4

India

Biotech Science Communication: Bridging Science and Society

Bhagirath Choudhary and Kadambini Gaur

The success of genetically modified (GM) crops in India hinges high on the country's ability to mainstream biotech science communication in the society at large. Bt cotton has outlived this exercise because cotton is perceived as a non-food crop contrary to the fact that cotton oil and cake have been a part and parcel of the large food supply chain in India. Bt brinjal (eggplant) or any other crops commonly referred as food crops have to undergo an intense public debate, scrutiny, and outcry despite the fact that the product under development has to strictly comply with the norms, procedures, protocols, and biosafety testing as prescribed by the biosafety guidelines in the country. Moreover, the tools of science communication and public debate have been largely used by a group of motivated individuals and organizations with the mindset to misguide rather than to inform the public about the risks and benefits of biotech crops. In this context,

COUNTRY PROFILE

India is the seventh largest country by geographical area, the second most populous country after China, and the largest democracy in the world. It is located in Southern Asia, dominating the South Asian subcontinent, bordering the Arabian Sea and the Bay of Bengal between Burma and Pakistan and the important Indian Ocean trade routes. The country has varied topography ranging from upland plain in the south, flat to rolling plain along the Ganges, deserts in the west, and the Himalayas mountain range in the north.

The country's economy is predominantly agriculture-based with 64% or close to 90 million of its population employed in agriculture. The major agricultural products are wheat, oilseed, cotton, jute, tea, sugarcane, lentils, onions, potatoes, dairy products, sheep, goats, poultry, and fish. India is a nation of small resource-poor farmers with an average income of US$50 per month (based on 40 Rupees per US dollar) and the average consumption expenditure of US$70. Sixty percent of the farming households own less than 1 hectare of land, and only 5% own more than 4 hectares. Of the 90 million farmer households in India, approximately 85 million (95% of all farmers) are small and resource-poor farmers who do not make enough money from the land to make ends meet – in the past, these included the vast majority of over 6 million Indian cotton farmers.

concentrated efforts are required by the government at the national level to institutionalize biotech science communication to achieve the desired goals of product development and commercialization with urgency to arrest declining yield and production of major crops. The remarkable success of Bt cotton, which has been adopted by millions of small farmers on a large scale in a short period of 7-8 years, is a testimony of the successful application of Bt technology in other crops to overcome major production constraints for ensuring self-sufficiency in food production.

Resurgence of Biotech Agriculture

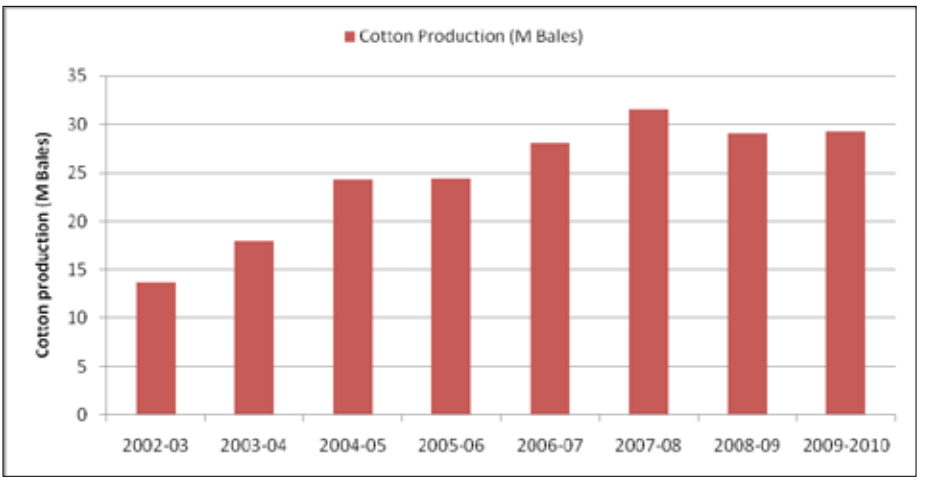
Agriculture is vital to India as majority of the country's population including millions of small resource-poor farmers and urban Indians, depend directly

or indirectly on agriculture. Agriculture is a source of livelihood for 52% or more than half of India's population (Economic Survey, 2009). Agriculture sector continues to influence the growth of the national economy. The importance of modern crop biotechnology for agricultural development has been well realized by leading politicians and policy makers in the country. The Prime Minister of India, Dr. Manmohan Singh, lauded the success of Bt cotton and emphasized the need for developments in biotechnology for greatly improving the yield of major crops in India. While inaugurating the 97th Indian Science Congress in Thiruvanthapuran, Kerala on January 3, 2010, he said: *"Developments in biotechnology present us the prospect of greatly improving yields in our major crops by increasing resistance to pests and also to moisture stress. Bt cotton has been well accepted in the country and has made a great difference in the production of cotton. The technology of genetic modification is also being extended to food crops though this raises legitimate questions of safety. These must be given full weightage, with appropriate regulatory control based on strictly scientific criteria. Subject to these caveats, we should pursue all possible leads that biotechnology provides that might increase our food security as we go through climate related stress"* (Singh, 2010; James, 2009).

Progress and Achievements in Biotech Crops

India is the fourth largest adopter of biotech crops globally. Bt cotton is the only biotech crop that continues to grow, with increasing adoption of Bt cotton hybrids by resource-poor farmers in the country. In recent years, India experienced significant increase in cotton production after the commercialization of Bt cotton hybrids in 2002 (Figure 1). With the boom in cotton production in the last eight years from 2002 to 2009, India has transformed from a net importer to a net exporter of cotton. The area occupied by Bt cotton hybrids in 2002, the first year of commercialization, was 50,000 hectares. It increased significantly every single year and reached 8.4 million hectares in 2009, an impressive 168-fold increase in eight years, occupying 87% of 9.6 million hectares of cotton in 2009. Similarly, the number of farmers who planted Bt cotton also consistently increased from a few thousands in 2002 to a record of 5.6 million small and resource-poor farmers. Coincidently, 34 seed companies by 2009 were engaged in the production of Bt cotton, involving 522 Bt cotton hybrids (including one variety). The

Indian biotech and seed industry has been growing at an unprecedented rate with high yearly growth because of the high adoption of Bt cotton by Indian farmers (James, 2009; Choudhary and Gaur, 2010). It is expected that the early introduction of advanced cotton traits, including stacking of insect resistance and herbicide tolerance, would further boost the cotton production to 35 million bales by 2012 – an indication that India can become the number one cotton producing country in the world replacing China by 2015 (Choudhary and Gaur, 2009b).



Source: Cotton Advisory Board, 2010

Figure 1. Cotton production in India, 2002 to 2010

In the last two decades, both public and private sectors have been investing heavily in research and development (R&D). Research activities include breeding improved cultivars using both conventional and modern biotech tools. The latter transforms crops with selected genes to confer resistance and introgresses them with popular open pollinated varieties and hybrids to deploy crops with desired traits. The country has prioritized investment in improving crops of national importance and the current R&D is focused on the development of biotech food, feed, and fiber crops that can contribute

to higher and more stable yields and also enhanced nutrition. Research projects focusing on insect resistance, herbicide tolerance, drought and salinity tolerance, nutritional enhancement and reduction of post-harvest losses, particularly in fruits and vegetables, through delayed ripening genes are underway (Natesh and Bhan, 2009). Efforts are also being made by small and medium indigenous seed companies and subsidiaries of multinationals to produce quality seeds and planting materials. These aim to substantially increase seed replacement rate (SRR) in order to achieve higher productivity and production. In recent years, private sector has also made huge investment in establishing breeding centers, R&D infrastructure, greenhouse facilities and processing plants to harness the potential of rich biodiversity and diverse agro-climatic conditions across India.

As a result of intense R&D activities, several institutions have made unparalleled progress in identifying biotech events of commercial value. While some of these biotech events are at early stage of regulatory approval, a few selected events have been field-tested and are showing promising results (Choudhary and Gaur, 2009a). After seven years of commercial approval of Bt cotton, India's biotech regulator, the Genetic Engineering Approval Committee (GEAC) recommended the commercial release of Bt brinjal (eggplant or aubergine) in October 2009. This, however, was put on hold by the Ministry of Environment and Forests (MoEF) in February 2010 (GEAC, 2009b; MoEF, 2010). Bt brinjal is at the most advance stage for commercial approval among a dozen of biotech crops awaiting approval for commercial release. A list of selected biotech crops with different traits at advance stage of field trials in India includes brinjal, cotton, cabbage, cauliflower, maize, mustard, okra, potato, rice, and tomato (Appendix 1) (IGMORIS, 2010; James, 2009).

Biotech Science Communication Initiatives

Mainstreaming science communication on biotech crops in India involves several initiatives for spreading biotech information by various government and non-government agencies primarily responsible for biotech crops development, regulation, and commercialization. Most of these initiatives are driven by individualistic approach aimed at providing biotech information to

a selected group of key stakeholders from the government, regulation and scientific community. However, these efforts have had limited impact with a majority of the general public left misinformed by a group of dedicated anti-biotech activists. These activists have been running an intense and years-long campaign maligning the credibility of biotechnology.

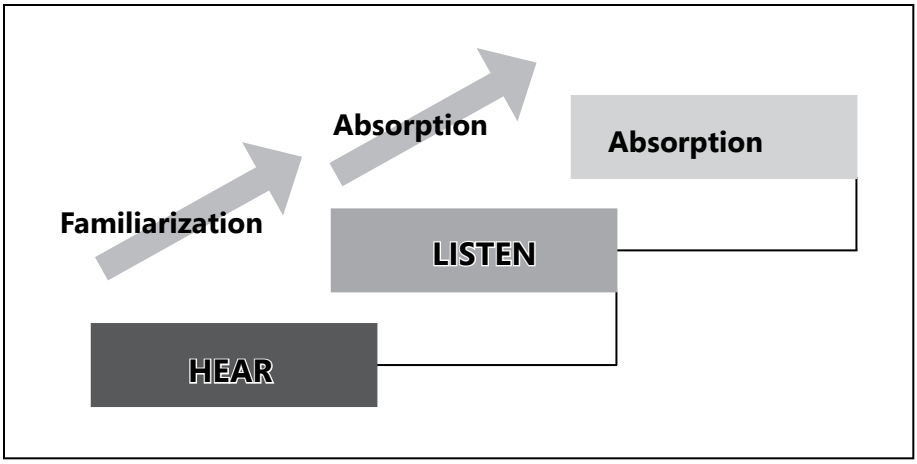
Table 1 demonstrates the advantages and shortcomings of two major biotech communication models for a knowledge-based society: the individualistic vs. the hub and spoke model. As evident from Table 1, it is highly desirable to adopt an institutionalized approach for biotech communication that would allow society to comprehend and acclimatize to the nuances of complex and diverse issues related to biotech crops. Based on the experiences of information sharing on biotech crops over the years at the International Service for the Acquisition of Agri-biotech Applications' (ISAAA) Global Knowledge Center on Crop Biotechnology (KC), effective biotech science communication requires the continuous flow of credible information from a reliable source for a society to familiarize and absorb science-based information. A three-layer societal framework for knowledge absorption is illustrated in Figure 2. It illustrates the process by which people understand and take in information. By hearing and listening to concepts and issues, people become familiar with new or abstract information. To get to the next level of absorption, people must progress to a higher plane of understanding so as to be able to internalize and make decisions that lead to specific actions. Therefore, it is important for the country to embrace an institutionalized approach for biotech science communication and adopt a hub and spokes kind of model for the absorption of science-based, factual and accurate information by every section of society. Such an intense approach would strengthen science-policy-public linkages and mainstream biotech in the daily life of the public at large.

Nevertheless, it is worthwhile to briefly highlight the progress and achievements by individual institutions involved in information dissemination, training and skill development, capacity building and communicating risks and benefits of biotech crops with key stakeholders. The current individualistic approach needs to be transformed to a holistic approach. This is to achieve the desired goals of effective biotech science communication that would fast track adoption and acceptance of biotech food crops by

Table 1. Comparison matrix of biotech communication models for a knowledge based society

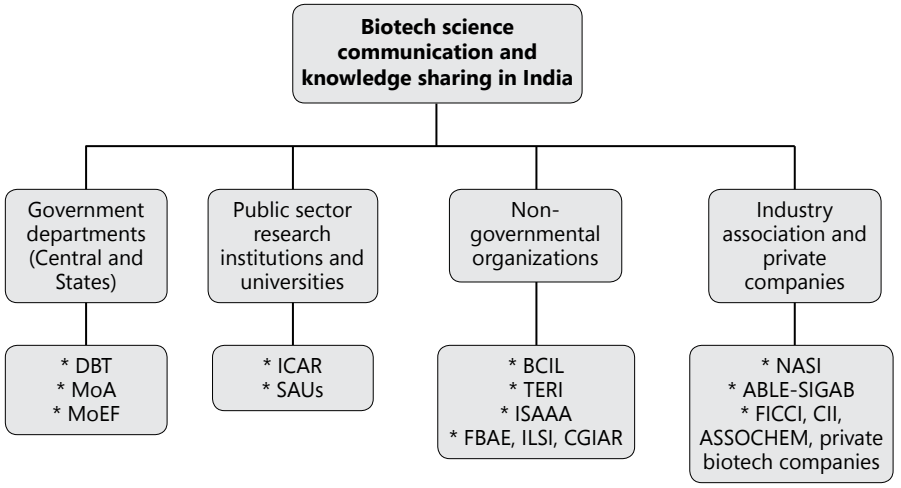
Model/Element	Individualistic Model	Hub and Spokes Model
Approach	Casual	Intense
Target Audience	A select group of stakeholders	Society at large
Time Frame	Arbitrary	Continuous
Channels of Communication	Restricted	Extensive
Modes of Communication	Limited involvement of mass media	Systematic involvement of mass media
Mechanism	Need-based	Supply-driven
Interval	Irregular	Regular
Knowledge Dissemination	Customized	Mass-produced
Nature of Information	Promotional	Rational
Decision Making	High-handed	Participatory
Impact	Short-lived knowledge	Knowledge-based society

Source: Compiled by Choudhary and Gaur, 2010



Source: Compiled by Choudhary and Gaur, 2010

Figure 2. Framework for societal knowledge absorption



Source: Compiled by Choudhary and Gaur, 2010

Acronyms:

DBT - Department of Biotechnology of the Ministry of Science and Technology
MoA - Ministry of Agriculture
MoEF - Ministry of Environment and Forests
ICAR - Indian Council of Agricultural Research
SAUs - State Agricultural Universities
BCIL - Biotech Consortium of India Ltd.
TERI - The Energy and Resources Institute
ISAAA - International Service for the Acquisition of Agri-biotech Applications
FBAE - Foundation for Biotechnology Awareness and Education
ILSI - International Life Sciences Institute
CGIAR - Consultative Group on International Agricultural Research
NASI - National Seed Association of India
ABLE-SIGAB - Association of Biotech Led Enterprises - Special Interest Group on Agriculture Biotechnology
FICCI - Federation of Indian Chambers of Commerce and Industry
CII - Confederation of Indian Industry
ASSOCHEM -

Figure 3. Biotech science communication and knowledge sharing institutions in India

farmers and consumers in the country. A brief description of existing biotech communication initiatives by different institutions that can become the foundation of the larger holistic approach is presented. Figure 3 illustrates multiple stakeholders involved in biotech science communication and knowledge sharing in India.

Biotech Communication and Capacity Building Programs by Central and State Governments

In recent years, the government at both central and state levels has shown a strong political will and commitment in the development of the biotech sector. The R&D in crop biotech has received a sustained and substantial support from the Indian government which has resulted in setting up of major biotech facilities, infrastructure, and imparting adequate training to a large pool of human resources. Different ministries including the Department of Biotechnology (DBT) of the Ministry of Science and Technology (MoST); Ministry of Environment and Forests (MoEF), and MoA deal with the R&D, product development, and regulation of crop biotechnology in India. While the DBT has played a crucial role in supporting crop biotech development programs, the MoEF, MoA, Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), and states department of agriculture all have contributed significantly in augmenting R&D of crop biotech in the country. Similarly, these agencies are involved in promoting biotech research as well as biotech science communication.

Department of Biotechnology, Ministry of Science and Technology

India is the only country in the world to have established an independent DBT within the MoST as early as 1986. DBT has proactively taken numerous initiatives in creating trained human resource, establishing institutional infrastructure, supporting R&D in agriculture and allied sectors, and promoting information dissemination (Natesh and Bhan, 2009; DBT, 2010). A number of projects specific to information, biotech science communication, and capacity building on biosafety regulation and its impact are listed in Table 2.

Table 2. Department of Biotechnology's initiatives on biotech communication

Projects	Target audience	Deliverable	Impact
Web based information & database	Biotech researchers, students, industry and concerned stakeholders	http://dbtindia.nic.in/	Information exchange limited to those who visit DBT website
Biotech News	Recipient of Biotech News, Only Subscribers	Bimonthly biotech publication	Making available latest information on biotechnology-related developments
Biosafety Portal and IGMORIS	Concerned stakeholders and interested parties	http://dbtbiosafety.nic.in/ www.igmoris.nic.in	Available information on biosafety regulation
SBIRI, BIRAP and BIPP	Researchers, entrepreneurs and private enterprises	Technology transfer and licensing, facilitating start-up companies, financial support and grant-in-aid	Setting up enterprises, new product development and promotion of public-private partnership
Biotech activities in states	State government and research institutions	Financial and expert support to set up necessary biotech infrastructure, biotech parks and incubators	Growing biotech based enterprises at state level
Conference, Travel, Exhibition and Popular Lectures (CTEP)	Scientists, researchers, students and concerned stakeholders	http://www.dbtctep.gov.in	Expedite processing of proposals and release of grants via online submission of proposals
Capacity building programs	Concerned stakeholders including central and state government officials, scientists, industry personnel, researchers, NGOs and farmers	Series of workshops on biosafety issues related to GM crops	Training cum awareness on the biosafety regulation of GM crops

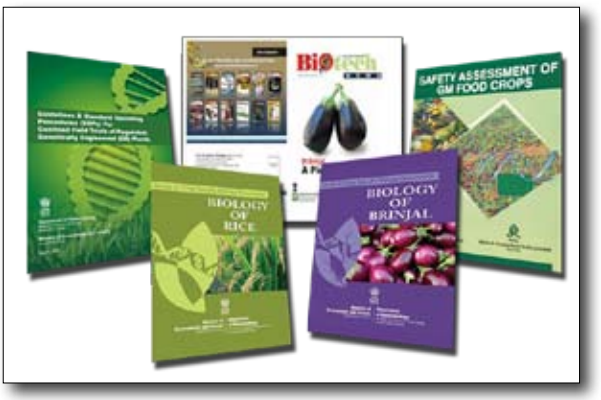
Projects	Target audience	Deliverable	Impact
Publications	Scientists, regulators, industry and concerned stakeholders	Developed several primers, manuals, guidelines, SOPS and pamphlets	Information sharing, research reference and public information Relevant and reliable information available to concerned stakeholders

Source: Compiled by Choudhary and Gaur, 2010
Acronyms:
IGMORIS - Indian GMO Research Information System
SBIRI - Small Business Innovation Research Initiative
BIRAP - Biotechnology Industry Research Assistance Program
BIPP - Biotechnology Industry Partnership Program

In an effort to provide information to the public, the DBT has set up an interactive website, which in addition to departmental related information, provides information on funding opportunities and tracking the status of regulatory clearances of biotech crops under regulatory scrutiny. The department has placed all documents including policy guidelines and protocols formulated for biosafety on its website for information to the concerned stakeholders and general public. In addition, an official bimonthly publication "BiotechNews" brings out the latest information on biotechnology- related developments in the sector.

The department recently launched a new user-friendly interactive website "CTEP" to facilitate online submission of proposals to DBT seeking financial assistance for organizing conferences, seminars, symposia and workshops; travel support for presenting research papers in international conferences; organizing scientific exhibitions; and arranging popular lectures within India (Biotech News, Feb 2010). It also launched many schemes to promote academia-industry interactions and support research and innovation in the biotech sector. These schemes include Biotechnology Industry Partnership Programme (BIPP), Small Business Innovation Research Initiatives (SBIRI) and Biotechnology Industry Research Assistance Program (BIRAP). Notably, these schemes have become a conduit of public-private partnership generating significant innovation and boosting delivery of biotech products.

Lately, the department assumed a more prominent role in promoting public awareness of biotechnology. Numerous capacity building programs with a far reaching impact on the target stakeholders were organized. Specifically, intense training workshops aimed to educate and train officials involved in field monitoring, regulations, and compliances with biosafety guidelines. The department also organized a series of workshops in different states on biosafety issues related to Bt cotton (DBT, 2010; IGMORIS, 2010; PCMU, 2006).



DBT has developed several primers, manuals, guidelines, SOPs, and crop biology documents for various categories of stakeholders.

In addition, production of information and communication materials for dissemination is a distinct feature of DBT. Publications continue to be a vital source of knowledge; therefore, the department has developed an array of resource materials to provide relevant and reliable information particularly on biosafety regulations to the public. These are meant for information sharing, research reference, and public information (DBT, 2010). However, there is an urgent need to intensify efforts on public awareness, education, and participation by involving all stakeholders, namely: central and state government officials, scientists, industry, researchers, NGOs, farmers, consumers, and general public. Most of the activities sponsored by DBT were implemented by the Biotech Consortium India Ltd. (BCIL) in collaboration with various institutions at state level.

MoEF – Global Environment Facility - World Bank Project on Biosafety

The MoEF is the focal point for all biodiversity and biosafety-related matters of biotech crops. It is also the nodal ministry for the implementation of the Cartagena Protocol on Biosafety (CPB) (MoEF, 2010). Genetic Engineering

Approval Committee (GEAC) that functions as a statutory body under MoEF is the apex regulatory authority for issuing permits to conduct experimental and large-scale field trials and also for granting approval for commercial release of biotech crops.

Biosafety is an integral part of modern agricultural biotechnology and therefore since 1989, MoEF in collaboration with DBT has been revising biosafety guidelines and procedures to regulate GM crops in the country. The ministry has also undertaken capacity building activities for enhancing biosafety awareness and regulatory compliance. However, there have been little effort from the ministry to spread information related to biosafety and biotech crops to the general public. The implementation of GEF-World Bank biosafety project was the only project undertaken by MoEF from 2004 to 2007 to strengthen capacity, human resource development, and dissemination of biotech information to the select stakeholders (Lok Sabha, 2010; Warrier, 2008).

The Global Environment Facility (GEF)-World Bank project on biosafety has achieved many milestones such as developing institutional capacity for risk assessment and management, human resource development, training programs, sensitizing the stakeholders, publication of quarterly biosafety newsletter, establishment of India Biosafety Clearing House (http://indbch.nic.in/), development of Biosafety regulatory website (www.envfor.nic.in/division/csurv/biosafety/default.htm) and enhanced information sharing and awareness through information booklets and training manuals (GEF-World Bank Project Completion Report, 2007; Lok Sabha, 2010).

Under the GEF-World Bank biosafety project, the ministry sponsored conferences and consultations on issues related to Cartagena Protocol and also organized workshops and programs on awareness about biotech crops and a better understanding of rules and regulations related to biosafety among all stakeholders. It also implemented awareness workshops on biotech crops in different states of India that greatly helped in sensitizing stakeholders regarding monitoring of biotech crops. In 2005, it organized a series of workshops with focus on Bt cotton that aimed at generating feedback regarding the performance of Bt cotton from different sections of the public such as the farmers, state agriculture department officials, state

agricultural universities (SAUs), and seed companies. The Ministry completed training workshops that involved scientists of 19 SAUs with respect to use of new guidelines for confined field trials, safe operation practices, and formats for monitoring/recording of data in association with DBT. The interactive workshops increased public awareness, education and participation at regional, state, and national level (PCMU, 2006).

MoEF's selected publications on biosafety and regulation (GEF-World Bank Project Completion Report, 2007; Biosafety Information Kit, 2007).

Many publications on biosafety and issues related to GM crops were made available for information sharing with key stakeholders. These were useful as background materials in awareness programs, training workshops, national consultations, and conferences. Publications like Biosafety Information Kit, Capacity Building on Biosafety, Training Needs Assessment and Biosafety, and issues and challenges allowed the public to access information about GM crops and biosafety. The resource materials for information sharing were provided in a variety of formats such as training manuals, technical bulletins, CDs, biosafety newsletters, primers, brochures, and booklets. These publications gained a lot of popularity and were useful in providing basic information for ready reference on biotech crops, regulatory framework in India, and biosafety issues.

The popularization of communication materials was attributable to the fact that they were strategically designed to meet the needs of specific stakeholders including policy makers and members of regulatory bodies, agricultural scientists, media personnel, school children and teachers. These informative materials especially the biosafety information kits were found very useful in educating students about the new technology in colleges and

SAUs. Under this project, MoEF also collaborated with ISAAA, Tamil Nadu Agricultural University (TNAU), and Punjab State Council for Science and Technology (PSCST) to organize bilingual media workshops in Punjabi and Tamil, for popularization of biotechnology and better understanding among local media of biosafety and related issues.

Currently, MoEF is developing the GEF Phase II capacity building project on biosafety under GEF-UNEP assistance to strengthen the biosafety management system in India and provide support for capacity building for the effective implementation of the Cartagena Protocol on Biosafety (CPB) (GEAC, 2009a; Lok Sabha, 2010).

Ministry of Agriculture

The Ministry of Agriculture of MoA is one of the important ministries to deal with concerning the application of biotechnology in agriculture in the country. India's Minister of Agriculture, Mr. Sharad Pawar, being a strong believer in science, technology and innovation, supports biotech crops as they are essential to address food security in the country (ICAR, 2010). In the wake of the recent decision on Bt brinjal, he urged scientists to double their efforts to remove all misgivings about biotech crops from the minds of policy makers and the public. Mr. Pawar while inaugurating the two-day conference of Vice Chancellors of Agricultural Universities and meeting of Directors of ICAR on February 17, 2010 at New Delhi said, *"Conventional technologies of agriculture are inadequate to meet the formidable challenges. The most compelling case for biotechnology and more specifically transgenic crops is their capability to increase crop productivity, lower production costs, conserving biodiversity, efficient use of external inputs, and improvement of economic and social benefits and alleviation of abject poverty in poor and developing countries"* (ICAR, 2010).

The Department of Agriculture and Cooperation (DAC) and Department of Agricultural Research and Education (DARE) under MoA are responsible for formulating and implementing national policies and research programs for agricultural growth. They conduct and promote research in the field of crop biotech. It has proactively taken various initiatives to accelerate agricultural growth and development in the country. The ministry has also implemented

capacity building and awareness programs aimed at information sharing and general awareness about biotech crops. These activities are briefly described as follows:

Enriching knowledge on biotech crops

MoA's selected publications on biotech crops.

The department organized a series of regional and state level awareness workshops on biotech crops focusing on post-release monitoring. The regional workshops sensitized various stakeholders involved in field trials management and monitoring, followed by wider dissemination through state level workshops. These workshops were organized in the nine major Bt cotton growing states including 70 districts (Biosafety Newsletter, 2007). They provided a forum for interaction about the Bt technology and created awareness regarding status and rules and regulations governing biotech crops. These workshops were highly successful in reaching out to stakeholders at grassroot level. The district level workshops exposed the district officials and farmers to Bt technology and biotech crops, its benefits, and status of biotech crops in India. The background documents providing information on the key issues concerning biotech crops were prepared in simple language and were translated in respective local languages. Some of these publications address issues related to GM crops with focus on post release monitoring; facts about GM crops; facts about Bt cotton; and regulatory framework for GM crops. These workshops were organized by the public sector-led organization Biotech Consortium India Ltd (BCIL).

Agricultural human resource development

DARE of MoA runs the world's largest network of R&D institutes and centers in the country referred to as the National Agricultural Research System led by

the Indian Council of Agricultural Research (ICAR). ICAR has made systematic efforts in implementing integrated programs of human resource development in agriculture to create a pool of talented agriculture scientists. One major thrust has been to announce special programs and grants from time to time and support high-performing state agricultural universities and their colleges in refurbishing/renovation of laboratories, classrooms, and farms.

All matters concerning the development of new technology in agriculture and HRD programs including faculty development, trainings, fellowships, and scholarships remain a priority area of ICAR. Recently, it instituted a *Norman Borlaug Chair in Agricultural Biotechnology for Crop Improvement* aimed at promoting research in agricultural biotechnology for crop improvement (DARE/ICAR Annual Report, 2009). For promoting agricultural research and education in the country, the ministry continues to support activities at both state and district levels. These include capacity building initiatives, training and exposure visits, organization of agricultural exhibitions, farmer-oriented activities, farmer information dissemination activities, research-extension-farmer linkages, and technology dissemination through demonstration and farmers fair (DAC Annual Report, 2010).

R&D in agriculture has been mostly in government funded institutions led by ICAR. Public sector research initiatives through modern crop biotechnology applications continue to widen with several research projects underway. India's increased public and private sector investment including government support for crop biotech is progressive. Parallel to the research and development in crop biotech, research organizations also realize the importance of communication activities and are taking keen interest in creating technology awareness for better understanding of biotechnology.

The State Agriculture Universities commonly known as SAUs play an important role in the development of the crop biotech sector. Forty-five SAUs undertake crop biotech research and are major centers for human resource development. With a strong base for planning, promotion, execution, and coordination of agricultural research and education for addressing the emerging challenges, SAUs have significantly contributed in the area of agricultural research and education. In addition, SAUs also provide support to state government in its biotech endeavors including policy issues

(Ayyappan, 2010; PIB, Dec 2009). The SAUs have been entrusted to monitor the performance of agricultural crops within their jurisdictions and are also involved in pre-release and post-release monitoring of biotech crops. The agricultural universities have developed effective mechanism to transfer knowledge and technology to farmers through its concerted efforts. It is important to mention selected SAUs that spearhead crop biotech sector including Tamil Nadu Agricultural University (TNAU), GB Pant University of Agriculture and Technology (GBPUAT), CCS Haryana Agricultural University (HAU), UAS Bengaluru, UAS Dharwad, Punjab Agricultural University (PAU), and Acharya N.G. Ranga Agriculture University (ANGRAU).

Scientists from these SAUs have been involved in the farmers training workshops that aim to make them familiar with benefits and risks of biotech crops. The first-hand experience by the farmers quells their curiosity on adopting the new technology. In order to continue these activities, 569 Krishi Vigyan Kendras (KVKs) or Farm Science Centers functioning under ICAR and SAUs need to intensify communication and information dissemination on crop biotech so that factual information reaches farmers and consumers at the right time.

Biotech Consortium India Limited

Biotech Consortium India Ltd. (BCIL) is a torch bearer of biotech in India. BCIL continues to forge linkages between research, industrial institutions, and the government and is promoted by the DBT. BCIL has implemented many projects involving technology transfer, project consultancy, information dissemination, and manpower training and placement related to biotechnology. Some of the major initiatives of BCIL are briefly described below.

Biotech Awareness Workshops

A major contribution of BCIL in promoting biotech outreach is its continued services in assisting government departments in organizing awareness seminars and workshops on various issues related to biosafety regulation. BCIL organized as many as 80 awareness workshops on GM crops with focus on post-release monitoring in all major cotton growing states during 2006-07 to 2008-09 on behalf of different government departments including

MoEF, DBT, and MoA (PIB, 2010). These workshops were highly successful in providing the right perspective on biotech crops to concerned stakeholders including policy makers, scientists, and state government officials. Over the years, BCIL has played a successful coordinative role in carrying out biotech outreach programs and has developed the expertise and experience in organizing various awareness programs on biotechnology related issues like biosafety, intellectual property rights, and other sensitization programs (BCIL, 2010). In addition to these, many consultations with various stakeholders were organized by DBT to discuss the setting up of Biotechnology Regulatory Authority of India (BRAI).

Production of Communication Materials

Bringing factual and credible biotech information to the public, BCIL is involved in information dissemination in the area of biosafety through websites, newsletters, and publications. It continues to develop numerous comprehensive documents on biosafety in association with government departments which are widely used all over the country. Research documents for awareness workshops, reports, primers, biotech bulletin, and manuals were prepared and made available to different sections of stakeholders. Some of the interesting and useful publications include Biotech Directory, Biotech Bulletin and Value Added Technology Information Services Update (VATIS) and SABP Newsletter (BCIL, 2010).

ISAAA's India Biotechnology Information Center

In August 2004, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) launched the Biotech Information Center (BIC) during the three-day International Conference on Agricultural Biotechnology: Ushering in the Second Green Revolution organized in collaboration with the MS Swaminathan Research Foundation (MSSRF) and the Federation of Indian Chambers of Commerce and Industry (FICCI) in New Delhi, India. The launch was co-hosted by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). India BIC became part of a growing network of Biotechnology Information Centers (BICs) of ISAAA's Global Knowledge Center on Crop Biotechnology popularly known as KC – a unique initiative on crop biotechnology established way back in 2000 to meet the growing

need for credible information on biotech crops in Asia, Africa, Europe, and Latin America. In the last six years, India BIC has become a hub of credible information on biotech crops and serves the need to provide reliable and most authentic information on biotech crops to various government agencies, state government departments, policy makers, officials, regulators, academicians, research institutions, researchers, students, media, NGOs, and general public at large.

India BIC is represented by a very small group of dedicated professionals and supported by different philanthropic foundations, small Indian seed companies and international and national organizations to disseminate information through publications, video documentaries, and scientific and media outreach programs. All programs are designed and executed in collaboration with existing national and international public sector institutions and not-for-profit organizations.

The center in India has successfully built and very effectively spearheaded knowledge sharing and biotech capacity building programs for diverse stakeholders ranging from policy makers, scientists, regulators, journalists to farmers. It has effectively engaged print and electronic media practitioners in a constructive dialogue and received enormous media mileage on new cutting edge crop technology that has potential to directly benefit small and marginal farmers in India. Extensive outreach media programs in different languages resulted in getting an unprecedented amount of positive media exposure and coverage for crop biotechnology through various activities including media workshops, interviews, articles, and regular briefings.

As an attempt to generate knowledge and share success stories with a large section of society, India BIC produced a range of publications highlighting the success of various technological revolutions in Indian agriculture. One such publication is "Trust in the Seed." It documents the Green Revolution era that has received world-wide appreciation on how effective technological dissemination can make local community self-reliant in food production and income generation resulting in reducing poverty and hunger. Similarly, the Indian section of ISAAA's flagship publication the Global Status of Commercialized Biotech/GM Crops which is published as an annual Brief has become a standard reference on adoption and impact of Bt cotton in India and around the world. The figures on Bt cotton adoption and impact from the

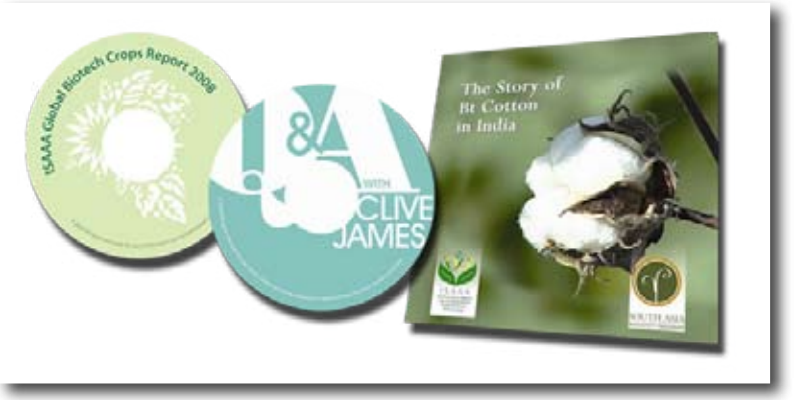
India BIC's publications on biotech crops.

ISAAA Annual Brief are widely quoted as the most authentic data in the Indian Parliament, annual reports, and by media, researchers, and the scientific community.

Anticipating the knowledge needs of society about the development and status of Bt brinjal in India, India BIC released a crop specific ISAAA Brief "The Development and Regulation of Bt Brinjal in India (Eggplant/Aubergine)" in 2009. The Bt brinjal Brief is the most comprehensive review of all aspects of the cultivation of brinjal in India. It summarizes the development and regulatory status of biotech Bt brinjal, which confers resistance to the most important insect-pest of brinjal, the fruit and shoot borer (FSB). Given that Bt brinjal is at the most advance stage of regulatory approval in India, the Bt brinjal Brief has become a standard reference document on all aspects of brinjal cultivation and development process in a short span of time of its release. It has been cited by scholarly articles in research journals and widely quoted in mass media during the nation-wide acrimonious debate on the release of Bt brinjal in the country. Fulfilling the need for right information on Bt brinjal, ISAAA also published a short and concise publication in the form of a Pocket K on Bt brinjal in India which was translated in eight major local languages and made available on ISAAA website for free access to the public.

In addition, India BIC has successfully engaged in an extensive outreach work program with many stakeholders from elected policy makers, government officials, scientists, extension workers, and farmers at both the national and state levels. All outreach programs are designed and executed in collaboration with public sector institutions and not-for-profit organizations. In recent years, India BIC displayed exhibits showcasing growth in biotech

Activities of India BIC during capacity building programs, exhibits, and field visits.



Some of the crop biotech documentaries produced by India BIC have been aired on prominent public sector TV channels.

using innovative posters and distributing short publications at various important programs such as the World Food Prize.

India BIC has also produced biotech documentaries and organized programs in different local languages to provide easy-to-comprehend and credible information to all stakeholders.

ISAAA's outreach and communication work across India will remain critical especially when Bt brinjal and Bt rice are finally released in the not-too-distant future. Bt brinjal is the first vegetable biotech food crop to undergo public scrutiny; it will certainly need effective parallel communication efforts to ensure public acceptance. India BIC assumes a significant enabling role in ensuring early deployment of these potential technologies to Indian agriculture. Therefore, it continues to implement its national level knowledge sharing and biotech outreach activities in alignment with the national agricultural research system and like-minded NGOs for the speedy approval of biotech crops in the country.

In addition, there are few organizations that deserve attention for their commendable efforts in popularizing crop biotech in the country. These include ICRISAT, The Energy and Resources Institute (TERI), the International Life Sciences Institute (ILSI), the Foundation for Biotech Awareness and Education (FBAE), Barwale Foundation, the National Seed Association of India (NSAI), ABLE's Special Interest Group on Agricultural Biotechnology (SIGAB) formerly known as All India Crop Biotech Association (AICBA), Asia Pacific Consortium on Agricultural Biotechnology (APCoAB) and the Trust for Advancement of Agricultural Sciences (TAAS).

Bt cotton delivered multiple benefits to farmers, agriculture, and ecology in India. With the significant experience of cultivating and reaping benefits of Bt cotton, there has been a tremendous demand for such Bt products in different crops from the farming community and, therefore, a large number of biotech crop products are at various stages of development in India. Both public and private sector institutions are incorporating different and stacked biotech traits in vegetables and other food crops in order to provide advanced biotechnology in the simplest form as seeds to farmers. These traits

include insect, virus and fungal resistance, effective weed control through herbicide tolerance, salinity and drought tolerance, yield improvement, nutritional enhancement, and delayed ripening for increased shelf life. Keeping in view the potential of these products to increase agricultural productivity and environmental sustainability, it is important that these products be made available to small and marginal farmers without hassle and unnecessary delay as experienced recently with Bt brinjal.

A Case Study of Bt Brinjal

In February 2010, the Minister of MoEF temporarily put off the commercial release of Bt brinjal despite the fact that India's biotech regulator GEAC declared Bt brinjal safe and recommended its commercial approval on October 14, 2009. Bt brinjal moratorium is a classic example of how scientists failed to communicate with critics and how sensible and organized communication by scientists might have led to a different result. The process of consultation and the decision of delaying the approval of Bt brinjal conform to what the late Dr. Norman Borlaug, the Father of the Green Revolution, envisaged when he stated *"the scientists have done a poor job of explaining the complexities and the importance of biotechnology to the general public"* (Bailey, 2000). In India, the on-going debate on modern biotechnology is propelled by public suspicion and resistance to the use of biotechnology. Therefore, there is a need to inform and educate the public about the potential benefits of crop biotechnology. Strategic communication initiatives are being pursued by the government, industry, research institutions, and science academies to enhance people's awareness and acceptance of the new technologies. However, inaccurate and misleading information by anti-biotech activists and lobbying by NGOs, numerous negative print articles, street protests by critics and anti-technology preaching by various spiritual gurus and celebrities are deterrents for the approval and acceptance of biotech crops by the public at large.

Anti-Bt brinjal campaigns by select anti-biotech groups, civil society organizations, religious groups, and NGOs gathered momentum anticipating its commercial release in late 2009. Scientific opinion and regulatory decision on Bt brinjal were sidelined by campaigners who succeeded in voicing their

anti-Bt brinjal views across the country. Hence, the drama that followed the GEAC nod to Bt brinjal illustrates the importance of biotech communication in this case study. Some of the events that unfolded include:

- Conflicting views and heated debates on the use of biotech crops especially Bt brinjal in print, online, and electronic media
- Screening of video documentary 'Poison on the Platter' in different states of India
- Protests by various anti-biotech groups, civil society organizations, spiritual gurus and Bollywood celebrities and other stakeholders
- Maneuvering the States' opposition to introduction of Bt brinjal
- National consultation in 7 States by MoEF in collaboration with the Center for Environment Education (CEE) with the bias against Bt brinjal and allowing anti-biotech groups to dominate the process of consultation

During the Bt brinjal consultation, the media played a key role in influencing the perception of public on biotech crops. The intensity of media coverage on Bt brinjal turned enormous public attention on biotech crops. Conflicting views expressed in the popular media regarding Bt brinjal generated an unjustified controversy. The number of articles and stories regarding safety of Bt brinjal were recorded to be highest during the debate period. Majority of the media articles evoked fear and concern among the public as they claimed the crop to cause kidney disorders, liver disease, reproductive disorders, infertility, homesexuality, and allergenic diseases. Articles in the media managed to implant fear in the public minds with word selections like "poison, unsafe, terrorism, and frankenfoods."

In addition, pictures of school children with signboards "Don't Poison Us" (MoEF, 2010) and some emotional activists drew the public attention away from the potential benefits of biotech crops. Visual snapshots appeared in newspapers, magazines, and web portals of leading anti-biotech NGOs featuring volunteers dressed in brinjal shaped costumes voicing ban on Bt brinjal (Karunakaran et al., 2010). The activists brought volunteers dressed as brides and bridegrooms to drive home the message that Bt brinjal caused infertility and serious reproductive disorders. The photos of activists holding placards, posters, signboards, and billboards against commercialization of Bt brinjal engaged people at large as visual devices tend to have a long

lasting influence on the public mind. Screening of the documentary "Poison on the Platter" strongly conveyed anti-biotech message across the general public with leading social activists, Bollywood directors and film celebrities, and religious and spiritual gurus influencing media prior to showcasing the documentary in major states in India (Bhat and Kanchan, 2008). The science angle was completely missing in public consultations, anti-Bt brinjal campaigns, videos and press releases raising suspicion and resistance to Bt brinjal.

Finally, the decision on Bt brinjal seems to have been completely influenced by the anti-Bt brinjal activists which affected public perception despite the success of Bt cotton in India over the last eight years. The decision also decreased the credibility of the regulatory system, its independence and capability of the scientific community to successfully work on GM crops in the country. Therefore, Bt brinjal debate in India calls for an innovative and strategic communication initiative to inform, educate, and mobilize stakeholders' views on biotech crops, particularly on Bt brinjal. Effective biotech science communication would have shifted the focus from moral, emotional, and cultural concerns relating to Bt brinjal to science-based facts with an entirely different outcome beneficial to the country's farming community. Thus, Bt brinjal debate necessitates an institutionalized approach to biotech communication to continuously spread science-based factual information on biotech crops in the country.

The Path Forward

The remarkable success of Bt cotton shows a very bright future of biotechnology in India. The huge investment by public and private sectors to develop biotech infrastructure, human resource, and product development facilities are evident signs of growth of the biotech sector in the country. The developers of a large number of biotech crops which are at various stages of regulatory approvals anticipate the timely outcome of these products from the regulatory agencies so as to deliver the benefits of these technologies to Indian agriculture. The regulatory agency has to respond to the need of technology developers and society to harness the potential of these technologies in a time bound manner. A robust and science-based

regulatory system is the need of the hour. Developed countries and few developing countries have made significant progress on the application of biotechnology for crop improvement, evolved trustworthiness, rationalized a time bound regulatory system and commercialized biotech crops, thus reaping bountiful benefits. It is time for the country to realize the importance and potential of biotech crops, evolve an effective regulatory mechanism and promote its trustworthiness in the country. Strengthening, not demeaning the existing regulatory mechanism, is the call of the day. Any attempt to discredit scientific opinion and regulatory process would further jeopardize the prospects of biotech crops and public confidence in the regulatory system. The current imbroglio caused by Bt brinjal moratorium calls for a new beginning to address issues of public confidence and trust in biotech crops in a more logical and systematic manner. This calls for adoption of a unique and long term approach by deploying the hub and spokes model in science communication and knowledge sharing on crop biotech with the general public in the country.

References

Ayyappan, S. 2010. Agricultural Research for Inclusive Growth. Press Information Bureau (PIB), January 14, 2010. Mumbai, Ministry of Agriculture. http://pibmumbai.gov.in/scripts/detail.asp?releaseId=E2010FR6 (Accessed May 27, 2010).

Bailey, Ronald. 2000. Billions Served. Interview with Norman Borlaug in Reason Magazine. http://www.highyieldconservation.org/articles/billions_served.html (Accessed July 20, 2010).

Bhatt, Mahesh and Ajay Kanchan. 2008. Poison on the Platter. http://www.poisonontheplatter.com/ (Accessed July 9, 2010).

Biosafety Information Kit. 2007. Project Coordinating and Monitoring Unit (PCMU). GEF- World Bank Capacity Building Project on Biosafety. Ministry of Environment & Forests, Government of India.

Biotech News. 2010. Department of Biotechnology (DBT). Government of India. Vol. 5, No.1, February 2010. http://biotechnews.in/index.html (Accessed June 7, 2010).

Biosafety Newsletter. 2007. Project Coordinating and Monitoring Unit (PCMU). GEF-World Bank Capacity Building Project on Biosafety. Ministry of Environment and Forests. Government of India. Vol. II, Issue 3, February 2007. http://envfor.nic.in/divisions/csurv/biosafety/newsletter/Newsletter6.pdf (Accessed July 9, 2010).

Biotech Consortium India Limited (BCIL). 2010. http://www.bcil.nic.in/ (Accessed May

28, 2010).
Choudhary, Bhagirath and Kadambini Gaur. 2010. Bt Cotton in India: A Country Profile. ISAAA Series of Biotech Crop Profiles. ISAAA: Ithaca, New York. 25 pp.
Choudhary, Bhagirath and Kadambini Gaur. 2009a. The Development and Regulation of Bt Brinjal in India (*Eggplant/ Aubergine*). ISAAA Brief No. 38. ISAAA: Ithaca, New York. 102 pp.
Choudhary, Bhagirath and Kadambini Gaur. 2009b. India Poised to Become Number One Cotton Producer in the World. Textile Times. Vol. 5, No. 7: 4-10, January-February 2009. Confederation of Indian Textile Industry (CITI), India.
Department of Agriculture and Cooperation (DAC). 2010. Annual Report. 2009-2010.Ministry of Agriculture. Government of India. http://agricoop.nic.in/AnnualRepor2009-10/AR.pdf (Accessed July 8, 2010).
DARE/ICAR. 2009. Annual Report 2008-2009. Department of Agricultural Research and Education (DARE). Indian Council of Agricultural Research (ICAR). Ministry of Agriculture, Government of India. http://www.icar.org.in/node/423 (Accessed July 10, 2010).
Department of Biotechnology (DBT). 2010. Government of India. http://dbtindia.nic.in (Accessed June 9, 2010).
Economic Survey. 2009. July 2009. http://ibef.org/economy/economicsurvey2009.aspx (Accessed May 27, 2010).
GEF-World Bank Project Completion Report. 2007. Project on Capacity Building for Implementation of the Cartagena Protocol, PCMU. Ministry of Environment and Forests, Government of India.
Genetic Engineering Approval Committee (GEAC). 2009a. Minutes of 92nd Meeting. February 11, 2009. Ministry of Environment and Forests (MoEF). http://www.envfor.nic.in/divisions/csurv/geac/decision-feb-92.pdf (Accessed July 2, 2010).
Genetic Engineering Approval Committee (GEAC). 2009b. Minutes of 97th Meeting. October 14, 2009. Ministry of Environment and Forest (MoEF). http://www.envfor.nic.in/divisions/csurv/geac/decision-oct-97.pdf (Accessed July 1, 2010).
Indian Council of Agricultural Research (ICAR). 2010. Sharad Pawar Urges Scientists to Remove All Misgivings Regarding GM Crops. Press Release, February 17, 2010. http://www.icar.org.in/node/1065 (Accessed July 8, 2010).
Indian GMO Research Information System (IGMORIS). 2010. Department of Biotechnology (DBT). Government of India. http://www.igmoris.nic.in/. (Accessed June 18, 2010).
International Service for the Acquisition of Agri-biotech Applications (ISAAA). 2009. http://www.isaaa.org/ (Accessed June 18, 2010).

James, Clive. 2009. Global Status of Commercialized Biotech/GM Crops: 2009. ISAAA Brief No. 41. ISAAA: Ithaca, New York. 290 pp.

Karunakaran, Naren, Kunal Tagleri, and Sriram Srinivasan. 2010. Bt Brinjal-Failure to Yield. Business Outlook. http://business.outlookindia.com/article.aspx?264358. (Accessed July 11, 2010).

Lok Sabha. 2010. Evaluation of Transgenic Crops. Press Information Bureau (PIB). Government of India. Press Release, March 8, 2010. http://www.pib.nic.in/release/release.asp?relid=59154. (Accessed July 9, 2010).

Ministry of Environment & Forests (MoEF). 2010. Annexure-I Report of National Consultations on Bt Brinjal. http://moef.nic.in/downloads/public-information/Annex_BT.pdf. (Accessed July 12, 2010).

Ministry of Environment & Forests (MoEF). 2010. Government of India. http://moef.nic.in/index.php. (Accessed June 15, 2010).

Natesh, Sribhargava and Maharaj Kishan Bhan. 2009. Biotechnology Sector in India: Strengths, Limitations, Remedies and Outlook. Current Science, Vol. 97, No. 2: 157-169, July 25, 2009. http://www.ias.ac.in/currsci/jul252009/157.pdf (Accessed June 4, 2010).

Press Information Bureau (PIB). 2009. ICAR Undertaking Major Capacity Building Exercise: Pawar. Government of India. Press Release, Dec 23, 2009. http://www.pib.nic.in/release/release.asp?relid=56402 (Accessed June 17, 2010).

Project Coordinating and Monitoring Unit (PCMU). 2006. Capacity Building on Biosafety: Training Needs Assessment. Ministry of Environment and Forests. Government of India. http://envfor.nic.in/divisions/csurv/biosafety/Files/TNA%20Abridge%20Version.pdf. (Accessed July 10, 2010).

Singh, Manmohan. 2010. PM Inaugurates the 97th Indian Science Congress in Thiruvanthapuran, Kerala, January 3, 2010. http://pmindia.nic.in/speeches.ht. (Accessed May 29, 2010).

Warrier, Ranjini. 2008. Biosafety Regulations: Need for Compliance and Monitoring, Presentation in the Regional workshop on Management and Monitoring of Field Trials of Genetically Modified Crops, March 29, 2008. Environmental Protection Training and Research Institute (EPTRI), Hyderabad.

Appendix 1. Status of field trials of biotech/GM crops in India, 2009

Crop	Organization	Transgene/Trait	Event
GM Tobacco	IARI, New Delhi	*cry1Aabc*/IR	-
	Sungro Seeds, New Delhi	*cry1Ac*/IR	*EE-1*
	Mahyco, Jalna	*cry1Ac*/IR	*EE-1*
	TNAU, Coimbatore	*cry1Ac*/IR	*EE-1*
	UAS, Dharwad	*cry1Ac*/IR	*EE-1*
	IIVR, Varanasi	*cry1Ac*/IR	*EE-1*
	Bejo Sheetal, Jalna	*cry1Fa1*/IR	*Event-142*
Cabbage	Nunhems, Gurgaon	*cry1Ba* & *cry1Ca*/IR	–
	Sungro Seeds, New Delhi	*cry1Ac*/IR	–
Cauliflower	Sungro Seeds, New Delhi	*cry1Ac*/IR	*CFE-4*
	Nunhems, Gurgaon	*cry1Ba* & *cry1Ca*/IR	–
Cotton	Mahyco, Jalna	*cry1Ac* & *cry2Ab/IR & HT*	*MON 15985 & MON 88913*
	Dow Agro Sciences, Mumbai	*cry1Ac* & *cry1F/IR*	*Event 3006-210-23 & Event 281-24-236*
	JK Agri-Genetics, Hyderabad	*cry1Ac* & *cry1Ec/IR*	*Event 1 & Event 24*
	Metahelix, Bangalore	*cry1C/IR*	*Event 9124*
	CICR, Nagpur and UAS, Dharwad	*cry1Ac/IR*	*BN Bt event (BNLA-601)*
Groundnut	ICRISAT, Hyderabad	*Rice chit and DREB/FR, DST*	–
Maize	Monsanto, Mumbai	*cry2Ab2* & *cryA105* & *CP4EPSPS/I*IR&HT	*MON89034 & NK603*
	Pioneer/DuPont, Hyderabad	*cry1F* & *CP4EPSPS/* IR&HT	*TC1507, NK603*
	Dow Agro Sciences, Mumbai	*cry1F*/IR	*TC1507*
Mustard	Delhi University, New Delhi	*bar, barnase, barstar/AP*	–
Okra	Mahyco, Mumbai	*cry1Ac*/IR	–
	Sungro Seeds, Delhi	*cry1Ac*/IR	
	Bejo Sheetal, Jalna	*cry1Ac*/IR	
	Arya Seeds, Gurgaon	*CP-AV1/*IR	
Potato	CPRI, Shimla	*RB, GA20 Oxidase 1 gene/*DR	–
	NIPGR, Delhi	*ama1/*NE	

Crop	Organization	Transgene/Trait	Event
Rice	IARI, New Delhi	*cry1Aabc, DREB, GR-1 & GR-2 (Golden Rice)/*NE	–
	TNAU, Coimbatore	*chi11/*FR	
	MSSRF, Chennai	*MnSOD/*DST	
	DRR, Hyderabad	*cry1Ac/*IR	
	Mahyco, Mumbai	*cry1Ac, cry2Ab/*IR	
	Bayer CropScience, Hyderabad	*cry1Ab & cry1Ca/*IR	
	Avesthagen	*NAD9/*NE	
Sorghum	NRCS, Hyderabad	*cry 1B/*IR	*Event 4 & Event 19*
Tomato	IARI, New Delhi	*antisense replicase, ACC*	–
	Mahyco, Mumbai	*synthase gene, osmotin,*	–
		*DREB/*IR, DR, FR, NE, DST	–
	Avesthagen	*cry1Ac/*IR	
		*NAD9/*NE	

Source: Indian GMO Research Information System, 2010, Compiled by ISAAA, 2009

Legends: **AP** – Agronomic Performance; **BR** – Bacterial Resistance; **DR** – Disease Resistance; **DST –** Drought and Salinity Tolerance; **FR –** Fungal Resistance; **IR** – Insect Resistance; **HT –** Herbicide Tolerance; **NE –** Nutritional Enhancement.

Abbreviations: **TNAU –** Tamil Nadu Agricultural University; **IIVR** – Indian Institute of Vegetable Research; **UAS** – University of Agricultural Sciences; **CICR** – Central Institute of Cotton Research; **ICRISAT –** International Crop Research Institute for Semi-Arid Tropics; **CPRI –** Central Potato Research Institute; **NIPGR** – National Institute of Plant Genome Research; **IARI –** Indian Agricultural Research Institute; **MSSRF –** MS Swaminathan Research Foundation; **DRR –** Directorate of Rice Research; **NRCS –** National Research Center on Sorghum.