GM CROPS IN INDIA: AGRICULTURAL SUSTAINABILITY AT STAKE

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Abstract: Introduction of genetically modified crops (GM Crops) has been entranced in severe controversies in India. Following Bt-Cotton, Bt-Brinjal the first genetically modified food crop, has caused a conflict of beliefs and generated heated debates regarding its safety throughout the length and breadth of the country. The Government of India is caught between strong proponents dominated by business houses and small farming community and general public as strong opponents to the proposal. Because of the long term ecological and health issues involved, even scientific community is divided on it.

Concerns regarding the release of GM Crops in environment are many. Effect on non-target species, flow into the host DNA, increased invasiveness, biosafety etc, all have affected its acceptance, research and development. On a bigger canvas, countries and continents stand divided. These divisions on contesting lines are getting stronger and stronger as the time passes by. The issue gets more polemic and complex in India as agriculture is the backbone of our economy.

Government of India is ceased of compulsions and limitations, as also the potential dangers of GM crops. For such reasons, policy framework of the Ministry of Science and Technology (Department of Biotechnology) and Ministry of Environment and Forests, has enforced certain guidelines like: (a) Rules for the Manufacture, Use/Import/Export and Storage of Hazardous Micro Organisms/Genetically Engineered Organisms or Cells, 1989. (b) Revised Recombinant DNA Safety Guidelines, 1994. (c) Guidelines for Research in Transgenic Plants & Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts, 1998.

The most important enforcing agency, Genetic Engineering Appraisal Committee (GEAC) is responsible for testing the environmental and food safety of GM crops before clearing it for commercial release in the country. Further, in an effort to bring the multi-departmental and multi-ministerial control of GM crops under one roof, Biotechnology Regulatory Authority of India (BRAI) Bill 2010 has been proposed in the Indian Parliament. But it has been slammed by many NGOs and concerned citizens for being highly partial and inequitable.

The development of GM crops has raised a variety of novel legal questions, which our regulatory system fails to answer. Instead, the current regulations burden in form of time and cost, abandonment of research, as well as exploitation of farmers. It is imperative that the regulatory attitudes must change. There is an urgent need to change the fundamental underlying statute to suit the needs of current innovations/ technologies and their repercussions on the society.

The inherent power of GM Crops and genetic engineering cannot be doubted. However their sustainability in the current agricultural and legal set-up of the country is highly questionable. The current synthesis is an attempt to dissect the nuances of implications of GM Crop cultivation on the agricultural set up of the country in the wake of weak policy framework. The primary aim of the synthesis is to trigger thought process and underpinning research in this field.

Keywords: Agriculture, Bt-cotton, Biosafety, Genetically Modified Crops, Indian Policy

INTRODUCTION

Agriculture is considered as mankind's largest activity with enormous impact on environment and lives [1]. It requires more land, water and human labour than any other activity. It accounts for 24% of the gross domestic product in low-income developing countries [2]. In India, agriculture is not only most important occupation but also forms backbone of the economy. It accounts for 15.7% of the country's gross domestic product (GDP) and provides employment to 55% of the work force [3].

Need to increase the food productivity, to feed the

growing human population, has lead to an increase in more energy inputs like the use of pesticides, fertilizers and irrigation in agricultural sector. These increased inputs coupled with excessive use of chemicals together deplete our natural resources, harm environment and lead to various health problems. Large amount of money is then required to rectify these problems. All these factors convert into cost to the society.

But in the present scenario, the agricultural yield shows little or negligible rise even after increasing the chemical inputs, as it has reached a saturation point. The scientists and governments around the world envision biotechnology as a possible solution to these impending problems. Advancements in biotechnology are used to apply the technique to modify the genetic constitution of crops by altering their genes. Out come of this process is what is known as Genetically Modified Crops (GM Crops). Their introduction at this point could steer it in either direction. On one hand, its introduction could be a boon in today's chemically intensive dying agriculture and the entire agro ecosystem. On the other hand, it is believed that, in the agriculture system already polluted with chemicals, introduction of these crops will disturb the entire agro-ecology by polluting the gene pool.

From the first commercial cultivation of GM Flavr Savr Tomato in 1993, number of crops has undergone rigorous research, lab testing, and field testing for one or more transgenics. Today, nearly 170 million hectare of global land is under GM Crops, with USA, Brazil and Argentina as the leading top three countries. Soya, maize, cotton and canola are the top four GM Crops [4]. Herbicide tolerance (HT) and Insect resistance (IR) are the two most widely transgenically induced traits, expected to decrease the pesticide usage and increase crop yields. On closer analysis, 170 million hectarage under GM Crops makes for meager 3.43% of global agricultural land, grown mostly with HT and IR traits of soybean, maize, canola and cotton.

Various direct and indirect potential impacts of these crops on human health, ecology and environment as whole makes them a hot topic of discussion. Apparently, their introduction has been met with resistance from various sections of the society. Adverse health effects may occur due to the new GM gene product or the GM transformation process or both[5]. In humans it may lead to emergence of new allergens in the food supply, antibiotic resistance, production of new toxins, and concentration of toxic metals. It can also lead to increased cancer risks as was reported in case of glyphosate resistant crops [6]. It leads to degradation of the nutritional food value, and many other unknown risks that may arise later [7]. These health risks vary with countries having different cultures, food preferences and consumption patterns as people are exposed to different intensities of health effects.

Breach of natural barriers to create a GM crop is an ecological folly in itself. Such genetic modification is considered unnatural as it tampers with the genetic make-up of living beings [8]. Excessive use of Roundup Ready (Glyphosate resistant) crops has resulted in rapid spread of Glyphosate resistant weeds [9] Where as in case of Bt crops secondary pests soon emerge in the place of the target pest [10]. A recent study by researchers of University of Arizona, highlighted the increased cases of major crop pests with evolved resistance to corn and cotton genetically engineered to make their own insecticide, providing lessons for extending the usefulness of such technologies [11].

Suitability in Indian Agriculture

In India, Bt cotton is the only commercially grown GM Crop. Approved for commercial cultivation in March 2002 in six states only, later it was allowed for plantation in north-western states of Punjab, Haryana and Rajasthan from 2006 onwards. Introduced by Mahyco-Monsanto Biotech (India) Limited under the brand name of Bollgard I, it contained a transgenic protein Cry1Ac, which secreted Bacillin toxin throughout the plant body making it resist the pink bollworm attack [12].

However, following the reports of secondary pest attack in Bt Cotton fields of China and India, Bollgard II was introduced in 2006. This variety contained two transgenic proteins, Cry1Ac and Cry2Ab and provided resistance from wider category of insects. A new stacked variety Bollgard III is under research and development stage containing two IR and one HT transgenes. Today, Bt-cotton covers 9.4mha of the total 10.3 mha land under cotton in the country [13]. Since its introduction, this crop has been intertwined inn various controversies on its benefits and impacts.

Close on the heels of Bt-Cotton controversy, Bt Brinjal, India's first GM Food crop was approved by Genetic Engineering Appraisal Committee (GEAC), for commercial cultivation. A safety debate broke out in the country when Union Minister of Environment, Jairam Ramesh took the issue in public domain where it was strongly opposed by various sections of the society. Consequently, a moratorium was put on its release on Feb 9, 2010 and in his decision, the minister appointed six premier academies to scrutinize safety of Bt Brinjal and give a rigorous scientific opinion on GM crops. This Inter Academy report on GM Crops when released declared Bt Brinjal safe.

Table 1: Research and Development over different GMCs in India [15]

S.No.	Crop	Organization	Trait
1.	Brinjal	Indian Agricultural Research Institute (IARI), New Delhi	Insect resistance
2.	Sorghum	National Research Centre for Sorghum (NRCS), Hyderabad	Insect resistance
3.	Groundnut	International Crops Research Institute for Semi-Arid Crops (ICRISAT), Hyderabad	Fungal disease resistance
4.	Potato	Central Potato Research Institute Leaf blight disease (CPRI), Shimla	Leaf blight disease resistance
5.	Castor	Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad	Insect resistance
6.	Rice	IARI, New Delhi Tamil Nadu Agricultural University Mahyco, Mumbai	Fungal diseases resistance and drought tolerance
7.	Tomato	IARI, New Delhi	Virus disease and insect resistance
8.	Sugarcane	Sugarcane Breeding Institute, Indian Council of Agricultural Research (ICAR), Coimbatore	Insect resistance
9.	Okra	Mahyco, Mumbai	Insect resistance
10.	Corn	Monsanto India Pvt. Ltd. Dow Agro Sciences Syngenta Biosciences Pvt.Ltd.	Insect resistance and Herbicide tolerance
11.	Mustard	Delhi University National Research Centre for Plant Biotechnology, IARI	Yield increase and Drought stress tolerance
12.	Wheat	National Research Centre for Plant Biotechnology, IARI	Effect of mutant strains
13.	Papaya	Indian Institute of Horticulture Research (IIHR) Bengaluru	Insect resistance
14.	Watermelon	IIHR, Bengaluru	Insect resistance
15.	Cabbage	Nunhems India Pvt. Ltd	Insect resistance

The very next day, Coalition for GM free India, highlighted malice in the above report terming it as superficial overview without any critical analysis. Later an updated report was tidied up by adding references but it was termed as scientifically invalid and socially sterile than the original one, by P.M. Bhargava, expert nominated to GEAC [14]. Release of such GM products can lead to an uproar and chaos in the society. It is thought that GM food will face strong opposition from different parts of the country as was the case of Bt Brinjal.

Undeterred by the commercial acceptability and adaptability of these crops, research and development over these continues in private and public sector on full throttle. More than 20 different crops are under transgenic research for various traits in country (table 1). Some of the notable examples are discussed in table 1.

Most of these crops have been under research and development stage for many years now. Controversies and contentions on the performance Bt Cotton, the only commercially grown GM crop, affected the release of any other new GM crop in the country. Thus, release and production of GM crops had hit a road block in the country. No crystal clear benefits from Bt cotton could be deduced even after decade of its release, instead apprehensions on its benefits and impacts increased year after year. Performance of Bt cotton varied throughout the country with varying agro-climatic an d geographic conditions. On one hand it was claimed to have abetted farmer suicides in Vidarbha district of Maharashtra while on the other lead to mealy bug infestation in Punjab. Introduction of Bt cotton has lead to emergence of new ecological and health problems.

It not only lead to evolution of resistant pests but in the absence of main pest other insects also became pests to the crop. Like in case of mealy bug infestation in Punjab, in 2006 and recent white fly infestation which damaged the Bt cotton crop in the country [16]. A recent ecological study proved that evolution of secondary pests was found to be faster

and more in India as compared to other Bt cotton growing countries. It reasoned that this was due to the absence of refuge crop required to be grown on the sides of the Bt crop [11]. Further no isolation distance is left between the Bt and non-Bt crops, which are found to be growing in adjacent fields in the country. In India, where 80% of the farmers have small to marginal landholdings, leaving isolation distance or growing refuge affects their output and is not feasible.

Although Bt cotton is not a food crop but it was tagged with serious health concerns. There were reports of a chronic skin allergy among the field workers from Bathinda (Punjab). While incidents of dead cattle and sheep after grazing on harvested Bt cotton fields in Warangal district (Andhra Pradesh) in Southern India as well as from other parts of the country has been reported since 2005 [17]. Biosafety of these crops has been questioned many times in absence of any stringent biosafety evaluation.

GE is an expensive technology and is in the hands of big multinational companies only. 80% of the research and development of GM Crops is held by the private groups and few by the public sector [18]. Further, these crops are developed with genetic use restriction technology (terminator technology) which makes the second generation seeds sterile so is with Bt cotton. This increases the dependence of the farmer on the technology/seed company. Now he cannot save the seeds from the last crop for next growing season, which is a common practice in India.

To add to this scenario is the IPR regime, which is favorable to big biotech companies who are patenting these crops. This increases the cost of growing these crops making the whole process more input intensive. In India Bt cotton is sold at the price five times higher than the non-Bt cotton seeds. For such reasons these crops are mostly grown by small fraction of affluent farmers only. Therefore, economic benefits if any from these crops but these do not extend to all segments of the society [19].

Especially in case of GM Crops which are profitable only to large landholders who practice monoculture where as for small/marginal landholders it requires new working methods, increased demand of skilled labor, which converts into additional cost for them [20]. In India, majority of the small and marginal landholders practice mixed cropping on their land and these GM crops are complete misfit as these advocate monoculture. These crops threaten the agro-biodiversity of the country leading to homogenization of agriculture.

Hence, these crops have been profitable predominantly only to its private sector developer and large landholders further concentrating the economic power. Consequently, the gap between rich and poor widens, leading to stratification and polarization of the society. For such reasons, Government of India nearly after a decade of its commercial cultivation in the Agriculture Ministry's Internal Advisory Report 2011, held Bt-cotton responsible for agricultural crisis and farmer suicides in the country [21].

Fragmented Indian Policy

Government of India is ceased of the compulsion and limitations, as also the potential dangers of GM Crops. For such reasons, the Ministry of Science and Technology (DBT), Ministry of Environment and Forests, and Ministry of Health and Family Welfare together exercise an elaborate policy framework over GM Crops. The premier government agency, Recombinant DNA Advisory Committee (RDAC); function under DBT. This agency advises any research organization interested in GE research in the country about the developments in biotechnology at the national and international level and help them prepare suitable guidelines for safety in research and applications of GMOs [22]. The institution interested in GMO research is also required by law to constitute an Institutional Biosafety Committee (IBSC) at its organization level. This committee develops a manual of guidelines for the regulatory process on bio-engineered organisms in research, use and application in the agency to ensure environmental safety (Fig.1). Before commencing any form of research activity the research agency needs approval of Review Committee on Genetic Manipulation (RCGM) under Department of Biotechnology (DBT). It formulates Monitoring cum Evaluation Committee to monitor and review all ongoing GM research projects up to the multi location restricted field trial stage by undertaking field visits to trial sites to ensure adequate security measures. It can also issue clearance for the import of raw materials needed in GM research projects.

Large scale field trials require approval of Genetic Engineering Appraisal Committee (GEAC) under MoEF. It approve activities involving large-scale use of bio-engineered organisms and recombinants in research and industrial production from an environmental safety angle as well as approve imports of bio-engineered food/feed or processed product derived thereof [23]. It has the power to take punitive actions on those found violating GM rules under EPA, 1986. Further State Biotechnology Coordination Committee (SBCC); functions under the state government where biotech research occurs. It can inspect and take punitive action in case of violations.

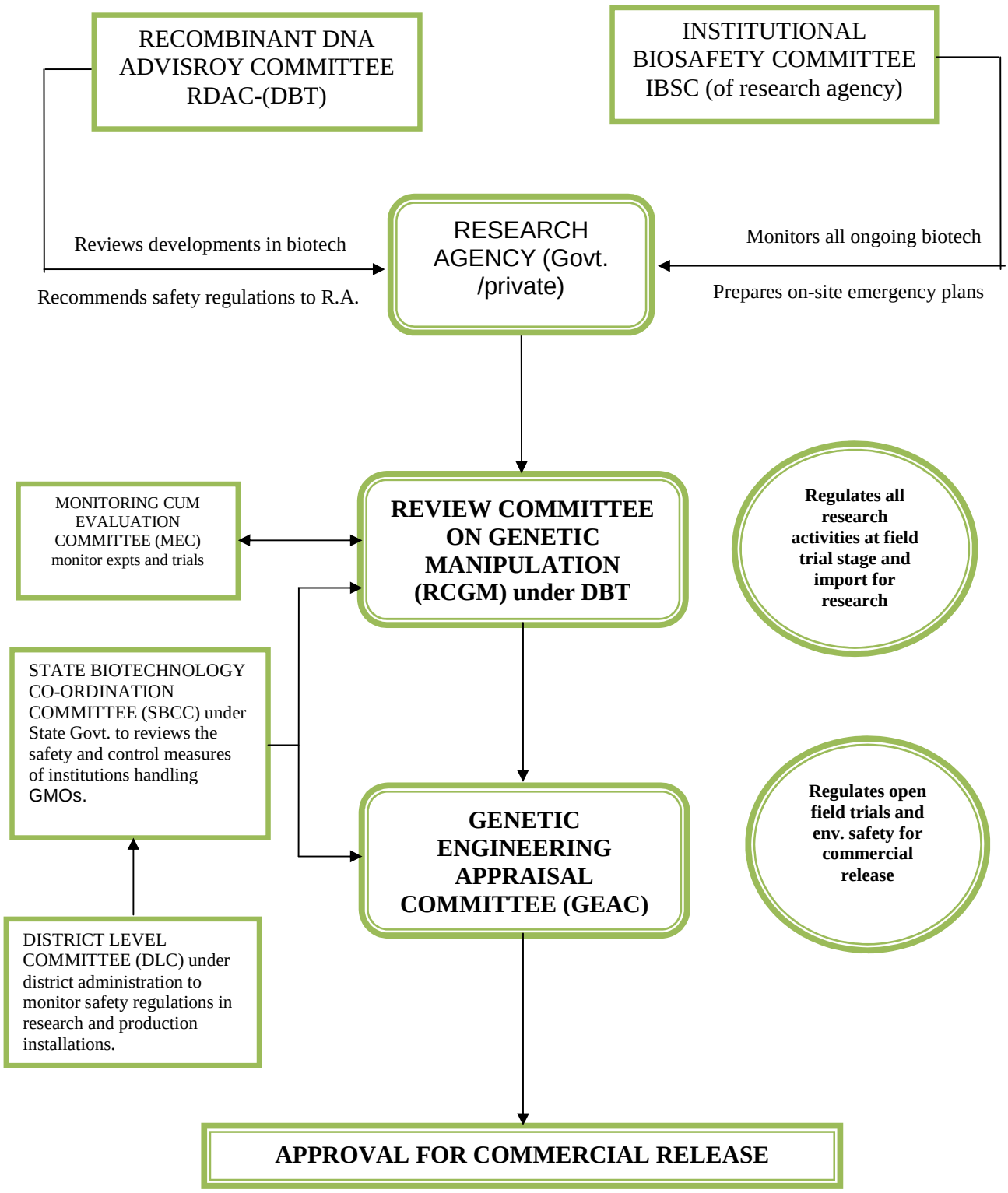

Figure 1: GM Crops Regulatory Framework India [22, 23]

Table 2: Legal statues governing GM Crop regulation in India

S.No.	Legal Statue	Department /Ministry	Function	Lacunae
1.	The Environment (Protection) Act, 1986	MoEF	Single window regulation of all kinds of pollution including genetic pollution [24]	Broad scope not specific
2.	The Manufacture, Use/Import/Export and Storage of Hazardous Microorganisms/Geneticall y Engineered Organisms or Cells Rules, 1989	MoEF	Most comprehensive set of rules on GMO regulation in the country [23]	No provision for public participation, no clause on liability issues
3.	Recombinant DNA safety Guidelines, 1990	DBT	Provisions and guidelines for rDNA research activities [21]	No criteria for evaluation and monitoring of the research labs and field experiments, no provision for setting up of disaster management and accident preparedness plan
4.	Revised Guidelines for Safety in Biotechnology, 1994	DBT	Modified draft of Recombinant DNA safety Guidelines on the basis of current scientific information[25]	fail to specify any monitoring mechanism of field trials and large scale trials
5.	Revised Guidelines for Research in Transgenic Plants & Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts, 1998	DBT	Specific guidelines for research in GM Crops [26]	Only guidelines on environmental risk assessment and biosafety evaluation no provisions for these to be carried out by government itself
6.	National Seeds Policy, 2002	MoA	Application of biotechnology in developing new crop varieties [27]	agronomic value of a new transgenic plant evaluated over two growing seasons only
7.	The Protection of Plant Varieties and Farmers' Rights Act, 2001	MoA	Guidelines for registration of a variety, duration and effect of registration as well as benefit sharing [28]	Plant variety should not contain any gene/ gene sequence involving terminator technology while all GM Crops use it for patent protections
8.	Food Safety and Standards Act, 2006	MoHFW	Evaluates food safety of GM Crops [29]	fails to standardize and set up a threshold level on presence of GM ingredients in a given food to label it as GM or not
9.	The Biological Diversity Act, 2002	MoEF	Fair and equitable sharing of benefits arising out of the use of biological resources [30]	weak Implementation MNCs are seen contravening its provisions
10.	The Traditional Knowledge (Protection and Management) Act, 2010	MoTA	Provides for protection, conservation and effective management of traditional knowledge [31]	regulatory in nature than restrictive, facilitates the access to the traditional knowledge at the pretext of access fees
11.	The Patents Act, 1970	DIPP	Comprehensive law on the intellectual property rights,	patenting regime restricts the usage and modification

			streamlines the Indian Policy with the global patent regime [32]	of crops and seeds by farmer community, Infringement of such patents difficult to control as these crops are released in open environment and bound to pollen pollution
12.	The Biotechnology Regulatory Authority of India Bill, 2010	DBT	To enhance the efficiency and effectiveness of biotechnology regulation and bring it under one roof [33]	Social issues, inter-generational equity and effect on political economy not been included, no clauses on public participation, Only advisory role to the state governments

It is the nodal agency at the state level to assess damage, if any, due to release of bio-engineered organisms and take on-site control measures. District-Level Committee (DLC); functions under the district administration where biotech research occurs to monitor safety regulations in research and production installations and investigate compliance with rDNA guidelines and report violations to SBCC or GEAC. This policy framework is implemented through various laws and legislations formulated under different departments of the ministry.

India's policy on GM Crops has been under the scanner of public groups and scientists because of its weak implementation and lacunae. Although it is found to be adequate in regulating these crops but is hampered due to its multi-departmental control and bureaucratic interference. Implementation of the rules and guidelines is very weak, because of lack of skilled human resource and infrastructure. There are strict guidelines over biosafety evaluation of these crops before approval but no such independent evaluation is done by the government. Moreover, these crops once released are bound to enter our food chain one way or the other. There is also possibility of GM food and food material entering the country during imports from GM crop growing countries like USA and Canada. But none of the legislations have provisions on labeling of these products produced, sold or imported in the country.

Current regulatory regime accords more power to the centre than the state governments, which has been vociferously opposed by many state governments. Most of the bigger states in India, including Bihar, Chattisgarh, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Orissa, Sikkim, Tamil Nadu and West Bengal, have refused to hold GM Crop field trials [34]. For such reasons, government has put the clearance given by Genetic Engineering Appraisal Committee (GEAC) for field trials of genetically modified rice, wheat, maize and castor on hold. Recently Supreme Court of India recommended a blanket ban on GM field trials throughout the country [35].

The development of these crops has introduced a variety of novel legal questions, which our regulatory system fails to answer. The regulation policy of the country has strong bearing on their political, economic and social set up [36]. There are number of stakeholders of this technology with varied interests and contrasting views. From government to scientists who promote this technology, to Biotech MNCs who want to earn money from it, the farmers who want to increase their yield to the common man who is unaware and wants healthy food at affordable price. As the numbers and interests of stakeholders increases, drawing a consensus on a stringent comprehensive policy becomes even more difficult.

CONCLUSION

Genetic Engineering is a complex science with many intricacies involved which have been overlooked by its developer. It was introduced without necessary checks and balances. In india, commercial cultivation of Bt cotton was on trial basis only. But till date no crystal clear benefits have been recorded even after a decade of its commercial release. In case of food crops a much stringent approach is required.

In the overall context of the extensive and rich background of farming in India, GM Crops specifically Bt Cotton remains a minor change. It is perhaps too early to critically evaluate the impact of such a change. The direct and indirect impacts of these crops on human health, ecology and environment have not been evaluated on long term basis.

Lack of legal capacity to monitor, assess and control activities involving GM Crops decreases their

chances in developing world. These crops are not an asset to us, unless they are developed keeping in mind geographic concerns, needs, farming practices, economic background, local innovations and ecology on a whole. Consequently, GM Crops in India, do not appear to be providing the solution we are looking for. Their sustainability in Indian agro-ecosystem is highly questionable. These may appear sustainable in case of a specific crop or specific trait or specific area. But on long term basis, under current scenario of lack of scientific expertise, efficacy of Bt crops, societal perception and weak regulatory framework, GMCs prove to be an unsustainable option. Therefore, there is urgent need for thorough scientific analysis and logical scrutiny before adopting them and formulating a policy for posterity. In the event otherwise, we are fraught with altering evolution process and biodiversity pool.

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