautionary approach. Nonetheless, there are evidences emerging that contest the claims made by pro-GM lobbies that the GM crop-adoption has increased production or has greatly benefitted the farmers. In a survey, conducted by Department of agriculture (in AP) 71% farmers reported low yield when compared to local hybrids (Stone, 2002). With respect to yield of cotton growing countries the average cotton yields have stagnated or at best remained neutral, since the adoption of Bt cotton (Kuruganti, 2009; Trivedi, 2008). Pertinently, the agriculture secretary (Gujarat) wrote to the chairperson of GEAC:

> "Yes, the productivity which was 175 kg/ha in 2002-03 is touching 460 kg/ha in 2004-05. But this is not solely due to Bt cotton hybrids as Gujarat recorded 450 in 1998-99 when there was no Bt cotton. In our opinion, all these years were good years of rainfall, with low to medium bollworm activity, hence this increase." *(*cited in Kuruganti, 2009)

Thus, the opponents of GM crops contest that the productivity of cotton in India, after adoption of Bt cotton, increased due to increase of irrigation facility by massive water harvesting programmes; rainfall; low pest pressure; black soil and farmers" experience (Durant, 2006; Ramanna, 2004). Likewise, there is a clear trend of yield (relative) growth declines in the case of soybean after the advent of the transgenic, herbicide-tolerant soybean in the US, (Meyer et al 2007 in Karuganti, 2003). In China"s Xinjiang province, that contributes 30% to cotton produce of the country, witnessed 3.74 times increase in its production of cotton. The reason, however, was not the adoption of Bt cotton (as it had only 7 % GM adoption rate) but the primary causes of increase were conventional varieties and traditional experience based technology *(*Xiaoling et al, 2006). Thus, it come to the forefront that the yield are much more complex than a linear function of technology.

Moreover, in the case of developing nations like India, the illegal adoption of GM crops of various varieties without any regulation and monitoring could have serious implications. As various reports indicate, especially the human health studies and the livestock mortality reports, there are serious shortcomings in the bio-safety testing of the country (Kuruganti, 2006; Patel, 2007). In terms of the enforcement of the regime as it exists, there are numerous reports which have repeatedly pointed to serious bio-safety violations and the regulators have proven themselves incapable of fixing accountability in each such case. Thus, in the present scenario there is an intense debate between the proponents and opponents of the GM crops, at both public and political levels. On one-hand, the increase in production and productivity with environmentally friendly ways is claimed and on the other hand, the bio-safety and the hazardous impact of GM crops on human and environment is emphasized. There seems to be no meeting ground between the two approach and understandings. One works at the behest of the agri- business

corporations, who control the GM crop and seed markets throughout the world. The enormous expensive research is being conducted to develop the GM crops, and support the same with the research backed and funded by the same corporations to mediate the construction of the market for GM crops worldwide. The pro-GM positions are grounded in the socially-embedded market, techno-scientific, non-deliberative and neo-managerialist constructs *(*Bender, 2001). It emphasizes the scientific analysis and objective rationality in understanding the problems of the world and also develops and suggests the strategies to deal with these problems on the similar lines. Infact, the markets are socially constructed by buyers and sellers, and markets are embedded in the broad socioeconomic environment in which they exist. Those seeking toconstruct a market for the GM crops using the existing commodity markets as a platform conflict with the sociopolitical environment that withholds normative and regulatory legitimacy from this outcome (Ibid*)*. Consequently, the opponents‟ positions regarding the GM crops are grounded in religious, normative, cultural, and collaborative constructs. The groups who oppose the adoption of GM crops are branded as ‘‘neo-Marxist’’, ‘‘socialists’’ or ‘‘anti-technology people’’.

A wide range of issues emerges out of the conflicts between the proponents andopponents of GM crops. The prominent among them could be identified as:

1. The integration of scientific progress with the public policy;
2. The impact of the current models of development on the environment;
3. The conflict of interest between the actor’s interests (agri-business corporations) with thatof public;
4. The relevance of the technological intervention to the cultural constructs dominant in thecommon people;
5. The social construction of market and its opposition in the certain socio-politicalcontext; and above all,
6. The changing role of the State in the dominant neo-liberal paradigm.

Quite interestingly, it must be mentioned that many scientists and researchers have been victimized (under the influence of agri-corporations) who have brought to surface the hazards of GM crops. Like the work (paper) of Chapela-Quist on genetic contamination published by *Nature , was later withdrawn by the Journal, citing „severe criticism".* Pusztai’s who worked ontransgenic potatoes, was victimized by the scientific community backed by the corporations. The Pusztai and Chapela-Quist case are only two of the most dramatic demonstrations of the results of the increasingly commercial environments in which science is being carried out these days (Dubhashi, 2004; Patel, 2007)

Public Health Risks and Implications:

It has been widely debated among few stakeholder groups that transgenic crops or GM foods have complex concerns for environment, public health and economy. It is being understood that GM technology is being used by agribusiness or multinational

corporations for pursuing profit without assessing potential hazards that this technology could have on diverse aspect of human and environmental interactions. These issues become more perilous when governments across the globe seem to be failing to exercise adequate regulatory mechanism on introduction and integration of GM technology with agriculture and economy of given region (Maghari & Adrekani, 2011). The potential risks and hazards of GM crops include:

1. Diminished efficacy of pesticides after introduction of transgenic crops in farms;
2. Genes get transferred to unintended or non-target plants/crops;
3. Harm to other organisms has been reported;
4. Risk to Human Health has been documented ;
5. Unexplored or unknown effects;
6. Impact on socio-economic aspects of farmers and agriculture sector (Prakash,Verma, Bhatia & Tiwari, 2011).

It goes without saying that rigorous and reliable research from an interdisciplinary perspective on the impact of GM technology and its products is inevitable. Yet, many studies and explorations have brought forth certain critical and crucial aspects of transgenic crops and food. Doubtlessly, these genetic innovations have positive implications for agriculture and food systems across the globe. Besides that there is also a huge global lobby against this technology which the opponents claim that it is being abused and misused by the big giant corporations, majorly located in US, which have great global market- and profit-share in the sector. Bringing a GM food to market is a lengthy and costly process, and of course agri-biotech companies wish to ensure a profitable return on their investment. Many new plant genetic engineering technologies and GM plants have been patented, and patent infringement is a big concern of agribusiness. Yet consumer advocates are worried that patenting these new plant varieties will raise the price of seeds so highthat small farmers and third world countries will not be able to afford seeds for GM crops, thus widening the gap between the wealthy and the poor. In the case of developing countries, there had been an increase in the agrarian distress and the suicides among farmers due to the economic strain. The economic cost of buying new seeds every season has driven farmers to extreme poverty and indebtedness, which is the main cause of suicides among farmers in developing countries like India. GM crops would aggravate economic strain, poverty and indebtedness by widening gap between poor and rich, promoting ecologically unhealthy genetic variations, and uprooting traditional and indigenous seed-saving and exchange (Shiva, 1999). In fact, evidence across the different countries indicates the transgenic crops have led to emergence of ‘super weeds‟ and „super pests‟ that has greatly been a worrying cause for farmers and eventually leading to increased the use of chemicals in the past seasons (Kuruganti, 2006, Patel 2007, Murthy, 2001). Also, the possibility of exploitation of farmers rapidly grows as the commercialization of seed technology though GM

technology is tightly controlled by big agri-business houses. For instance, lawsuits filed by Monsanto, an agri-business MNC, against farmers for using 'the Monsanto-licensed GM seeds from an unknown source and did not pay royalties to the company. In fact, the farmers contested that their traditional/unmodified crops get cross-pollinated from someone else's GM crops planted a field or two away *and g*enes are exchanged between plants via pollen (Bender, 200; Pistorius, 1999).

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Green Revolution, Indo-US Agricultural Knowledge Initiative:

Tracing the roots of green revolution, for two decades after 2nd world war, hunger in developing nations was tackled by US food surplus. But with the following economic strain in US and the favoring breakthroughs in agriculture and hybrid technology the 1st green revolution got mediated. The US food aid to India resulted in stagnation and degrading of the indigenous agricultural system, adding serious maladies to the food scenario in the country. When the food aid stopped the problem surfaced throughout the nation and it witnessed food riots across states. Consequently, the influx of hybrid-seeds, fertilizers and the related technology termed to be the 1st green revolution for India (Patel, 2007).

Though the hybrid varieties yielded more than the traditional ones, but this technology heavily depended on increased-irrigation, fertilizers and pesticides. Thus, it had serious social and economic cost that had more serious implications on the hunger and food scenario in the developing nations. In India, green revolution weighed heavy on farmers, who were not able to buy irrigation and fertilizers. The number of smallholdings of farmers dropped by a quarter; risks of defaulting were higher and farmers were driven to poverty by debt, (Shiva, 1989). As the spiral of cost associated with needing increased levels of fertilizer, they were not able to secure the same level of yield. Three quarter of all farmers, cultivating one-third of the country's landmass, continue to be marginalized by Government *(Ibid).* In this context, the solutions provided by agri- business corporations to tackle the prevailing hunger and food crisis were based on genetic

modifications of crops. This is further being mediated by the alignment of the US and Indian elites‟ interests and sharing of common assumptions and values about governance and economic order (Patel, 2007; Sahai, 2009). The Indo-US Agriculture Knowledge Initiative, (a secret attachment to the NUKE 123-deal) is basically for sharing knowledge and working together to develop better way to grow crops and lead a second green revolution. But why? Has the first green revolution achieved what it was supposed to? The Indo-American Knowledge Initiative is to achieve the goal that Indian biotechnology markets remain open to United States, which will have access to Indian biodiversity, genetic material, DNA, etc. The Private companies would develop gene patents and sell them at higher prices to the developing nations. The companies behind the Knowledge Initiative are the same chemical companies linked to 1st Green Revolution; now world's largest owners of seed firms (Mishra, 2005). Reflecting the same about the Indo-US initiative, Suman Sahai, an Indian geneticist, argues:

> "Earlier a private company like Monsanto only had the status of a business entity. Now they can ask the director-general of ICAR to get our vast genetic wealth from any of its more than 200 research establishments." *(in Patel 2007).*

It has opened the political and economic doors to a ''second green revolution‟ based not on fertilizers and improved seeds but this time on biotechnology and genetic engineering-the GM crops. Besides, the Bt Brinjal debate in India demands some attention. The moratorium on the environmental release of Bt brinjal was seen by the anti-GM crop activists as victory for now. It puts on hold the approval given by GEAC for environmental release of Bt Brinjal developed by Maharastra Hybrid Seeds Co. Ltd. (Mahyco). However, the way the Biotechnology Regulatory Authority of India (BRAI) Draft Bill is taking shape, with its draconian clauses to thwart any anti-GM voice, the pro-GM lobby seems to win in near future. It is seen as a tyrannical, secretive and frightening bill to eliminate all the opposition to GM crops (Frontline March, 2010). The bill has imprisonment and fine to dissent against the new technology in agriculture. Even in US there is a three-tier regulatory mechanism, the Bill here, however, proposes a single-window clearing body. It is seen by the anti-GM lobby as to dilute the sovereignty of India in agriculture and essentially about changing Indian regulatory regimes around agriculture so that it suits the American business interests better *(Kurugnati, 2009).*

Conclusion:

The harms and hazards of GM crops are far more that its benefits. More so, when bio- safety of GM crops is not ensured; when faulty regulation and monitoring systems prevail. The solutions to poverty, deprivation and food crisis are seen in faulty technology, neglecting the distal determinants that are located in the wider socio-economic and political contexts. As it is argued that the not physical availability but the problem in food crisis is economic accessibility and affordability, for which the

proponents and promoters of such technology are themselves responsible, in one way or the other. It becomes imperative to state that the 1st green revolution, if there was any, was mediated by the government or simply the State had a central place. Contrarily, the so-called 2nd green revolution of GM crops is out and out driven by the agri- business corporation and seed companies. As is evident from the experience of developing nations (particularly after the neo-liberal turn after 1980s), the governments are used to create such a policy architecture in these nations that facilitates self-benefiting interventions. Lessons need to be learnt from the Cuban experience of the heavy mechanizations and industrialization. It found Industrial-agricultural model to be unsustainable and proposed agrarian reforms. Moreover, they heavily regulate the GM crop adoption throughout the country and allow it very restrictedly, where farmers resort to it not as a matter of course but as a matter of last resort. The farmer is seen as an expert in the use of chemicals and the related technology like GM crop technology.

Thus, it is high time that the stakeholders in the developing countries come to the frontline and re-orient their economic and agricultural system on the publication of knowledge rather than its privatization; develop on the knowledge shared by peers rather than on the wisdom handed down by ''international experts''; and adapting farming to the land, rather than land to crops. The development must emanate from the public's own knowledge initiative, so that socially relevant, economically viable, culturally acceptable and environmentally safe lives are ensured for humans; beyond that, infact.

References:

Anderson, K., and et al (2004). Trade, Standards, and the Political Economy of Genetically Modified Food; *World Bank Policy Research Working Paper* 3395.

Ando, A., W., and Khanna, M., (2000). Environmental Costs and Benefits of Genetically Modified Crops: Implications for Regulatory Strategies; *American Behavioral Scientist; 44:435.*

Bawa, A. S., & Anilakumar, K. R. (2013). Genetically modified foods: safety, risks and public concerns-a review. *Journal of food science and technology*, *50*(6), 1035–1046. Retrieved from https://doi.org/10.1007/s13197-012-0899-1

Bender, K., L., l. & Westgren, R. (2001). Social Construction of the Market(s) for Genetically Modified and Non-modified Crops; *American Behavioral Scientist* 44; 1350.

Bhargava, D; (2009). Insufficient Regulatory Supervision Prior to Release of Genetically Modifi ed Crops for Commercial Cultivation in India; *J. Biosciences.* 34(2), June , 167–168, *Indian Academy of Sciences*.

Bruce, D., & Bruce, A. (2014). *Engineering genesis: ethics of genetic engineering in non-human species*. Routledge.

Chandra, A. & Pental, D. (2003). Transgenic Crops and the Myths; *Current Science*, 84, 381– 387.

Dalazen, G., & Merotto Júnior, A. (2016). Genetic use restriction technologies and possible applications in the integrated pest management. *Ciência Rural*, *46*, 1909-1916.

Das, Kasturi (2006); GM Crops in India: Is the Government‟s Policy Stance Justified?;
Economic and Political Weekly; March 4.

Dubhashi, Devdatt P (2004); Review: GM Foods-Inside Story of Don't Worry [It is Safe to Eat],The True Story of GM Foods, BSE and Foot and Mouth by *Andrew Rowell* (2003), Earthscan London. in Economic and Political Weekly, Jan 10.

Ehrlich, P. R. (1968); *The Population Bomb*, Ballantine Books, New York.

Kuruganti, K (2006). Biosafety and Beyond: GM Crops in India; *Economic and Political Weekly*, October 7.

Kuruganti, K (2009). Bt Cotton and the Myth of Enhanced Yields; *Economic and PoliticalWeekly*; May 30. vol xliv no 22.

Liam, D., (1999): Health Implications of Genetically Modified Foods; *Royal Society Review*, Vol. 14:334.

Maji, S., Dwivedi, D. H., Singh, N., Kishor, S., & Gond, M. (2020). Agricultural waste: Its impact on environment and management approaches. In *Emerging Eco-friendly Green Technologies for Wastewater Treatment* (pp. 329-351). Springer, Singapore.

Maghari, B. M., & Ardekani, A. M. (2011). Genetically modified foods and social concerns. *Avicenna journal of medical biotechnology*, *3*(3), 109–117.

Mauro, I., Stéphane, M., M., and Rene, C., V. (2009). Farmer knowledge and a priori risk analysis: pre-release evaluation of genetically modified Roundup Ready wheat across the Canadian prairies; *Environmental Science Pollution Research;* 16:689–701.

Meyer, G. and et al (2005). The Factualization of Uncertainty: Risk, Politics, and Genetically Modified Crops – a Case of Rape; *Agriculture and Human Values* 22: 235–242.

Oliver M. J. (2014). Why we need GMO crops in agriculture. *Missouri medicine*, *111*(6), 492–507.

Patel, R., (2007). *Stuffed and Starved: Markets, Power and the Hidden battle for the World"s Food System*; Portobello Books, London.

Pental, D., (2003). Transgenics for productive and sustainable agriculture: Some considerations for the development of a policy framework; *Current Science*, Vol. 84, No.

3, 10 February.

Prakash,D., Verma,S., Bhatia, R., & Tiwari,B.N., (2011). Risks and Precautions of Genetically Modified Organisms. International Scholarly Research Network ISRN Ecology Volume 2011, doi:10.5402/2011/369573

Pistorius, R. and Van Wijk, J., (1999). *The Exploitation of Plant Genetic Information*, CABI Publishing, New York.

Quist, K (2001); Transgenic pollen harms monarch larvae; *Nature*, Vol 399, No 6733, p 214,

Robert, D and Jerome S. Legge, (2006); "Wicked Problems," Public Policy, and Administrative Theory: Lessons From the GM Food Regulatory Arena; *Administration & Society;* 38; 30.

Stone, G., D. and Washington U-St Louis (2002); Biotechnology and Suicides in India;
Anthropology News, Vol 43 No. 5, May.

Tiedje, J. M., Colwell, R. K., Grossman, Y. L., Hodson, R. E., Lenski, R. E., Mack, R. N., & Regal, P. J. (1989). The planned introduction of genetically engineered organisms: ecological considerations and recommendations. *Ecology*, *70*(2), 298-315.

Thamarajakshi, R., (2001). *Towards Hunger Free India*, *Agenda and Imperatives* (eds Asthana,
M. D. and Medrano, P.), Manohar Publishers, New Delhi, pp. 37–45.

Trivedi, Bhargav (2008). "Weather, Spurious Seeds Hit Cotton Yield in Gujarat", *The EconomicTimes,* 22 April.

Whitman, D., B., (2000). Genetically Modified Foods: Harmful or Helpful?; *CSA DiscoveryGuides.*

Vision 2020; *Indian Council of Agricultural Research*, New Delhi.

Xiaoling Yu, Mark Yu and Frank Ewell Xinjiang (2006): "Cotton Production and Its Impact to China‟s Cotton Market", *The Beltwide Cotton Conferences,* National Cotton Council of Americaand The Cotton Foundation.