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Managing Biotechnologies for Resource Poor Farmers Using "Interactive Bottom Up" Process: A Case Study of the Biotechnology Programme for Dryland Agriculture

P. S. Janaki Krishna*, M. L. N. Rao*, V. Anji Raju* and R. K. Mishra**

Abstract: The "Interactive Bottom Up" (IBU) approach builds on the insights gained in agricultural development studies, technology assessment and in studies on innovation processes. It is consciously directed at creating learning processes between the various actors on the possibilities and constraints of a technological innovation and application. The paper attempts to elucidate the experiences of using this unique approach in the biotechnology programme supported by the Netherlands. In this programme using 'IBU' process the end-user is consulted and considered first before conceptualisation of the programme. The programme focused on two typical dryland districts of Andhra Pradesh, India. The present paper also emphasizes on biotechnology development in a way designed to bring the benefits of this modern science directly to bear on poverty alleviation and food security. Dovetailing the experiences of the programme the paper examines how it is possible to implement an international technical cooperation programme in a unique manner while combining research with development dimension. The paper also elucidates about how 'IBU' helped in capacity building in biotechnology and developing new transdisciplinary professionalism.

Key Words: dryland agriculture, biotechnology, interactive bottom up process, transdisciplinary professionalism, networks, institutional frameworks

Introduction

In India both dryland and rainfed agriculture are being practiced with 30 to 40 per cent productivity. Of net sown area of about 135 m.ha, dryland area accounts for about 68.4 per cent.[1] Dryland agriculture in India supports 40 per cent of rural population, 60 per cent of cattle heads and contributes 44 per cent to total food production.[2] Improving both productivity and

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sustainability of rainfed agriculture in the more difficult and marginal environment is a challenging task. Despite significant advances made in the management and development of dryland agriculture, uncertainty and low profitability continue to haunt it and, therefore, significant dent could not be made in crop productivity. Also, green revolution technologies have had little impact in these areas. The challenge, therefore, is to introduce technologies that increase agricultural production and sustainability. Biotechnology emerged as one of the options employed to meet this challenge. In this regard, efforts have been made to analyze the scope for agricultural biotechnologies in the socio-economic context of difficult, uncertain and small farm situations. Biotechnologies oriented towards such situations are expected to address the issues of food security and poverty alleviation.

With a view to develop appropriate biotechnologies to suit to the needs of the farmers and address the problems of the farmers the Dutch assistance was made available to India, Colombia, Kenya and Zimbabwe.[3] These country programmes are based on three aspects - the integration of the development aspect in Dutch biotechnology policy; while collaborating with these four countries, and international coordination and cooperation.[4] Unlike most of the internationally funded research projects, research agenda for these programmes is derived from the felt needs of local communities. Thus, the process used is in contrast to the typical top down approach, which is often referred to as 'interactive bottom up' (IBU) approach wherein the end-user is considered first. Here, the research focuses on different crops, their resistances and properties unlike the priorities set up by MNCs.[5] If research in biotechnology is not directed to meet to the needs of common people it becomes counter productive as it might add up to biopiracy and one sided profits instead of meeting the expectations on biotechnology 's potential to contribute to food security and poverty alleviation. In the last decade or so, the transnational corporations have emerged as a major source of biotechnology products. This trend has further raised the concerns among many developing countries as reports about biopiracy galore.[6]

The Indian biotechnology programme, which was supported by the Government of the Netherlands, was implemented by the Institute of Public Enterprise, Hyderabad. The programme evolved over a period of time. After two years of elaborative preparatory phase implemented by the Institute of Public Enterprise, the substantive phase began from November 1995. Using IBU approach, a multi-disciplinary team consisting of natural scientists from public sector organizations, social scientists, extension workers, administrators, and representatives of non-governmental organizations and farmers participated in the local need assessment survey conducted in Mahaboobnagar and Nalgonda districts, which led to intensive discussions and deliberations in prioritizing specific areas for intervention in dryland agriculture. The output of the survey resulted in designing and defining the priority areas in a priority-setting workshop conducted in the Institute of Public Enterprise, wherein different stakeholders including farmers and policy makers participated and deliberated.

The Biotechnology Programme, the result of these extensive deliberations started in 1996 and was initially for a period of six years. Impressed with the progress and innovative approaches adopted in the programme the Government of the Netherlands approved Second Phase of the programme for a period of five years. The programme successfully concluded in 2007.

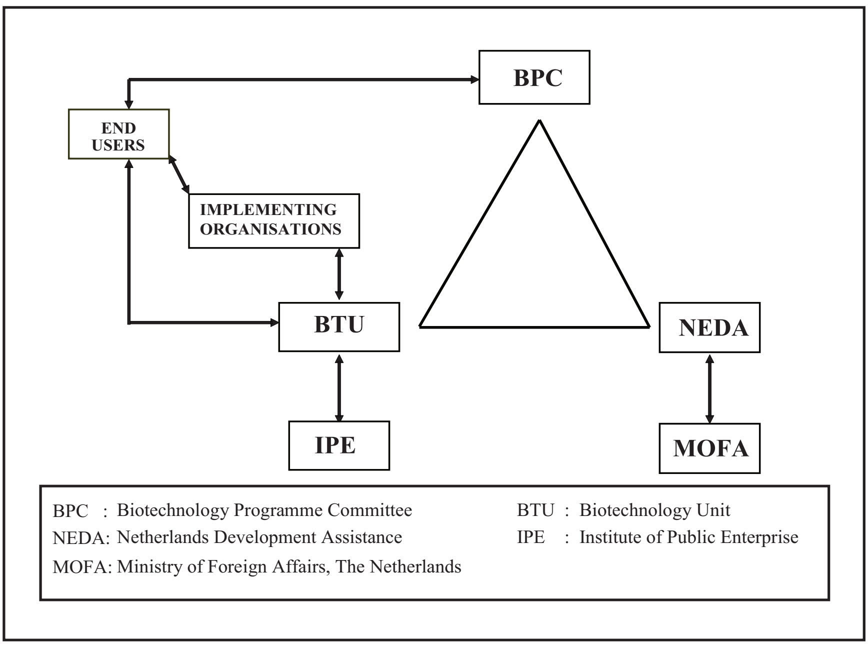
Interactive Bottom Up (IBU) Process in Practice

The overall objective of the programme was to contribute to food security and poverty alleviation through the development and adoption of appropriate biotechnologies for the benefit of small farmers. It aims to achieve this objective using the interactive bottom up (IBU) approach. The IBU approach was named deliberately in contrast to the 'top down' approach that was followed extensively in agricultural extension and rural development programmes. In 'IBU' the enduser of the technology is considered primary. This approach starts with analysis of farmers' problems and reviews relevant scientific developments to address those needs where there is a need for technology intervention. The IBU approach is successfully followed in Kenya, Columbia and Zimbabwe for implementation of biotech programme which again is supported by the Netherlands. The Indian biotechnology programme is one such example which follows IBU. As stated, the 'IBU' process in principle is based on the principles of participation.[7] The 75 projects funded by the programme were set up using this approach where farmers, NGOs working for agricultural development, government officials, and scientists from the public sector organizations participated in a series of meetings. *It wants to develop model approaches for the application of (modern) biotechnology on identified and prioritized problems. It regards farmer's participation in the project formulation and implementation as essential. The programme is not only interested in research but also in development. It means that the objective is to get products and technologies in the field, not on the shelf.*[8]

The IBU approach in practice enabled farmers to build up confidence in systematically assessing their problems and prioritizing the possible solutions. The planning process involved wide consultations and participation from a range of stakeholders.

The traditional view is still to think in terms of division of labour between knowledge search and knowledge use. IBU process enabled in bridging this gap and building new networks at global and local level. For example, the partners in the new networks included the Ministry of Foreign Affairs (MoFA); the Netherlands, policymaking body, that is, Biotechnology Programme Committee (BPC); the Secretariat, that is, the Biotechnology Unit (BTU) of the Institute of Public Enterprise (IPE); Hyderabad, India; and project implementing institutions, extension agencies, non-governmental organizations and end users. (Figure 1)

Figure:1 Institutional Structure



Since the process demands feasibility and adaptability at local level, it also necessitated for new innovations in technology development and transfer. One of the positive achievements of the process is that a number of local youth and women groups, that are often difficult to reach and involve, are attracted to these projects as they help in capacity building. This was achieved through regular training programmes and awareness camps and farmers' exposure visits to the laboratories. The Indian biotechnology programme followed broad definition of biotechnology for implementation, which considers the use of living organisms to make or modify the products. Considering this definition, the programme implemented biotechnology projects at low and medium levels such as vermiculture, biofertilisers, biocontrol agents, biopesticides, botanical pesticides, tissue culture propagated planting material, agroforestry, medicinal plants, mushroom cultivation and extension of shelf life of tomatoes wherein farmers also participated in the evaluation of effectiveness of technologies at enduser level. In the area of animal husbandry, vaccine for sheep pox has been extensively used and farmers participated in the integrated livestock development programme and in the evaluation of extruded feed for buffaloes, and fat supplements in sheep.

The other impacts of process are resource mobilization and maximization of their utilization at the organization level, knowledge and material sharing which is more pronounced in the case of projects dealing with tissue culture, genetic transformation, vermiculture and agroforestry. The frequent interactive meetings among project partners helped in evolving a participatory monitoring and evaluation system. The IBU approach has ensured delivery of qualitative and reliable products as the researchers and farmers jointly conduct the field experiment. Since the endusers are the partners in the project implementation, the spread of technology has been faster. Also the transfer was effective as it moved from farmer to farmer. Thus, while internalizing the technologies the IBU approach has created a space for new science, capacity building and institutional changes.[9]

Here, in this case study though attempts were made to follow the IBU approach in rigorous manner, it has its own limitations as some technologies like genetic engineering take much longer time than the farmers' expectation. In these cases, farmers' interaction is limited to the identification of crop, problem, variety to be opted and making them aware of the 'pros' and 'cons' of the new technology like biotechnology. On the positive side, major contributions of IBU process is the capacity building of the scientists and the project staff to be equipped with advanced biotechnological experiments and to analyse the problems of farmers in larger perspective, and also enhancing the ability of farmers to analyse their problems and prioritise them. Most of the genetic engineering projects are being carried out at national institutions where breeding programmes are strong and in the case of traditional universities efforts are made to link them up with national institutions responsible for seed breeding. Thus, the process is facilitating to build up networks and production chains in order to achieve the ultimate goal of making available the bioproducts to the farmers. Also, the process enabled interactions among the scientists, which further encouraged sharing of the materials (the genes), the protocols and infrastructure. As the process has its own advantages, we cannot rule out the importance of IBU even in the basic research projects. However, the nature of involvement and magnitude of farmers' participation in the technology development varies from project to project, depending on the nature of the technology.

Strengthening Capacity and Development of New Transdisciplinary Professionalism

A significant contribution of the biotechnology programme was creating capacities to analyze, prioritize and develop biotechnologies among partners. In this programme, capacity building took place at three different levels - societal, organizational and individual. At the societal level, the programme provided opportunity to people to analyze their problems, prioritize them and seek solutions through biotechnologies. At the organizational level, their ability to undertake research on biotechnologies is enhanced through access to additional resources, information and knowledge. At the individual level, capacities are created through training, access to additional resources, access to information and interactions among network partners.[10]

However, setting apart the biotechnology programme, at the national level, the experience of agriculture research in India is marked by strong hierarchies and separation between research, extension and farmers with relatively less importance given to social considerations. This approach has led to development of technologies that are not welcomed by the end-users. Development of tailor made biotechnologies by way of addressing research problems with development dimension help in solving the problems of food security and poverty alleviation to some extent.[11] However, achieving this is not an easy task, as it needs major policy changes and institutional rearrangements. Towards this, multidisciplinary and multi-institutional networks (national and international) with good linkages and willingness to share the facilities and expertise need to be worked out. However, continuation and further enhancement of such collaborations for product development remains another challenge. It also demands development of new trans-disciplinary professionalism which can deal with the issue of embedding biotechnology in the complex development scenario. Perhaps, careful consideration of these aspects lead to biotechnology based collaborative programmes and these advanced research networks will have a positive impact upon research and development. Sustenance and management of these trans-disciplinary capacities lies in designing systematic demand-driven research and training programmes in biotechnology through multidisciplinary and multi-institutional national/international networks like the ones developed by the ndian biotechnology programme wherein all stakeholders came together to develop tailor made technologies. Short-term vocational training courses in various biotechnologies including basic courses in management, marketing, financing and farmer field schools, preparation of educational kits, formulation of distant learning courses are some of the possibilities in enhancing the capacities at various levels. It not only helps in strengthening the national capacities at various levels but also tries to fill some of the gaps difficult to be bridged in the mainstream R&D networks. Readers may also be aware that biotechnology has no solution for the so-called non-technical constraints. It is in this area that adequate policies need to be designed to facilitate the contribution of biotechnology to development and equity.

National Networks and Institutional Frameworks

Networks in the programme are developed at different levels. Some of them are international like the network between MoFA, the Netherlands and IPE and some others are embedded like the networks between scientists and farmers. At global level the network consists of the Netherlands Development Agency (NEDA) of the Ministry of Foreign Affairs, Government of the Netherlands and four country programmes, two in Africa, one in Latin America and the other in Asia. South-South cooperation helped in the exchange of scholars especially in training some of the scientists from Kenya in tissue culture, exchange of project ideas, management practices and promoting discussion on specific aspects like biosafety and IPRs.

At local level, networks existed at the programme level and project level. In the case of the programme, the entire programme is a network with a number of partners. They included the policy making body - the Biotechnology Programme Committee (BPC); the Secretariat - the Biotechnology Unit (BTU) for programme management and implementation at the Institute of Public Enterprise; project implementing institutions; extension agencies; non-governmental organizations; and end users. At the project level, the partners in the networks included end users of technology, NGOs, research organizations and the Institute of Public Enterprise. Their relationships were governed by mutually acceptable agreements which explain the role and responsibility of partners, the anticipated outcome of the networks, the methods of sharing these outcomes, the means of resources required to obtain the outcome, etc,. Partners of the project are identified through a process of consensus. Usually agencies and individuals who subscribe to the philosophy of the programme are chosen as partners. Such partners would have had minimum capabilities to undertake the execution of a research project. Though a few organizations were initially reluctant to become partners, they have forged alliances willingly and created both tangible and intangible impacts which included: convergence of indigenous knowledge with modern biotechnology, innovations in technology transfer, resource mobilization, knowledge and materials sharing, concern for social relevance of technology and quality and reliability of products.

Conclusions

The Indian biotechnology programme supported by the Ministry of Foreign Affairs, the Government of the Netherlands, has thus been able to implement the novel concepts of participation for development of appropriate biotechnologies. The programme also made significant contribution to local capacity building. Most of the scientists and farmers appreciated the opportunity of two-way interactions and learning that occurred in the IBU process. Certainly it is a learning experience for all the networks. It was learnt during implementation that building consensus among multi-stakeholder groups takes time and effort and scientists generally view the principle of participation as an exception rather than rule that need to be addressed.

From the case study presented above, we may notice that the precondition set in the IBU for participation of all the stakeholders, mainly the end users, has enabled in developing appropriate technologies to suit to the local conditions. However, the process is not a straight jacketed one and the approach varies depending on the nature of the technologies (basic to applied). Nevertheless, the exercise of an interactive participatory process is certainly essential and fruitful for the programmes whose objective is to make available the technologies to the unreached thereby encouraging the local capacities and indigenizing the local resources for sustainable development. Finally, while implementing an innovative programme initially follow the adage of “Small is Beautiful”.

Endnotes

[1] Balasubrmanium, 2010.
[2] Kannaiyan, 2001.
[3] Pakki Reddy G, *et al.,* 1994.
[4] Integral Policy Document on Biotechnology.
[5] Bunders J. *et al.,* 1991
[6] Chaturvedi, Sachin *et al.,* 2004
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Pesticide Applications in Bt cotton Farms: Issues Relating to Environment and Non-Tariff Barriers

N. Lalitha and P. K. Viswanathan*

Abstract: Ever since the introduction of Bt cotton in India, the acreage under Bt has been steadily increasing in the country, particularly in Gujarat. This paper was undertaken to examine various aspects of farm level adoption of Bt cotton in Gujarat as well as explore the issues relating to environment and non-tariff barriers affecting the cotton trade of India. The farm level analysis reveals that the Bt cotton adoption is nearly complete with 90 per cent of cotton land being under Bt cotton. Except 1 per cent of the land which is under Bollgard II, the rest of the Bt cotton area is under Bollgard 1 variety, which aims at controlling the incidence of bollworms. Hence, a sizeable per cent of pesticide applications has been aimed at sucking pests. Interestingly, farmers growing both approved and unapproved Bt varieties seem to undertake almost equal amount of care for control of pests through increased number of chemical sprays than scientifically recommended. Almost 70 per cent of the farmers use more than one chemical in pesticide applications, which entomologists do not approve of.The paper argues that though India's exports of cotton have increased in recent years, the export prospects suffers from two main issues of contamination and non-tariff barriers. The US, Mexico and EC are known for levying a number of non-tariff barriers. The EU has even brought out a legislation called 'REACH' which requires the Indian exporters to get their products tested and certified that they do not contain any hazardous chemicals. The paper concludes that since a large number of pesticide application take place especially among the marginal land holdings, appropriate extension services and IPM programmes would help in rationalising the use of pesticides in cotton in India, which might help the industry in the emerging context.

Key words: Bt cotton, pesticide, environment, non-tariff barriers, Gujarat, India.

Introduction

Livelihood of about 60 million people depends directly and indirectly on cotton cultivation, processing, trade and textiles. Textiles including raw cotton contribute 20.24 per cent of India's exports (Barik and Gautam, 2009). Production of cotton in India which was 142.3 lakh bales in 1996-

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97 had dropped to 86.24 lakh bales in 2002-03, but increased steeply to reach 258.06 lakh bales in 2007-08 (advance estimates, as on 9 July 2008)[1], thanks to wide scale adoption of genetically modified (GM) cotton in India. Cotton cultivation in India which accounts for about 5 per cent of the land under cultivation uses nearly 50 per cent of the pesticides produced in India (Shetty, 2004; Barik and Gautam, 2009). Continuous use of pesticides causes irreversible damage to the environment, affects the health of both humans and livestock besides increasing the cost of cultivation.

An additional impact to be added to this list is the potential of pesticide use affecting the trade prospects due to the pesticide residue causing chemical contamination in agricultural products. This new dimension of pesticide impact on trade comes in the form of non-tariff barriers/non-tariff measures or sanitary and phytosanitary measures (SPS)[2] Non-Tariff Measures (NTMs) are all measures other than normal tariffs, namely, trade related procedures, regulations, standards, licensing systems and even trade defense measures such as anti-dumping duties, etc. which restrict trade between nations. The recorded use of NTMs in international trade has been on the rise with the lowering of tariffs in the member countries of WTO which accelerated since the conclusion of the Uruguay Round in 1994 (Sandrey, *et al.*, 2008). NTMs are used as entry barriers and could be subjective. For instance, banning import of an agri biotech product by a country could be viewed as a trade restricting measure by another.[3] Recently, the American labour department has singled out six products, namely, hybrid cotton seeds, bricks, stones, embroidered textiles, garments and rice, which when exported should have special certification that these products did not use forced or indentured child labour.[4]

In the backdrop of the increasing cotton exports from India in recent years, this paper attempts to understand and analyse whether pesticide residue in cotton is becoming a barrier in exports. We also use the farm level data from Gujarat in order to examine whether the GM technology has helped the farmers reduce pesticide use in cotton which will minimize residue levels on the output with a positive impact on trade. With this focus in mind, in Section 2 we analyse the cotton scenario in India and Gujarat. The third section discusses the pesticide use pattern among the cotton farmers in Gujarat. Section 4 discusses the export scenario and the NTMs. The fifth section presents the conclusion.

Cotton Scenario in India and Gujarat

Cotton is an important cash crop, grown in more than 9.5 million hectares spread over nine states in India. These nine states are Gujarat, Maharashtra, Madhya Pradesh, Punjab, Haryana, Rajasthan, Karnataka, Tamil Nadu, and

Andhra Pradesh. Though India's share in world cotton area has stagnated and increased only marginally from 24 per cent in 1961-62 to 28 per cent in 2007-08, production during the same period has increased from 8 to 16 per cent (21 per cent according to the Cotton Advisory Board, Table 1). Increasing production in recent years has resulted in reducing the gap in cotton production between the world and India from 338 KG lint per hectare in 2001-02 to 212 KG lint per hectare in 2007-08. The average yield per hectare for all India in 2007-08 has been 563 (KG lint per hectare) with yield levels above the national average reported from Gujarat (743/ha), Tamil Nadu (691/ha), Andhra Pradesh (667/ha) and Punjab (630/ha).

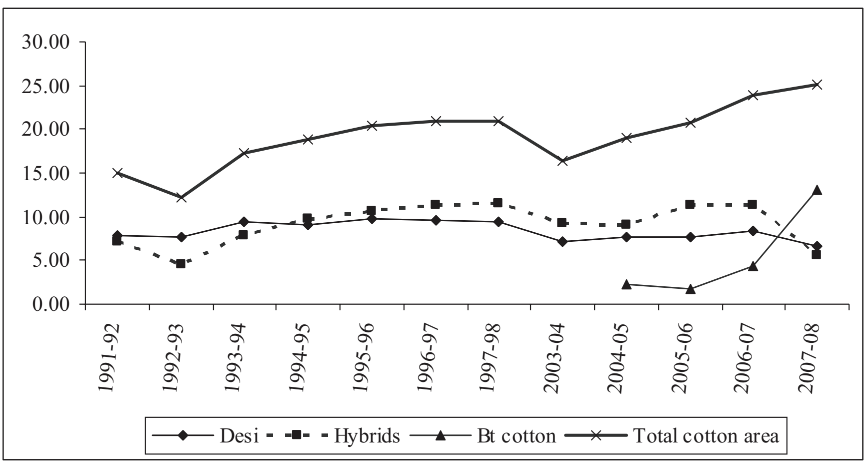
Table1: Share of India in Global Cotton Area and Production

Year	Area (million ha)			Production (Lakh bales)		
	World	India	%	World	India	%
1961-62	32.77	7.98	24	57.75	4.85	8
1971-72	32.98	7.8	24	76.59	6.95	9
1981-82	33.84	8.06	24	88.53	7.88	9
1991-92	33.03	7.66	23	111.84	9.71	9
2001-02	33.38	9.13	27	126.41	10	8
2005-06	34.19	8.68	25	145.64	18.5	13
2007-08	33.6	9.55	28	152.35	24.35	16
				CAB	31.5	21

Note: CAB stands for Cotton Advisory Board.

Source: Barik and Gautam (2009).

Figure 1: Trends in Cotton Area in Gujarat, 1991 – 2007



Note: Data was compiled from Season and crop report for the years 1991-92-1997-98 and data from 2003-04 was obtained from the Department of Agriculture, Government of Gujarat

Though Gujarat has the credit of developing the first cotton hybrid (H4, from the Gujarat Agricultural University, Surat) in the 1970s, large scale adoption of hybrid surpassed the area under the *G.Arboreum* (desi cotton) in the mid-1990s (Figure 1). This scenario further changed with the introduction of GM/ Bt cotton. The *G.Arboreum* variety is known for its drought tolerance and resistance to pests. The *G. Hirsutom*-hybrid varieties which were much sought after by the farmers are long staple varieties and are susceptible to both sucking pests and bollworms. Bacillus Thuringencis (Bt) is a naturally occurring bacterium that acts against the bollworm in cotton plants. Plant biotechnology has enabled that the Bt trait is introduced in the plant itself through the seeds, by which the entire plant acts against the pests. The main advantage of Bt cotton is believed to be its trait –the Cry 1 AC gene (referred to as single gene) that protects the crop from bollworm, tobacco budworm and pink bollworm, which are the major pests that attack cotton in all the cotton growing parts of the world. The remaining important pests include the aphids, jassids, leafhoppers, mirids, mites, stinkbugs, thrips and whiteflies. The importance of these pests in cotton varies regionally (Showalker, *et al.*, 2009). Recognizing the ineffectiveness of the Cry 1 gene on the whole range of sucking pests, scientists have now introduced Bollgard II, which produces two distinct toxins –Cry 1 AC and Cry 2 AB to delay the pest resistance. "This is called pyramid strategy. The pyramid strategy is expected to be most effective when: the majority of susceptible pests are killed by the transgenic crop, resistance to each toxin is recessive, refuge is present and selection with either of the toxins does not cause cross resistance to the other" (Showalker, *et al.*, 2009). Bollgard II (double Bt to use farmers' parlance) referred to as multiple gene, which is supposed to provide protection against both bollworms and the sucking pests, has been adopted by farmers in India in recent years (Table 2).

Table 2: Adoption of Single and Multiple Gene Bt Cotton Hybrids in India (Million Hectares)

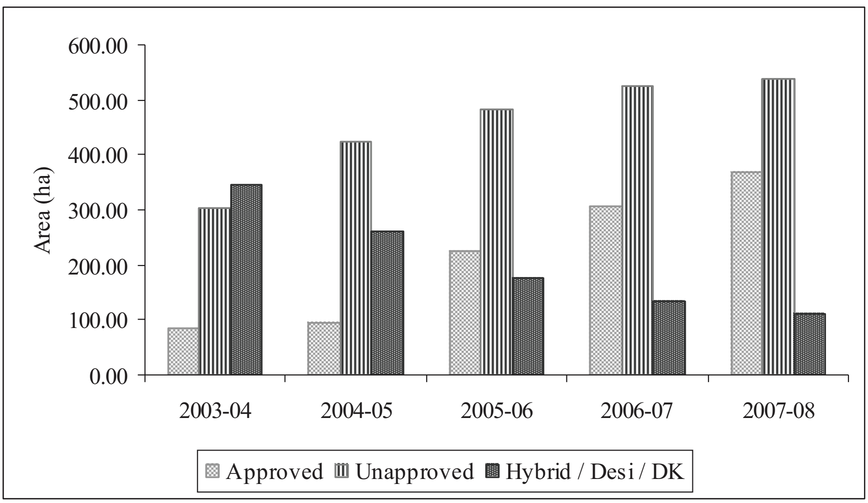
Number of gene	2005	2006	2007	2008	2009
Multiple	-	0.15 (4)	0.46 (8)	2.04 (27)	4.82 (57)
Single	1.3 (100)	3.65 (96)	5.74 (92)	5.56 (73)	3.58 (43)
Total	1.3 (100)	3.8 0(100)	6.20 (100)	7.60 (100)	8.40 (100)

Note: Figures within parentheses indicate the percentages

Source: Table 4, Chaudhury and Gaur (2010).

In 2002, Government of India provided approval for the introduction of three Bt cotton varieties (Cry 1 AC gene), viz. Mech 161, Mech 112 and Mech 184 including in the state of Gujarat. By the time the approved varieties were planted in Gujarat in 2002, it came to limelight that the farmers were also planting on a large scale another Bt variety that was not commercially approved by the Government of India. While the widespread adoption could not be prevented as farmers found the yield difference between the approved and unapproved variety to be negligible (Lalitha *et al.*, 2007, yet it had contributed to bringing in more area under Bt cotton which increased from 2.34 lakh hectares in 2003-04 to 13 lakh hectares in 2007-08 bringing about 453.8 per cent rise in the area under Bt and thereby the area under cotton increased by 67.56 percent from 1991-92 – 2007-08.[5] In 2005, the Government of India approved more Bt varieties for commercial cultivation and thus there were 70 Bt varieties available to farmers in the central region (which includes Gujarat) to choose from in 2007. In spite of the fact that more approved varieties are available, the unapproved varieties are still sought after by the farmers in Gujarat as shown by Figure 2.

Figure 2: Area under Varieties of Cotton in Gujarat



Note: Misc. includes those varieties where farmers did not know the name of the hybrid variety.

Source: Farm Household Survey by GIDR, 2007.

Figure 2 denotes that in 2003-04 when the hybrids and *desi* (indigenous) varieties were still occupying a larger share of land as compared to unapproved Bt, the area under the approved Bt was very small, which remained the same during 2004-05 as well. However, a policy intervention reducing the price of the seed of the approved variety to Rs.750 per pack of 450 grams in 2005 from Rs. 1600 that was prevalent from 2002 as well as the availability of more varieties to the farmers have resulted in significant increase in area under approved Bt cotton in Gujarat. Interestingly, the area under unapproved varieties continued to be higher than the area under the approved variety, which makes the Gujarat cotton farmers a distinct group in the Indian context.

Bt Technology and Its Impact on Pesticide Use

Studies done elsewhere bring out the favourable impact of Bt cotton in reducing the pesticide use. For example, assessing the impact of Bt cotton in China, Pray *et al.* (2001) observe that the Bt cultivators could substantially reduce or eliminate the use of pesticides to control bollworm during the middle and late part of the season. Their study carried out during 1999 notes that majority of the farmers could reduce the number of sprays from 12 to 3 or 4 sprays. Hence, assuming that 320,000 hectares were under Bt cotton cultivation, it had resulted in reduction in pesticide use by 15,000 tons. Their study observes that reduction has also occurred in organophosphates some of which have been banned due to their adverse impact on health and environment.

A recent study done in China (Huang *et al.*, 2009) emphasises that introduction of Bt cotton led to significant decrease in the use of bollworm insecticide. However, late in the season some insecticides were required to be controlled which varied in magnitude in different locations. The authors also note that Bt cotton in China has been managed with a fairly stable but sill quite a high level application of insecticides. They note that insecticide use could be further reduced through education and agri insurance. The authors found that Bt cotton growers' insecticide use ratio at 10 Kg/hectare is higher than the optimum as farmers used more than what is recommended in the label.

Edge *et al.* (2002) observe that in the US, the total number of spray reductions per hectare for all arthropod pests ranged from 1.0 to 7.7 sprays and an average reduction of 3.5 sprays per hectare was achieved by Bt cultivators, which had resulted in an estimated loss of $200 to $300 million a year for the pesticide manufacturers. Hence, assuming an average reduction of 2.2 sprays per hectare on the 972,000 hectare cotton produced in 1998 in the US, they conclude that 962280 KG insecticide active ingredient did not enter the environment and local watersheds thus reducing the potential exposure to non-target animals.

Similarly, Qaim and Janvry (2005) report that in Argentina, Bt farmers on an average used 50 per cent less insecticides on their Bt plots than on plots grown with conventional cotton. Almost all the reductions occurred in a highly toxic chemical, which emphasizes the positive effect of Bt on the environment.

In Colombia, use of Bt cotton is not associated with a significant reduction in insecticide use. As Boll-weevil is the major pest in cotton in Colombia, Bt growers spend more on insecticide than farmers growing conventional varieties (Patricia *et. al.,* 2009).

In South Africa, on an average, Bt variety reduced the number of insecticide sprays to three. Though producers of Bt cotton still used insecticides to guard against pests such as aphids, jassids and thrips, yet the reduction of three sprays for bollworm would reduce the costs, amount of labour and the distance walked carrying the knapsack (Bennett *et. al.*, 2006).

In India, Kranthi *et al.* (2005) found that the commercial Bt cotton hybrids introduced in the country, express less than the critical levels of Cry1Ac gene required for full protection against bollworms late in the season and in some plant parts. Hence, they observed that the "Bt cotton hybrids in India may require more supplemental insecticide sprays than being used in Bt cotton varieties elsewhere in the world". However, studies that have been carried out so far tend to analyse the pesticide use on Bt *vs* non Bt and have not focused on the varietal differences within Bt or hybrids.

Qaim *et al.* (2005) and Indira *et al.*[6] (2005) clearly bring out the advantages of Bt cotton in pesticide reduction over hybrids and conventional cotton variety.

In Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh, during the 2002 season, Bt cotton required 2.6 times less pesticide sprays than conventional cotton, which had a positive impact on yield due to less crop losses. However, these savings in pesticide reduction did not compensate for the higher seed costs incurred by farmers on Bt seeds (Qaim *et al.,* 2005).

Narayanamoorthy and Kalamkar (2006) analysed the performance of Bt cotton in two districts of Maharashtra. Their analysis of inputs on Mech 184 and Mech 162 compared to other non-Bt varieties shows that Mech 184 consumed less pesticide as compared to Mech 162 and both the Bt varieties together consumed more pesticides than the non-Bt varieties.

The study carried out by Mahendra Dev *et al.* (2006) in four districts of Andhra Pradesh point out that farmers use insecticides as a precautionary measure or on noticing any pests on the plants without any regard to the threshold limits of the pests. Hence, the cost of insecticide is likely to be more than the benefit it provides. Nevertheless their study proves that the cost of insecticide in Bt cotton reduced by 18.2 per cent over non-Bt cotton and the number of sprays on an average have reduced from 12 in non Bt cotton to 9 in Bt cotton.

Gandhi *et al.*'s study (2007) carried out in Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu observes that adoption of Bt cotton has resulted in significant reduction in cost of production as pesticide use reduced by as much as 36 per cent in Maharashtra and Andhra Pradesh. In Tamil Nadu it reduced by 50 per cent.

Lalitha and Ramaswami (2007) analyzing the pesticide use among the cotton cultivators in Gujarat during the kharif 2003-04, observed that approved Bt varieties required as many as 6.3 number of sprays per hectare, while hybrids and unapproved varieties required an average of 5.9 and 4.6 sprays respectively. Desi cotton required the least of just 0.25 sprays. Of the total of 1926 sprays on the cotton crop, 35, 48 and 17 per cent have been sprayed against bollworm, sucking pests and the other pests respectively. Thus, it emerges that during 2003-04 farmers had to spray an average of 1.8 times on sucking pests, as compared to 1.3 times on boll worm.

The study by Lalitha *et al.* (2009) on Gujarat and Maharashtra highlights the differences in pesticide use between the two states. In Gujarat, an average of 7.39 sprays was sprayed on the approved Bt, while an average of 6.91 sprays were used in the unapproved variety. In Maharashtra, Bt cotton required an average of 3.23 number of sprays as against 3.35 sprays on non Bt cotton. (We were only drawing attention to the fact that Bt cotton required about 7.39 and 3.23 number of sprays. There are differences in the varieties cultivated and the condition in which Bt is cultivated in both the states. Hence, we cannot compare it straight away.)

Subsequent to the introduction of Bt cotton in India, cotton consumed only 18 per cent of the total pesticides market in 2006 compared to a much higher share of 30 per cent in 1998. Similarly, the market share of cotton insecticides as percentage of total insecticides declined from 42 per cent in 1998 to 26 per cent in 2006 (Choudhary and Gaur, 2010).

Thus, while a majority of the studies indicate a reduction in the pesticide use on Bt cotton, in the rest of the paper we attempt to probe whether pesticide use pattern differ significantly across different size groups of farmers and what kind of pesticides are being used by the Bt cotton farmers in Gujarat. The farm level information has been collected through a household survey carried out by the GIDR during Kharif 2007-08. The survey was conducted in five districts of Gujarat, namely, Rajkot, Bhavnagar, Baroda, Surendranagar and Ahmedabad involving a total sample size of 200 farmers selected at random. The information regarding farm management practices was collected by canvassing a detailed questionnaire from the farm households.

Pesticide Use Scenario in Gujarat

The survey revealed that of the total 1014.87 hectares of cotton land cultivated by the 200 farmers during 2007-08, almost 53 per cent was planted with unapproved Bt varieties , followed by approved Bt with 36.3 per cent and desi variety with 10.7 per cent of the land. Thus, Bt adoption is nearly complete with 89 per cent of the area under Bt cotton (both approved and unapproved). While majority of the Bt cotton adopters have used the Bollgard 1 variety, 1 per cent of the total Bt cotton land is under Bollgard II variety.

As per the biosafety regulations, companies selling Bt cotton seeds are required to sell a small packet (120grams) of non-Bt seeds referred to as refuge seeds along with the regular Bt cotton seeds (which are packed together). The purpose of growing refuge is to delay the bollworm resistance to Bt. The refuge strategy is based on the principle that the dominance of resistance depends on the dose of transgenic toxin. Resistance is often dominant when the dose of a toxin is low, but recessive when the dose of a toxin high (Showalker *et al.,* 2009). Hence, for effective protection, farmers are supposed to grow these non-Bt seeds as a border to the Bt cotton plot which is indicated in the form of a diagram in the short literature page that accompanies the seed packet. While the approved Bt companies are required to sell this non-Bt seeds as well, the unapproved seed sellers do not sell any refuge seeds. It has been demonstrated that wherever refuge is grown around the Bt plot, resistance to Bt is delayed (Qaim and Janvry 2005) and the technology. However, we found in our survey that only 27.8 percentage of the approved plots were planted with refuge (non-Bt seeds), while only 3.8 per cent of the unapproved plots were planted with refuge.

Pests Attack

During the 2007-08 Kharif season, farmers reported more of sucking pests' infestation on cotton than bollworm. In fact, farmers reported names of 12 different sucking pests and six types of bollworm that affected the cotton crop in the entire season. Only 22 per cent of the farmers reported the occurrence of any new pests in cotton. Interestingly, among the new pests that the farmers had seen during 2007-08 season were the ones that they had never seen five years before. Mealy bug was the prominent name as reported by 77 per cent of the farmers. Mealy bug that belongs to the category of sucking pests is reported to be devastating in effect among all other types of sucking pests.

Pesticide Spraying Pattern

There were totally 2833 pesticide applications on the total cotton crop (1014.87 hectares) by the chosen farmers which is 2.79 sprays per hectare and 14 sprays per farmer. Of the total 2851 responses received against pesticide application, 2833 responses included pesticide applications ranging from one to 20 times and hardly one per cent were cases of not spraying any type of pesticides.

Among the districts, Rajkot and Bhavnagar together accounted for 52 per cent (27 and 25 per cent respectively) of the total number of sprays while Surendranagar had the lowest share (15 per cent) of the applications. Notably, in Rajkot, the largest number of pesticide applications (70 per cent) were on approved Bt than on unapproved Bt (30 per cent), while reverse was the case in Bhavnagar (22 and 78 per cent respectively). Such differences were not seen in other districts.

Our analysis then tried to look at the pesticide spray pattern across the different size classes of farmers (Table 3).

Table 3: Descriptive Statistics Showing the Pesticide Spray Pattern among Different Land Holdings

Land holdings	Seed variety	Mean no of sprays	Total reported cases	Std. Deviation	Median (No of sprays)	Maximum (No of sprays)	CV %
Marginal	Approved	4.85	525	2.99	4.0	15	61.6
	Unapproved	4.25	514	2.59	4.0	15	61.1
	Desi	3.57	14	2.03	3.5	7	56.8
	Total	4.54	1053	2.81	4.0	15	61.9
Small	Approved	5.16	388	3.34	5.0	15	64.7
	Unapproved	4.92	552	3.40	4.0	20	69.1
	Desi	2.65	17	1.87	2.0	7	70.6
	Total	4.97	957	3.37	4.0	20	67.7
Medium	Approved	4.44	312	2.77	4.0	14	62.4
	Unapproved	4.74	446	2.94	4.0	15	62.0
	Desi	3.06	18	2.15	2.5	8	70.5
	Total	4.58	776	2.86	4.0	15	62.6
Large	Approved	5.06	18	2.75	5.0	10	54.5
	Unapproved	3.46	28	1.84	3.0	7	53.0
	Desi	1.00	1	0.00	1.0	1	0.0
	Total	4.02	47	2.36	4.0	10	58.8
All classes	Approved	4.85	1243	3.06	4.0	15	63.1
	Unapproved	4.61	1540	3.00	4.0	20	65.1
	Desi	3.02	50	2.02	2.5	8	66.7
	Total	4.69	2833	3.02	4.0	20	64.5

***Source**:* Farm Household Survey by GIDR, 2007.

It is evident that the mean number of sprays is close to five sprays across holdings with differences between approved and unapproved cotton grown plots. Mean number of sprays are higher for approved plots in the case of marginal, small and larger holdings. Only medium scale farmers show an exception in this pattern. Desi grown plots are important in terms of less number of sprays undertaken and only marginal farmers have shown the highest number of pesticide applications for desi cotton.

The behaviour of marginal farmers with respect to adoption of sprays seems to be quite distinct as compared to rest of the groups. It seems farmers in marginal, small and large categories tend to distinguish between approved and unapproved varieties when it comes to pesticide applications as is evident from relatively more number of sprays done in case of approved varieties than unapproved varieties. Notably, though the mean number of sprays shown an overall average within the range of 4 to 5 sprays per approved and unapproved plots, the variations are large as explained by the coefficient of variation in number of sprays. This is also corroborated to an extent by the maximum number of sprays, which has gone to an extent of 15 or 20 as evident from the table.

It is important to examine how farmers schedule their insecticide applications as the entire cotton season lasts for 6-8 months from sowing to harvesting. Table 4 provides the summary of the schedule of insecticide applications undertaken by the farmers across the three varieties. It is evident that insecticide application rises significantly after the first month of sowing and reaches the peak when the plant is about 90 days old. We find that pesticide application reduces from this point onwards in all the varieties which is different from the experience of the farmers in China where pesticide application is required late in the season also (Huang *et al.,* 2009). This pattern is also different from Non-Bt plots where maximum number of sprays (4.37) takes place during the period of 151-180 days after sowing. In the entire season, insecticide application is higher in approved Bt plots (16.73) as compared to the unapproved Bt plots (14.19).

Table 4: Insecticide Applications Per Plot

Days after sowing	Approved Bt	Unapproved Bt	Non-Bt	All plots
1-30days	0.63	0.68	0.59	0.65
31-60 days	4.33	4.15	1.26	4.04
61-90 days	5.92	4.99	0.96	5.10
91-120 days	3.97	3.12	0.56	3.29
121-150 days	1.45	0.89	0.22	1.07
151-180 days	0.35	0.27	4.37	0.28
Above 181 days	0.08	0.09	1.20	0.08
Entire season	16.73	14.19	9.16	14.51

Source*:* Lalitha *et al.* (2009)

The status of insecticide applications as described above raises an important question as regards the effectiveness of the Bt technology:

Why farmers growing approved and unapproved Bt varieties tend to spray more as against those growing non-Bt varieties? Our analysis in this regard yielded interesting results, which suggests the new complexities faced by the farmers in internalizing the benefits of the Bt technology. It was found that with bollworm under control (perhaps technology worked well), larger proportions of the insecticide applications (over 73 per cent across varieties) have been targeted towards sucking pests as evident from Table 5.

Table 5: Insecticide Application by Variety and Pest for the Entire Season

Pests	Approved Bt plots	Unapproved Bt plots	Non-Bt plots	Total
Sucking pests	5.89 (79.7)	5.05 (73.1)	3.64 (83.1)	5.17 (76.0)
Bollworms	0.48 (6.5)	0.55 (8.9)	0.29 (6.6)	0.5 (7.4)
Spodeptora	0.39 (5.3)	0.15 (2.2)	0.11 (2.5)	0.25 (3.7)
Others	0.07 (0.9)	0.2 (2.9)	0 (0.0)	0.12 (1.8)
Unknown	0.56 (7.6)	0.96 (13.9)	0.34 (7.8)	0.76 (11.2)
Total	7.39 (100.0)	6.91 (100.0)	4.38 (100.0)	6.8 (100.0)

***Note**:* Figures in parentheses indicate the respective percentages in total insecticide applications.
***Source**:* Lalitha *et al.* (2009)

To substantiate this, the survey revealed that only 19 farmers were growing Bollgard II variety which targets sucking pests, spodeptora and bollworm within a total area of 10.9 hectares. It is presumed that wider adoption of this variety (Bollgard II) may reduce the number of sprays in future.

Pesticide Awareness among the Farmers

In analyzing the use of pesticides, it is also essential to understand, the awareness among the farmers about these products. In this regard, the information we gathered pertained to: the name of the pesticides, active ingredients, against which pest the product is used, why pesticide application is required at a particular point of time, indication on the label, impact of pesticide use on health, etc. Precise understanding in these lines would help the farmer in using the pesticides rationally. In the following pages information on some of these aspects is presented.

In all, the farmers have reported 244 names of pesticides which mostly consisted of the trade or brand names. It is a common practice among the farmers to use combinations of chemicals when they apply pesticide, which according to the entomologists will work against the control of pests. This is because, if a pest is resistant to one chemical X, a combination of chemicals that include X would render the entire group of chemical useless and if farmers are not aware of this property of chemicals, they would spray more pesticides, which perhaps is the reality. In our survey, only 20 per cent of the total sprays had used just one ingredient, while 52 per cent of sprays included two chemicals and 21.8 per cent of sprays used cocktail of three chemicals (Table 6).

Table 6: Number of Insecticides Used in each Spraying

Combination	Responses	%
No pesticide	25	0.9
One chemical	569	20.0
Two chemicals	1483	52.0
Three chemicals	622	21.8
Four chemicals	118	4.1
Five chemicals	31	1.1
Seven chemicals	3	0.1
Total	2851	100.0

Source: Farm Household Survey by GIDR, 2007.

Since more than 240 names of pesticides have been reported by the farmers, it may be likely that some of these pesticides would turn out to be harmful to the health of farmers and the environment. While examining this aspect, we could match about 50 per cent of the names reported with the active ingredients as per the WHO classification of pesticides (Table 7).

Table 7: Classification of Pesticides Used in Bt Cotton Farms

Classification	**Number of Pesticides**	**%**
Class 1a(WHO)	6	2.45
Class 1b(WHO)	19	7.78
Class 2(WHO)	66	27.04
Class 3(WHO)	19	7.78
O(WHO)	5	2.04
U(WHO)	15	6.14
Not available	113	46.31
Not classifiable	1	0.4
Total pesticides reported	244	100

Note: Class[8] 1a, 1b, 2, 3, O and U refer to extremely hazardous, highly hazardous, moderately hazardous, slightly hazardous, obsolete as pesticide and unlikely to cause any hazard in normal use.

Interestingly, 37 per cent of the pesticides used by the farmers are coming under the first three categories with majority belonging to the moderately hazardous group (27 per cent). Further a small percentage (2 per cent) of the pesticides fall in the obsolete category, which when used in combination with any other chemical might nullify the chemical effects, thus necessitating more sprays, as observed above.

We have arrived at a short list of pesticides that were found to be common for all the three cotton varieties and which appeared to be popular among the farmers in terms of their frequent application (Table 8). It shows that except for Acepahte, which is considered by the WHO to be slightly hazardous for humans and environment, rest of the pesticides either fall in highly hazardous or moderately hazardous category. Monocrotophos, which particularly is the favourite of the farmers, comes under the highly hazardous category and is also banned under the UN PIC (prior informed consent). According to the PIC convention, export of chemicals can take place only with the prior informed consent of the importing country. The PIC procedure is a means of formally obtaining and disseminating decisions of importing countries as to know whether they wish to receive further shipment of a particular chemical and for ensuring compliance to these decisions by the exporting countries. The aim is to promote a shared responsibility between exporting and importing countries in protecting the humans and environment from the harmful effect of the chemicals (WHO 2004).

Table 8: Use of Pesticides in Varieties*

	Classification		Approved Bt	Unapproved Bt	Non-Bt	Total
Name of pesticide	Pesticide Group	WHO Class				
Monocrotophus	Organophosphate	1b	502	510	21	1033
Acephate	Organophosphate	Class3	330	689	29	1048
Confidor	Neonicotinoids	Class2	245	240	11	496
Acetamapride	Neonicotinoids	NA	183	128	2	313
Imidacrop	Neonicotinoids	Class2	156	165	3	324
Computor	Neonicotinoids	Class2	62	217	0	279
Ektara		Ib	75	82	1	158
Endosulphun	Organochlorin	Class2	124	134	5	263
Starthion	Organophosphate	Class3	101	18	0	119
Prophanophus	Organophosphate	Class2	37	40	0	77

***Notes**:* *Compiled from the number of insecticides used per spray; 1b- highly hazardous, class 2 - moderately hazardous and class 3 - slightly hazardous.
***Source**:* Farm Household Survey by GIDR, 2007.

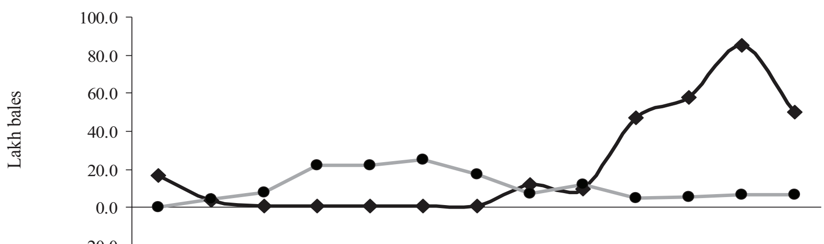
In quantitative terms, while the approved Bt cultivators have used 1228 litres and 709 kg of pesticide, unapproved cultivators have used 1299.9 lires and 782 kg of pesticides. We then tried to examine whether farmers are able to differentiate between the different colours indicated on the wrapper of the pesticide. Normally, the red, yellow, blue and green colours, as indicated on the cover of the insecticides, denote the extreme, high, moderate and slight toxicity of insecticides respectively. In all 50 per cent of the farmers had observed the colour label on the pesticide pack which indicates the level of hazardous of the product inside. While most of the farmers responded correctly about the red and green indication, 23 per cent of the farmers thought that yellow label indicates that it is not harmful. In spite of being aware of the hazard indicator on the pack, only 52 per cent of the farmers said that they take some precaution while spraying pesticides. These precautions range from wearing gloves to not eating while spraying pesticides. Nevertheless, it should be mentioned that only 50 per cent of the farmers indicated that wearing face masks (covering the mouth and nose with a piece of cloth) appear to be the most used precaution as compared to wearing gloves or wearing goggles while spraying pesticides. However a very small number of farmers (7 out of 200) reported getting sick after spraying pesticides. Skin irritation is the most observed impact (44 per cent) on farmers who spray pesticides. However, none of the symptoms were serious according to the farmers to get medical attention immediately and hence there was no medical expenditure reported or man days lost due to sickness. Similarly none of the farmers reported any adverse impact on the environment due to pesticide use. It is also a limitation of the study as we did not pursue beyond asking the farmers about the `observed' environmental impact like hardening of the land, reduction in the beneficial insects etc and have not undertaken any scientific testing of the water or land to prove the adverse impact of the pesticides.

Thus, the foregoing analysis of the pesticide use among the cotton cultivators in Gujarat indicate that: (1) though the number of pesticide applications per plot is higher in approved Bt as compared to the unofficial variety, the quantity of pesticide used is less than the unapproved variety; (2) majority of the farmers have used cocktails of two chemicals; (3) a large number of applications were meant for sucking pests; and (4) it is likely that a number of chemicals used by the farmers may belong to the hazardous category.

Export of Cotton from India and NTBs

With the increase in cotton production in the recent years, India which used to be one of the eight largest importers of cotton has become an important exporter (Figure 3). Export of cotton from India is regulated by the Ministry of Textiles based on the availability for domestic use and international prices for cotton. The import of cotton takes place under open general license (OGL) with 10 per cent of import duty. While the increase in cotton production contributed by the wider Bt adoption in different states is one of the reasons for increase in exports, favourable monsoon and weather conditions have also helped the farmers to reap better harvests than that they have realized few years back.

Figure 3: Trends in India's Exports and Imports of Cotton



	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Export	16.8	3.5	1.0	0.7	0.6	0.5	0.8	12.1	10.0	47.0	58.0	85.0	50.0
Import	0.3	4.1	7.9	22.0	22.0	25.2	17.6	7.2	12.0	5.0	5.5	6.5	7.0

Source: Government of India, 2006; Barik and Gautam, 2009.

However, India's cotton exports face two problems which could be a serious issue in future affecting the cotton trade. These issues are: (1) contamination in cotton and (2) the NTBs as discussed below.

Contamination

Though Indian cotton is 100 per cent hand picked, lack of care in handling the cotton at farm, farmyard, ginneries, etc. result in 20 types of contamination in cotton. Six to eight per cent of trash is common in Indian cotton bales as pre-cleaning is not a common practice in the ginneries (Barik and Gautam, 2009). Contamination can lead to downgrading of the cotton and the eventual rejection of the consignment. Notably, India, Uzbekistan, Turkey and Mali figure prominently in the list of countries where the most contaminated cotton originates. Some types of contamination are oily substances/chemicals, dust, sand, organic matter like leaves, feather, hair, and plastic. The least contaminated cotton originates from the USA, Israel, Australia and some countries from West Africa (ITMF, 2009).

The international textile manufacturers' federation has compiled the results of the surveys on contamination in cotton from several countries. We provide here a comparison of Shankar 4-6 varieties used by ginneries in 1999 and 2009 (Table 9). It indicates that on an average, percentage of responses, which reported that contamination was non-existent, has declined from 73 per cent in 1999 to 54 per cent in 2009. While the serious type of contamination has remained the same in both the years, moderate levels of contamination have increased from 15 to 34 per cent.

In the specific case of chemical related contamination, 48 per cent of the responses have said that grease or oil substances were not existent or insignificant. This response has increased to 83 per cent which is encouraging. However, the serious types of contaminations have increased due to presence of rubber particles or stamp colour.

Table 9: Comparison of Contamination in Cotton Due to Oily Substances/Chemicals (1999 to 2009)

Sources of contamination	1999 (54)			2009 (23 samples)		
	Degree of contamination (%)			Degree of contamination (%)		
	Non existent/ insignificant	Moderate	Serious	Non existent/ insignificant	Moderate	Serious
Grease/oil	48	33	19	83	17	0
Rubber	86	7	7	74	26	0
Stamp colour	63	20	17	74	26	0
Tar	92	4	4	92	4	4
Average of 1-16 contamination*	73	15	12	54	34	12

***Notes**:* * Source of contamination of 1-16 types are: fabrics made of woven plastic, plastic film, jute/Hessian, cotton, strings made of woven plastic, plastic film, jute/Hessian, cotton, organic matter like feather, leaves, leather, paper, inorganic matter like, sand, dust, rust, metal/wire, oily substances/ chemicals like grease/oil, rubber, stamp colour, and tar. Comparison of Shankar 4/6 alone is made here due to the relatively large number of samples as compared to the other varieties considered in the ITMF survey.

***Source**:* Compiled from cotton contamination surveys of ITMF.

The level of contamination varies with different varieties that the ginneries have used. We chose to present the Shankar case here as the sample size was relatively larger for this compared to other varieties considered in the survey of ITMF. Unfortunately, since Bt varieties were introduced in the year 2002, we do not have the data on chemical contamination in Bt variety. But in view of the number of pesticide applications with some of the hazardous chemicals, non-tariff barriers due to the use of chemicals could be a potential issue that needs further scrutiny.

NTMs could be in the form of product standards, process standards, registration and certification and testing, where the use of pesticides could become a major concern for exporters. Among the countries, the US, Mexico, and EC are the countries which impose number of NTMs (Table 10). Though a number of NTBs like minimum import price, import restrictions, anti dumping, customs, labour, rules of origin, etc. are associated with the textiles and finished products, yet the environmental, SPS and other standards tend to directly focus on the raw material itself. For instance, in terms of product and environmental standards, the insecticides and pesticides that are being used in cotton cultivation and their impact on environment would be scrutinized. Similarly, besides pesticides that are used in the production stage, different solvents, pigments and dyestuffs that are used by the cotton textiles processing and manufacturing industry would be under scrutiny as per the process standards. NTBs in the form of documentation necessitate all the documents regarding the export of a product to be authenticated by the embassy of the importing country in India. Cotton textiles already attract a number of NTBs of which minimum import price, import restriction and certification account for 28, 20 and 15 per cent of the different types of NTBs on textiles and clothing (Saini, 2009).

It is in this context that we need to consider the pesticide use practices of Bt cotton farmers as described above, which might have significant implications for India's trade in cotton ensuing from the imposition of process and product standards. As shown in the analysis, though the number of sprays against bollworm is less than sprays for controlling sucking pests, the pesticide Monocrotophus which is under the UNPIC and banned in many countries, (Mukhopadhyay, 2003) is being manufactured and widely used by the Bt cotton farmers. The permissible Maximum Residue Limit (MRL) of monocrotophus in cottonseed and cotton seed oil (raw) is 0.1 and 0.05 respectively (Mukhopadhyay, 2003). With majority of farmers reporting the extensive use of monocrotophus, it is most likely that the threshold levels of MRL might exceed the permissible limits, which itself is an important area of enquiry.

Already cotton importers, like Vietnam and the Philippines, require the exporters to give report on the chemistry of the product and toxicity of the product in the case of pesticides and fine chemicals. Toxicity tests are conducted over a period of time and may take up to two years. Presently toxicity studies are insisted only by Vietnam and the Philippines and exporters from India find it time consuming and unviable to trade with these countries. Similarly, the process standards concerning yarn are required by Singapore (Saqib and Taneja, 2005).

European Union already has passed legislation on the use of chemical substances called 'Registration, evaluation, authorization, restriction of chemical substances (REACH) in 2007 which would become a major issue for cotton textile exporters from India. The objective of this regulation is to protect humans from the exposure to hazardous chemicals and to ensure that the product is safe for human beings. REACH is a complex regulation and a variety of infrastructure is required for certifying various products under this regulation. Various suppliers in the cotton value chain will have to ensure that their cotton supplies do not contain the 'substances of very high concern' listed by the European Chemical Agency which is regularly updated.

Table 10: Non-tariff Barriers in Cotton and Related Products

Product	Type of NTB	Country	Details
Cotton	Minimum import price	Argentina	If price is below MIP, importer to validate invoice from customs in origin country and submit full set of original documents
Cotton fabrics	Minimum import price	Brazil	MIP in Brazil
Cotton fabrics	Minimum import price	EC	MIP in Czech Republic
Cotton textiles	environmental	EC	Dyes and carcinogenic chemicals to be eco friendly: environmental safeguards under REACH

Table 10 continued

Table 10 continued

Cotton textile	Labour	EC	
Cotton textiles	Customs	EC, Mexico, US	
Cotton fabrics	labeling	Japan	Voluntary labeling increases cost, time and efforts
Cotton yarn	Labeling	Korea	Mandatory labeling, composition and composites
Cotton textiles	labeling	Mexico, US	
Cotton textiles	Rules of origin	Mexico, US	
Cotton textiles	Documentation	Mexico, US	
Cotton fabrics	Import restriction	Nigeria	Ban on imported fabrics
Cotton textiles	MFN	Pakistan	Non-extension of MFN status to India

***Source**:* http://commerce.nic.in/trade/NTB productwise.pdf accessed August 15th, 2010.

As organic farming is limited to a small number of farmers in Gujarat, pesticide use in Bt cotton cultivation may not reduce significantly with the current level of technology adoption and awareness about the impact of pesticide use. As India's exportable surplus increases in future, more NTBs could be levied by the competitors and importing countries might insist upon strict adherence to the environmental and social/health safety regulations. In fact, the long term implications emerging from such concerns are yet to be known.

Conclusion

This paper shows that in Gujarat, Bt cotton adoption is 90 per cent in the major cotton growing regions in the state. Majority of the farmers use Bollgard 1 which offers protection against bollworm, which shows that the technology has been effective to that extent. However, farmers continue to spray pesticides to protect cotton from sucking pests. Fifty per cent of the farmers use two chemicals and 22 per cent use three chemicals. We doubt the efficacy of such combinations which might have prompted the farmers to use more chemicals. Perhaps due to the reduced efficacy of the chemicals, the farmers have not observed any immediate adverse health or environmental impacts in spite of relatively large number of sprays. We found both approved and unapproved cultivators to be using large quantity of pesticides. Nevertheless, the increase in cotton production as reported since introduction of Bt has also increased the exports.

But on the export front, already India has the distinction of being the country with most contaminated cotton. India's textile and clothing attract a number of NTBs. In view of the large number of pesticide sprays and as well as the new regulations like the REACH, this paper raises the concern whether pesticide residue could be a potential NTB.

Though the wider adoption of Bollgard II variety promises protection from spodeptra and bollworms, varietal differences and changes in the pest infestation pattern might warrant spraying of some pesticides. While farmers may not be willing to totally stop applying chemical insecticides, yet rational use of pesticides can be promoted along with popularisation of Integrated Pesticide Management (IPM) programmes in the predominantly cotton growing areas in the country. IPM programmes have achieved a significant reduction in the pesticide use (Barik and Gautam, 2009). As pesticide application is highest among the marginal farmers, extension services and IPM programmes have to be targeted amongst these farmers. This would ensure that repeated dose of pesticide do not leave the land infertile reducing the productivity.

India has been witnessing a rise in export of cotton in the recent years. With more number of countries adopting NTBs to prevent imports, cotton with intensive use of pesticides could be subject to NTBs in the days to come. Consumers especially in the foreign markets are increasingly aware of the environmental impact of their lifestyle and consumption pattern and are willing to pay a premium price for the eco-friendly products. Hence, if India needs to sustain its exports to other countries, measures need to be introduced to curb pesticide use by inducing more awareness regarding pesticide use and IPM programmes in cotton cultivation. India will also have to create adequate infrastructure for testing the products within the country for instance to comply with the REACH type of regulations. The health and environmental hazards of pesticides are known and only more awareness could lead to reduction in the use and safe application of pesticides that will lead to quality cotton being exported from India.

Endnotes

1 Agriculture Statistics Division, GOI, available at http://dacnet.nic.in/eands/Advance_Estimate/4_advance_2007-08.pdf (accessed on 27th Sept, 2008).

2 We recognise that there are definitional issues regarding the terms non-tariff barriers and non-tariff measures. However, for the limited discussion of this paper, we have used both the terms interchangeably following the WTO nomenclature, which describes non tariff measures same as non tariff barriers and includes quotas, import licensing, sanitary regulations, prohibitions, etc. (http://www.unescap.org/tid/projects/postdoha_s5dhar.pdf) accessed on January 31, 2011

3 The case between Canada and EC was based on the measures taken by EC which were affecting the import of agri biotech products from Canada. http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds292_e.htm

4 http://www.dnaindia.com/india/report_prove-zari-isn-t-made-by-child-labour-us-tells-india_1422226

5 "Although many of the details concerning variability in Cry 1 AC expression and toxin content remain unknown, it is clear that the genetic background of a transgenic plant plays a significant role in Bt toxin production and efficacy against insect pests. For this reason, careful plant breeding and testing are necessary to optimize the efficacy of transgenic cotton. Not only should breeders rigorously select the genetic background of their transgenic cotton plants, but these plants also should undergo stringent laboratory and field testing to ensure optimal transgene expression and efficacy under local growing conditions" (Showalker, *et al.*, 2009).

6 Qaim's study is based on the field trial data of Mahyco-Monsanto and Indira *et al.* (2004) had carried out a survey of farmers who participated in the field trial in 2001.

7 The survey enquired about the source of seed at the time of purchase of the seed and also the name of the variety. The trade names of the approved Bt and desi cotton varieties were collected from the authorized seed sellers and was matched with the names that we obtained from the farmers.

8 This is based on the WHO classification (2005).

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Biodiversity Associated Traditional Knowledge and Access and Benefit Sharing (ABS): A Critical Appraisal of Kani Experience from a Customary Law Perspective

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Abstract: The growing interaction and interdependence between local cultures and modern science in the sphere of BATK should be encouraged in an equitable framework not only to maintain the sustainable development but also to produce umpteen numbers of innovations and inventions to the benefit of the society. But such marriage is needed to take into account the environment in which such knowledge systems are constituted. This study attempted to examine the experience of India and Kani tribe of Kerala in particular in the backdrop of the TRIPS and CBD.

Key words: Biodiversity Associated Traditional Knowledge, CBD, TRIPS, Bio-piracy Access and Benefit Sharing, Prior Informed Consent, Kani Tribe.

Introduction

The issue of depletion of Biodiversity Associated Traditional Knowledge (BATK), growing relevance of BATK's commercial applications and indigenous communities' reluctance to share their knowledge with scientific community are serious concerns the contemporary society face. BATK is considered as the cradle of inventions that provide leads in the discovery, development, and manufacture of pharmaceutical products but scientific community's reticence to acknowledge and share the monetary benefit with indigenous community is a common practice in the society. This dichotomy is reflected in the benefit-sharing arrangements where indigenous communities are not given chances to participate into the pre and post - production research process. This is happened due to the effort to map local knowledge on institutional scientific parameters which is in contrast rooted and developed in a holistic framework under the

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indigenous customary legal system. So the Access and Benefit Sharing (ABS) agreement that is mostly lopsided, without respecting the self determination aspect of indigenous community may withhold the synergy between the biotechnology and BATK. By critically analyzing the benefit sharing arrangement of Kani Tribe from a customary law perspective, the study tries to delve into issues of first Access and Benefit Sharing mechanism to explore a more fruitful synergy between the biotechnology and BATK.

Value of Biodiversity Associated Traditional Knowledge

Global economic value of BATK is increasing day by day as it is the foundation and essential component that provide leads in the discovery, development and preservation of host of medicinal plants, health giving herbal formulations, agriculture and biological pesticides. Farnsworth (1988), Grifo and Downess (1996), etc. highlight the innumerable market value directly benefited by pharmaceutical and associated products from BATK. Pharmaceutical research that is greatly based on sampling all the plants to find out the therapeutic paths avoids the process of screening all of them with the help of BATK. BATK is not only a major source of base used by modern science in a great manner but it is also a system that is proven for sustainable development and protection of the environment (see Table 1).

There is a merit in recognising the dynamic interplay that exists between the contours of creativity within the BATK system and influence and interaction with the formalized science. But the effort to map and value local knowledge on institutional scientific parameters reduces the relative importance of both (Gupta). This process damages not only the economy of parent countries of indigenous communities but also their own socially and culturally embedded customary legal practices and rich knowledge systems. It is certain that blending of BATK with institutional knowledge, science and technology can unleash tremendous creative power inherent in human ingenuity. Scientifically advanced countries with their technological leverage attempt to tap BATK without recognising or sharing huge monetary benefits derived from such creative outputs. Institutionalization of such exploitative legal system under the ambit of WTO's Trade Related Intellectual Property Rights (TRIPS) worsens the entire scenario.

Table 1: The Use of Traditional Knowledge by Industry Sectors

Sector	Manner of Use	Source
Pharma-ceuticals	TK is not considered a useful tool during the early stages of high-throughput screening, but once an active compound is identified, most companies use TK (when available) to guide subsequent research. A (very) few companies direct their research programmes based on TK; some will use TK as the basis for setting up screens to select for competing (or better) compounds with similar bioactivity, that is, as a reference compound to select more active synthetic analogue compounds.	Literature, databases, inter-mediary brokers. A minority of companies commission field ethno botanical collection. Ethnobotanical information is often attached to samples as an "add-on," even if collections are primarily chemotaxo- nomic or ecology driven.
Botanical medicine	TK is used as the basis of identification of potential new product development; in safety and efficacy studies; and formulation. It is widely used in marketing commercial products, sometimes in developing wildcrafting or cultivation strategies for raw materials.	Literature, databases, trade-shows, Internet, and so forth. Middlemen brokers will follow up on leads in literature with local communities and research institutions. In rare cases the literature leads marketing companies to conduct field-based research on species of promise; this is directed, rather than bulk collecting, research.
Personal care and cosmetics	TK is used as the basis of identification of potential new leads and to direct research on a species' commercial potential. It is used in safety and efficacy studies; is widely used in marketing commercial products; and is sometimes used in developing sourcing strategies for raw materials.	Literature, databases, trade shows, Internet, and so forth. Occasionally, middlemen brokers will follow up on leads from the literature with local communities. Companies conducting high-throughput screening will commission the collection of ethnobotanical samples with identified uses. Other companies have entered into direct, field-based partnerships with communities to use their TK in product development.

Table 1 continued

Table 1 continued

Crop protection	A small proportion of companies use TK to guide the collection and screening of samples. As with pharmaceuticals, once activity is demonstrated, TK is sometimes used to decide on the direction of subsequent research.	Literature, databases.
Bio-technology	Many biotechnology applications, such as brewing and bread-making, are based on TK dating back millennia, but contemporary biotechnology makes little use of TK.	
Seeds	Companies make little use of TK, but they do use germ plasm that has been pre bred by other organizations to which genes from traditional varieties may have made an important contribution.	
Hort-iculture	Many popular ornamental varieties and horticultural vegetable crops owe their existence to traditional domestication and selection over long periods of time. However, TK is rarely used in the selection and breeding of new horticultural varieties today.	

Source: J. Michael Finger & Philip Schuler. 2004. "Poor People's Knowledge Promoting Intellectual Property in Developing Countries." Washington DC: The World Bank.

Politics of TRIPS and Exclusion of BATK

The TRIPS agreement which is mostly known as "hyperownership" (Safrin 2004) is created and promulgated by developed countries. When taken from the perspective of developing nations, the formation, evolution, and current status of international Intellectual Property (IP) laws are extraordinarily different. Michael Finger describes the prevailing attitude reflected in the TRIPS agreement: it is about the knowledge that exists in developed countries, about developing countries' access to that knowledge, and particularly about developing countries paying for that access. Finger further states that international IP laws have largely overlooked the "knowledge that exists or might be created in developing countries"; when it has been addressed, it is to protect "'traditional knowledge' against misappropriation by industrial country interests" and police "'biopiracy' on the part of the industrial country interests (Finger 2004)."

This process is fueled by the capital mobility and ideological shift toward a radical free market agenda that served to enhance the power of multinational companies particularly those engaged in knowledge intensive processes and production. Thus, private interests of the market are integrated with the state, asymmetrically in accordance with their structural power and organisational capacity, through their close relationship to state institutions and in the policy making process. Though the WTO advocates global free trade based on the economic theory that incur benefits to all, the reality of the implementation of free trade in the global arena may not yield such benefit for all (Sell 2004).

In the current global scenario, intellectual property received great attention as it is the symbol of economic development and competitive advantage. The concept and nature of property, its changing notions, evolved in course of time and were shaped by the philosophical, cultural, economic and socio-political aspects of the particular stage of the society. What IP has common with tangible property is the exclusion aspect of possession and enjoyment. With Intellectual Property Rights (IPR), the problem becomes as how to measure out the scarcity between owner and society. At the same time, the scarcity created by granting IPR is modulated by different constructs of property rights, which inevitably affect the relation between the values at stake (Vinciguerra 2005).

The human capabilities approach popularized by economist Amartya Sen and Martha Nussbaum strongly suggest that intellectual property should include a substantive equality principle, measuring its welfare-generating outcomes not only by economic growth but also by distributional effects. Because development encompasses not only economic but also cultural, social, and political dimensions of national well-being, a more deliberate consideration of these newer concepts in development economics could ameliorate intellectual property's one-sided emphasis on pure wealth or utility maximization (Chon 2006).

The intellectual property embrace all the intangible assets at stake, including raw genetic resources, the ethnobiological knowledge, advanced agricultural and pharmaceutical research that often transform a locally useful organism into a globally valued application of biotechnology. With the advent of information technology and biotechnology that touch vital interests like freedom of speech and the sanctity of life introduce a more conscious ethical and political dimension to the question of property rights (Chen 2005). Southern countries have limited internal technological and scientific capacity to enable them to transform local knowledge into knowledge that might be protected under current intellectual property frameworks. Without the establishment of structures within current global intellectual property frameworks intended to help the development of such capacity, TRIPS has the potential to exacerbate existing disparities in technological and scientific capacity (Arewa 2006).

Exclusion of BATK from TRIPS

The epistemological distinction between traditional and modern, or formal and informal may be thin. In the informal knowledge system, the method of knowing, feeling and doing follows a very different logic than in the formal system. The problem arises when one tends to ascribe local knowledge a consistency which is impossible among so many variations of locals. In other words, the expectation that universalistic features of institutional science would somehow become apparent in indigenous or local knowledge is only partly true (Gupta).

BATK systems, while generally holistic, have some reductionist elements too. In order to cope with the complexity of ecological change, some people in the community specialise by knowing more and more about less and less. Such specialised expertise requires focusing, targeting and steering strategies on specific themes or aspects of nature. So-called Western science is biased in favour of reductionist relationships, whereas local knowledge systems are biased in favour of systemic linkages and a holistic perspective on nature. Local Traditional Knowledge (TK) system is not static. They evolve, adapt and transform dynamically with time. New materials are incorporated, new processes are developed, and sometimes new uses or purposes are evolved for existing knowledge besides the acquisition of knowledge. Hence, there is a need for rewarding not only traditional knowledge but also contemporary innovations.

The global power relationships evident at the negotiating table in the international trade and other international arenas reflect longstanding global power hierarchies in culture and power. Cultural hierarchies also played an important role in the type of knowledge that came to be protected under global intellectual property standards. Traditional knowledge that did find protection in existing national intellectual property systems and eventually in global frameworks as well was geographical indications, which is notable because such frameworks protected types of knowledge that existed in Europe. The inclusion of geographical indications provisions in TRIPS, thus, reflects the experience of national and international lawmaking and the vigorous advocacy of such protection by the European Union during the adoption of TRIPS (Gupta).

The availability of genetic resources and traditional knowledge as 'common' is of much importance to industry which attempts to enclose this 'common' through IP. In biotechnology, this reliance on the commons as building blocks of intellectual property is so standard that it even has a name: "bioprospecting." Thus, there is a dialectical relationship between the public domain and intellectual property. Intellectual property flourishes from the public domain, and the public domain grows as information passes, over time, out of intellectual property. The public domain and private property are intimately intertwined, both historically and economically (Chander and Sunder 2004). So folklore and traditional knowledge must remain in the public domain. This cocktail of robust private property rights and foreign access thereto is leading to a steady transfer of the "ownership" of intellectual "products" from the developing world to the developed world. So IPRs in the international arena are tailored to enhance the interests of industrial exploitation of intellectual capital by highlighting the role of the rights owner and underplaying the role of other needs (Vinciguerra 2005).

In regards to indigenous peoples in particular, scholars are now asking the question as to what is the appropriate balance between their respective contributions and their rightful share in the vastly increased output of goods and services which have been made possible by the combination of traditional knowledge with modern science. Under current intellectual property regimes, the appropriation, distortion, and commodification of indigenous peoples' traditional knowledge can occur almost instantaneously and without legal redress (Riley 2003).

IP laws presume that the act of innovation is largely individual, rather than social, and that innovators are motivated by financial gain. Whereas custodians of the BATK believe that knowledge is socially created through interaction among humans, animals, nature and the spirit world, that individuals are obliged to put their knowledge to use for the good of the community, and that holders of such knowledge have a responsibility to ensure its proper use. Indigenous peoples possess their own locally specific systems of jurisprudence with respect to the classification of different types of knowledge, property procedures for acquiring and sharing knowledge, and the nature of the rights and responsibilities that attach to possessing knowledge (Gervais 2005). Indigenous peoples have linked their quest for self-determination to the protection of their knowledge, thus making knowledge the new frontier of the indigenous question in international law.

According to the WTO, "intellectual property rights are the rights given to people over the creations of their minds." When goods and services are made possible by combining traditional knowledge with western science, the contributor of the western scientific thinking is entitled to patent protection - a recognition of his or her property interest in creations of the mind - under TRIPS, the contributor of traditional knowledge is entitled to nothing. At its worst, TRIPS legitimizes the transfer of exclusive ownership and control of biological resources and traditional knowledge from indigenous innovators to western ones, with no recognition, reward or protection for the contributions of the indigenous innovators (Kadidal 1993).

Thus, in the definitional moment itself, TRIPS excludes indigenous innovation about biological diversity from what will be property in this new globalized legal world. This treatment stands as a sharp contrast to the patent rights that biotechnology routinely generates, and that TRIPS requires be recognized. Politics of exclusion and inclusion clearly evident by defining property to exclude the resources of indigenous peoples while including what is developed from those resources. TRIPS has to date proven itself resistant to accommodating and protecting indigenous works within the hyperowned world it has created. While the Doha Declaration recognized this problem of inequitable recognition of property rights, the Minister's state-based perspective suggests that the fundamental problem of inequity with regard to indigenous rights is unlikely to be resolved in the near future (Bratspies 2007).

Irresolvable Issues Between CBD and TRIPS

There are irresolvable differences in rationale, origins and overall framework of the CBD and the TRIPS Agreement. While emphasizing the conflict between TRIPS and CBD, it is important note that members of the Convention on Biological Diversity (CBD) have an obligation to ensure that IPRs are "supportive of and do not run counter to the CBD's objectives." Although TRIPS subject matter does not suffer from an identity problem per se, some provisions regulate the same object and have the same purpose as CBD provisions. In order to fully apply and universally ratify both treaties, certain provisions contained in both treaties need to come into harmonization.

TRIPS is a treaty with commercial objectives that largely benefit strong private firms. On the other hand, the establishment of the CBD was prompted mainly by the growing concern over the rapid worldwide loss of biodiversity, a recognition of the important role of traditional knowledge and the rights of local communities that develop and hold the knowledge, and the need to regulate access to and the sharing of benefits deriving from the conservation and sustainable use of biodiversity.[1]

Article 16(5) of the CBD, in fact, recognises that IPR can have a negative effect on the implementation of the CBD provisions, and thus, urges Parties to cooperate to ensure that IPR are supportive and do not run counter to the CBD objectives. The discussions raised under the TRIPS Council have dealt with the relationship with the CBD, as well as the review of Article 27.3(b)(Gervais 2003). Nonetheless, developing countries argue that they feel consistently exploited because of structural imbalance between countries rich in biological diversity and those strong in technological and legal instruments (Curci 2003).They contend the CBD is intended to conserve and use biological diversity of developing countries on a long-term basis, while TRIPS is intended to provide private property rights over products and processes. [8]According to the developing countries' standpoint, TRIPS Agreement influences the provisions of the pre-existing CBD in the access to genetic resources, the fair and equitable sharing of benefits from the utilisation of genetic resources, and the respect for traditional knowledge held by the indigenous communities (Curci 2003).

A key aspect of the CBD is that it recognises the sovereign rights of states over their biodiversity and knowledge, and thus gives the state rights to regulate access, and this in turn enables the state to enforce its rights on arrangements for sharing benefits. Access, where granted, shall be on mutually agreed terms (Article 15.4), shall be subject to prior informed consent (Article 15.5), and countries providing the resources should fully participate in the scientific research (Article 15.6). Each country shall take legislative, administrative or policy measures with the aim of "sharing in a fair and equitable way the results of research and development, and the benefits arising from the commercial and other utilisation of genetic resources with the contracting party providing such resources. Such sharing shall be upon mutually agreed terms".[2]

Based on the principle of national sovereignty enshrined in the CBD, countries have the right to regulate access of foreigners to biological resources and knowledge, and to determine benefit sharing arrangements. TRIPS enables persons or institutions to patent a country's biological resources or knowledge relating to such resources in countries outside the country of origin of the resources or knowledge. In this manner, TRIPS facilitates the conditions for misappropriation of ownership or rights over living organisms, knowledge and processes on the use of biodiversity. The sovereignty of developing countries over their resources, and over their right to exploit or use their resources, as well as to determine ABS arrangements, is compromised. However, on the contrary, it is said that biological resources should be subject to private intellectual property rights under TRIPS Articles 21 and 27. Thus, developing countries assert that the conflict arises, while national sovereignty in the CBD implies that countries have the right to prohibit patents on life forms, and TRIPS requires provisions of intellectual property rights on life forms.[3]

There is a debate to review the article 27.3 (b) of TRIPS to incorporate provisions for disclosure of the source of origin of genetic resourses, evidence for obtaining PIC and evidence for fair and equitable sharing of the benefits. In fact, there is little that a country of origin can do to enforce its benefit-sharing rights (recognised in CBD) if a person or corporation were to obtain a patent in another country based on the biological resource or related knowledge of the country of origin. While a legal challenge can be launched, such legal cases are prohibitively expensive. Even if a state has the resources to legally challenge a patent in another country, it may not have the resources to track down and challenge every patent that it believes to be a case of bio-piracy, nor is there a guarantee of success. Thus, if the patent laws, the administration of approvals, or the courts of a particular country operate in a context that is favourable to granting such patents, there is little that can be done by a country of origin to ensure that bio-piracy does not take place, or that if it takes place that it can get a remedy.[4]

In TRIPS, the award of IPR over products or processes confers private ownership over the rights to make, sell or use the product or to use the process or sell the products of that process. This makes it an offence for others to do so, except with the owner's permission, which is usually given only on license or payment of royalty. IPR, therefore, have the effect of preventing the free exchange of knowledge, of products of the knowledge, and their use or production. This system of exclusive and private rights is at odds with the traditional social and economic system in which local communities make use of, and develop and nurture, biodiversity. For example, seeds and knowledge on crop varieties and medicinal plants are usually freely exchanged within the community. Knowledge is not confined or exclusive to individuals but shared and held collectively, and passed on and added to from generation to generation, and also from locality to locality. However, the contribution and nature of community knowledge and community rights are not recognised in the TRIPS agreement.[5]

Instead, the patent system endorsed by TRIPS favours private individuals and institutions, enabling them to acquire "rights", including rights over the products or knowledge, whose development was mainly carried out by the local communities. TRIPS and the enactment of patent laws relating to biological materials in some countries have facilitated the misappropriation of the knowledge and resources of indigenous and local communities, and the number of "bio-piracy" cases has been increasing at a rapid rate.[6] This misappropriation is counter to the principles and provisions of the CBD that oblige countries to recognise local community rights and fair benefit sharing. Indeed, one of the main objectives of establishing the CBD was to counter the possibility of misappropriation or "bio-piracy", whilst one of the effects of TRIPS has been to enable the practice of such misappropriation.

Access and Benefit Sharing (ABS)

The CBD through various Conferences of the Parties (COPs) including COP-7 which took place in Malaysia in February 2004 has been discussing various issues relating to the establishment of an international regime on ABS mechanism. It is in this context that the Bonn Guidelines on ABS were developed and on the basis of which the Working Group (WG) formed to negotiate an international regime on ABS. In this context, there has been a clear trend at the CBD to elaborate and consolidate a multilateral ABS regime as well as to develop elements for *sui generis* systems for the protection of traditional knowledge and to explore the conditions under which the use of existing intellectual property rights can contribute to reaching the objectives of the CBD.

In this regard, the ninth meeting of the Ad Hoc Open-ended Working group on ABS, which was held in Cali Colombia, from 22 to 28 March 2010, finalized a draft protocol for further negotiations at Montreal Canada during 10-16 July 2010. The seven days intense negotiations on many complex issues finally reached a text draft of legally binding protocol on ABS to use genetic resources of the planet. This ABS draft is nicknamed as "Nagoya Protocol," an international instrument aimed at preventing misappropriation of genetic resources was adopted by members of the United Nations Convention on Biological Diversity. The protocol is also intended to ensure that benefits accrued from the use of those genetic resources are shared equitably with the provider country. Besides ABS protocol, over 40 decisions that are adopted including a decision on the strategic plan for the Convention on Biological Diversity (CBD) for the years 2011-2020, as well as a decision on resource mobilisation strategy. The Nagoya Protocol is expected to enter into force by 2012, with support from the Global Environment Facility of one million United States dollars to support early entry into force.[7]

Whether the protocol is strong enough to address the issue of biopiracy is a matter of debate. Because during the plenary session, countries like Cuba, Venezuela, Namibia, Bolivia etc. are not satisfied with final draft. Venezuela said that eight years ago the country wanted a strong agreement to prevent piracy with efficient tools but, the delegate said, the ABS protocol has suffered many changes since the first draft and the country was now very concerned about nature being turned into merchandise (Saez 2010). Implementation of this protocol will also depend upon non-CBD members like the US and their reaction to it.

CBD emphasises state sovereignty over territory or the fruits of private invention whereas indigenous leaders conceive these resources as an aspect of self-determination, as a recognition of their fundamental rights to property and culture. Indigenous groups are thus trying to expand the discourse over biological resources so that it includes their interests and their hopes for wresting back control over their territories, resources and heritage. This effort is critical because while the tug of war may currently be between TRIPS and CBD over whether to assign ownership of these resources to individuals or states, both of these regimes potentially conflict with indigenous claims and aspirations to group ownership of these same biological materials. To date, their success has been muted. Indigenous peoples find themselves in direct conflict not only with states but also with multinational corporations - all vying for control over traditional knowledge, land and resources. As has happened throughout history, aboriginal peoples are too often finding themselves on the losing end of this struggle over ownership and access to resources.

The CBD has given some guiding principles to go by. Article 15 thereof confers on States sovereign rights over their genetic resources. It obliges Parties to provide access to others, but only on mutually agreed terms and subject to prior informed consent. It also authorises Parties to ensure fair and equitable sharing of benefits arising out of research as well as commercialisation of the resources. But CBD does not clarify who has the rights on the resources in the first place: the country, the community concerned, the individual or some association on behalf of the individuals. The 'rights' issue, therefore, is perhaps left for resolution at the national level. The various means through which this is being achieved at the national level shows the great diversity of perceptions in this area, as well as the diversity of cultural and traditional moorings on which rights accrue.

As in the case of access, for benefit sharing also, CBD gives solutions that need national level implementation. In fact, CBD perhaps assumes that the exploitation of the right of the holder will be ensured through a process of fair and equitable benefit sharing. There is an implicit recognition that outsiders misappropriate resources and associated traditional knowledge, and therefore a benefit sharing mechanism would reverse the wrong. In some of the benefit sharing agreements that have been concluded between developing country right holders and developed country corporations, royalties promised range from 0.1per cent to 3-4 per cent. On the other hand, the royalty proposed to a developed country right holder by a developed country corporation was as high as 10 per cent (Anuradha 1999). It is this realisation that has perhaps made countries, like India, to install regimes that provide for State intervention in determining access as well as benefit-sharing arrangements.[8]

In addition to the general provisions on equitable sharing results and benefits in article 15(7), the CBD also provides that: *Each Contracting Party shall take . . . measures . . . with the aim that Contracting Parties, in particular those that are developing countries, which provide genetic resources, are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights*. Furthermore, the CBD underlines the need to grant the countries providing genetic resources effective participation in biotechnological research activities and priority access on a fair and equitable basis to the results and benefits arising from biotechnology based upon genetic resources.

The latter set of rights is firmly grounded in the recognition of the indigenous community's entitlement to its own tangible and intangible resources. In particular, the community has the right to economic compensation for the commercial exploitation of its biological resources, and this right stems from the property rights local communities have in their own genetic resources. The intangible character of TK makes the recognition of rights to TK more difficult. Indigenous people have their customary law traditions for the use and application of their knowledge. However, foreign companies filter traditional medical knowledge through the lens of industrialised intellectual property systems, which results in the perception that TK is free to be exploited.

Effective conservation of biodiversity, which has been recognised as a global good in its own right, requires that local communities benefit; the potential value of genetic resources may provide a vehicle for providing such benefits. Just as recognition of the value of these resources has increased, so too has the sense that the current governance structure for providing access and use rights over these benefits is inadequate (LaMotte 2006).

Need of a Multilateral Regime of ABS at International Level

A problem to the contractual approach is that the owner of a patent for a new product that is based on TK must be obliged to state the source of origin in order for the indigenous communities to be aware of how their TK was used. Article 27 of TRIPS provides for patentability irrespective of the source of origin. Thus benefits will not be shared equally amongst the innovator and the indigenous community.[9]

Using some form of IPR or *sui generis* systems for protection of TK based on prior informed consent and benefit sharing are certain supplementary efforts available for the prevention of bio-piracy. It is almost clear that a uniform international system for protection of biological resources and associated TK would not be able to cater to the requirements of individual country. Rather, the need is for a system which recognises such diversity preserved through national legal systems. Action at the national level would be inadequate for achieving the stated objectives of CBD unless an international recognition is given to these national systems, through an enforceable instrument. Hence, an internationally accepted solution to such bio-piracy is being considered necessary.[10]

In general, the discussions within the CBD are taking place against the backdrop of those IPR debates. Not surprisingly, therefore, almost all the basic questions remain the subject of debate: the legal nature of the regime, its scope, its modalities, and consequences for noncompliance. International certificates of origin have been discussed as a potential mechanism to trace genetic resource flows and identify whether PIC requirements for their use have been satisfied. There are many open and complex issues that would need to be addressed in any IPR disclosure scheme, whether within TRIPS or within the CBD.

The main risk is that the regime will impose excessive and unworkable burdens or increase the already considerable legal uncertainties associated with the development of these resources. The main opportunity is that a well-designed ABS regime could minimise existing obstacles to genetic research in a way that would maximise the sustainable use of these resources, while at the same time ensuring their conservation and the equitable sharing of benefits associated with their development.

Customary Law

Customary law is the system of rules and customs that governs conduct and rights in indigenous communities. Therefore it is relevant in any analysis of rights and obligations under the *sui generis* models. Customary law involves rights and obligations with respect to such matters as “marriage and private arrangements, food gathering, distribution and sharing of the other goods, certain trading relationship and educational roles.” Customary law also recognises procedures for the conduct and resolution of disputes, and “responsibilities for land and for objects and ideas associated with land”(Kuruk 2007).

Customary law is not uniform across ethnic groups in indigenous societies. Differences in the customary laws of indigenous groups can be traced to such factors as language, proximity, origin, history, social structure, and economy. Generally, the customary law rules among ethnic groups speaking a common language tend to be similar, but the rather significant differences that can sometimes exist make it misleading to talk of a uniform customary law rule applicable to all members of the language group (Allott and Cotran 1971).

An important characteristic of customary law is its dynamism. Customary law is not static, and its rules change from time to time to reflect evolving social and economic conditions. Like any system of unwritten law, customary law has a capacity to adapt itself to new and altered facts and circumstances as well as to changes in the economic, political, and social environment (Cotran, and Rubin 1970).

Similar elements are found in the definitions of folklore, traditional knowledge, suggesting a link with customary law. In relation to folklore, it has been noted that “descriptions of the amorphous term folklore tend to emphasise its diverse nature, as consisting of, for example, the traditional customs, tales, sayings, or art forms preserved among a people,” applicable “not only to ideas, or words, but also to physical objects.” Other characteristics of folklore include “its oral nature, group features, and mode of transmission through generations of people” (Kuruk 1999).

With respect to the use of the term indigenous knowledge as alternative terminology, one can distinguish between a broad and narrow meaning, with the former for all practical purposes being equated with traditional knowledge (Simpson 1997). Therefore, like customary law, all these definitions focus on rights of particular ethnic groups and practices that are constantly evolving and not static. In this sense customary law on the one hand, and traditional knowledge on the other, are interrelated. Accordingly, one cannot seek to understand traditional knowledge without reference to customary law which is the system within which the scope of rights in such knowledge is determined. This link also suggests that solutions to traditional knowledge issues drawn from customary law are likely to be more successful than the western oriented top-down approaches reflected in current international instruments on traditional knowledge (Riley 2005).

African and Pacific Customary Laws

The African Model Law provides for the rights of communities over their innovations, practices, knowledge, and technology acquired over generations. The Pacific Model Law emphasises the rights of individuals, clans, and groups as owners and holders of cultural rights. Such formal recognition is significant because it confirms the primacy of rights of indigenous groups to traditional knowledge and relegates to a secondary right any claim the State may purport to assert in relation to traditional knowledge. It also clarifies the rather tenuous basis of claims in some international instruments that purport to provide for State "sovereign" rights in traditional knowledge.[11]

As a corollary to this fundamental right of ownership, custodianship, or other relevant right in traditional knowledge by indigenous groups, there is also an acceptance in the model laws of the principle that the scope of such rights would be determined with reference to customary practices and not qualified by rules laid down by States. The African Model Law incorporates this principle by noting that community rights are to be "protected under the norms, practices and customary law found in, and recognised by, the concerned local and indigenous communities."[12]

Given the objective under the *sui generis* models to mitigate the problems posed by the application of intellectual property criteria to traditional knowledge, the model laws permit deviations from established IP criteria where necessary to effectively protect traditional knowledge. For example, the African Model Law tackles the bias evident for "individuals" under intellectual property law by emphasising instead the "collective" nature of indigenous rights in traditional knowledge. To remedy the problem caused by the IP requirement that protected matter be recorded or reduced to some form of writing, the *sui generis* models dispense with such a requirement altogether. Thus, traditional knowledge would be protected under the African and Pacific Model Laws whether or not it is in writing or material form (Ekpere 2000).

Another difference between IP and customary law taken up in model laws is the duration of rights. Unlike the limited period of protection for IP rights, customary law rights in traditional knowledge are held for an indefinite period. Accordingly, the Pacific Model Law provides that such rights "continue in force in perpetuity"(Kuruk 1999). While there is a general disposition under customary law to allow free use of traditional knowledge under notions of reciprocity, the right to such use is not automatic. Access to traditional knowledge could be denied on account of the sacred secret nature of an item or simply out of a desire of the indigenous group not to commercialise it. The right to refuse access as an important means of protecting traditional knowledge is also incorporated into the *sui generis* models. The African Model Law not only recognises this right, but like the Pacific Model Law, provides elaborate rules on prior informed consent to ensure that indigenous groups have sufficient information on proposed uses of traditional knowledge to make a decision on whether or not to grant access. Even where approval has been granted, such consent can be withdrawn for reasons including the failure to comply with the conditions of the grant or unauthorised uses of traditional knowledge (Janke 1998).

Significantly, the sharing ethic, which is part of the concept of reciprocity, imposes an obligation on the individual who benefits from the exploitation of communal property or rights to pass on some of the benefits from the exploitation, either in the same form or in kind to other members who may require such assistance. Because this sharing ethic has been threatened by exploiters who have taken undue advantage of indigenous groups by not rewarding them appropriately for uses of traditional knowledge, it is imperative that a protective scheme based on customary law incorporate some form of benefit-sharing arrangement (Correa 2001).

The scheme should require that a portion of the benefit obtained from access to traditional knowledge be assigned to indigenous groups to be applied in accordance with traditional practices. Also, such benefits need not be in monetary terms only; they could include in-kind arrangements such as the construction of schools, hospitals, or roads to benefit traditional communities. Accordingly, the Pacific Model Law provides for equitable monetary or non-monetary compensation, while the African Model Law guarantees indigenous groups at least fifty percent of the benefits gained from the utilisation of indigenous resources.[13]

Regarding the enforcement of these rights and obligations, the expectation under the African Model Law is for the enforcement of rights and obligations in accordance with traditional practices. The Pacific Model Law contemplates use of national courts but does not preclude a resort to customary dispute resolution mechanisms. Unfortunately, both model laws do not elaborate on the enforcement mechanisms under customary law. For an understanding of the effectiveness of customary law in protecting traditional knowledge, relevant issues surrounding such mechanisms must be clarified (Kuruk 1999). Of prime importance is whether customary law is recognised as a viable component of the national legal system; no legal basis will otherwise exist for the enforcement of customary law rules. An equally important consideration is how the relevant institutions ascertain and apply customary law rules.

A Critical Appraisal of the Kani Experience

The Indian experience reveals that there have been several cases of bio-piracy of traditional knowledge (TK) from India (Rao and Guru 2003). A benefit sharing approach based on legally binding contracts would allow for flexible solutions on a case-by-case basis. But the first successful benefit sharing model of the world not only attracted appreciation but has been attended with certain crucial issues and concerns. When CBD identifies it as one of the earliest successful models, it is supposed to be coherent with proposed legal aspects regardless of the classification of pre and post CBD era. It all began with a study about the traditional medicinal system of India. In order to implement All India Co-ordinated Research Project on Ethnobiology (AICRPE) project, scientists of the Tropical Botanic Garden and Research Institute (TBGRI) sought the permission of the Kani tribe to accompany them as guides in the Agasthy hills, the Western Ghats in South India. It is good to ascertain whether the scientists who engaged in survey officially sought the permission of the Moottukani[14] to assist them in the survey. During the visit, the scientists "accidentally"[15] get to know about the antifatigue use of Arogyapacha meaning ever green health which was later identified as *Trichopus Zeylanicus spp. Tranvancoricus* from Kani tribe.

This "accident" is only applicable to the scientists but not to the tribals who nurtured that knowledge through their customary law practice for generations. Here again one has to make certain whether the knowledge that is culled from the two kani guides are based on the monetary inducements or have got ratification of the Moottukani and the tribal community. The initial reluctance of the Kani men to share the knowledge with scientists reveal not only that it is a sacred knowledge of the community but also the knowledge is secret and not available in the public domain as many would think (Bijoy 2007). Nevertheless based on this knowledge and subsequent research, patent applications were filed and some patents were granted (see Table 2). The time-line of the whole process is given in Box 1.

The question of prior informed consent becomes valuable or fit into customary law only when scientists get permission of Moottukani who gives final assent with the consent of the community. But according the Biodiversity Act, 2002 any person who is not a citizen of India, a non-resident citizen or a corporate body not registered in India, or registered under law having non-Indian participation in its share capital or management, is not authorised to obtain any biological resource or knowledge without the previous approval of the National Authority. It is interesting to note that the provision, while empowering the National Authority to grant approval, does not in any way refer to the necessity of consent of the communities whose resources are being approved (Dam 2006).

The limitation contained in this provision is of little consequence though because it does not address the issue of consent of the communities per se. On the contrary, the provision presumes the existence of a standing consent and imposes an obligation on the National Authority to evolve a formula for "equitable sharing of benefits." By not allowing communities, tribal or otherwise, to decide whether to allow aspects of their cultural life to be made subject matter of commercial utilisation, the provision infringes the communities' fundamental right to culture (Dam 2006)

Below the National Authority and the State Boards, the Act does permit local bodies to create a "Biodiversity Management Committee for the purpose of promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, and folk varieties." Local bodies have been relegated to a consultative entity, both with reference to the National Authority and State Boards, and they have been given no authority to veto decisions permitting the commercial utilisation of cultural knowledge. The actual consent of a community to commercial utilisation of its cultural property has been made irrelevant by the presumption of consent. By presuming a standing consent, the Biological Diversity Act effectively denies tribal communities any meaningful realisation of their fundamental right to culture. The Act does not recognise any traditional dispute resolution mechanism to resolve differences arising from decisions permitting the commercial utilisation of such cultural property (Dam 2006). It is good to know whether through the loop hole of presumption of consent scientists have bypassed PIC of Kani community.

Scientists highlight different scientific experiments conducted on Arogyapacha and discovered the presence of certain glycolipids and non-steroidal compounds (Polysaccharides) with profound adaptogenic immuno-enhancing antifatigue properties. It is quite interesting to know how could such an uncivilised indigenous community arrived at the practical use of such plant without the help of scientifically advanced chemical and pharmacological investigations methods. It is very clear that scientists were only just verifying knowledge that is given by the informers with the modern scientific tools. There is a conscious effort to undermine the practical use of the knowledge by such trivial arguments like Kani tribe members were using only the fruits of the plant and most of the ingredients of the final product are from other ayurvedic knowledge and wisdom, etc. except leaves (Chaturvedi 2007). Ironically TK, in the pedagogic sense, is a way of knowing of a community or a culture. This knowledge is considered indigenous despite being contemporary. In order to cope with the complexity of ecological change, some people in the community specialise by knowing more and more about less and less (Gupta). Such specialised expertise requires focusing, targeting and steering strategies on specific themes or aspects of nature. Hence, there is a need for rewarding not only TK but also contemporary innovations. It is indigenous because the meanings as well as the categories of sense making are generated internally within a cultural community. With regard to Kani tribe, a particular family or an individual is assigned to do such advancing process in the community. So it is community knowledge that is secretly practiced by certain families or individuals for the community.[16] Under the customary practice the traditional knowledge transmitted through *shruti*, that is, orally often legally binds both giver and receiver of the knowledge. Such an oral transmission becomes more valuable when the plant species was already documented by the scientific community with out knowing the traditional practical use of it.

There is an open discontent regarding the compensation package offered under ABS arrangement for the sacred community knowledge. When you compare the Kanis 2 per cent royalty agreement, a fairly common level for Latin America and Asian countries, to the 10 per cent royalty received by Yellow Stone Park, USA, for similar bio-prospecting activities something of the variable remit of such agreements becomes apparent, as well as the fact that the bargaining positions of the parties involved is a crucial determinant (Anuradha 1999). Participants of the agreement do not have an equal bargaining position and most of the decisions, it is criticised, are taken by TBGRI on behalf of Kanis. The concept of benefit sharing also raises critical questions about the perception towards a biological resource and the knowledge pertaining to it. Is it a mere raw material in the path of modern scientific progress; should it be accorded the same respect as the scientific knowledge base of another corporate entity, which would then mean that the terms of negotiation would then be far more equitable (Anuradha 1999).

Though, standardised herbal formulation of 'Jeevani' consists of *Trichopus zelanicus* as major ingredient and some other herbal ingradients like *Withania somnifera (ashwagandha), piper_longum, evolvalus alsinoides*, what novel invention other than kani's traditional use of *Arogyapacha* is attributed to this product is a question that has to be answered by those who applied for process patent of this product. When the license fee as well as the royalty was equally shared between the TBGRI and the Kani tribe, why such sharing is missed in the patent application process.

Table 2: Five applications for Process Patents

Application number	Applicants	Derivative process	Product	Patent
959/MAS/ 1996	Pushpangadan P, S. Rajasekharan and George V	A process for the preparation of a novel immunoenhancing, antifatigue, antistress and hepatoprotective herbal drug	Jeevani	The process patent published in Indian Patent Gazette No.31 dated August 3, 2002 and sealed in 2005 due to non renewal

Table 2 continued

Table 2 continued

88/Del/ 1994	Bhutani K K, Gupta D K, Jaggi B S, Amanda K K, Kapil R S, Pushpangadan P, Sreedharan Nair, S.Rajasekharan	for isolation of a Glycolipid Fraction from Trichopus Zelyanicus possessing adaptogenic activity		Process patent Awarded
957/MAS/ 1996		For the preparation of diabetic medicine		
958/MAS/ 1996		For the preparation of sports medicine	Vaji	
MAS/650/ 2001	Appian Subramonium, Sreedharan Rajasekharan, Palpu Pushpangadan, Varghese George and Gopalapillai Sreekandan Nair	for the process to prepare an herbal preparation for cancer		Awarded Patent on 22 September 2006.

Source: Data compiled after the personal interaction with Dr. S. Rajasehkaran on 19/06/2009)

Not only Kanis are excluded from the patent applicants list but also are not educated to effectively participate in biotechnological research activities to participate in the R&D process of the product formulation and technical know-how.[17] As a result, Kanis were merely limited to the collectors of plants in the forest on which they do not have any rights which not only broken their conformity with nature and sustainable BATK making under the holistic framework but also annihilated their customary law system and oral transmission of their rich TK in the tribal community.

The logistical apathy to renew the process patent in 2005 of Jeevani product as well as the seven year license period that was ended in 2002 with the Arya Vaidya Pharmacy (AVP) and failure to get global IPR rights for Jeevani reveal that a resource is best protected when custodians of traditional knowledge are the decision makers (Francis 2004 and 2006). But their lack of capability to deal with such situations and modern state's symmetrical interests of neo-liberal regimes worsen the entire process and thwart the emulative spirit of ABS. The successful hit rate that the author and his team got while screening plants of the Western Ghats was in the range of

Box: 1 From Documentation to Benefit Sharing

The ICAR floated the idea for documentation of ethno-biology for conservation of IKS of the tribal communities of India.	21 September 1976
The Department of Science and Technology launches the AICRPE under the 'Man and Biosphere Programme'.	July 1982
Ministry of Environment and Forests takes over the AICRPE.	September 1983
Coordination Unit for the AICRPE established at the RRL, Jammu, under Dr. Pushpangadan.	18 September 1983
First Group of AICRPE led by Dr. S Rajasekahran meets the Moottu Kani (tribal head) and gets permission for the expedition.	June 1987
Full AICRPE Group led by Dr. Pushpangadan in the Agasthyar hills, accompanied by Mottu Kani's Representatives.	December 1987
First scientific paper on Arogyappacha in Ancient Science of Life.	July 1988
Two Kanis join the TBGRI as consultants on monthly salary of Rs. 3000/- (they remain there until 1999).	January 1993
First Patent on Arogyappacha (Application No. 8/ DEL/94).	8 December 1994
Original proposed date for signing of an agreement between the TBGRI and the AVP.	22 July 1995
Executive Committee reconsidered the matter.	16 October 1995
Final approval to transfer the technology to the AVP.	20 October 1995
Agreement for Transfer of Technology signed.	10 November 1995
Direction by the Executive Committee to consult the SC/ST Department for working out the modalities.	30 September 1996
Filing of Jeevani Patent (Application No 959/MAS/96).	4 June 1996
Transfer of technology to the AVP.	September 1996

***Source*:** Chaturvedi, Sachin (2007) Kani Case. A Report for GenBenefit, available at: www.uclan ac.uk/genbenefit.

10-12 percentage. This means the money and time invested in screening can be reduced significantly. The revival of interest in natural products the world over, the rich knowledge base of traditional communities offers enormous opportunities for developing a range of value added products - herbal drugs and refined pharmaceutical products, pesticides, gums, resins and dyes, etc. Whilst doing so, it is equally important to protect the intellectual property rights of the traditional communities, who are the ultimate custodians of this knowledge (Arunachalam 2002). TBGRI has not made any fresh deal either with AVP or with any other company. But the negotiation for the second ABS agreement is progressing in the recent past in a more democratic and transparent manner (Chaturvedi 2007). See Box 2, Table 3 and Box 3 for details of recent development.

Box 2: Comparison of First and Second ABS agreement between Stakeholders

First Agreement, 1996	Second Agreement, 2006
Parties were the TBGRI and the AVP	Parties included Kanis, the TBGRI and the AVP
Entered into force on November 10, 1996	Yet to be implemented
Valid for a period of 7 Years	Would be valid for a period of 7 Years
License fee of Rs. 10,000,00	License Fee 20,000,00
Royalty to be paid at 2 % for 10 years	Royalty to be paid at 4 % for 10 years

***Source*:** Chaturvedi, Sachin (2007) Kani Case. A Report for GenBenefit, available at: www.uclan.ac.uk/genbenefit

Though the informers claimed the information as their family knowledge and claimed for the exclusive control over it, the scientists considered the knowledge as the collective knowledge of the community in respect to the customary practices of the tribe. So any benefits derived from the knowledge should be beneficial to the tribe as a whole. Several ways of transferring the benefits to 'Kani' tribe was discussed. Subsequently, a trust was formed in November 1997 with support from TBGRI, local Government officials and NGOs. The major functions of the Trust were to facilitate sustainable supply of Arogypacha to AVP as well as to undertake the social welfare activities of its members. It is good to ascertain what kind of capability Kani tribe has achieved in terms of knowledge creation when they alienated their sacred traditional knowledge through this ABS mechanism. At same time, there is no documentary evidence supportive of the inclusion of Kani Tribe in the entire process.

Table 3 A Jeevani –License fee paid

Sl. No.	Name of the Bank/ Cheque No.	Date	Amount paid (in Rupees)
	SBT, 092496	22/02/1999	5,00,000/-

B Jeevani – Royalty paid

Sl. No.	Name of the Bank/ Cheque No.	Date	Amount paid (in Rupees)
	SBT, 092496	22/02/1999	19062.00
	SBT, 098845	04/12/2003	30000.00
	SBT, 109446	03/03/2004	30000.00
	Cheque No. 031056	24/10/2005	37382.00
	SBT, Palode cheque No.866555	31-12-2008	24728.50
	Total Royalty received from Coimbatore Aryavaidya Pharmacy from 1999 to 2008.		282345.00
	50% of the Royalty given to the Trust as per the agreement (Rupees one lakh forty one thousand one Hundred and Seventy Two and fifty paise only).		141172.50
	The amount donated to the Trust by Dr. P. Pushpangadan.		1,00,000.00
	The amount donated to the Trust by Dr. Anil K. Gupta.		5000.00

Total asset of the trust A + B = Rs.7,46,172.50 (Rupees Seven Lakhs Forty Six Thousand One Hundred and seventy two and fifty paise) which excludes interests accrued from the above amount.
Source: Data collected from Dr. S Rajasekharan on 19/06/2009 through the personal interaction at TBGRI).

Box 3: Post Benefit Sharing Effects

- Rs. 2500 is maintained as a fixed deposit in the name of two Kani girls aged 8 and 10 whose mother was killed by a wild elephant in 2002.
- Constructed a Community Hall (Arogyapacha Bhavan) with necessary infrastructure facilities including table, chairs etc.
- Facilities provided for running single teacher school in the community hall for the last three years and now it has been shifted to the new building.

Box 3 continued

Box 3 continued

- Solar lamp was installed with the help of ANERT.
- Purchased a new Jeep for transportation of people, marketing goods and Non Wood Forest Produce.
- KKSKT has given employment to two Kani tribesmen as Driver of the Jeep and Helper and both of them are drawing salary every month.
- Telephone facilities have been provided to the office of the Trust.
- Construction of a small building for providing computer education to the school children is in progress.
- Established Rain Water Harvesting System
- Established reading room for the benefit of the tribal community.
- TBGRI in association with KKSKT implemented a 'Pilot Participatory Programme on Conservation and Sustainable Utilisation of Medicinal and Aromatic Plants' under the Kerala Forestry Programme aided by World Bank.
- Recently Kerala Forest Department have already started implementing a novel scheme entitled Cultivation of Medicinal Plants for Improving the Livelihood of Kani tribes residing in the Agastyar Vanam Biological Park (Kottoor forest) with the support of the National Medicinal Plant Board Govt. of India. Arogyapacha is one of the medicinal plants included for large scale cultivation under the above programme. This will definitely help the tribal community to generate considerable income.

Source: Data collected from Dr. S Rajasekharan on 19/06/2009 through the personal interaction at TBGRI.

Of late in 2008, the Kerala government came out with an IPR policy to protect BATK associated with Ayurveda. Though there is no legal sanctity for the policy when there is a national law on the issue, the basic elements of the policy suggest for the protection of traditional knowledge. All traditional knowledge, including traditional medicine, the practice of which sustains livelihoods, must belong to the domain of "knowledge commons", and not to the "public domain". For operationalising this policy arrangement a body called the Kerala Traditional Knowledge Authority (KTKA) is proposed, with which all practitioners of traditional knowledge of the first category will have to be registered.[18] This IPR policy fails to define 'commons' in the context of existing IPR regimes. The 'commons' are more of a utopian idea in the current terrain of globalisation. Because utilitarian and natural rights perspective consider 'common' under public domain as necessary prerequisite to privatisation of property rights (Chander and Sunder 2004; Boyle 1995). This policy seems to give certain amount of authenticity to the TK holders in terms of Benefit Sharing but never mention about the cultural and legal context of indigenous community under which such knowledge is formulated. By and large this policy seems to facilitate bio-piracy as 'prior art' (Bagley 2002) is recognised only within jurisdictional territory of a state in certain countries like US.

Conclusion

The forgoing discussion suggest that the mismatch in the provisions related to the protection biodiversity associated traditional knowledge resources in the international conventions especially those in the TRIPS Agreement have served the corporate interests of the multinational companies and countries that have monopoly over biotechnology innovations. The provisions related to ABS and PIC in the CBD is capable of offering remedy to many of the grievances advanced by the victims of bio-piracy. CBD does not clarify who has the rights on the resources in the first place: the country, the community concerned, the individual or some association on behalf of the individuals. When CBD emphasis on the aspect of state sovereignty over territory, or the fruits of private invention, indigenous leaders conceive of these resources as an aspect of self-determination, as a recognition of their fundamental rights to property and culture. Paradoxically, a viable solution remains too far away in view of the overlapping and mutually contradictory nature of the provisions in various conventions and international initiatives. The TK base of Indian ethnic and local communities is perhaps the richest in the developing countries and has the potential to capture the world drug and pharmaceutical markets, provided the country strives to bring in substantial improvement and value addition to the existing TK base through appropriate scientific and technological intervention and policy support. Indian experience in this direction suggests that there is ample scope for effective protection of such challenged resources and proprietary rights over it. There is an implicit recognition that outsiders misappropriate resources and associated traditional knowledge, and, therefore, a benefit sharing mechanism would reverse the wrong. The experience of the Kani Tribe in Kerala on matters related to Prior Informed Consent and ABS suggest that legal mechanisms at the international and at the national level that give recognition to both customary laws and ABS system may be a flexible solution to bio-piracy as well as for blending two systems of knowledge for the generation of new IP invention and innovations. The ABS experience of the Kani Tribe, initially, appeared to be encouraging and emulative. The custodians of Arogyapacha did receive certain amount of benefits but the prevailing arrangements and mechanisms seem to be silent on many vital questions related to ABS and PIC. A well designed ABS regime that respects customary laws of indigenous communities could not only resolve current obstacles at the national level to bioprospecting but also enable the indigenous communities to share their rich TK with the scientists without any suspicion.

Endnotes

1 Intellectual property rights, TRIPS Agreement and the CBD, Issued by Third World Network for the second meeting of the Expert Panel on Access to Genetic Resources and Benefit-sharing held in Montreal, Canada from March 19 - 22, 2001, at http://www.twnside.org.sg/title/benefit.htm

2 Ibid.

3 Ibid.

4 Ibid.

5 Ibid.

6 Ibid.

7 A new era of living in harmony with Nature is born at the Nagoya Biodiversity Summit, Secretariat of the Convention on Biological Diversity, United Nations Environment Programme, October 29, 2010, at www.cbd.int

8 The Biodiversity Act 2002, chapter II of the Act deals with regulation of biological diversity in India.

9 Access and Benefit Sharing: Special Disclosure Requirements in Patent Applications, Discussion paper, International Chamber of Commerce, 25 May 2005, at iccwbo.org/.../intellectual_property/.../ABS_%20Special%20Disclosure.pdf

10 Protecting Traditional Knowledge : Why it is Important, at http://commerce.nic.in/wtoapril2002.htm

11 "Council of Ministers of the Organisation of African Unity, African Model Law for the Protection of the Rights of Local Communities, Farmers and Breeders, and for the Regulation of Access to Biological Resources," at http://www.opbw.org/nat_imp/model_laws/oau-model-law.pdf, art-16.

12 Ibid, art-17.

13 "Model Law for the Protection of Traditional Knowledge and Expressions of Culture," (2002): reprinted in Secretariat of the Pacific Community, Pacific Regional Framework for the Protection of Traditional Knowledge and Expressions of Culture, art 12.

14 According to the customary law practice Moottukani, eldest and highest authority of the Kani tribe, has to give permission to his men to help the scientists.

15 The scientists refer this as an incident when I had a discussion with one of the scientists on 19/06/2009 during field work.

16 Guides or Informers claimed that it is their family knowledge to the scientists. Personal interaction with Dr. S. Rajasehkaran on 19/06/2009

17 The two Kani men were given some remuneration during the process of research for a stipulated period. But there are educated Kani tribesmen in the community who could have been encouraged to join the research process.

18 Intellectual Property Rights Policy of Kerala, 2008, at www.keralalawsect.org/ipr2008.pdf

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Genetically Modified Crops: Global and Indian Perspective

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Abstract: The necessity of a Gene Revolution in the background of declining performance of Green Revolution has drawn a lot of attention in recent times. This article reviews the progress of genetic modification in plant varieties at the global level as well as in India with various benefits available from GM crop and the potential risks associated with it towards mankind and environment. It brings in the issue of biosafety regulations in different countries, diverse consumer perceptions about GM crops across nations, Intellectual Property Rights and the role of WTO. The article also documents the journey of GM crop, mainly Bt cotton in India with briefly touching upon the existing regulatory process, labelling policy and public concern towards Bt Brinjal. The discussion brings out the fact that agricultural biotechnology is expected to play a pivotal role in future in ensuring food security through higher productivity, reducing pesticide use and soil erosion, enhancing nutrition and at the same time preserving the environment for the future generation. However, strict scientific regulations and monitoring are absolutely necessary for its safe and fruitful use by mankind.

Key words: GM, India, global, agriculture, crops, biosafety.

"Genetics will surely play a major role in the still infant technology of biological engineering. Already it has borne a huge harvest of practical results through improvement in breeds of food plants and animals." Theodosius Dobzhansky, Scientific American, 1950

Introduction

Agriculture is one of the oldest technologies human beings have ever adopted and it has a great role in the development process of the world economy. The technological revolutions that transformed agriculture in the late 19th and early 20th century reached its highest level in the middle of 20th century, with Green Revolution, which dramatically increased the food production in the developing countries with rapid spread of high-yielding varieties of wheat and rice, which required adequate supply of fertilizer, pesticides and irrigation facilities. Even though Green Revolution

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had its share of success in increasing total factor productivity growth in some parts of the developing countries including India (Dholakia and Dholakia, 1993; Rosegrant and Evension, 1994; Desai, 1994; Rao, 2005) along with infrastructural development, its effect started to diminish from early 1980s. For example, the state of Punjab in India was one of the most significant beneficiaries of Green Revolution. However, it can be inferred from Tables 1 and 2 that there was deceleration in the growth rates of agricultural production and productivity in Punjab from the early 1980s (Roul, 2001). Moreover, there were persistent hunger and malnutrition, income inequalities and more importantly harmful effects on the environment like decreasing water availability, soil salinity as well as erosion and contamination through uncontrolled use of chemical fertilizers and pesticides. Thus, long run agricultural sustainability and food security for the rapidly growing population were still the important policy issues to be resolved.

With the world population projected to reach 8 billion by 2025, declining crop yield and a poor growth of agricultural output, the need of the hour is to introduce a new technology that can raise agricultural productivity to ensure food security as well as reduce adverse effect on environment which is the key to agricultural sustainability. The modern biotechnology, especially the Genetically Modified (GM) Crop, has the potential to bring about a gene revolution that can not only offer higher yield, enhanced nutritional content and increased self-life but also protects the environment through lesser use of fertilizer, pesticide, insecticide and conferring draught and salt-tolerance among crop-plants.

There are enough evidences of positive potential of biotechnology in agriculture. At the same time there are concerns over the commercial release of biotech crops even after a decade of its first appearance. Our objective in this article is to provide an unbiased overview of the evolution of GM crops in the global arena and given that background we try to give a brief description of the journey of GM crops in India.

Table 1: CAGR of Productivity (yield) of Important Crop in Punjab

Crop	CAGR of Productivity (yield)		
	1971-72-1980-81	1981-82-1990-91	1991-92-1996-97
Rice	4.16	0.73	-0.18
Wheat	2.41	2.71	1.86
Sugarcane	2.83	-0.14	-0.47
Potato	5.20	0.52	-0.41
Cotton	-1.55	8.04	-5.86

Source: Roul, 2001.

Table 2: Range of Productivity of Major Crops in Punjab (kg/ha)

Crops	1966-67	1981-82	1994-95	**1998-99**
Rice	1185	2935	3507	3152
Wheat	1524	2932	4090	4332
Maize	1383	1838	2293	2286
Pulses	774	495	884	788
Oil seeds (Groundnuts)	783	769	1333	744
Sugarcane	1804	5779	6219	5952
Cotton	335	334	636	506

Source: Roul, 2001

The Technology

Traditionally the term 'biotechnology' encompasses all the techniques that use biological organisms, or parts of organisms, to produce or alter a product, or that develop micro-organisms according to the needs of humanity including the initial modifications of native plants into improved food crops through artificial selection and hybridization. 'Genetic engineering' is a part of modern biotechnology, which uses the techniques of molecular cloning and transformation to insert, remove or alter the structure and characteristics of genes directly. According to the definition of the Codex Alimentarius Commission (CAC 2001a) (adapted from the Cartagena Protocol on Biosafety), modern biotechnology is defined as the application of (i) *in vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or (ii) fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers, and that are not techniques used in traditional breeding and selection.

GM Crops, being an important contribution of modern biotechnology, contain genes that are artificially inserted via genetic engineering techniques instead of plants acquiring them through sexual means. GM or Transgenic plants carry the gene introduced into them to express desired beneficial, new, stable and inherited traits. The specific traits addressed by transgenic crops are: resistance to pest and diseases, improved resistance to herbicides, better post harvesting characteristics, manipulation of seed storage protein, increased iron content or vitamin "A"content in rice, etc. (Roul, 2001). Depending on where and for what purpose the plant is grown, desirable genes may provide features such as higher yield or improved quality, tolerance to heat, cold or drought; or enhanced nutritional content – all desirable agricultural traits for farmers and consumers in the developing world (see Table 4 for different traits of GM crops). For example, Bt Corn and Bt Cotton, contain genes from different subspecies of a soil bacterium *Bacillus Thuringiensis* (Bt) that give plants the ability to manufacture their own pesticides. Besides, herbicide resistant soybean, corn, canola and cotton are commercialized already. Delayed ripening tomato is another important finding.

Though modern biotechnology has created a lot of excitement as well as concerns among the scientists, environmentalists and general public, one can trace the roots of genetic intervention in nature long back in the beginning of the civilization (Table 3) and if we compare this with traditional green revolution technology it can be observed that in most cases biotechnology provides wider range of benefits (Table 4).

Table 3: Evolution of Agricultural Technology

Technology	Timeline	Genetic Intervention
Traditional	About 10,000 years BC	Civilization started harvest from natural biological diversity, domestication of crops and animals, selection of plant materials for propagation and animals for breeding
	About 3,000 years BC	Beer brewing, cheese making and wine fermentation
Conventional	Late 19th century	Principle of inheritance by Gregor Mendel in 1865 laid the foundation of classical breeding methods
	1930s	Development of commercial hybrid crops
	1940s-1960s	Tissue culture, plant regeneration, use of metagenes, transformation and transduction started.
		Invention of DNA structure by Watson and Crick in 1953.
		Identification of genes that can detach and move.
Modern	1970s	Arrival of gene transfer technology through recombinant DNA techniques
	1980s	First commercial product of gene transfer came in the form of Insulin
	1990s	Field trial of GM plant varieties in 1990s followed by its first commercial release in 1992.
	2000s	Bioinformatics, genomics, protenomics, metabolomics.

Source: Rao and Dev, 2010.

Table 4: Comparison of Green Revolution Technology and Biotechnology

Item	Green Revolution Technology	Biotechnology
Drivers	Seed-fertilizer technology is a product of discoveries in the field of technology.	Biotechnology is a product of Biology.
Domain	Public Sector	Private Sector (Multi National Company) with proprietary rights
Nature of technology	Transfer of desirable traits can be accompanied by undesirable traits which then needs to be eliminated through time consuming back crossing.	Can quickly and precisely target the required characteristic by indentifying the gene to obtain novel crops.
Dependencies	Largely depends on chemical inputs as seed are developed to respond to fertilizers and availability of irrigation is also crucial.	Seed is central to this technology and no dependence on chemical inputs.
Access	Mainly successful in well-endowed regions though later reached dry land also, but with less success	This technology can be used to create products that can survive in marginalized environment and adverse climatic conditions.
Coverage	Limited to crops only	Apart from crops can be extended to livestock, fisheries, forestry, food processing, waste management, pollution control, chemicals, raw materials, energy, cosmetics, pharmaceuticals etc.
Nature of crops	Mainly wheat and paddy	Started with cash crops like soybean, cotton, maize and canola but in principle can be extended to any crop.
Nature of technology	Scale neutral but not resource neutral. The technology development is continual.	Can be scale and resource neutral, though the method of harnessing the technology is crucial.

Source: Rao and Dev, 2010.

History of Genetically Modified Crops

First Field Trial

From ISAAA Brief No. 1 (James and Krattiger, 1996), it can be noted that the first field trial of GM crops involved herbicide resistant tobacco in the USA and France in 1986. Belgium, United Kingdom and Chile followed soon in 1987 and by 1990, 10 more countries joined the list. By the end of 1995 all the OECD countries except Austria, Greece, Iceland, Ireland, Luxembourg and Turkey authorized field trials. In the first 10 year period of commercialization of GM crops, that is 1986-1995, the industrialized countries of the US, Canada, EU and Asia accounted for 91per cent of the field trials whereas the developing countries of Latin America, Asia, Africa, East Europe and Russia conducted 9 per cent trials. Table 5 provides the number and percentage of most frequently trialed transgenic crops worldwide and the trait categories respectively during the period of 1986-1995. Table 6 shows how these traits are continuing their dominance after 10 years.

Table 5: Number of Worldwide Field Trials of Most Frequent Trait Categories for the Period of 1986-1995

Trait Categories	Number of field trials worldwide
1. Herbicide Tolerant	1450 (35)
2. Product Quality	806 (20)
3. Insect Resistant	738 (18)
4. Others	555 (13)
5. Viral Resistant	466 (11)
6. Fungal Resistant	109 (3)
Others include marker genes, selectable markers, Bacterial resistant, nematode resistant.	
Includes agronomic traits	

Note: Figure in parenthesis present area under respective crops in percent.

***Source**:* James and Krattiger, 1996.

Table 6: Global GM Crop Planting by Main Traits and Crops in 2005

GM Crops and Trait	Global Planting (in Percent)
1. GM herbicide tolerant soybean	58
2. Insect Resistant (Bt) Corn	16
3. Insect Resistant (Bt) Cotton	8
4. GM herbicide tolerant Corn	9
5. GM herbicide tolerant Canola	5
6. GM herbicide tolerant Cotton	4

Source: ISAAA Brief No. 36.

GM Crop Planting in Different Countries

Though China was the first country to commercially produce GM crops, the US was by far the leading country to adopt it in a large scale. By 2005, US captured the largest global share of GM cultivation, that is 55 per cent, followed by Argentina (19 per cent of total planting). The other prominent GM producing countries are Brazil (10 per cent), Canada (7 per cent) and China (4 per cent). In USA the main GM crops are soybean and corn having a share of 57 per cent and 33 per cent respectively in total GM planting in the country. Cotton (9 per cent) and canola (1 per cent) are the other GM crops produced by the US. Argentina also shows the same trend as soybean (89 per cent) is the leading GM crop there, followed by corn and cotton. On the other hand GM canola captures 74 per cent share in Canada's production of GM crops. Corn (14 per cent) and soyabean (12 per cent) share the rest of the GM cultivation in Canada. Brazil and Paraguay produce GM soyabean only whereas China and Australia are confined to GM cotton (James and Krattiger, 1996).

Though the first commercialization of GM crop took place in 1994, it was the year 1996 when GM planting covered a significant area of cultivation. In this way, 2005 marks the 10th year of GM planting which saw an increase in global planting area from 1.66 million hectares to 87.2 million hectares. In 2009, number of countries planting biotech crops has increased to 25 with a continuing growth of hectarage of biotech crops globally reaching 134 million hectares, which is 80-fold increase over 1996. Additional 32 countries including Japan and 57 in total have granted regulatory approvals for biotech crops for import for food and feed use and for release into environment since 1996.

Soybean, corn, cotton and canola are the main four crops which are genetically modified to incorporate suitable traits and they all together accounted for 29 per cent of global cultivation of these crops in 2005. Despite the economic recession of in 2009, these four main biotech crops continued to record high hectarage like biotech soybean occupying 77 per cent of total global soybean production, 49 per cent of total cotton hectarage was biotech, biotech maize dominated 26 per cent of its global cultivation and 21 per cent of hectarage of canola was biotech.

Number of farmers getting benefited from biotech crop production reached 14 million in 2009 compared to 7 million in 2008 and 8.5 million in 2005, over 90 per cent of which were small and resource-poor farmers from developing countries. The developing countries continued to increase their share in total biotech crop production by occupying 46 per cent of the global hectarage of 134 million hectare in 2009, compared to 44 per cent in 2008. The big five, developing countries, that is, Brazil (21.4 million hectares), Argentina (21.3 million hectares), India (8.4 million hectares), China (3.7 million hectares) and South Africa (2.1 million hectares) together represent 1.3 billion people who are absolutely dependent on agriculture including small, resource poor and landless laborers. The strong leadership of these countries in biotech adoption will be a driving force for wider acceptance of GM crops all over the world. It can also be mentioned here that Brazil has replaced Argentina to become the second largest grower of biotech crops in the world in 2009.

The countries which were already growing biotech crops have planted new biotech crops like Brazil planting Bt maize, Australia biotech canola, biotech sugar beet in the US and Canada in 2008.

Africa has shown significant progress with South Africa being joined by Burkina Faso and Egypt. Among the Latin American countries Bolivia planted biotech soybean for the first time in 2008 whereas Costa Rica listed for the first time in 2009; Germany though discontinued its cultivation of biotech maize in the end of 2008.

As far as the important traits are concerned, the trait of herbicide tolerance has dominated in GM crops with soybean, maize, cotton and canola occupying respectively 52 per cent, 41.7 per cent, 12 per cent and 5 per cent of total biotech crop area in 2009 as almost the same trend continues from 2005. Moreover, the stacked double or triple traits, which meet multiple needs of farmers and consumers, have occupied more biotech crop area than the insect resistance variety as 11 countries have adopted these products in 2009, eight of them being developing countries. Future stacked products are expected to comprise multiple agronomic input traits for pest resistance, tolerance to herbicides, plus output traits such as high omega-3 oil in soybean or enhanced pro-Vitamin A in Golden rice.

The largest beneficiary from GM crops in 2008 as well as in 2009 was India, where an additional 0.6 million small farmers have planted Bt cotton with an adoption rate of 87 per cent in 2009 as compared to 80 per cent in 2008. However, in 2005 Bt cotton covered 16 per cent of total cotton plantation with 1.3 million hectare of cultivation. The benefits are mainly emerging from higher yields, lower pesticide application and improved profitability.

An important observation is that of the US$ 51.9 billion additional farmer income coming from GM cultivation in the first 13 years (1996-2008) of cultivation, 50 per cent was generated in developing countries and the rest came from the industrial countries (Brooks and Barfoot, 2010 forthcoming). Thus biotech crop has its contribution in alleviation of poverty and has huge potential of fulfilling the Millennium Development Goals of reducing poverty by 50 per cent by 2015 in its second decade of commercialization (2006-2015). As far as adoption rate of biotech crop is concerned, it has improved in every single year from its first commercialization in 1996 at a consistent double digit growth rate in the first 12 years at 7 per cent growth rate even amidst economic recession in 2009.

An important development in biotech industry took place in 2009 in the form of approval of Bt rice and phytase maize by China, both of which are nationally-developed proprietary products sponsored by the Government. This landmark decision will facilitate the approval process in other developing countries as well.

Due to the enormous benefits towards higher productivity and environmental sustainability, biotech crops have fetched much political support from various global political organizations. G8 member countries in their meeting in Hokkaido, Japan, for the first time recognized the important role of biotech crops in providing food security and have promised to promote science-based risk analysis to accelerate research and development activity in agricultural biotechnology. Even European commission has acknowledged the role of GM crops in combating the emerging food crisis. The World Health Organization (WHO) has emphasized on the contribution of the biotech crops towards improving human health through raising the nutritional content of food, reducing allergenic components and providing efficient production technique.

The Significant Benefits Obtained from the Progress in the First Decade[1]

After the commercialization of transenic crops in China in 1990 and later in the US in 1994, there have been significant benefits accrued to mankind within the first decade. These are the first generation of biotech crops which have farmers as its targeted beneficiaries.

The following are the benefits those were already being observed and were expected to be observed in near future (James and Krattigerm; 1996).

(i) More efficient weed control in the crops like corn, tomato, cotton, soybean and tobacco. This not only reduces loss due to weeds but also leads to more sustainable cropping system through no or low-till practices which leads to less soil erosion. A better control of pollination helps production of hybrid seeds.

(ii) Biotic stresses like insect, disease and weeds cause respectively a global loss of total 36 per cent in production. Given that the transgenic crops are mostly herbicide tolerant, disease and insect resistant, a significant reduction in the use of insecticides and losses from pests and viruses are expected to have substantial impact on global food, feed and fiber production as well as saving the environment from use of indiscriminate pesticides and insecticides.

(iii) With increase in the shelf-life for delayed ripening tomato and valuable perishable fruits and vegetables, there is a fall in post–harvest losses. This provides better marketing opportunities for the resource-poor farmers of the developing countries who suffer from poor road condition, lack of proper transportation facility and insufficient refrigerated storage system.

(iv) With application of biotechnology the conventional seeds are expected to provide enhanced and stable productivity and yield thereby giving an edge to the farmers whose demand for seeds are increasing at an alarming rate.

Economic Impact of GM Crops[2]

The Farm Level Economic Impact of GM Adoption

There has been a positive farm income effect on the GM adopting countries which is derived from enhanced productivity and efficiency. The largest income gain came from the soybean sector, where the additional income is equivalent to adding 6.05per cent to the value of global soybean production in 2005 itself. The cotton sector also gained much from higher yield and reduced cost of production. The income gain from cultivation of GM cotton in 2005 is equivalent to addition of 7.3 per cent to the value of global cotton production.

The maize sector has gained from a combination of GM herbicide tolerant and insect resistant technology whereas the canola sector showed significant farm income gain. In terms of division of farm income benefit going to developing and developed countries, it is notable that the developing country farmers have acquired 55 per cent of it in 2005, majority of which has come from GM IR cotton and GM HT soybean. Cumulatively over the ten year period of 1996-2005, 47 per cent of the total income benefit went to the developing countries. If we take into account the cost of accessing the GM technology, it is 13 per cent of the total income benefit of the developing country farmers whereas 38 per cent for the developed countries. Here we note that the size of the farm does not matter at all in the adoption of GM technology.

In fact in 2005, 90 per cent of 8.5 million farmers producing GM crops were resource-poor developing country farmers. However, agricultural biotechnology can contribute to poverty reduction in three ways by: increasing net profits with decreasing unit cost of production; reducing cost of food by increasing productivity; providing benefits to net purchasers in both rural and urban areas (Rao & Dev, 2010). Several studies have shown that improved agricultural productivity raises growth in rural non-farm sector and thereby contribute to reduction in poverty (Dev, 1990). Moreover, GM crop adoption has led to significant employment and income generation at macro-economic level in some countries, like Argentina, where huge increase in soybean production has led to additional agricultural jobs and export-led economic growth.

Trade Impact

The trade in GM crops by the leading trading countries is significant enough to report. The trade in different GM crops is the following:

Soybean: In 2005, 30 per cent of the soybean production was exported, 90 per cent of which was from the GM producing countries. If the proportion of GM soybean in total soybean production in these GM producing countries is same as that is exported then 77 per cent of global soybean export is GM. On the other hand, if it there is no segregation between the GM and non-GM soybean in the export basket then the share can be as high as 98 per cent in 2005.

Maize: Among the GM producing countries the leading players in the trade of maize are the US, Argentina, Canada and South Africa as they together account for 80 per cent of global trade in maize. In 2005, 11 per cent of the global maize production was traded. If the proportion of GM maize in total maize production in these GM producing countries is same as that is exported then 53 per cent of global maize export is GM. On the other hand, if it there is no segregation between the GM and non-GM maize in the export basket then the share can be as high as 80 per cent in 2004. Even if there is segregation between GM and non-GM variety, the share of GM maize if expected to lie between 53per cent and 80 per cent, but closer to the higher end of this range.

Cotton: The US and Australia are the main GM producing countries who account for 54 per cent of global trade. In 2005-06, 26 per cent global cotton production was traded. If the proportion of GM cotton in total cotton production in these GM producing countries is same as that is exported then 47per cent of global cotton export is GM. On the other hand, if it there is no segregation between the GM and non-GM cotton in the export basket then the share can be as high as 57 per cent in 2005.

Canola: In 2005, 12 per cent of canola production was exported, 73 per cent of which was done by US and Canada (accounted for 98 per cent). If the proportion of GM canola in total canola production in these GM producing countries is same as that is exported then 60 per cent of the global cotton export is GM. Since there has not been any significant segregation between the GM and non-GM canola market, the share of GM canola in global canola export is expected to be as high as 73 per cent.

Quam and Traxler (2002) estimated that the impact of RR soybean technology adoption on global soybean prices have been -1.9 per cent by 2001.

This kind of transfer of farm income gain towards the supply chain has also occurred in case of other GM crops, but at a lower level as adoption of cost saving GM technology has not been so wide at the global level as soybean.

Environmental Impact of GM Crop[3]

The environmental impact of GM technology has the two aspects to be discussed, viz. insecticide and herbicide use. To analyze the environmental impact of GM crops a reasonably robust measurement is used which incorporates both an assessment of pesticide active ingredient use, as well as the assessment of the specific pesticides used via an indicator known as the Environmental Impact Quotient (EIQ). This is a universal indicator, developed by Kovach *et al.* (1992 and updated annually), that effectively integrates the various environmental impacts of individual pesticides into a single 'field value per hectare'. This gives a balanced assessment of the impact of GM crops on the environment as it takes into account all the key toxicity and environmental exposure data related to individual products to assess the impacts on farm workers, consumers and ecology and hence provides not only a consistent and comprehensive measure of environmental impact.

However, we must remember that EIQ is only an indicator and, therefore, does not take into account all environmental issues/impacts. To provide a meaningful measure of environmental impact, the EIQ value is multiplied by the amount of pesticide active ingredient (ai) used per hectare to produce a field EIQ value.

The specific environmental gains associated with GM crop cultivation in the ten year period under consideration are the following:

A 15.3 per cent net reduction in the environmental impact on the cropping area devoted to GM crops since 1996 has been observed. The total volume of active ingredient (ai) applied to crops has also fallen by 7 per cent. Here we note that, the actual herbicide active ingredient (ai) used and the EIQ impact or load in any year is compared with the likely ai use and EIQ load arising out of plantation of non GM crops for any year, using the same tillage system as used in the GM crop. For GM herbicide tolerant crops, comparison has been made with the non GM variety delivering the same level of weed control as delivered by the GM production system.

GM HT soybeans have given the maximum environmental benefit since 1996 which is mainly due to its large share in global GM crop plantings. The herbicide use is 4.1per cent lower along with a 20 per cent lower environmental impact compared to the levels that would have probably arisen if all of this GM crop area had been devoted to conventional cultivation. Here we must take note of the fact that as GM HT soybean has facilitated the switch over from conventional cropping system to low or no-till conservation tillage system to capture the environmental benefit, there is an increase in volume of herbicide used in those areas. As a result there is net increase in environmental impact and the general dynamics of agricultural production system has changed.

The largest environmental gains on a per hectare basis have been derived from the adoption of GM insect resistant (IR) cotton. Since 1996, there has been a 24 per cent reduction in the environmental impact, and a 19 per cent decrease in the volume of insecticides applied.

Significant environmental gains have also come from the maize and canola sectors. From reduced insecticide use, 4.6 per cent reduction in the environmental impact has occurred in the maize sector. A switch to more environmentally benign herbicides has resulted in a further 4 per cent reduction in the environmental impact of maize herbicides and a 23 per cent reduction in canola sector.

Another beneficial aspect of GM crops towards the environment is reduction in use, environmental contamination and human exposure to pesticides. This has been possible mainly due to the pesticide-resistant Bt cotton, which has proved to reduce pesticide poisoning among farm workers (Pray *et al.,* 2002). Moreover, low-end biotechnological tools like bio-fertilizers, bio-pesticides, tissue culture, molecular markers, etc. can be used as a part of integrated pest management system. However, they should be commercialized after rigorous cost-benefit analysis (Rao and Dev, 2010).

Potential Risks of GM Food[4]

Even if biotechnology has a lot of promise in opening up dramatic opportunities in agricultural development it has its share of controversies arising out of the environmental risks and food safety concerns.

Risks towards the Human Health[5]

Even if biotechnology claimed to provide healthier food, that is, food with more micronutrients like iron, zinc and Vitamin A (Bouis, 2002), there are some potential health risks from consuming and producing GM crops as per the critics. The three main debatable issues regarding the potential health effects are allergenicity, gene transfer and outcrossing

Allergenicity: Generally, on principle, the transfer of genes from commonly allergenic foods is discouraged unless it can be demonstrated that the protein product of the transferred gene is not allergenic. While traditionally developed foods are not generally tested for allergenicity, protocols for tests for GM foods have been evaluated by the Food and Agriculture Organization of the United Nations (FAO) and WHO.

Gene transfer: Gene transfer from GM foods to cells of the body or to bacteria in the gastrointestinal tract is a cause of concern if the transferred genetic material adversely affects human health. This would be particularly relevant if antibiotic resistance genes, used in creating GMOs, were to be transferred. Although the probability of transfer is low, the use of technology without antibiotic resistance genes has been encouraged by a recent FAO/ WHO expert panel.

Outcrossing: Outcrossing is the movement of genes from GM plants into conventional crops or related species of the wild variety as well as the contamination of conventional crops with GM material. It can have an indirect effect on food safety and food security by contamination of genetic resources. Several countries have adopted strategies to reduce mixing, such as a clear separation of the fields within which GM crops and conventional crops are grown. Improved molecular methods for containment of the transgenes as well as farm management measures are under discussion, for example, isolation distances, buffer zones, pollen barriers, control of volunteer plants, crop rotation and planting arrangements for different flowering periods, and monitoring during cultivation, harvest, storage, transport and processing (Daniell 2002).

GM Crops and Potential Risks Towards Environment

Environmental risk assessments cover both the evaluation of the characteristics of the GMO and its effect and stability in the environment, combined with ecological characteristics of the environment in which the introduction will take place. The assessment also includes unintended effects which could result from the insertion of the new gene. Currently, the Cartagena Protocol on Biosafety (CPB) of the Convention on Biological Diversity is the only international regulatory instrument which deals specifically with the potential adverse effects of GMOs (known as living modified organisms (LMOs) under the Protocol) on the environment, taking also into account effects on human health. Issues of concern include: (i) the capability of the GMO to escape and potentially introduce the engineered genes into wild populations, (ii) the persistence of the gene after the GMO has been harvested, (iii) the susceptibility of non-target organisms, for example, insects which are not pests) to the gene product, (iv) the stability of the gene, (v) the reduction in the spectrum of other plants including loss of biodiversity, and (vi) increased use of chemicals in agriculture.

The environmental safety aspects of GM crops vary considerably according to local conditions. The ongoing investigations focus on: the potential adverse effect on beneficial insects or a faster induction of resistant insects; the potential generation of new plant pathogens; the potential detrimental consequences for plant biodiversity and wildlife, and a decreased use of the important practice of crop rotation in certain local situations and the movement of herbicide resistance genes to other plants (WHO, 2005).

Public Concern over the GM Food

The first generation genetically modified crops provided improved agronomic traits such as tolerance of specific chemical herbicides and resistance to pests and diseases (James, 2003),providing direct benefits to the producer through increased profitability by increasing factor input productivity, that is reducing factor cost (Marra *et al.,* 2002). Unlike farmers, who have been benefited and quickly adopted the transgenic plants such as Bt cotton and corn and herbicide-resistant soybeans (Economic Research Service, 1999), consumers have reservations about the foods produced from these crops. Introduction of the so-called first generation of GM crops met with consumer resistance on health, environmental, moral and philosophical concerns (Hobbs and Plankett, 1999; Lindner, 2000).

This led to a second generation of genetic modification seeking also to improve various attributes of GM crops to provide direct benefit to the final consumer such as enhanced nutritional content, improved durability and less pesticide application (Kishore and Shewmaker, 1999), such as Golden Rice. It is a GM variety, in which beta-carotene (Vit A) synthesizing gene is introduced through genetic engineering technique, that may not improve farm productivity but can improve health significantly by providing pro-vitamin A (Dawe, Robertson and Unnevehr 2002, Zimmermann and Qaim., 2004). Thus, the distinct benefits provided by the GM food which are not available in non-GM food are going to be critical in forming consumers' preference for GM products (House *et al.,* 2002).

From Smale *et al.* (2006) we find a detailed review of literature in the context of both industrialized and non-industrialized agricultural countries which are either based on surveys conducted to examine consumers' concern or evaluation of consumers' willingness to pay for GM food based on stated preference method. The conclusions of the studies are mixed in non-industrialized countries with some consumers being concerned about the consumption of GM Food and some being open to it. In industrialized countries also some consumers are willing to pay price premium for non-GM food (Huffman *et al.*, 2003) or demanding discount for consuming GM food (Grimsrud *et al.*, 2004), though most of the studies conclude in favour of acceptance of GM crops. Curtis *et al* (2004) have concluded that consumers are more inclined towards GM food in developing countries compared to the developed countries as the benefits like cost reduction, yield-increase and nutritional enhancement dominate the risk perceptions.

For more recent studies reference can be made to Nayga *et al.* (2006), Jan *et al.* (2008), and Kimenju and Groote (2008), Deodhar *et al.* (2008). As per survey conducted by Hall and Moran (2006), consumers are more concerned about the future risk of GM crops rather than the future benefit from the GM crops, though there are differences in the degree of risk perception. This had called for the necessity of labelling containing the information about the existence of GM content in the food. Some studies have also focused on the welfare effect of the labeling policy or information on genetic modification on consumer welfare (Fulton and Giannakas, 2002; Huffman, 2003; Lusk *et al.,* 2005; Carlsson *et al.,* 2007).

Counter Argument by Proponents of GM Food

The proponents of biotechnology argue that mutations and gene flow occur in nature also and there are possibilities of weedy relatives acquiring traits form improved varieties in conventional breeding as well (Prakash, 1999). The process of traditional hybridization is also genetically engineered and molecular method of combining different genes is just the continuation of enormous genetic fluctuations happening in nature (Rao and Dev, 2010). Moreover, the random chance driven genetic engineering taking place in nature continuously have not always been good for the mankind (Bhargava, 2002).

As far as the concerns about the adverse effect of production and consumption of GM food on the environment and the consumers are concerned, they are inconsistent with statements made by the EU scientific community (EPSA, 2004), and with a report commissioned by the UK government (King, 2003, p.23).

The latter report, by eminent scientists, extensively reviews available evidence and finds no adverse effects anywhere in the world. So like previous similar reports it concludes that, on balance, "the risks to human health are very low for GM crops currently on the market" (King, 2003). King committee could not find any theoretical reason or empirical evidence to suggest that GM crops would be any more invasive or persistent, or toxic to soil or wildlife outside the farmed environment than conventional crop varieties, or spread their genes to other plants. Later Food Safety Department of the UN's World Health Organization has concluded: "GM foods currently on the international market have passed risk assessments and are not likely to, nor have been shown to, present risks for human health" (WHO, 2005).

Moreover, no effects have been found so far on human health due to the consumption of such foods by the general population in the countries where they have been approved. Thus, the debate that started with StarLink corn controversy (www.agbioworld.org) had shifted to potential risks from the future GM products having less faith on the regulatory regimes to prevent crosspollination and effective segregation of GM and non-GM products (Bernauer, 2005). Very recenty Dr. Swaminathan has also commented that there is no scientific evidence in favour of the environmental and human health risk from GM crops in reality after 10 years of commercialization of transgenic crops in the world (http://www.fnbnews.com/article/print.asp?articleid=26024).

Issue of Intellectual Property Rights

By the end of 1990s, six Multinational companies Novartis, Monsanto, Du Pont, Zeneca, AgrEvo and Rhone-Poulenc (last two merged to form Aventis), accounted for major share of of the world market for GM crops. It is in contrast to the new non-GM varieties of crops developed by the publicly funded research organizations for which farmers need not pay any technology fee to the inventors as they are public good (Bernauer, 2005) . Roul (2001) have pointed out some serious aftermaths of the unprecedented control of the MNCs over the biotech industry on the traditional farmers of the developing countries.

These companies tend to focus on the products completely oriented towards industrial countries and large scale farmers (Pintstrup-Andersen and Cohen,2000; Pintsrup Andersen and Shioler, 2001). The crops and traits important for smallholders of developing countries may not be developed by these companies in view of market failure in these case (Evenson and Gollin, 2007; Naylor *et. al.*, 2004; Spielman, 2007). But there are some instances of technology developers giving free access to the technology (Kenyan Sweet potato being donated by Rockefeller Foundation).

Further it can be inferred that more public investment in agricultural R&D, collaboration between public sector agricultural research Institutions with international institutes, NGOs and industry may help to spread the fruits of GM technology at a reasonable cost as was the case with green revolution technology (Roul, 2001; Bernauer, 2005). The public sector research institutions can focus on traits of significance for the small and resource poor farmers like drought tolerance and salinity resistance and release open pollinated varieties, which are not part of the agenda of the MNCS due to lack of profit (Rao and Dev, 2010).

National Regulations

The concept of risk assessment of GMOs was first discussed at the Asilomar Conference in 1975 (Fredrickson 1979; Talbot 1983) followed by the USA guidelines for research in modern biotechnology developed in 1976 by the National Institutes of Health Recombinant DNA Advisory Committee, which the other countries were soon to follow (OECD 1986). These early regulatory requirements tried to prevent the accidental release of microorganisms from research laboratories. However, after the guidelines of the EU regulations of 1990, many countries have established specific pre-market regulatory systems requiring the rigorous assessment of GMOs and GM foods before their release into the environment and/or use in the food supply (OECD 2005). The differences in the regulatory systems though led to confusion and disagreements regarding the implementation of those regulations.

This lack of agreed upon measures of agro-ecosystem health and integrity (WRI, 2000; Wood et al. 2000) has led to various international regulatory and uniform standard-setting bodies (see Box 1), the most prominent of which is International regulatory systems covering GM food safety (Codex *Principles*) (CAC 2003b) and environmental safety (Cartagena Protocol on Biosafety) (CBD 2000) coming into force in 2003. The Codex Alimentarius Commission (CAC, or Codex) adopted the following texts in July 2003: *Principles for the risk analysis of foods derived from modern biotechnology*; *Guideline for the conduct of food safety assessment of foods derived from recombinant-DNA plants*; and *Guideline for the conduct of food safety assessment of foods produced using recombinant-DNA microorganisms*.

The Codex safety assessment principles for GM generally investigates: (a) direct health effects (toxicity), (b) tendencies to provoke allergic reaction (allergenicity); (c) specific components thought to have nutritional or toxic properties; (d) the stability of the inserted gene; (e) nutritional effects associated with genetic modification; and (f) any unintended effects which could result from the gene insertion. Codex principles do not have a binding effect on national legislation, but are referred to specifically in the Agreement on the Application of Sanitary and Phytosanitary *Measures* of the World Trade Organization (SPS Agreement, WTO 1995), and are often used as a reference in the case of trade disputes (WHO, 2005).

Box 1: Protocols and Guidelines for monitoring GM crop impact

Legal instruments and conventions that address monitoring for GMO:

- Cartagena Protocol on Biosafety (UN, 2000)
- Directive 2001/18/EC on deliberate release of the GMOs and the decision of the Council to the EU establishing guidance notes on GMO monitoring (Council of the EU, 2002)
- International Plant Protection Convention (IPPC) phytosanitary standard for pest risk analysis (FAO, 2004b)

Monitoring Guidelines:

- European Food Safety Authority (EFSA) guidance document on GMO risk assessment (EFSA, 2004) p. 41-43
- GMO monitoring in Germnay
- UK guidance on best practice for post-market monitoring (Defra, undated)

Source: Jepson, 2006.

Regulatory Regime in EU[6]

EU directive on contained use of GMO (Directive 90/219/EEC) and on their deliberate release (Directive 90/220/EEC) adopted a preventive approach emphasizing on environmental risk assessment before any experimental or commercial release of GMOs. In June 1999 a de facto moratorium on commercialization of GMOs was agreed upon to suspend all approval applications until revision of Directive 90/219/EEC in order to incorporate more strict regulation including labelling and traceability issues.

EU Regulation 258/97/EC required pre-market approval of novel food products including GMO and also mandated labelling to indicate presence of GMO. Directive 2001/18/EC replaced Directive 1990/220/EEC in February 2001 which required post-market monitoring of each approved GMO in order to detect their unanticipated effects on environment and human health. It also declared that no GMO will be commercially released after 2005 if it contains antibiotic resistance marker genes.

In November 2003, Regulation 1829/2003/EC on GM food and feed came into force to partially replace novel foods regulations. It is foreseen in this regulation that notifications for market approvals of food and feed products are to be delivered to the central authority, that is, European Food Safety Authority (EFSA). In July 2003 the European Commission published guidelines for developing strategies and best practices to ensure the coexistence of GM crops with conventional and organic agriculture.

Regulatory Regime in the US[7]

In Early1980s there were differences in the of approach towards regulating agricultural biotechnology among the US regulatory bodies. The White-House Office of Science and Technology (OSTP), USDA and FDA were in favour of promoting biotechnology whereas EPA argued for new risk assessment procedures and process based regulation. In 1986 a Biotechnology Science Coordinating Committee (BSCC) was set up which assigned the primary responsibilities for regulations to FDA, USDA and EPA and set forth principles of coordination and cooperation these authorities. It viewed no risk to human health and environment from GM crops.

Transportation, field trial or commercial cultivation and propagation of GM crops, which are not intended for human consumption and are not modified to contain a pesticide, are governed by USDA's Animal and Plant Health Inspection Service (APHIS) under the Federal Plant Pest Act. EPA is responsible for regulating pest-resistant GM crops which are subject to risk assessment regimes. EPA has the regulatory authority for GM foods, food additives, processing aids and biotech medical products along with primary labelling responsibility except for meat and poultry products (governed by USDA). GM foods are subject to same labelling requirement as that of all foods in US market. Mandatory labelling is only applicable for GM foods which are no longer substantially equivalent to the corresponding conventional food in terms of composition, nutrition or safety. In 2001, FDA formally introduced two measures to strengthen its regulatory oversights. The first one made hitherto voluntary consultation between biotech firms and the FDA in the approval process mandatory. The second one issued guidelines for voluntary labeling of GM/non-GM foods.

As far as Asian countries are concerned, most of them have signed and ratified the Cartagena Biosafety Protocol though they do not have a specific labelling regime. Most of the African countries are yet to formulate their biosafety regulation. Some countries have even refused food aid from GM producing countries being skeptical about the adverse health and environment effect. Australia and New Zealand have similar labelling regime for food containing more than 1 per cent GM ingredients (Lalitha, 2007).

GM Crops in India

The Department of Biotechnology (DBT) was created in February 1986 to independently pioneer the multifaceted development of biotechnology in the country. In India use of all GM substances is regulated under the Environment (Protection) Act 1989 (EPA) and the Rules 1989 (Rules). As per the notification of the Ministry of Environment and Forest dated 5 December, 1989 the Genetic Engineering Approval Committee (GEAC) was established among others which was responsible for approval of proposals related to release of Genetically Engineered Organisms and products into the environment including experimental field trials.

There is a three-tier procedure in India for getting approval for GM crops to be commercially produced. Individual research institutes need to get permission from the Review Committee of Genetic Manipulation under the Department of Biotechnology for carrying out field trials after laboratory experiments. This committee, if satisfied, will grant limited permission for greenhouse trial and final field trial under the supervision of scientists nominated by DBT and other state government agencies like State Agricultural University, State Agricultural Department, ICAR institutes. The final approval for commercial trial and use will come from GEAC (Roul, 2001).

In March 2002, GEAC took a milestone decision to give permission for commercial production and sale of three Bt cotton varieties (MECH 162 Bt, MECH 184 Bt, MECH 12 Bt) suitable for the central and southern India having in-built resistance to bollworms through the introduction of a gene from soil bacteria Bacillus Thurisgiensis Kurstaki. For timeline summery for regulatory processes leading to commercial release of Bt cotton in India see Barwale *et al.* (2004). In 2004, a fourth hybrid was commercialized followed by 16 in 2005 and three more in 2006. There were 274 GEAC approved and commercialized bollworm resistant cotton hybrids in India which became 522 in 2009 (Rao and Dev, 2010, Choudhary and Gaur, 2010).

However, there was a lot of controversy ever since Monsanto Mahyco Biotech Limited (MMBL) started field trials of Bt cotton in 1998 in 40 locations of different states without public knowledge. Though it was later clarified that it was only bollworm resistant Bt gene rather than terminator genes, the debate continued over several issues like hasty permission granted, method of conducting field trials, sustainability of resistance of Bt cotton to bollworms, safety to farmer friendly insect populations with Bt cotton (Bhargava, 2002; Iyenger and Lalitha, 2002; Naik, 2002; Shiva *et al.*, 1999).

Here we can also take a note of the presence of illegal unlicensed Bt hybrids in India produced by Navbharat Company containing Monsanto's cry1Ac gene occupying more than 10,000 acres of land in Gujarat (Sadashivappa and Qaim, 2009). Even after GEAC's action against these illegal varieties, its cultivation rose to 2 million acres in 2004-05 (Pray, Bengali and Ramaswami, 2005).

The first year of Bt cotton production was a disaster in several states in India like Andhra Pradesh, Maharashtra, Madhya Pradesh, Karnataka and Gujarat (Krishnakumar, 2003). There are many studies based on field surveys which report mixed results during this period like small saving in pesticide, less profit, more attack of sucking pests, loss in average income even if there is increase in yield of 34 per cent (Sahai and Rehman, 2003; Qayum and Sakkhari, 2003; Naik *et al.*, 2005).

In 2003-04, the situation became better as Narayanamoorthy and Kalamkar (2006) showed with survey in Maharashtra that there were improvements in yield by 52 per cent with an increase of 79 per cent profit. A nation-wide survey by Nielson and ORG-MARG concluded that there was 60 per cent reduction in pesticide, 29 per cent increase in yield and 78 per cent improvement in net profit. However this survey was criticized to be biased as it was commissioned by Monsanto (Rao and Dev, 2010). Another significant study in this context is that of Qaim (2003) who analyzed field trial data from seed companies to conclude that insecticide use was reduced by 1/3 of that used in conventional cotton along with a yield improvement by 80 per cent even in bad bollworm infestations. There are several other studies which validate the fact that Bt cotton growers are benefited from reduction in pesticide use and improved effective yield in India (Benett *et al.,* 2006; Crost, Shankar, *et al.,* 2007; Qaim, Subramanian *et al.,* 2006).

Cotton is very much prone to damage from insect pests like bollworm, sucking pest and whiteflies and this pest pressure is very high in Andhra Pradesh as cotton is grown in a typically tropical climate. Qaim and Matuschke (2004) has explained that Bt cotton cultivation gives better yield and enables to reach its potential under this situation mainly because of the better management of the pest problem.

Criticizing field trial data on the ground that they do not reflect the typical real condition prevailing in Indian conditions, Bennett *et al.* (2004) have collected data from a large sample of farmers growing both conventional and Bt cotton under real commercial field conditions over 2002 and 2003. He also concluded in favour of reduction of insecticide spray but with high average cost. This increase in cost will, however, be outweighed by large yield improvement (45 per cent in 2002 and 63 per cent in 2003). Another study in Maharashtra by Morse *et. al*. (2007) in the same time span shows that income of Bt cotton adopter is more compared to non-adopter and income inequality measured by Gini coefficient was greater among non-adopters. A region-wise regression analysis using NSSO data also confirms the significant positive yield effect of Bt cotton in India (Bedi and Cororation, 2008).

In a more recent study by Sadashivappa and Qaim (2009) has taken a panel data spread over five years (2002-03 to 2006-07) on the field performance of in four cotton growing states of southern and central India unlike the previous studies which have considered data over 1 or 2 years (Bennett et al., 2006, Qaim *et al.*, 2006, Gandhi and Namboodri, 2006; Crost *et al.*, 2007). This panel data analysis has shown sustainable improvement of yield (about 30-40 per cent) and reduction in pesticide by 40 per cent accompanied by a profit gain of \$60 per acre. They have also got high willingness to pay for Bt cotton among both small and large farmers. They have also taken into account the aspect of price control on Bt seeds as the India states started setting maximum retail prices Bt seed below the level of private companies at Rs 750 per packet on political pressure. This may reduce the spread of illegal Bt seeds across the country though its effect on aggregate technology adoption was not significant.

Another longitudinal survey in Andhra Pradesh in 2004-05 and 2006-07 by Rao and Dev (2010) has showed that biotechnology has the potential to reduce the gap between the actual and potential yield by withstanding biotic stresses from bollworms. Apart from yield improvement, reduction in cost and increase in net income, the results show that Bt cotton cultivation has improved the position of the small and SC farmers in terms of their profitability. See Table 8 for comparison of various benefits obtained Bt cotton in different studies.

As per Cotton Association of India (2008), cotton accounts for 30 per cent of India's gross domestic product and with 20 million acres under cotton cultivation India has got the largest area under cultivation for cotton in the world. As per estimates of the Cotton Advisory Board of India, the country has recorded an all-time high production of 5.27 million tons with 23.8 million acres of cultivation in 2007-08. This has transformed India from third largest cotton importer in 2002 to second largest cotton exporter after the US in 2007-08 (Sadashivappa and Qaim, 2009). This significant improvement in both area under cultivation and production of cotton can be attributable to the remarkable success of Bt cotton in India (CAI, 2008; Khadi, *et al.*, 2007).

As per ISAAA Brief 41, the success story of Bt cotton in India for eight consecutive years is a remarkable one. In 2009, 5.6 million farmers planted

Bt cotton in 8.4 million hectares, which accounted for 87 per cent of total cotton cultivation in the country. This is an unprecedented 168 fold increase in area under cultivation which was merely 50,000 hectares in 2002 (See Table 8). In 2006, India's Bt cotton area (3.8 million hectares) for the first time exceeded that of China (3.5 million hectares). In 2007 India has got the largest hectarage of Bt cotton with a record increase of 63 per cent over 2006 (Choudhary and Gaur, 2010). In a short span of 7 years that is, 2002-2008, India has experienced economic benefit of US$ 51 billion with insecticide application being halved and a double yield. Another important achievement in 2009 is commercialization of a publicly bred Bt cotton variety, named Bikaneri Nerma and another hybrid NHH-44 thereby rectifying the balance between public and private sector participation in biotech industry (James, 2009).

It is worth mentioning here that there has been a significant positive impact of Bt cotton on cottonseed oil production in India over the years. As per the Cotton Advisory Board (CAB), Bt cotton has been a major contributing factor for increasing cottonseed oil production by 22 per cent or more than 1.1 million tons in 2007-08, from 0.9 million tons in 2006-07. "The Solvent Extractors' Association of India (SEA) estimated that the recovery of cottonseed oil, particularly from Bt cotton hybrid seeds, is higher, which has helped to increase the production of cottonseed oil. This may be attributed to availability and wide spread use of good quality cotton hybrids (James, 2008). Interestingly, cottonseed oil is generally consumed as such or blended with other vegetable oils in India as a cheaper alternative to most other edible oils and is gaining popularity among consumers.

One researcher has pointed out that Bt cotton has not performed uniformly well in all the states. (Lalitha, 2007). However, Choudhary and Gaur (2010) have opined that over the last eight years India has greatly diversified the deployment of Bt genes and genotypes, which were well adapted in the different agro-climatic conditions to ensure equitable distribution to small and resource poor farmers. See Table 7 for the distribution of Bt cotton in the major states of India, which shows that Maharashtra has been dominating Bt cotton cultivation in terms of hectarage followed by Gujarat and Andhra Pradesh in 2009.

Another important point needs a mention here. There have been some reports linking the issue of recent resurgence of farmer suicide in central and southern states of India with that of costly and inefficient Bt cotton technology (Gentleman, 2006; Lean, 2008; Sahai, 2005). However, Gruere, *et al.* (2008) have clearly rejected this hypothesis put forth by the civil societies and has reviewed the existing literature to reach the conclusion that Bt cotton has been very much effective in India though the context in which it was introduced in India may have given some disappointing results in the initial years. They showed Bt cotton was neither necessary nor sufficient for resurgence in farmer suicide rather high indebtedness of the farmers due to lack of proper credit system and wide availability of toxic pesticides could have played significant role in farmer suicides.

Table 7: Adoption of Bt Cotton in Different States of India in 2002-09 (thousand hectares)

State	2002	2003	2004	2005	2006	2007	2008	2009
Maharashtra	25	30	200	607	1840	2800	3130	3396
Andhra Pradesh	8	10	75	280	830	1090	1320	1049
Gujarat	10	36	122	150	470	908	1360	1682
Madhya Pradesh	2	13	80	146	310	500	620	621
Northern Region[8]	-	-	-	60	215	682	840	1243
Karnataka	3	4	18	30	85	145	240	273
Tamil Nadu	2	7	5	27	45	70	90	109
Others	-	-	-	-	5	5	5	8
Total	50	100	500	1300	3800	6200	7605	8381

Source: Choudhary and Gaur, 2010.

Biosafety Policy in India

India is party to the Cartagena Biosafety protocol in 2001 and, therefore, is committed to safe handling of GMO (Lalitha, 2007). In India manufacture, import, use, research and release of GMO as well as products made by the use of such organisms are governed by EPA, 1986 and Rules, 1989. The regulatory authorities responsible for implementations of rules 1989 are MoEF and DBT Government of India through six designated authorities (for functions of these committees see Figure 1). Recombinant DNA Advisory Committee (RDAC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), Institutional Biosafety Committees (IBSC), State Biotechnology Coordination Committees (SBCC), District Level Coordination Committees (DLCC),Monitoring and Evaluation Committee (MAC).

The Swaminathan Task Force

A task force was set up under the chairmanship of Dr. M. S. Swaminathan in 2003 by the Ministry of Agriculture to examine the potential and problems of biotechnology applications, particularly GM crops. The task force recommended the following (Damodaran, 2005, Chhotray, 2007): a) setting up of an autonomous and professional supervisory body, namely, the National Biotechnology Regulatory Authority (NBRA), to generate public confidence in the use of GMOs; b) setting up of State Biotechnology Regulatory Board which will be liasonning with NBRA; and c) initiation of District Biotechnology Risk Assessment and Communication Committee. The role of the GEAC may be confined to biosafety and environmental safety till the formation of the authority; and the Monitoring and Evaluation Committee (MEC) should report to the GEAC on biosafety and environment safety issues. Further, the Committee also called upon that the Indian Council of Agricultural Research under the Union Agriculture Ministry should organize testing of GM crops through an all-India Coordinated Research Project. The Committee also advocated in favour of transparent field trials, highlighting of unfavorable results and highly credible evaluation mechanism.

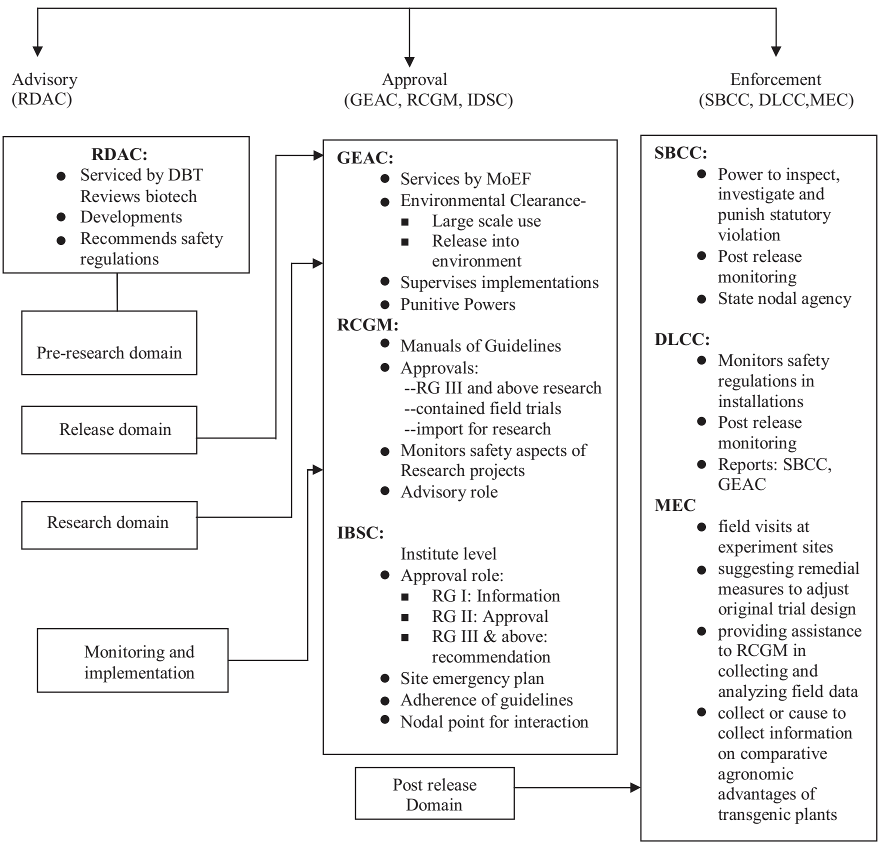
Various guidelines issued by DBT in relation to monitoring of field trial of regulated GM crops and food safety assessments are available at http://dbtbiosafety.nic.in/.

Table 8: Performance of Bt Cotton vs. Non-Bt Cotton in India from Different Studies

Authors	yield%	pesticides %	profit%	Cost of production %
Qaim, 2003	80 (30-40)	-60	500	NA
Nielson-ORG MARG, 2004	29	-60	78	NA
Naik *et al.,* 2005	34	-41	69	17
Narayanmoorthy and Kalamkar, 2006	52	-5	79	34
Gandhi and Namboodri, 20006	31	-24	88	7
Rao and Dev, 2010 2004-05 (with and without) 2006-07 (After adoption)[9]	32 42	-18 -56	83 251	17 -1
Qaim *et al.,* 2006	26	-73	47	NA

***Source*:** Rao and Dev, 2010.

Figure 1: Administrative Mechanism



Source: Biosafety regulatory framework in India by Dr. Veena Chhotray, 2007, Damodaran, 2005

Labelling Requirement

On March 10th, 2006 the Central Government of India, in consultation with the Central Committee for Food Standards, published two draft rules to amend the Prevention of Food Adulteration Rules (1955), introducing labelling and approval requirements for GM food and products derived form it. The *Draft Rule 37-E Labelling of Genetically Modified Food* states that all primary or processed foods, food ingredients or food additives derived from a GM food require to be labelled accordingly and the imported GM foods should indicate the status of approval in the country of origin (Gruere *et al*., 2007).

Legislation for Protection of Biodiversity, Protection of Plant Varieties and Farmers' Right in India

As a signatory of UN's Convention of Biological Diversity (CBD) India had to take legislative action to integrate consideration of conservation and sustainable use of biological diversity. This led to enactment of Biological Diversity Act in 2002 by Parliament, which provides for conservation of biological diversity, sustainable use of its component and equitable sharing of its benefits from use of biological resources. For detailed scope of this Act see Brahmi *et al*. (2004). As a signatory of the TRIPs agreement of 1994, India had to provide legislative protection to the plant varieties. This came in the form of Protection of Plant Varieties and Farmers' Right Act, 2001 which recognizes the right of both the breeders and farmers in respect of their contribution in conserving, improving and making available plant genetic resources for development of new plant varieties. For detailed analysis see Sahai, 2003 and Brahmi, Saxena and Dhillon, 2004.

Future Road Ahead

The second decade of commercialisation of biotech crops that has already started from 2006 will end on 2015. According to ISAAA Brief 39, the future prospect regarding the adoption of biotech crops in the remaining seven years of the decade depends on three main issues: establishment and effective operation of appropriate, responsible and cost efficient regulatory system; strong political will and support towards adoption of biotech crops to secure supply of more affordable food, feed and fiber; and continued and expanded supply of appropriate biotech crops to meet the priority needs of the developing countries of Asia, Latin America and Africa. The ISAAA Brief 2005 had made the following future projections about the decade of 2006-2015. Depending on when biotech rice will be approved, the number of biotech crop adopting countries, hectarage and number of benefited farmers will get doubled by 2015.

Within the period of 2009-2015, 15 more countries are expected to adopt biotech crops for the first time taking the number to 40. Among the new countries 3-4 will be from Asia, 3-4 from southern and eastern Africa, 3-4 from west Africa, 1-2 in north Africa and Middle east, 2-3 from the region of Latin/Central America and Caribbean. As far as Europe is concerned, in Eastern Europe up to six countries including Russia are expected to adopt biotech crops. In Western Europe, however, it is difficult to project as the issue of biotech crop adoption here is not an issue related to science and technology, rather it depends on the political willingness and the ideological views of the activist groups. The adoption of biotech rice as a crop and drought tolerance as a trait are going to the significant catalysts in further adoption of biotech crops. RR2 soybean, which is a second generation of GM crop, will further enhance the yield by 7-11 per cent. The most important new biotech crop to be released soon is GM rice. The pest/disease resistant GM rice is extensively field-tested in China and is awaiting the approval of the Chinese regulatory authorities. Moreover, Golden rice is expected to be available from 2012. Several other medium hectarage crops such as pest-disease resistant potato, sugarcane with quality and agronomic traits, disease resistant bananas are expected to get approved before 2015.

Vegetable crops like biotech tomato, broccoli, cabbage and okra which can be modified to reduce the amount of insecticides they consume, are in the pipeline. Some other pro-poor crops like sweet potato, pulses, cassava and groundnuts are also under consideration. By 2015, the global plantation of biotech crops is projected to reach 200 million hectares grown by 20 million farmers across the world.

Conclusion

As per the World Bank 2008 Development Report, agriculture is the vital development tool that can achieve the Millennium Development Goal of halving the number of people under extreme poverty and hunger by 2015. It is an alarming truth that 70 per cent of the poorest people are small and resource-poor farmers and landless laborers, who depend on agriculture for their livelihood. It is to be noted that the concentration of poverty is high among the rural people of the Asian (600 million rural poor) and Sub-Saharan African countries (population of 800 million). However, the way the developing countries are making progress in adopting GM crops and getting benefited from their cultivation, one can be optimistic of reducing poverty through the use this environmentally sustainable technology. With the growing political will and support at the international level as well as at the national level of the leading developing countries, agricultural biotechnology is expected to play a pivotal role in ensuring food security through higher productivity, reducing pesticide use and soil erosion, enhancing nutrition and at the same time preserving the environment for the future generation. India has also off late recognized the positive role of biotechnology in general and success of Bt cotton.

Endnotes

[1] There are a large number of literature that support the potential benefits of agricultural biotechnology (Damodaran, 1999; Middendorf et al., 1998; Rao, 1989, 1994, 2005; Qaim, 2001; FAO, 2004; World Bank, 2007)

[2] Source: Brookes and Barfoot, 2006

[3] Source: Brookes and Barfoot, 2006. One can also see Dale (2002) for a review of literature on environmental impact of GM crops. Lemaux (2009) provides a vivid description of environmental issues related to GM crops citing various scientific literatures. Also see Brooks and Barfoot, (2005), WHO (2005), Phipps and Park (2002).

[4] Shiva et al. 1999; Ho, 1997; Qaim, 2001; FAO, 2004a, Azevedo and Araujo, 2003; Storkey et al., 2008

[5] WHO, Biotechnology (GM food) Publications, Source: http://www.who.int/foodsafety/publications/biotech/20questions/en/).

[6] Source: K. Menard , 2007

[7] Source: Bernauer, 2005

[8] Punjab, Haryana and Rajasthan

[9] All the non-Bt farmers in 2004-05 later adopted the new technology.

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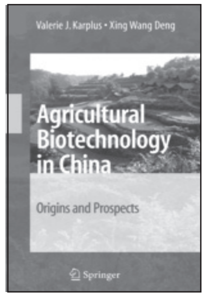
Book Review

Agricultural Biotechnology in China



Author : Valerie J. Karplus and Xing Wang Deng
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Transgenic technology accounts for a large fraction of China's agricultural biotechnology investment, though tissue culture is widely used to eliminate virus from plant stocks or to create large quantities of genetically uniform organisms. The first of transgenic crop to be developed was a virus resistant tobacco, followed by other crops such as cotton, rice, tomato, rice, etc. Transgenic tobacco was immediately released for commercial cultivation, but had to be halted soon as the importers of Chinese tobacco expressed concerns on the marketability of their tobacco products. Currently research is on to study the nutrient utilization in plants and fluctuations in nutrient levels in response to stresses such as drought, soil salinity. Attempts are also made at identifying the genes that regulate the flow of nutrients and enable plants to respond to a particular stress. In China, the public sector accounts for bulk of the investments in agricultural biotechnology.

The book under review gives a succinct history of the development of agriculture in China. There are 10 chapters in the book and the fist chapter gives an overview of the development of agricultural technologies in China. Chapter two and three are on green revolution technologies – its development and diffusion. Chapter four to eight focus on biotechnology in agriculture - types of technologies and their use, development in biotechnology in foreign countries and development and adoption of biotechnology in China. Chapter nine looks into the prospects of biotechnology for Chinese agriculture and chapter 10 is the conclusion.

The rule of dynasties that existed in China till 1911 paved the way for incremental technology innovations in agriculture as technology change was a crucial factor that led to the rise and fall of dynasties. Gains in agricultural productivity enabled military campaigns and state expansion. Irrigation projects have been traced to around 430BC and during this period iron replaced stone as the primary material used in plougshares. During the 10th and 11th century, rice varieties were developed that ripened earlier, enabling farmers to grow multiple crops in a year. By the 17th century, many crops from Americas-sweet potato, corn, peanuts, etc. were introduced in China. However, the fundamental organization and technologies on China's farm remained relatively unchanged till 1911, when the Republic of China was established.

The finding of Gregor Mendal that traits disappear and reappear over successive generations in a predictable manner laid the foundation for selective breeding for higher yields. The development of a dwarf wheat variety which could support the weight of larger grain loads by Dr. Norman Borlaug as part of Mexican Agricultural Programme funded by the Rockefeller Foundation, marked the beginning of Green Revolution. In a few season, Mexico had moved from importing at least half of its grain to self sufficiency. The development of a number of (more than 300) high yielding rice varieties by the International Rice Research Institute, funded by Ford and Rockefeller Foundations, resulted in the increased cultivation of these varieties in Asian countries including China. The lack of readily available nitrogen, which limited the agricultural production was solved with the discovery of a method for converting gracious nitrogen to ammonia, a chemically active nitrogen containing compound. As the high yielding varieties required more water, the irrigation system also got advanced. The development of pesticides, herbicides and fungicides also helped in increasing the yield of the new crop varieties. These technologies had its deleterious consequences as well – environmental degradation, over irrigation of crop land resulting in leaching of soil nutrition, making soil more saline and leaving fields unable to support cultivation. A major factor that helped the diffusion of green revolution varieties and associated inputs has been the free access to advancements generated in the publicly funded research institutions and access to the technology advancements were not restricted by strong IPRs.

In the 20th century, major developments that transformed Chinese agriculture occurred in the second half. The Commune system introduced in 1958 adversely affected agricultural production in many ways. Communes consisted of a large geographical area comprising of 5400 households. Farmers were told what to cultivate and a share of the produce went to the state quota. The commune system took away the household based incentives and ultimately productivity dropped significantly leading to famine in early 1960s. It is said that 70 per cent of this famine has been human made and 30 per cent nature made. The Cultural Revolution started in 1966 further debilitated the progress in agriculture. Education and industrial production were affected and the low levels of per capita food consumption remained unchanged from 1957 to 1978.

China embarked on a sweeping reform process with the ascendancy of Deng Xiaoping to the helm in 1978. Education system was revitalized; many scholars were sent abroad, billions of dollars in foreign technology were imported to modernize the economy. Steps were taken to reinstall household based incentives in agricultural production. During the 1980s and 1990s, additional incentives were created for local officials, banks and business to encourage the growth of rural industries. The Chinese Academy of Agricultural Sciences led the way in the introduction of high yielding varieties. Introduction of new varieties together with household based incentives provided a sizable boost to the agricultural production. The introduction of hybrid rice was in part responsible for 2.3 per cent increase in rice yield frontiers across China from 1980 to 1995. The introduction of 'two line' system of hybrid breeding by the Chinese scientists as against the 'three line' system considerably reduced the time required for generation of suitable plant materials for seed production. This period also saw the expansion in the production of nitrogen based chemical fertilizers, irrigation and pesticides. Introduction of plastic sheeting also helped to guard crop against extreme temperatures and weather conditions. The advancements in green revolution technologies in China also brought with them the negative aspects of the technologies. In some areas, lands have suffered so much that crops are no longer viable there.

Agricultural biotechnology in China began to develop with the reforms initiated by Deng Xiaoping. In the early 1980s agricultural biotechnology ranked among the most prominent components Chinese science and technology. The agricultural biotechnology can be grouped into three categories: genomics, transgenic technology and tissue culture. Genomics help improve the efficiency of plant breeding. Knowing the pressure sequence of an organism's genome makes the outcomes of particular crosses more predictable. Tissue culture is primarily used to eliminate viruses or other plant pathogens by selecting unaffected cells for regeneration. Transgenic technology is used for creating desired properties into the plants by transferring the genes responsible for the desired property into the plant by DNA recombination. The use of antibiotic resistant genes as marker genes for testing the expression of 'transferred property' has been one of the sources of the controversy related to the transgenic technology for the production of crops. The biotechnology research in China received additional boost with the 'National High Technology Research and Development Programme (863 Programme)' started in March 1986. With this programme, there was a dramatic increase in funds for science and technology development. It focused on basic as well as the applied research. The responsibility for administering research programme was spread among CAS, the State Education Commission, the Ministries of Health, Agriculture, Medicine and Light Industry. The Ministry of Agriculture held responsibility for defining agricultural research agenda. The Ministry of Science and Technology retained discretion to translate this agenda into decisions to fund specific laboratories or projects.

Currently Bt cotton is the widely cultivated transgenic crop in China. Cotton cultivation in china faced the problem of bollworm infestation which rose the per hectare pesticide cost to reach $101 in 1995. Pesticides purchase in total agricultural input expenditure increased from 12-13 per cent in early 1980s to 20 per cent in early 1990s. The integrated pest management practices to counter the pest menace met with little success. Bt cotton was permitted for cultivation in late 1990s and by 2001, 35 per cent of total cotton area has been under the Bt. Studies on the economic benefits to farmers of Bt cotton found that farmers saved 20-33 per cent of production costs o account of reduced pesticide use and better yield by 5-6 per cent more than conventional cotton on average. In addition to these economic benefits are the positive benefits to human health and ecosystem.

Concerns also have been raised on the cultivation of transgenic crops. One such concern was that the transgenic material may spread to other organisms or could spread in the wild adversely affecting the genetic diversity. Pests building resistance to these crops has been another concern. Laboratory experiments have shown that bollworms feeding on Bt cotton develops resistance to the plant. However, resistance of people to transgenic crops has not reached the levels in other countries for two reasons: one, research on transgenic crops went quite unnoticed in the country and two, people are not aware of the controversy and ongoing debate on this issue. Though works on transgenic rice began at the time of Bt cotton in early 1990s, no variety has been approved for commercial cultivation. Rice being a staple food crop, the government is more cautious on its release.

China has a biosafety regulatory system for the transgenic crops. The responsibility for the evaluation of study of food products derived from transgenic crops is with the ministry of Health whereas the Biosafety Committee which is comprised of food safety, health, nutrition and toxicology experts evaluate the results of tests for allergenic, toxic or other health related properties. The scientific community which had the monopoly on biosafety decision making, lost its prominence as ministries and international organizations representing environmental, consumer or trade interests acquired more influence over the regulatory process. China's regulation of commercial approvals of transgenic crops is in favour of a precautionary approach.

Despite the fact that the public sector plays a leading role in the development of agricultural biotechnology, its dissemination to the farmers has not been easy. There are a number of factors that influence dissemination of technology. Where the state owned enterprises (at the provincial level) have historically dominated local seed markets, local officials and enterprises have tended to show a preference for locally produced varieties. They have no incentives for moving around to identify the best technology and to make it available to their farmers. As a result, there have been difficulties in transferring the Bt cotton varieties developed by the Chinese Academy of Agricultural Sciences to farmers in a number of provinces.

The agricultural biotechnology development in China faces some challenges now. The reform started by Deng Xiao Ping was characterized by reduced government funding for research institutes and they were required to do the fund raising. This has forced many institutes to divert their energies to activities those which would guarantee a steady income, affecting the quality of research. Lack of intellectual property protection also affected the development of technologies. When research institutes were not adequately compensated for their efforts, they sought alternate marketing channels or became reluctant to continue the development.

Agricultural biotechnology in China has two important national agendas - scientific leadership and rural development. The significant increase in government spending on agriculture and agricultural research in the 11th plan (2006-2010) and shifting of the responsibility of biotechnology development from National Centre for Biotechnology Development to China Rural Technology Development Centre by shifting the allocation of funds indicates the shift in the focus of biotechnology research in China. These concerns are linked to broader government priorities such as food security and political stability in rural areas. Majority of the people still are dependent on agriculture for their living. It is argued in the book that agricultural biotechnology will continue to be relevant for China because *one*, it will enable Chinese farmers to continue to be competent as the country is required under WTO to open its agricultural sector for international competition; *two*, this technology would reduce production costs, pest infestation or adverse health effects and could directly impact the welfare of the rural population, and *three*, efforts at increasing the agricultural productivity in the first half of the 20th century had detrimental consequences on environment.

As the book concludes that agricultural biotechnology particularly the transgenic technology will continue to be an important strategy for food security and rural development, a number of fundamental questions remain unanswered. Is transgenic technology a sustainable solution to pest problems? It has been observed in parts of the globe that transgenic crops provide resistance to major pests only in the initial years. It has also been reported that introduction of transgenic crops has altered pest pattern, the secondary pests become major pests. It has been seen in the Indian contexts that when Bt cotton resisted bollworms, mealybugs a secondary pest till then became major source of pest infestation and farmers had to spend more on pesticides to control mealybugs. The claims on environmental benefits of transgenic technology remain doubtful. Transgenic technology is often applied on hybrids (for higher yields) which require intensive manuaring and watering. So, the issue of soil degradation will continue. Further, the concerns on the spread of transgenic material to other organisms become more serious when the size of landholdings is small. This raises questions on the desirability of adoption of transgenic technology in agriculture in developing country contexts.

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