

*A Study of Industry Structure and Strategy for Indian Seed Industry:
Potential for Genetically Modified Crops*

Doctoral thesis submitted to the University of Hyderabad in fulfillment of the
requirement for the award of the degree of the

Doctor of Philosophy

by

SARVESH KUMAR

Under the Supervision of

PROF. VENKATA RAMANA VEDULLA



**SCHOOL OF MANAGEMENT STUDIES
UNIVERSITY OF HYDERABAD
HYDERABAD
INDIA
November 2009**

Declaration

I hereby declare that the thesis entitled, “*A Study of Industry Structure and Strategy for Indian Seed Industry: Potential for Genetically Modified Crops*”, being submitted at School of Management Studies, University of Hyderabad, is the result of my own work carried out at School of Management Studies, University of Hyderabad as a full-time researcher (*Registration Number: 03MBPH03*) and that, it has not been wholly or in part, been submitted for any other degree. Due acknowledgement for the sources referred has been made wherever applicable.

Date:

(SARVESH KUMAR)

Place: Hyderabad

Registration Number: 03MBPH03
School of Management Studies
University of Hyderabad
Hyderabad – 500046
India

CERTIFICATE

This is to certify that the research work embodied in this thesis entitled, “*A Study of Industry Structure and Strategy for Indian Seed Industry: Potential for Genetically Modified Crops*”, submitted to School of Management Studies, University of Hyderabad, has been carried out by **Mr. Sarvesh Kumar** (*Registration Number: 03MBPH03*), in total fulfillment for the award of the degree, Doctor of Philosophy in Management Studies, under my supervision for the full period under the Ph.D. ordinances of the University and to the best of my knowledge, the same has not been earlier submitted for the award of any degree of any University or Institute.

Date:

(Dr. V. VENKATA RAMANA)

Place: Hyderabad

Research Supervisor

Acknowledgements

At the outset, I would like to thank everybody who have supported and encouraged me since I enrolled as a Doctoral student at University of Hyderabad and started to plan this thesis, including all the friends, relations, and colleagues. These have, at regular intervals, enquired about the progress of my work and supported me in many ways.

My first thanks are due, of course, to my ever-accessible and supporting research advisor Prof. Vedula Venkata Ramana, Dean, School of Management Studies. Right from the conception of the topic through out the research period at every stage he participated in this endeavour. Be it in the form of demands of academic rigor or timely rescue with appropriate intervention or in introducing me to ideas, sources, arguments I could not have dreamt of exploring without his constant guidance, or the humane approach towards my academic and non-academic problems and shortcomings, his role has been more than mere professional partnership in this research. His remarkable capacity to combine uncompromising attitude towards academic quality with an unfailing understanding towards the scholars difficulties is surely a lasting impression on me.

A special mention should be given to Prof. Arif A. Waqif (retired), Dr. S. Mallikarjuna Rao, Dr. V. Sita, Dr. B. Rajashekhar, Dr. P. Jyothi, Dr. Mary Jessica, Dr. G.V.R.K. Acharyalu and Dr. Chetan Srivastava, members of the faculty of School of Management Studies, who have been a great team to work with and learn from. Their comments, advice, encouragement benefited the thesis in many ways. I am grateful to Prof. E. Hari Babu and Prof. Prajit Basu for allowing me to attend their classes on Sociology and Technology.

Particular thanks to Prof. N. Linga Murthy, Vice Chancellor, Kakatiya University. He generously gave me many of his books and articles to me and also for illuminating discussions he held with me on the issues related to me research area. His contribution to my thesis is greater than I had the opportunity to acknowledge in my references.

I owe an immense debt to numerous scientists, researchers and staff at ICRISAT, Lam Farm, CICR, CIRCOT, NBSS&LUP, NERI, and different Agricultural Universities and Agricultural Research Institutes, and Scientists from different Seed Companies. Too many discussions I had with them and innumerable forms of support they kindly extended to me are an essential part of carrying out this research work. I regret not being able to acknowledge all of them by name. Moreover, I am obliged by the confidentiality required concerning some confidential information and critical insider knowledge they shared with me. I gratefully acknowledge the patience and seriousness with which many respondents cooperated with me in agreeing to be interviewed.

Dr. Debasis Patnaik, Dr. Sanjay Kumar Jha and Ms. Y. Shobha Rani, provided constructive criticism and continuous support and encouragement through out.

Publications by various NGOs, Deccan Development Society (DDS), Centre for World Solidarity (CWS), Modern Architects for Rural India (MARI), Navdanya, GeneCampaign, Kudumbam, M. S. Swaminathan Foundation, Farmer Federation of India and others have been particularly useful for formulating some of the central findings of this thesis. I should be happy if my modest thesis will prove to be not only a beneficiary but also a contribution to their noble work.

I am indebted to ISAAA, IFPRI, ICRISAT, FAO, WIPO, Monsanto and Syngenta for their databank and newsletters that with out which I could not have managed to keep abreast of the recent developments in the field of my research.

The farmers, retailers, distributors, middlemen, Government employees, managerial and scientific staff of many seed companies, Dr. Y. R. Ambedkar, Mr. Chandu Kharade, Mr. Manohar Bannaliker, Mr. Sai Nath Chaple and their relatives for their help during my field survey in variant locations in Andhra Pradesh and Maharashtra. The villagers, translators, hosts and felicitators taught me what a pleasure field work and conduction of surveys could be. My expression of gratitude in these pages many of them cannot read is no match to the enormity of my indebtedness to them.

I am grateful Dr. Sudipto Bhattacharjee and family for being such great hosts throughout my stay at Nagpur. They not only went out of their way to make feel at home in their home but also provided valuable guidance in fieldwork. Dr. Kesava Kranthi and Dr. Sandhya Kranti helped finding accommodation at CICR Guest House during my field trip to Nagpur and also kindly gave me their published work.

School of Management Scholars Mr. E. A. Vinod Kumar, Mr. N. S. Rao, Mr. Laxma Reddy, Dr. Prem Shyam Sunder, Dr. V. Balaji Venkatachalam, Dr. G. Anupama, Mr. Sanjay Kumar, Ms. Nazia, Ms. Uma, Mr. Azhar, Mr.China Babu, Mr. Lalith Khurana, Ms. Anitha, Mr.G. Pravin Kumar, Mr.M. Sudhakar, Mr. Pramod Kumar Mishra, Mr. Shekhar, Ms. Aparna, Mr. Srinu Naik, Ms. Sunitha, Ms. Sri Jyothi – I am lucky to have so many such friendly, helpful peers. I cannot thank them enough. Thanks are due for Dr. Sudip Singh Parihar, Mr. Yasser Arafath, and Ms. Shreya K. Varma for all the love and affection bestowed upon me during research. Alumni of UoH, Dr. Gurram Srinivas, Dr. Sukumar, Dr. Romesh Singh, Dr. Kasi Eswarappa, Dr. V. J. Varghese, Dr. Suma Varghese, Dr. Satyajit Acharya, Dr. D. Anand, Dr. Koteswar Rao Naik, and Mr. Bhima Kumar deserve special mention for their encouragement and support in many ways. Mr. Issac Sippi, Mr. Jagannatham Suresh, Mr. Taj-ud-din, Mr. Degala Ravi Kumar, Mr. V. Dhanraju, Mr. Sarin, Mr. Chiti Babu, Mr. Ramesh C. Malik and Mr. Praveen are there with me and for me through out the research period.

I express my sincere thanks to Mr. Pradeep Kumar Roy for constructive criticism during questionnaire design. I would like to mention his help as resource person and as facilitator stakeholders. As a true friend he also supported financially during my tough days. I am thankful to friends and alumni from Sainik School Tilaiya: Mr. Lokesh Choudhary, Mr. Rakesh, Mr. Dharmendra Kumar, Mr. Ajit Kumar, Mr. Gautam Kumar, Mr Shiv Shankar Mehta and their family members for all the support extended to me.

I would also like to seize this opportunity to acknowledge all the non-teaching staff of the department Mr.Vijaya Bhaskar, Mr. Deevi Prakash, Mr. Krishna Murthy, Mr. Narsing Rao,

Mr. Mallesh, Mr. Sheetal Singh, Mr. Sharf-ud-din for their unfailing and continuous support to me.

I am also thankful to the Librarian and Staff at the library of University of Hyderabad, ICRISAT, ASCI, IDRBT, NIRD, MANAGE, NARM, Directorate of Economics and Statistics Govt. of A.P, Osmania University, CESS, Acharya N.G. Ranga Agricultural University, Pusa Agriculture University, British Library, CICR, NBSS&LUP, NERI, B.R. Ambedkar Marathwada University, Nagpur Agricultural University, Kakatiya University, Andhra University, Birsa Agricultural University, Ranchi, ICAR, Delhi, FCI, Delhi, JNU, Delhi, IIT-Delhi.

Finally I would like to thank all my family members, especially my parents Smt. Kailash Pati Devi and Sri. Munshi Baitha who have always considered education as the most important thing one should give to their children and extended their support during the course of this project.

Last, but not the least, I would like to thank members of the Theosophical Society whose vision informs and flares up my commitment to academics.

Sarvesh Kumar

Preface

The Seed Industry refers to the production, processing and marketing of the basic agricultural input 'seed'. This Industry encompasses suppliers, farmers, traders, processors, wholesalers and retailers, and all the institutions and arrangements that affect and coordinate the various stages of the supply-chain of the seed. The need to look at the problems and issues in agriculture as part of a larger chain rather than as a separate activity or sector is increasingly felt by all those involved in studying this Industry. Such way of looking at Seed Industry as part of a much larger entity is particularly important in the context of new competitive and globally integrating environment and changing nature of the markets. Present study deals with the macro business environment, both national and international, structure and strategies and dynamics of Indian Seed Industry with special reference to the budding new technology-Biotechnology.

The use of biotechnological techniques for producing transgenic plants (Genetically Modified Crops or Genetically Modified Organisms; acronym: GMC or GMO) results in the transfer of desirable traits across the species barrier. This has led worldwide debate on a range of ethical, moral, and social considerations associated with the risks and benefits of this technique to humans and our environment. The world has virtually become a battleground involving scientists, politicians, policy-makers, journalist, industry representatives, farmers, and consumers with a polarization of society into proponents or opponents of biotechnology. However, it is equally true that the achievements of the Green Revolution are proving insufficient to increase productivity and counter negative externalities of Green Revolution. Biotechnological interventions can play a vital role by not only increasing crop productivity but also taking care of the increasing threat of biotic and abiotic stresses on crop plants.

This study hopes to go in the way of integrating management discipline with the biotechnology by bringing down an ongoing technology based phenomenon which is reshaping the Indian Seed Industry by introducing new product choice.

Chapter one maps the seed industry both at global and local settings. Structure of existing format of Indian seed industry is to be discussed with reference to economic, political and

technological environments. It gives the broad introduction and outline of the growth and development of Indian seed industry, present state of public and private sector, and an outline of the business environment scenario and changing trends. In addition, an attempt has been made to provide a brief introduction to the phenomenon of technology transition.

The diverse knowledge streams, the actors and drivers of technology transition are to be discussed in *chapter two* which is based on theme based review of literature. The chapter provides an overview of conceptual framework drawing from a range of disciplines. An attempt is made to bring the scientific literature on biotechnology and the knowledge on the business environment in which it is taking place together. In this way, both the insights of scientific literature on the technical aspects of the biotechnology and information on the state of the industry will not only be seen together but also be made to mutually illuminate. Basic aspects of the question of study- research and development, science, technology, new product development- will be interrogated against the backdrop of the fast changing business environment. In other words, the question of biotechnology in the Seed Industry will neither be left to a ‘scientific’ approach ignorant of its social consequences or business/marketing practicalities nor be treated from a narrowly understood perspective of business oblivious of the nature and possibilities of the technological innovation involved. Research Gaps evolved as upshot of review of literature leads to formulation of research questions, hypotheses and research objectives which have been investigated in the study.

In view of the new technology i.e. Biotechnology and its ramification on the seed industry, there was a necessity to design new frame of methodology for pursuing this study because the nature of the actors and drivers of the seed industry and their dependency on many streams of knowledge required a new approach of investigation. The step by step evolution and synthesis of research process and research framework for hypotheses testing and research objectives are explained in *chapter three*.

Chapter four attempts to interpret data and finding from one set was triangulated with other to bring out facts. Being an ongoing phenomenon, it was necessary to understand the forces which are the cause of technology transition occurring in the Indian Seed Industry. Triangulation gives the flexibility of interpreting archival data and primary data.

Chapter five scans the legal and policy environment in which the seed industry exists and the Indian policy structure for seed and biotechnological related issues juxtaposed with International policy initiative. The chapter provides a basis for understanding, analyzing and implementing legal systems that can properly balance the public and private interests in agricultural biotechnology inventive contribution. The chapter investigates the possible effect of Plant Breeders' Rights, Plant Variety Protection Act and Farmers Rights with respect to the Indian farmers and Indian Seed sector.

Chapter six brings out the R&D commercialization and its influence in agricultural sector and its manifestation in seed industry.

Chapter seven brings out the science and technology environment for seed industry. Scientific churn leading and ramification of biotechnology in agricultural sector in general and seed industry in particular. The form of Genetically Modified Crops is probed in this chapter.

Chapter eight concludes with suggestions for the Indian seed industry, policy makers, academia and future researchers in this field. The study explores ramifications of other product portfolios of seed market that use biotechnology. Observing the magnitude of change brought in by biotechnology, it might prove to be useful to understand the nature, structure and potentials of other sectors that too use biotechnology-based inputs. An attempt will be made to develop an outline of a framework for the industries that employ biotechnology-based inputs. An historical pattern will be explored, namely the curious case of every major global economic recession of the century being overcome by the impetus provided by a technological breakthrough to the economy. It is the contention of the thesis- albeit a hesitant one- that the future innovations of biotechnology may prove to be such technological breakthrough to save us from the ongoing economic recession.

Chapter nine sums up the recommendations that flow from the findings of the study which argue both for a new perspective for better understanding of the issue studied and also for a better set of intervention at policy level for improvements in the sector.

The Glossary, Appendix, Reference and Bibliography are given at the end of the dissertation.

Contents

	Page No.
Declaration.....	i
Certificate.....	ii
Acknowledgements.....	iii-vi
Preface.....	vii-ix
Contents.....	x-xiv
List of Tables	xv-xvi
List of Figures.....	xvii
Abbreviations and Acronym of Terms.....	xviii-xx
Chapter I: Introduction.....	1-46
1.1 Background.....	1
1.2 Significance of Agricultural Development.....	3
1.3 Indian Agriculture during the Five Year Plans Periods.....	4
1.3.1 Indian Seed Industry during these planning periods.....	7
1.4 Global Seed Industry.....	9
1.4.1 Global Seed Industry and GMC.....	13
1.4.2 The Global Value of the Biotech Crop Market.....	15
1.5 Indian Seed Industry.....	16
1.5.1 Green Revolution and its actors for the understanding of the genesis of Modern Indian Seed Industry.....	18
1.5.1.1 Manifestation of Green Revolution.....	18
1.5.1.2 Green Revolution vs. Evergreen Revolution:Several Dimensions of Technological Transformation.....	21
1.5.2 Public Sector Seed Companies.....	24
1.5.3 Seed Industry Structure for Variety Development.....	27
1.5.4 Private Sector Seed Companies.....	29
1.5.5 Public-Private Sector Cooperation.....	30
1.6 Gene revolution and transformation of Indian seed industry.....	31
1.6.1 Agricultural Biotechnology Structure of the Indian Seed Industry.....	32
1.7 A Case Study of Cotton Crop.....	32
1.7.1 Cotton Sector: Species and Varieties.....	33
1.7.2 Cotton Breeding in the Public and Private Sector: A Short Chronology.....	34
1.7.3 Bt. Cotton: The New Product.....	37
1.7.4 India and GMC.....	38
1.7.5 Review.....	39
1.8 Rationale for conducting the market research.....	40
1.8.1 Purpose of this Research.....	41
1.9 Overview of the Chapters.....	42
References.....	44
Chapter II: Literature Review.....	47-93
2.1 Rationale.....	47

Content	Page No.
2.2 Development in Science.....	49
2.3 Role of Seed.....	51
2.3.1 Available literature related to Seed Industry.....	52
2.4 The Potential of Biotechnology.....	55
2.4.1 Conceptual theory of Genetically Modified Crops (GMCs).....	56
2.4.2 Risks involved with GM Crops.....	57
2.4.3 Types of hazards.....	58
2.5 Genetic Resources: Biodiversity, Biotechnology, and Biosafety.....	58
2.6 Industry Structure and Strategy.....	60
2.7 Issues Related to Intellectual Property Right (IPR).....	60
2.7.1 Patent Issues.....	63
2.8 Policy Initiatives and Indian Seed Industry.....	66
2.8.1 Policy Linkages to strategy and structure.....	67
2.8.2 Agricultural Science and Technology Policy.....	67
2.9 Science & Philosophy of Science.....	68
2.10 Innovation, Technology and R&D.....	69
2.10.1 Innovation.....	69
2.10.1.1 New Knowledge.....	70
2.10.1.2 Management Innovation.....	70
2.10.2 Technology.....	70
2.10.2.1 Science and Technology.....	72
2.10.2.2 Technology as a Strategy for Market Competition..	73
2.10.3 Research and Development (R&D).....	74
2.10.3.1 Agricultural research and development (R&D).....	75
2.11 New Product Development.....	76
2.11.1 Scope of Product Line.....	78
2.11.2 Life cycle management of a product.....	79
2.12 Impact of Globalisation on Indian Agriculture.....	79
2.13 Rural Market and Rural Marketing.....	80
2.14 Questions evolved from review of literature.....	80
2.15 Research Gap.....	82
2.16 Formulation of Research Hypotheses.....	84
2.16.1 Research Hypotheses.....	84
2.16.2 Null Hypothesis.....	84
2.17 Formulation of the Research Objectives.....	85
2.17.1 Research Objectives.....	86
References.....	87
Chapter III: Methodology.....	94-117
3.1 Rationale.....	94
3.1.1 Key Factors of the Research.....	95
3.1.2 Literature Based Substantiation.....	96
3.2 Defining the stakeholders.....	98
3.3 Significance of the methodology.....	100
3.4 Study Design and the Process of Selection of Different Methodology	100

Content	Page No.
3.4.1 The Customer.....	100
3.4.2 Seed Industry Supply Chain.....	101
3.5 Data Sources.....	106
3.6 Different Stages of the research process.....	106
3.7 Scope and Limitations of the Study.....	110
References.....	112
Chapter IV: Consumer’s Response and Data Interpretation.....	118-146
4.1 Introduction.....	118
4.1.1 Goal.....	119
4.1.2 Objectives.....	119
4.1.3 Methodology.....	120
4.1.3.1 Data Collection.....	120
4.1.3.2 Total Sample Size.....	120
4.2 Consumers’ Response from Andhra Pradesh.....	121
4.2.1 Case A: Consumers’ Response from Nizamabad.....	122
4.2.2 Case B: Consumers’ Response from Adilabad.....	125
4.2.3 Case C: Consumers’ Response from Khammam.....	127
4.3 Consumers’ Response from Maharashtra.....	130
4.3.1 Case A: Consumers’ Response from Hingoli.....	131
4.3.2 Case B: Consumers’ Response from Nanded.....	133
4.3.3 Case C: Consumers’ Response from Yawatmal.....	136
4.4 Conclusions.....	137
Chapter V: Policy and Regulatory Framework.....	152-211
5.1 Introduction.....	152
5.1.1 Methodology.....	154
5.2 International Regulatory Framework (WTO Agreements Related to Agriculture).....	154
5.2.1 Evolution of Structure and System based on International Intellectual Property System.....	156
5.2.2 Plant Variety Protection in International Context.....	161
5.2.3 Trade Related Aspects of Intellectual Property Rights (TRIPS).....	163
5.2.4 WTO & QR’s.....	165
5.2.5 The Regular Patent System.....	166
5.2.5.1 Important differences among national systems.....	166
5.2.5.2 Typical coverage of actual patents.....	166
5.2.5.3 Trade Secrecy and Material Transfer Agreements....	168
5.2.6 Biosafety and Product Labeling Considerations.....	169
5.3 Regulatory Environment in India.....	170
5.3.1 Trade Related Aspects of Intellectual Property Rights and India.....	175
5.3.2 Post-WTO Indian Legislation Pertaining to Agriculture.....	176

Content	Page No.
5.4 Patent Issues in Indian context.....	178
5.4.1 Salient feature of Indian Version of Plant Variety Act.....	180
5.5 Pattern and Direction of Agricultural Research and Development in new IPR regime.....	188
5.6 Agricultural Biotechnology and Policy initiatives in India.....	190
5.7 Technology and Regulation.....	190
5.8 Impact of New Technology and IPR on Agricultural R & D.....	191
5.9 Implications for commercial companies.....	193
5.10 Government of India intervention.....	194
5.11 The Debate.....	195
5.12 Inferences.....	203
5.13 Conclusions.....	205
References.....	208
Chapter VI: R&D in Agriculture and Indian Seed Industry.....	212-262
6.1 Introduction.....	212
6.1.1 Methodology.....	215
6.2 Agriculture Research and Development System in India..	215
6.2.1 Structure of Agricultural Research System in India.....	216
6.3 Investment Pattern of Public R&D in Agriculture.....	218
6.4 Public Investment in R&D and Productivity.....	221
6.4.1 R&D and Agricultural Productivity.....	221
6.5 Public and Private Debate on investment in Agricultural R&D.....	226
6.6 Issues of Research and Development in Indian Seed Sector.....	228
6.6.1 Seed Research in Public Sector.....	230
6.6.2 Thrust and challenge of Seed Research and Developments...	232
6.6.3 Seed Research in Private Research.....	234
6.6.4 Major Constraints in the Private Seed Sector.....	238
6.7 Relevance and Need for Agro-Biotechnology in Seed Sector.....	239
6.7.1 Investment in Biotechnology.....	240
6.7.2 Agro-biotechnology opportunities in the Indian seed sector.	242
6.7.3 Transgenic Research in India.....	243
6.7.4 R&D priority for transgenic in the Seed Sector.....	250
6.8 Regulation and Risk with transgenic.....	252
6.9 Technological dimension of Bt. Technology based on Primary Survey..	254
6.9.1 Entry Barriers: Pre-Bt.....	254
6.9.2 Entry Barriers: Post-Bt.....	255
6.9.3 Competition in the Post-Bt. Scenario.....	256
6.9.4 Competition between different Bt. genes.....	258
6.9.5 Illegal Bt.....	259
6.10 Inferences.....	260
References.....	262

Content	Page No.
Chapter VII: Scientific Environment Vs Views of Scientists and Industry Managers.....	263-297
7.1 Methodology.....	263
7.1.1 Primary Sources.....	263
7.1.2 Secondary Sources.....	263
7.1.3 Institutions from where the respondents have been selected.....	263
7.1.4 Sample Size.....	265
7.2 Chronological Finding of Primary Survey.....	265
7.2.1 Excerpts from Responses of Scientists during 2003.....	266
7.2.2 Excerpts from Responses of Scientists during 2004- 2005....	268
7.2.3 Excerpts from Responses of Scientists during 2006- 2008....	270
7.3 Agriculture.....	272
7.3.1 Genetically Modified Foods.....	273
7.3.1.1 Scientific Foundations.....	273
7.3.1.2 Development.....	274
7.3.1.3 Current Issues.....	275
7.3.2 Scientific Background.....	276
7.3.3 Recombinant DNA.....	277
7.3.4 Scientific Evaluation of Genetically Modified Crops based on Published Literature.....	279
7.3.5 Bt. Insect-Resistant Crops.....	280
7.3.5.1 Scientific Foundations.....	281
7.3.5.2 Development.....	281
7.3.5.3 Current Issues.....	282
7.3.6 Corn, Genetically Engineered.....	282
7.4 The Importance of Agricultural Science and Technology Indicators.....	283
7.5 Inference: Linkage between Science, Policy and Business and their practitioners' view.....	284
7.6 Conclusion.....	289
7.7 Discussion and Future Dimension.....	290
References.....	293
Chapter VIII: Findings and Conclusions.....	298-309
8.1 Findings.....	298
8.2 Conclusions.....	304
8.2.1 Hypotheses.....	310
Chapter IX: Recommendations.....	311-316
9.1 Suggestions and Recommendations.....	311
9.2 Scope for Future Research.....	316
Glossary.....	317-318
Reference and Bibliography.....	319-354
Appendices and Research Instruments.....	355-378

List of Tables

Table Number	Table Title	Page No.
Table 1.1	Estimated Value of the Domestic Seed Market in Selected Countries (US\$ million).....	9
Table 1.2	Countries having reported more than 1 million US\$ planting seed exports Calendar year 2007. Million US\$.....	10
Table 1.3	Countries having reported more than 1 million US\$ planting seed imports Calendar year 2007. Million US\$.....	11
Table 1.4	Chronological milestone in India's Seed Industry.....	17
Table 1.5	Production of Breeder, Foundation and Certified Seed in India (1991-1992 to 2007-2008).....	27
Table 4.1	Breakup of Total respondents (Farmers) from Andhra Pradesh and Maharashtra.....	121
Table 4.2	Breakup of respondents (Farmers) from Andhra Pradesh.....	122
Table 4.3	Breakup of respondents (Farmers) from Nizamabad District.....	122
Table 4.4	No. of cotton seed brand grown by individual farmer (Nizamabad District).....	123
Table 4.5	Breakup of respondents (Farmers) from Adilabad District.....	125
Table 4.6	No. of cotton seed brand grown by individual farmer (Adilabad District).....	126
Table 4.7	Breakup of respondents (Farmers) from Khammam District.....	128
Table 4.8	No. of cotton seed brand grown by individual farmer (Khammam District).....	129
Table 4.9	Breakup of respondents (Farmers) from Maharashtra.....	130
Table 4.10	Breakup of respondents (Farmers) from Hingoli District.....	131
Table 4.11	No. of cotton seed brand grown by individual farmer (Hingoli District).....	132
Table 4.12	Breakup of respondents (Farmers) from Nanded District.....	133
Table 4.13	No. of cotton seed brand grown by individual farmer (Nanded District).....	135
Table 4.14	Breakup of respondents (Farmers) from Yawatmal District.....	137
Table 4.15	No. of cotton seed brand grown by individual farmer (Yawatmal District).....	138
Table 4.16	State-wise Area and Productivity of cotton.....	140
Table 4.17	Area, Production and productivity of cotton in India during last six decades.....	140
Table 4.18	Availability of Cottonseed for Processing in India (2001-2002 to 2003-2004 and 2005-2006 to 2007-2008).....	142
Table 4.19	Cotton imports in India – 1996-97 onwards.....	143
Table 4.20	Pricing of Bt. Cotton.....	144
Table 4.21	State-wise Consumption of Pesticides (Technical Grade) in India (2000-2001 to 2007-2008).....	146
Table 4.22	Crop-wise Availability of Certified/Quality Seed with Various Agencies in India (Kharif, 2007).....	149

Table No.	Table Title	Page No.
Table 4.23	Share of Public Sector in Making Available/Supply of Certified/Quality Seeds in India (2005-2006 to 2007-2008)	149
Table 4.24	Breakup of the Number of Respondents (Farmers) growing, number of different brands of Bt. cotton in their individual fields.....	150
Table 5.1	Comparison of UPOV, 1978 Act and 1991 Act.....	155
Table 5.2	Comparison of Indian PVA with UPOV, 1978 and 1991 Acts.....	276
Table 6.1	Central Government Grant to ICAR (Rs.in million).....	214
Table 6.2	Place of India's Agricultural Production and Productivity.....	217
Table 6.3	Public and Private Investments in Agriculture at Current and 1980-81 Prices (Rs.Crore).....	219
Table 6.4	Growth Rate of Public Investment in R&D and Agricultural Productivity: All India.....	221
Table 6.5	Research expenditures by private firms and state-owned enterprises (SOE), India, 1984-95.....	224
Table 6.6	Distribution of Certified Quality seeds and Seed Replacement Rate (SRR) in lakh quintal.....	228
Table 6.7	R&D programmes and expenditures.....	231
Table 6.8	Hybrid varieties and number of companies R&D available in market 1996-97.....	232
Table 6.8	Number of private and public bred in may on crop in major crop in market during 1995-1997.....	233
Table 6.9	Investment on biotechnology in next five years.....	237
Table 6.10	Percentage Market Share of Agro Biotechnology in India.....	237
Table 6.11	Consumption trend in biotechnology in year future.....	238
Table 6.12	The institute/organization are engaging in transgenic research.....	241
Table 6.13	Alliances of major companies with different institutions and industries in Agriculture seed research.....	243
Table 7.1	Broad Response of segmented Scientists during 2003.....	262
Table 7.2	Broad Response of segmented Scientists during 2004-2005.....	264
Table 7.3	Broad Response of segmented Scientists during 2006-2008.....	267
Table 7.4	Key Differences in Guidance between Agri-business Managers Policy Makers and Scientists.....	280

List of Figures

Figure Number	Figure Title	Page No.
Figure 1.1	Growth in International Seed Trade.....	12
Figure 3.1	A Framework for Studying Methodology Issues in Strategic Management.....	97
Figure 4.1	Breakup of the total respondents (Farmers).....	121
Figure 4.2	Growth in area and productivity of cotton in India during last six decades.....	141
Figure 4.3	Cotton Imports in India- 1996-97 to 2007-08.....	143
Figure 4.4	Price of Bt. cotton seed during different cropping years	145
Figure 4.5	State-wise Consumption of Pesticides (Technical Grade) (2000-2001 to 2007-2008) (In MT).....	146
Figure 4.6	Number of Respondents (Farmers) growing, number of different brands of Bt. cotton seed in their individual fields.....	150
Figure 6.1	Major Sources of Investment in Agricultural Research & Development in India	214

List of Acronyms and Abbreviations

AICCIP	All India Coordinated Crops Improvement Project
AICRP	All India Coordinated Research Project
AoA	Agreement on Agriculture
APC	Agricultural Prices Commission
AVRDC	Asian Vegetables Research and Development Centre, Taiwan
BOP	Balance of Payment
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro International de Mejoramiento de Maiz Y Trigo
CSIR	Council for Scientific and Industrial Research
CSC	Central Seed Committee
CVRC	Central Variety Release Committee
DBT	Department of Biotechnology
DNA	Deoxy-ribo Nucleic Acid
DST	Department of Science & Technology
EPA	Environment Protection Act
FAO	Food and Agriculture Organization (UN)
FCI	Food Corporation of India
GATT	General Agreement on Tariffs and Trade
GEAC	Genetically Engineered Approval Committee
GM	Genetically Modified
GMO	Genetically Modified Organism
GMC	Genetically Modified Crop
HYV	High Yielding Variety
IARI	Indian Agricultural Research Institute
IBSC	Institutional Biosafety Committee
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre

IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IP	intellectual property
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ISAAA	International Service for the Acquisition of Agri-biotech Applications
MAHYCO	Maharashtra Hybrid Seeds Company Limited
MEC	Monitoring-cum-Evaluation Committee
MoEF	Ministry of Environment and Forests
MNC	Multi National Company
MMB	Mahyco Monsanto Biotech
M&A	merger and acquisition
MTA	Material Transfer Agreement
NABARD	National Bank for Agriculture and Rural Development
NARC	National Agriculture Research Centre
NARS	National Agricultural Research Systems
NBPGR	National Bureau of Plant Genetic Resources
NBTB	National Biotechnology Board
NGO	Non-governmental organization
NSC	National Seed Corporation
NSP	National Seed Project
NBSS&LUP	National Bureau of Soil Survey& Land Use Planning
OECD	Organization for Economic Cooperation and Development
PBR	plant breeders' rights
PCT	Patent Cooperation Treaty
PGRs	Plant Genetic Resources
PVP	plant variety protection
QR	Quantitative Restrictions
R&D	research and development
RCGM	Review Committee on Genetic Manipulation

Rs.	Rupees (Indian Currency)
RNA	Ribonucleic acid
S&T	Science & Technology
SAU	State Agricultural University
SFCI	State Farms Corporations of India
SIL	Special Import License
SPS	Sanitary and Phytosanitary Standards
SSC	State Seed Corporation
SSCAs	State Seed Certification Agencies
SSDC	State Seeds Development Corporation
SSTLs	State Seed Testing Laboratories
SVRCs	State Variety Release Committees
TBT	Technical Barriers
TNC	transnational corporation
TRIPS	Trade-related Aspects of Intellectual Property Rights
UGC	University Grants Commission
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCTAD	United Nations Conference on Trade and Development
UNCTC	United Nations Centre for Transnational Corporations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UPOV	International Convention for the Protection of New Varieties of Plants
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UNU-INTECH	United Nations University Institute for New Technology
WHO	World Health Organization
WIPO	World Intellectual Property Organization (UN)
WTO	World Trade Organization

Chapter I: Introduction

1.1 Background

Agriculture is the mainstay of the Indian economy. Agriculture and allied sectors contribute 22 percent of Gross Domestic Product (GDP) of India, while about 65 to 70 percent of the population is dependent on agriculture for their livelihood (GoI, 2009)¹. Agriculture supplies the bulk of wage goods required by the non-agricultural sector and raw materials for large section of the industry in India. ‘The primary role of agriculture is to provide sufficient food and manpower to an expanding industrial and tertiary economy. Hence, agricultural sector is considered as the dynamic leading sector of overall economic development in the initial stages. One of the best known theoretical two sector models of economic development that focused on the structural transformation of a primary subsistence economy was formulated by Nobel Laureate W. Arthur Lewis. This model emphasized on faster industrial expansion with an agricultural surplus stimulating industrial growth by means of cheap food and surplus labour’².

Indian agriculture has witnessed several changes from freedom to till this date. In the year 1947, India got independence from British rule, but they left behind problem of hunger, malnutrition, food and social insecurity. This was because the colonial regime overexploited India’s rich bio-wealth and natural resources. Colonial rule used India as a place for raw material generation and as a market for manufactured goods of contemporary trans-nationals. British rule did not want to develop scientific and technological capability among Indians. They also hampered Indian agriculture and cottage industry. After independence the need of technological self-reliance was realized in every sector and several steps have been taken from then to boost the technological capability of the nation, and agriculture had given major emphasis by policymakers. The major emphases of the first two five year plans were to give strength and shape to the Indian agriculture. During 1960s-70s, India witnessed the Green Revolution by adopting high input responsive technology in Indian agriculture: thus relieving itself from severe hunger problem upto some extent and import dependency in food grain sector.

¹ Government of India (2009). India 2009, Ministry of Information and Broadcasting, p.57.

² Rudrapan, 2003, p.42.

Indian agricultural sector is characterized by numerous challenges like unpredictable weather/rainfall condition, substandard seeds, non-availability of the required quality and quantity of fertilizer and pesticides. On top of this is the ignorance to best farming practices. The performance of the economy is crucially dependent upon agriculture. On the supply side, it produces food for the people, fodder for animals and raw materials for different industries. This 'supply side' is dependent on the nature of basic inputs used in agriculture. Seed is the one basic input which determines the produce in terms of both quality and quantity. Green Revolution had shown the potential of breeding methods in enhancement of the productivity. Along with these inputs, the hefty increase in agricultural production over the past decade was due to the appropriation of new land. In the words of Norman Borlaug³, "There has been no great increase in the yield capacity of wheat and rice since the dwarf varieties sparked off the Green Revolution of the 1960s and 1970s. In order to meet mankind's rapidly escalating need for food, we need to come up with new and appropriate technological methods for increasing the yield capacity of grains." At the same time M.S. Swaminathan⁴, father of Indian Green Revolution shares his view in his words, "Technological empowerment requires us to reach those previously neglected and unreached and to be a voice of the voiceless". Swaminathan conceptualizing '*Ever-green Revolution*⁵' talks of '*Eco-technology*⁶' - Ecological Technology- must satisfy the five E's: *Ecology*, *Economics*, *Equity* that is particularly applicable in gender terms, renewable *Energy* and *Employment*. These five E's are the principle behind the Ever-green Revolution. The revolution must be ecologically sound and economically viable; otherwise it won't be replicable. The concept of Eco-technology tries to address the need of today and tomorrow in a harmonious way.

McDonald and Dunbar(2004)⁷ explicate, "Marketing is a process for: defining markets; quantifying the needs of the customer groups (segments) within these markets; determining the value propositions to meet these needs; communicating these value propositions to all those people in the organization responsible for delivering them and getting their buy-in to their role; playing an appropriate part in delivering these value propositions (usually only

³ Borlaug,1999.

⁴ Swaminathan and Ikeda, 2005, p. 59.

⁵ ibid, p. 62

⁶ Ibid.

⁷ McDonald and Dunbar,2004,p.9

communications); monitoring the value actually delivered. For this process to be effective, organizations need to be consumer/customer driven.” The tension between wants and means to satisfy this is directly influenced by technical change; both from qualitative and quantitative point of view. This relationship between scarcity and technical change was noticeable in Indian Green Revolution of late 1960s in the area of wheat crop. The success story and technical format was not only limited to the cereal crops; but it was also extended to oilseed, pulses, cash crops, fruit orchards and even on to horticulture plants. Seed is the basic input of agriculture and Green Revolution started with one basic input i.e. High Yielding Varieties (HYVs) of seed. The seed sector in India has seen many changes in recent past and has evinced keen business and academic interest due to the agricultural development and trade involved. Past economic reform and new development in biotechnology and protection regime are serious concerns to the industry. Carrying the process of technological development further, the Genetically Engineered Approval Committee (GEAC) of India had allowed Genetically Modified (GM) variety of one crop (i.e. cotton crop with *bacillus thuringiensis*, a bacterial gene inserted to cotton crop’s genetic material for protection against pest problem. It is also known as *Bt. cotton*) to be produced and marketed. The core of this dissertation is to study the outcome of this step:

- i. Nature of structured transition of Indian Seed Industry brought by Biotechnology.
- ii. Impact of technological transition on stakeholders.
- iii. Developing strategy to manage & understand stakeholders’ comprehension of Indian Seed Industry and its MNC counterparts.

1.2 Significance of Agricultural Development

The significance of agricultural development is well elaborated by Misra and Puri (2007), who states that:

- a. agriculture still contributes more than one-fourth of the GDP,
- b. Agriculture is largest employment providing sector. Millions of farmers, agricultural workers and others engaged in backward and forward linked sectors,
- c. Agriculture provides raw materials to the cotton textiles, jute, sugar and vanaspati industries which are of basic importance to the national economy. It provides the

- essential consumption commodities to the workers engaged in industries. It also provides market for the industrial products,
- d. Agricultural based exports of cotton textiles, jute, tea, horticulture, floriculture and agro-products, do contribute substantial export earnings of the country,
 - e. Per capita income being low in India, large part of income is spent on fulfilling basic consumption needs. It is observed that rural Indian population spends about 64 percent and the urban Indian population spends about 56 percent of the total expenditure on food. Agriculture meets these demands, thus providing food security and self-reliance and,
 - f. Agriculture with appropriate policies and programmes can contribute to the preservation of bio-diversity, forests, water, soil and other natural resources.

1.3 Indian Agriculture during the Five Year Plans

The *First Five Year Plan (1951-1956)* was directed mainly towards increasing agricultural production and strengthening the economic overheads of development like irrigation, power and transport. Agriculture including irrigation and power was given the topmost priority in the plan. The agricultural programmes during *Second Five Year Plan (1956-1961)* were intended to provide adequate food to support the increased population and the raw materials needed for growing industrial economy and also to make available larger exportable surpluses of agricultural commodities. This plan implied therefore, even more than the First Five Year Plan, a close interdependence between agricultural and industrial interdependence between agriculture and industrial development.

The *Third Five-Year Plan (1961-1966)* seen as a plan of the long-term strategy. It was a great significance for the agriculture sector. It held out a great promise for the future and the new strategy of agriculture production came to be introduced around this period. The first stage of new strategy pertaining to the Intensive District Programme started in 1960-61 in three districts and was subsequently extended by stages to another thirteen districts. While the performance varied, it clearly demonstrated both the value of the 'Package' approach and the advantage of concentrating effort in specific areas. In 1964-65 and subsequent years, a modified version of the same approach was extended to several other parts of the country in

the form of Intensive Agriculture Programme (IAAP). The main concern of the programme was with specific crops, while both the IADP and IAAP were concerned with the promotion of intensive agriculture, operated within the limitation set by existing crop varieties, which had relatively a low response to fertilizers. A major change occurred with the introduction of the High Yielding Variety (HYV) seeds, which came to be widely adopted by the end of the third plan. Besides, a new emphasis came to be laid on the role of agricultural technology as a major input of agriculture production. The Indian Council of Agricultural Research (ICAR) was reorganized in 1965 to evolve a new technology suitable for the Indian conditions. The National Seeds Corporation was set up in 1963 with responsibilities in the field of seed production, particularly the foundation stock of HYV seeds. Starting with 1965, Agro Industries Corporations have been set up in different states. The National Co-operative Development Corporation was set up on a statutory basis in 1963 and in the same year, the Agriculture Refinance and Development Corporation, now merged with the National Bank for Agriculture and Rural Development (NABARD) was set up. A policy of support prices for food grains came to be adopted throughout the country in 1964. In 1965, the Agricultural Prices Commission (APC) was set up to advise the government from time to time on appropriate price policies for agricultural commodities. In the same year the Food Corporation of India (FCI) was also established to provide all India machinery for purchase of food grains. Thus, it would be seen that *Third Five Year Plan* provided an entirely new structure of machinery which was geared up to meet the challenge expected to be posed by the new agricultural strategy which had its beginning in this plan period, although it came to bear fruit only in the later years.

The programmes of agricultural development during the *Fourth Five Year Plan (1969-1974)* fell broadly into two categories, namely those that aimed at maximizing production and those which aimed at remedying imbalances. The second part of the strategy was tried out in the pilot schemes of dry farming taken up during the later part of the Fourth Five Year Plan. The *Fifth Five Year Plan (1974-1979)* sought to modify and correct the weakness evidenced in the strategy of intensive production, as also in various programme during the Fourth Five Year Plan.

The *Six Five Year Plan (1980-1985)* emphasized that the agricultural growth pattern should take into account immediate as well as the long term needs of agricultural commodities both for domestic consumption and for export. Therefore, the plan proposed to accord the highest priority to bridging the gap prevailing between actual and potential farm yields even at current levels of technology through the removal of constraints responsible for this gap. The government played an important role both in the emergence, institutional development including Science & Technology (S&T) policies and in catalyzing public-private partnerships. India's Sixth Five Year Plan committed considerable support to this area and underlined the importance of biotechnology as a future S&T field to address the growing needs in agriculture related areas. As early as 1982 an apex agency called the National Biotechnology Board (NBTB) was constituted to fulfill the plan objectives. NBTB formulated a 'Long Term Plan in Biotechnology in India' in 1983 which focused on several priority projects including the institutional development of the sector.

The central element in the development strategy of the *Seventh Five Year Plan (1985-1990)* was the generation of productive employment and removal of poverty. This was sought to be achieved through increase in cropping intensity, made possible by increased availability of irrigation facilities, extension of new agricultural technologies to low productivity regions and to small farmers through measures to make the rural development programmes more effective in the creation of productive assets. In 1986 the government created a full fledged Department of Biotechnology (DBT) with an annual budget of Rs.400 million. Since then DBT has been giving support to R&D frontiers of ICAR and Universities of India.

The agricultural policy in the *Eight Five Year Plan (1992-1997)* focused on production using limited resources of land and water. Couple of thrust areas of this planning period was improvement in the technologies of production storage and marketing; modernizing agricultural research and extension systems according to future needs. Agricultural Policy Resolution (APR) 1992 was the key initiative of this planning period; consequently Agriculture was given Industry status November 28, 1994.

The *Ninth Five Year Plan (1997-2002)* aimed to set up the growth of agriculture production from the level of an annual growth rate of 3.5 percent realized during Eight Plan to a level of 4.5 percent during the Ninth Plan period. In order to reduce regional disparities, it was proposed to take recourse to higher agricultural growth and rural development rather than depending on industrialization. With this objective in view, Ninth plan strategy of agricultural development adopted different strategies for different regions depending on the agro-economic situation of the region. Indian Agricultural Policy 2001 was the milestone step taken in this direction. Issues of biodiversity, growth with equity, strategy formulation to face the challenges arising from economic liberalization and globalization were some of the thrust areas of this plan. The National Agricultural Policy focuses on the optimal use of land, water and genetic resources in a sustainable manner. It includes leasing of land, consolidation of land, the use of 80 million hectares of marginal and waste lands and community lands for agro-forestry and improvement of rural marketing infrastructure. It also indicates the creation of cold storage and processing facilities close to production centers in rural areas.

Considering the market, the *Tenth Five Year Plan (2002-2007)* had dwelt at length on the policies that would be necessary and the design of key institutions. Key reforms for agriculture sector includes: eliminating inter-state barriers to trade and commerce; amending agriculture produce marketing act; liberalizing agri-trading, agri-industry and exports; encouraging contract farming and permitting leasing in and leasing out of agricultural land; replacement of various acts dealing with food by comprehensive 'Food Act'. During this period a significant change; Patent Act, took place.

1.3.1 Indian Seed Industry during these planning periods

Efforts to shape to India's formal seed system began during the second Five Year Plan Period (1956-61) when special emphasis was laid on multiplication of nucleus and foundation seed, which acted as the basis for further multiplication of nucleus and foundation seed, which acted as the basis for further multiplication and distribution of seed. The All-India Coordinated Maize Improvement Project was launched in 1957 as a result of collaboration between the Indian Council of Agriculture Research (ICAR) and the Rockefeller Foundation. Other All India Coordination Crop Improvement Schemes followed and several agricultural

universities initiated efforts to develop new crop varieties and hybrids. This enabled chain multiplication of certified/quality seed – from breeder to foundation seed and from foundation to certified seed – and making it available to farming community. The Maharashtra Hybrid Seeds Company Limited (MAHYCO), a private sector seed enterprise, was established in 1961, and the National Seeds Corporation (NSC) was established 1963 to produce foundation seed. In 1964, state variety release committees (SVRCs) were established to monitor the timely release of new varieties to farmers. The Seed Act came into existence in 1968-69 and at the same time the Central Seed Committee (CSC) was constituted under the Seed act. It took over the functions of the Central Variety Release Committee (CVRC). The National Seed Project (NSP) was formulated in 1975 to establish the State Farms Corporation of India (SFCI), four state seeds development corporation (SSDCs) and breeder seed production units in state agriculture universities (SAUs). These were mandated to provide support to NSC in 1985, during the second phase of NSP, 13 additional SSDCs were established to promote seed quality standards. Nineteen state seed certification agencies were also established under the NSP in 1988, NSP's third phase focused on encouraging export-oriented horticulture industry. The Seed Act, decreed by Parliament in 1966 to regulate the quality of seed production and marketing in the country, was amended in 1972. It was only in 1983 that the Seed Control Order was issued, but was not implemented by various states until 1994. Liberalization of the Indian economy paved the way for the entry of multinational corporations (MNCs) into the Indian Seed Industry.

1.4 Global Seed Industry:

**Table 1.1: Estimated Value of the Domestic Seed Market in Selected Countries (US\$ million)
(updated June 2008)**

Country	Value domestic market	Country	Value domestic market
USA	8,500	Morocco	140
China	4,000	Egypt	140
France	2,150	Bulgaria	120
Brazil	2,000	Chile	120
India	1,500	Serbia	120
Japan	1,500	Nigeria	120
Germany	1,500	Slovakia	110
Italy	1,000	New Zealand	100
Argentina	950	Switzerland	90
Canada	550	Paraguay	80
Russian Federation	500	Portugal	80
Spain	450	Ireland	80
Australia	400	Algeria	70
Korea	400	Uruguay	70
United Kingdom	400	Kenya	60
Mexico	350	Iran	55
Poland	350	Israel	50
Turkey	350	Tunisia	45
Taiwan	300	Colombia	40
South Africa	300	Bolivia	40
Hungary	300	Slovenia	40
Netherlands	300	Zimbabwe	30
Czech Republic	300	Peru	30
Denmark	250	Libya	25
Bangladesh	250	Saudi Arabia	20
Greece	240	Zambia	20
Sweden	240	Ecuador	15
Romania	220	Tanzania	15
Belgium	190	Malawi	10
Finland	160	Uganda	10
Austria	150	Dominican Republic	7
			Total = 32,002*

* The commercial world seed market is assessed at approx. USD 36.5 billion

Source: International Seed Federation (www.worldseed.org), accessed on 20/07/2008.

Global seed industry, estimated to be around US\$36.5 billion⁸. Estimated Value of the Domestic Seed Market in Selected Countries is shown in Table 1.1. Value of export and import for selected countries is represented by table 1.2, table 1.3 and Figure 1.1 shows the growth in international seed trade. The Global Seed market is dominated by Multinational companies.

⁸ International Seed Federation. 2008.

**Table 1.2: Countries having reported more than 1 million US\$ planting seed exports
Calendar year 2007. Million US\$.**

Country	Agricultural Seeds	Vegetable Seeds	Total	Country	Agricultural Seeds	Vegetable Seeds	Total
Netherlands	186	854	1040	Guatemala	8	6	14
USA	650	369	1019	Taiwan	3	11	14
France	698	216	914	Lithuania	12	1	13
Germany	442	41	483	Peru	4	8	12
Canada	265	82	347	Bulgaria	10	0	10
Denmark	281	44	325	Slovenia	8	2	10
Chile	124	80	204	Russian Fed.	7	2	9
Hungary	186	10	196	Costa Rica	2	7	9
Italy	114	70	184	Greece	8	1	9
Mexico	162	9	171	Portugal	4	4	8
Belgium	139	3	142	Ireland	8	0	8
Argentina	97	21	118	Ukraine	8	0	8
Austria	102	3	105	Kazakhstan	7	0	7
Japan	30	71	101	Serbia	6	1	7
Spain	54	35	89	Tanzania	1	6	7
China	41	47	88	Moldova	6	0	6
Australia	66	13	79	Vietnam	1	4	5
United Kingdom	44	28	72	Croatia	5	0	5
Israel	9	62	71	Pakistan	2	3	5
Brazil	45	8	53	Kenya	4	0	4
Poland	46	2	48	Luxemburg	4	0	4
South Africa	40	8	48	Colombia	3	0	3
New Zealand	27	17	44	Uruguay	3	0	3
Czech Rep.	38	4	42	Morocco	1	2	3
Turkey	29	8	37	Egypt	2	0	2
Romania	31	0	31	Bolivia	2	0	2
Sweden	24	5	29	Indonesia	2	0	2
Slovakia	29	0	29	Estonia	1	1	2
Thailand	2	25	27	Malta	0	2	2
Switzerland	22	2	24	Latvia	1	0	1
India	12	10	22	Belarus	0	1	1
Korea, Rep. of	2	18	20	Venezuela	1	0	1
				TOTAL	4171	2227	6398

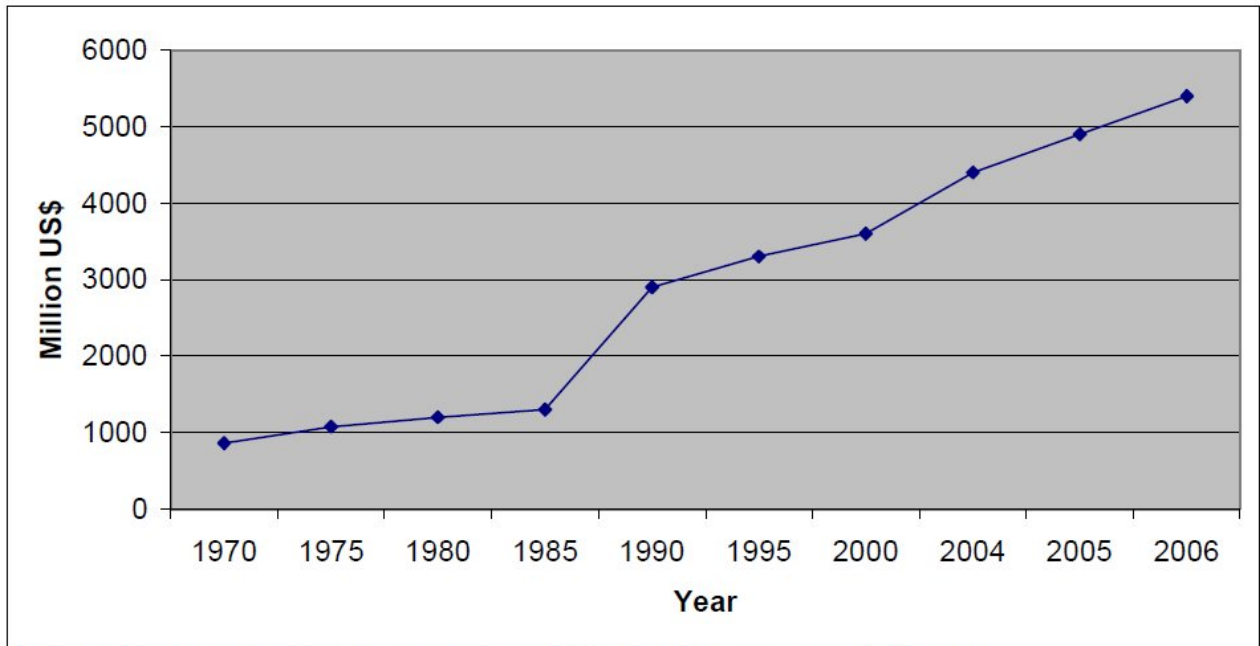
Source: International Seed Federation (www.worldseed.org), accessed on 20/07/2008

**Table 1.3: Countries having reported more than 1 million US\$ planting seed imports
Calendar year 2007. Million US\$.**

Country	Agricultural Seeds	Vegetable Seeds	Total	Country	Agricultural Seeds	Vegetable Seeds	Total
USA	461	211	672	Lithuania	20	3	23
France	331	91	422	Croatia	17	6	23
Mexico	258	156	414	Serbia	17	5	22
Netherlands	182	199	381	Ireland	21	0	21
Germany	304	64	368	Uruguay	18	3	21
Italy	197	130	327	Israel	9	12	21
Spain	121	171	292	Pakistan	10	11	21
Canada	181	56	237	Tunisia	14	6	20
Ukraine	204	31	235	Finland	12	8	20
United Kingdom	133	65	198	Vietnam	15	2	17
Russian Fed.	157	33	190	Algeria	4	13	17
Belgium	125	27	152	Hong-Kong, China	4	13	17
Japan	79	62	141	Taiwan	4	11	15
Poland	98	41	139	Colombia	11	4	15
China	63	53	116	Syria	8	6	14
Hungary	92	17	109	Thailand	1	12	13
Austria	76	15	91	Jordan	4	7	11
Greece	65	21	86	Norway	6	5	11
Romania	64	11	75	Kenya	7	4	11
South Africa	9	66	75	Paraguay	11	0	11
Turkey	31	42	73	Guatemala	6	4	10
Denmark	52	14	66	Peru	7	3	10
Brazil	39	19	58	U.A.Emirates	7	3	10
Saudi Arabia	44	14	58	Latvia	8	1	9
Switzerland	44	13	57	Ecuador	6	3	9
Czech Rep.	51	5	56	Moldova	8	1	9
Argentina	42	10	52	Bosnia & H.	6	2	8
Portugal	30	21	51	Philippines	5	3	8
Bulgaria	44	6	50	Yemen	2	6	8
Australia	29	17	46	Costa Rica	3	4	7
Sweden	31	10	41	Lebanon	4	3	7
Korea, Rep. of	14	26	40	Angola	2	5	7
Slovakia	36	4	40	Tanzania	2	5	7
New Zealand	12	24	36	Bolivia	6	0	6
Morocco	20	15	35	Luxemburg	6	0	6
Chile	23	12	35	Panama	5	1	6
Egypt	12	21	33	Uzbekistan	2	4	6
Iran	17	14	31	Zimbabwe	5	1	6
India	11	18	29	Kazakhstan	3	3	6
Belarus	24	5	29	Iraq	3	3	6
Slovenia	21	4	25	Estonia	5	1	6
Venezuela	14	10	24	Senegal	2	3	5
				TOTAL	4157	2034	6191

Source: Compiled from International Seed Federation (www.worldseed.org), accessed on 20/07/2008

Figure 1.1: Growth in the International Seed Trade



Source: International Seed Federation (www.worldseed.org), access on : 20/07/2008.

The top five Gene Giants (AstaZeneca, DuPont, Monsanto, Novartis, Aventis) accounts for almost one-quarter (23%) of the commercial seed market, and virtually 100% of the transgenic (genetically engineered) seed market. The top 10 multinational seed firms control half of the world's commercial seed sales (a total worldwide market of approximately US\$21,000 million per annum). The intensifying international competition, shorter product life cycles for new varieties, increasing R&D costs and complexities of biotechnology and increasing concentration within the food processing and retail sector. A study by the US Department of Agriculture examines the impact of seed industry concentration on agriculture-biotech research.⁹ Access to proprietary genes and technology is essential for developing and commercializing genetically modified varieties. Dispute and uncertainty over intellectual property rights have induced mergers, take-over and strategic alliances.

The key global players - Monsanto, Pioneer, Syngenta (top three); Limagrain, Sakata, Advanta, Aventis (minor league) and Cebeco, Pau Euralis, Ball, Pennington, DLF, Svalof Weibul, Sigma, Ragt, Malsadour etc. (niche players) - are using biotechnology to deliver products that help farmers protect crops, improve the environment and grow grains that

⁹ USAID, 2005.

improve the quality of food we eat. Year 2005 saw an upsurge in seed industry takeovers and a shake-up in rankings. The perennial kingpin, Dupont's Pioneer Hi-Bred International, was dethroned from the top spot when Monsanto acquired Seminis in January 2005 for US\$1,400 million. With the acquisition of Seminis, Monsanto became the world's leading seed company - and the world's biggest commercial vegetable seed company. Broadly, it is observed that Multinational companies dominate the Global seed market. This is due to MNCs caters to attractive niche markets; the marketable products are technology driven products which are the outcome of heavy investment on R&D.

1.4.1 Global Seed Industry and GMC

In 2007, the number of countries planting biotech crops increased to 23, and comprised 12 developing countries and 11 industrial countries; they were, in order of hectarage, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland. Notably, the first eight of these countries grew more than 1 million hectares each - the strong growth across all continents in 2007 provides a very broad and stable foundation for future global growth of biotech crops. The two new biotech crop countries in 2007 were Chile producing over 25,000 hectares of commercial biotech crops for seed export, and Poland, an EU country, growing Bt. maize for the first time. The accumulated hectarage from 1996 to 2007 exceeded two thirds of a billion hectares for the first time at 690 million hectares (1.7 billion acres), with an unprecedented 67-fold increase between 1996 and 2007, making it the fastest adopted crop technology in recent history. This very high adoption rate by farmers reflects the fact that biotech crops have consistently performed well and delivered significant economic, environmental, health and social benefits to both small and large farmers in developing and industrial countries. Thus, this is a strong vote of confidence from approximately 55 million individual decisions by farmers in 23 countries over a 12-year period to plant biotech crops, year after year, after gaining first-hand insight and experience with biotech crops on their own or neighbor's fields. Notably, 2007 marks the first year when the accumulated number of farmer decisions to adopt biotech crops has exceeded 50 million.

In 2007, the USA, followed by Argentina, Brazil, Canada, India and China continued to be the principal adopters of biotech crops globally, with the USA retaining its top world ranking with 57.7 million hectares (50% of global biotech area) spurred by a growing market for ethanol with the biotech maize area increasing by a substantial 40% - this was partially offset by smaller decreases in biotech soybean and cotton. Notably, 63% of biotech maize, 78% of biotech cotton, and 37% of all biotech crops in the USA in 2007 were stacked products containing two or three traits that delivered multiple benefits. Stacked products are a very important feature and future trend, which meets the multiple needs of farmers and consumers and these are now increasingly deployed by ten countries - USA, Canada, the Philippines, Australia, Mexico, South Africa, Honduras, Chile, Colombia, and Argentina, with more countries expected to adopt stacked traits in the future.

Biotech crops achieved a very important milestone in 2007 with humanitarian implications – the number of small and resource-poor farmers benefiting from biotech crops in developing countries exceeded 10 million for the first time. Of the global total of 12 million beneficiary biotech farmers in 2007, (up from 10.3 million in 2006), over 90% or 11 million (up significantly from 9.3 million in 2006) were small and resource-poor farmers from developing countries; the balance of 1 million were large farmers from both industrial countries such as Canada and developing countries such as Argentina. Of the 11 million small farmers, most were Bt cotton farmers, 7.1 million in China (Bt. cotton), 3.8 million in India (Bt. cotton), and the balance of 100,000 in the Philippines (biotech maize), South Africa (biotech cotton, maize and soybeans often grown by subsistence women farmers) and the other eight developing countries which grew biotech crops in 2007. This initial modest contribution of increased small farmer income from biotech crops towards the Millennium Development Goals of reducing poverty by 50% by 2015 is a very encouraging and important development, which has enormous potential in the second decade of commercialization, 2006 to 2015.

During the period 1996 to 2007, the proportion of the global area of biotech crops grown by developing countries has increased consistently every single year. In 2007, 43% of the global biotech crop area, (up from 40% in 2006), and equivalent to 49.4 million hectares, was grown in developing countries where growth between 2006 and 2007 was substantially higher (8.5

million hectares or 21% growth) than industrial countries (3.8 million hectares or 6% growth). It is noteworthy that the five principal developing countries committed to biotech crops, span all three continents of the South; they are India and China in Asia, Argentina and Brazil in Latin America and South Africa on the African continent – collectively they represent 2.6 billion people or 40% of the global population, with a combined population of 1.3 billion who are completely dependent on agriculture, including millions of small and resource poor farmers and the rural landless, who represent the majority of the poor in the world. The increasing collective impact of the five principal developing countries is an important continuing trend with implications for the future adoption and acceptance of biotech crops worldwide. Each of the five countries, reviewed in the following paragraphs, have benefited in a different way from biotech crops.

1.4.2 The Global Value of the Biotech Crop Market¹⁰

Genetically modified seeds now account for one quarter of the total value of the commercial seed market worldwide. The market for biotech seed traits (herbicide tolerance and insect resistance) has shot up from \$280 million in 1996 to \$4,700 million in 2004 - a 17-fold increase over the past nine years.

In 2007, the global market value of biotech crops, estimated by Cropnosis, was US\$6.9 billion representing 16% of the US\$42.2 billion global crop protection market in 2007, and 20% of the ~US\$34 billion 2007 global commercial seed market. The US\$6.9 billion biotech crop market comprised of US\$3.2 billion for biotech maize (equivalent to 47% of global biotech crop market, up from 39% in 2006), US\$2.6 billion for biotech soybean (37%, down from 44% in 2006), US\$0.9 billion for biotech cotton (13%), and US\$0.2 billion for biotech canola (3%). Of the US\$6.9 billion biotech crop market, US\$5.2 billion (76%) was in the industrial countries and US\$1.6 billion (24%) was in the developing countries. The market value of the global biotech crop market is based on the sale price of biotech seed plus any technology fees that apply. The accumulated global value for the eleven-year period, since biotech crops were first commercialized in 1996, is estimated at US\$42.4 billion. The global value of the biotech crop market is projected at approximately US\$7.5 billion for 2008.

¹⁰ Compiled from ISAAA Briefs

1.5 Indian Seed Industry

Seed is a critical and basic input for enhancing agricultural production and productivity in different agro-climatic regions. Indian seed programme largely adheres to the limited generation system for seed multiplication. The system recognizes three generations, namely breeder, foundation and certified seeds and provides adequate safeguards for quality assurance in the seed multiplication chain to maintain the purity of variety as it flows from the breeders to the farmers.¹¹ Seed is an essential input in agricultural production. The seed industry requires special techniques for production of seed. It is essential to nurture the special assortment of seed for enhancing agriculture output.

Indian seed programme includes the participation of Central and State governments, Indian Council of Agricultural Research (ICAR), State Agricultural University (SAU) System, public sector, co-operative sector and private sector institutions. Seed sector in India consists of two national level corporations i.e. National Seed Corporation (NSC) and State Farms Corporations of India (SFCI), 13 State Seed Corporations (SSCs) and about 100 major seed companies. For quality control and certification, there are 22 State Seed Certification Agencies (SSCAs) and 101 State Seed Testing Laboratories (SSTLs). The private sector has started to play a significant role in the production and distribution of seeds. However, the organized seed sector particularly for food crops cereals continues to be dominated by the public sector.¹²

This sector was open for private players in late 1980's; which led to sprout of many independent companies. ICAR sponsored institutions were centre for improved varieties of seed; Breeder seed of different crops were researched and developed in these institution. These breeder seeds were procured by Private companies to propagate and develop for certified seed for selling in the market. These private companies were also dependent on Government organization like 'State Agriculture Universities (SAU)' or ICAR Research centers for breeder seed and foundation seed. So R&D initiative was initially lacking in these companies. Their job was limited to producing quality seed and marketing of it as per law set

¹¹ India 2009, pg. 78.

¹² *ibid.*

by Government of India. These companies were having their own niche geographical presence and products. Mostly these companies had their product portfolios in cash crops like cotton and chilly or vegetable seeds because these product portfolios were more profitable. Very few of them had their presence felt in lower profit margin cereal crop like wheat and rice etc; these low profit margin portfolios were left to Government institutions. Chronological milestone events in India's Seed Industry are represented by Table 1.4:

Table 1.4: Chronological milestone in India's Seed Industry

Year	Events
1957	First All India Coordinated Maize Improvement Project established
1960	Similar projects on sorghum and pearl millet started
1961	First four hybrids released
1963	National Seeds Corporation established
1965	First hybrid in pearl millet released; 250 tons of seed of dwarf varieties of wheat imported from CIMMYT; All India Coordinated Project on wheat established
1966	Seed Act passed
1968	Report of Seed Review Team submitted; Seed Act operational
1969	State Farms Corporation of India created, UP Seeds & Terai Development Corporation established
1971	National Commission on Agriculture constituted; Indian Society of Seed Technology established; minimum seed certification standards adopted
1975	National Commission on Agriculture's report submitted; report of National Seed Project (NSP) submitted
1977-78	NSP phase-I launched with World Bank assistance of US\$52.7 million
1978-79	NSP phase-II launched with World Bank assistance of US\$34.9 million
1979-80	All India Coordinated National Seed Project (Crops) launched; All India Coordinated Project on Seedborne Diseases launched
1981	First workshop on seed technology held under NSP
1988	Separate section on seed created in ICAR; New Seed Policy implemented
1989-90	Special project on hybrids in nine selected crops and seed, National Technology Research Project started by ICAR
1990-91	NSP phase-III launched
1991	All India Coordinated Research Project (AICRP) on Seedborne Diseases merged with NSP (Crops)
1994	Government of India signs the GATT
2001	Protection of Plant Variety and Farmer' Right Act passed
2003	National Seed Policy formulated
2004	Directorate of Seed Research established
2005	New seed bill introduced in Indian Parliament

Source: Seed System Innovations in the Semi-Arid Tropics of Andhra Pradesh, pg. 21

1.5.1 Green Revolution and its actors for the understanding of the genesis of Modern Indian Seed Industry

Before the 1960s, agriculture production was the result of factor combinations of land and labor with little capital and management. After 60s, capital and management have acquired greater importance. The changes in technology have contributed greatly to their increased importance. The form of capital is also changing. The traditional form of capital in agriculture was composed of livestock, farm building, indigenous implements, and materials produced on the farm, such as seed and manures. Between 1961 and 1971, fertilizers and pesticides, farm machinery, and equipment to lift water for irrigation have acquired greater importance. These new inputs in agriculture have brought about changes in agriculture production.¹³

Randhava¹⁴ (1982) acknowledges India's food sufficiency as the gift of Green Revolution. In his words, "Initially Green revolution started with Wheat; later on it extended to Rice and other crops like Groundnut, Sugarcane and Jute etc." Here we see how exotic crops were used for crop improvement at that time. Later years of 1990s and beginning of 21st century see many externalities of Green Revolution which are both positive and negative. It is not true that Green Revolution became the doomsayer's story or devastated the agriculture. On the other hand, it brought food sustainability in India but along with this it also brought certain form of externalities which we need to assess properly.

1.5.1.1 Manifestation of Green Revolution

The multiplier effect of Green Revolution not stopped at agriculture betterment rather it percolated to the social behavior of farming community in terms of buyer behavior and created new market for new types of product. This market was not only created for the agricultural product, but also for lifestyle product giving impetus to new type consumerism creating new segment of consumers whose demand and preference was new. The basic cause of 'surplus produce' which bring farming community 'some extra money' in turn enhanced their 'purchasing power parity' was '*Hybrid Seed*'; a new product as a outcome of advancement of science gifted as 'newer form of technology'. This increase in Purchasing

¹³ Desai, D. K. and Prakash, Hari (1973). Indicators of Change in Indian Agriculture 1961-1971.p.25

¹⁴ Randhava (1982). History of Indian Agriculture.

Power created demand and transformed Indian farmers 'wants' into 'need'. Hence we see that a single input has such a larger impact on the economy and market which also became a core competence of a nation.

There is a need to bring out what are the key factors which influence 'new technology' and Seed Industry as a whole. The study also talks of what are the key drivers of this technology. The enquiry also investigates how the new technology brings competitive advantage to this sector. So it has become very important to understand the forward and backward linkage of technology.

The breakthroughs in science that permitted genes, and thus heredity, to be identified and manipulated as molecules ushered in the biotechnology era, which is now more than a decade old. The new tools of biotechnology are changing the way scientists can address problems in the life sciences; agriculture is one area facing major changes as a result of this new technology. The unanticipated rapid rate at which discoveries and their applications in biotechnology have unfolded has stressed the capacity of society; more specifically, our agricultural research and educational institutions which need to absorb and adjust to change. We are challenged by pressing decisions, opportunities, and problems that we face now and will continue to face in the future. Competition from abroad impels us to devise and use new technologies that can improve the efficiency and quality of Indian agricultural production. These concerns led to this study of structural overview of how the agricultural research system is responding to biotechnology and how it might prepare for future opportunities.

Agriculture has moved from resource-based to science-based industry as science and technology have been substituted for land and labor. This transition now affects agriculture and food producing systems throughout the world. Technology has driven this change towards more effective and efficient production practices. The adoption of new technologies has improved the efficiency of agricultural production practices. Agricultural systems throughout the world continue to adopt new and better technologies that enable them to become more efficient and competitive in developing new markets and capturing old markets for their agricultural products. The future leadership and competitiveness of the Indian agricultural

enterprise is dependent on the health and effectiveness of the agricultural research system in the country and its ability to translate better technologies into practice. Research must make Indian farming more profitable, reliable and durable business able to compete in both domestic and international markets. Innovation is crucial to enhance productive efficiency and environmental acceptability. Biotechnology is the key to this innovation. Indian agriculture has achieved its preeminence through innovation and substitution of knowledge for resources. This trend must continue. Yet technological innovations cannot revitalize Indian agriculture unless farm business management, farm policy, Department of Agriculture, Agricultural Universities, extension services, and private sector businesses that serve agriculture are innovative. Indian farmers can take the lead in adopting new biotechnologies. These technologies should emphasize maximizing economic yield rather than total production. That is, they should increase the efficiency of production by reducing the costs of production. Such technologies become increasingly important as support prices are removed and world competition stiffens.

There is also an ongoing debate initiated after the onset of biotechnology in agriculture sector. The transformation of Indian agriculture from Green Revolution has several vistas, angles and shapes. It is argued that Green Revolution is based on public technology owned by the public and used for the betterment of the public.¹⁵ Whereas, transgenic (base technology and precursor for GMC development) technology is seen as a tool for commercialization, commodification and monopolization of agriculture *in toto*.¹⁶ It is argued that new technology is based on proprietary system and legally protected by IPR and patent. The country witnesses the case of Genetically Modified Cotton Crop (Bt. cotton), the only approved crop in India by the Genetic Engineering Approval Committee (GEAC) under the auspice of Ministry of Environment and Forest (MOEF).

¹⁵ Sahai (2004) p 161-170.

¹⁶ Shiva (2002) p 11-70.

1.5.1.2 Green Revolution vs. Evergreen Revolution: Several Dimensions of Technological Transformation

Suman Sahai (2004) stated about the green revolution technology that it was a publicly owned technology, belonging to the people. The research was conducted with public money to fulfill public need namely inadequate food production, and it created public goods which everyone has access to. There were no IPR, no patent vested in multinational companies, no proprietary technology or product. The ownership of GR was vested in farmers. On the contrary, the ‘evergreen revolution’ is a privately owned technology, six corporations (Monsanto, Syngenta, Bayer Crop Science, Du Pont, Dow and BASF Plant Science) control practically the entire research and output in the fields of transgenic processes and products, including research methodologies are patented and farmers has no control on the means of production with the development of new varieties.¹⁷

Mangla Rai and B. Prasanna (2000) also came to the same conclusion and put forward that an important difference between ‘green revolution’ and ‘gene revolution’ is regarding the patenting of processes as well as products.¹⁸ The main process behind the green revolution was conventional plant breeding technology, which has been well established and exploited by public sector institutions. Access to genetic resources and improved cultivars, or even the methodology was not an issue. Today, the processes and key components used in modern agricultural biotechnology are increasingly subjected to intellectual Property Rights (IPR) Protection along with the products and results.¹⁹

Dayanath Jha²⁰ (2003) also favoured technological change in agriculture and revealed that technological change has emerged as a powerful source of growth. The green revolution illustrated it dramatically. Even poor producers were able to internalize its production and benefits to improve their incomes and food security. Poverty level in rural area declined and country moved from food deficit to food surplus in two decades.

¹⁷ Sahai, Suman (2004). Is Agbiotechnology suited to Agricultural Production in India? India's Agricultural Challenges: Reflection on Policy, Technology and other issues. pp.161-170.

¹⁸ A new era of both product and process patent is originated with new Patent Amendment Act.

¹⁹ Rai, Mangla and B. Prasanna (2000). Transgenic in Agriculture. Directorate of Information and Publication of Agriculture. Krishi Bhawan, ICAR publication Pusa, New Delhi.

²⁰ Jha, Dayanath (2003). ICAR, National Professor, National Centre for Agricultural Economics and Policy Research.

Ronald J. Herring (2004) argued that the genomics revolution created potential, but contested, economic value in biodiversity per se. Herring also emphasized that public goods are at stake due to this new revolution.²¹ Many see the new transgenic technologies as a great opportunity to enhance productivity and concomitantly increase the sustainability of agriculture. Many opponents see it as a dangerous tool of science and technology which has implication for human health, biodiversity and sustainable development and well being of small farmers.²²

Some others on the based on the development argued that developed countries are gene poor while the developing nations are gene rich. The developed countries are technology rich while the developing countries are technology poor. The green revolution and current technology widened this gap. But there is also a counter argument that new technology may bridge this gap by effective enhancement of capabilities of gene rich and technology poor segment by the effective utilization of modern tools of science and technology like gene mapping, tissue culture and genetic engineering. Most of the scientists from developing countries are also in favour of adoption of new genomics for maintaining food security of the developing countries. They have positive argument that, if quality specific traits of genes from traditional biowealth are incorporated into new crop varieties then it will give economic benefit to both the actors that is gene provider and gene user due to benefit sharing concept of new IPR regime.

Technology like transgenic seed and terminator technology is often debated with several facts, figures and assumption. Some have opposite argument some have positive thoughts. Schell (1993); Young (1994) said that genetic engineering is based on the transfer of 'defined genes' and considerable amount of data available from field tests with transgenic plants demonstrate that no risk are involved in releasing transgenic. However, critics of transgenic technology refuted these propositions.²³

²¹ Herring Ronald J (2004)

²² Grover Anil and Rental Deepak; 'In this Issue' Current Science. Vol.84.No.3-10 February 2003.

²³ Schell(1993); Young (1994)

Regal²⁴ (1994) asserted that the mechanism and potential of conventional selective engineering and genetic engineering can be profoundly different. Although this does not mean that every transgenic is ecologically dangerous, some transgenic may be considered riskier than what could be produced with selective breeding, especially when an ecologically competitive host is supplemented with noble feature that may increase its competitiveness.

The concept of doubly green revolution was first put forward by the former head of the Rockefeller foundation, Gordon Conway, in 1997 by that name. Dr. Conway argued that the world needed a doubly green revolution that would be even more productive than the first green revolution and doubly green by conserving natural resources and protecting the environment,²⁵ Dr. Cantrell added that modern technologies can be environmental sensitive if they are designed and used with the benefit of modern ecological knowledge.²⁶ Some has also negative argument about green revolution. Gordon Conway²⁷ (1997) stated that the high yielding technology that heralded the green revolution has, no doubt rescued the country from chronic food deficiency and starvation, but, it has its adverse effect too. The high input cultivation of rice and wheat has led to excessive water use and eroded soil quality; indiscriminate use of chemical pesticide has led to pesticide resistance making pest management increasingly difficult.

Vandana Shiva²⁸ (1992) differentiating between the first Green Revolution and the second Green Revolution put forward argument as, “In the first Green Revolution the seeds end of it largely took place in the public system, and in the international agriculture research system run by Consultative Group on International Agriculture Research (CGIAR) which is run by World Bank, and with the National Agriculture Research System (NARS). The fertilizers were 100 percent of the transnational corporations (TNC), except when after a battle in the early years in India; we got some amount of fertilizer production under the corporate sector. In the second Green Revolution, there is a total marriage between the seed and the chemical companies. On the one hand, the selling and the advertising says that the second Green

²⁴ Regal (1994)

²⁵ IRRI press release (October 29, 2004). Asia New Rice Revolution

²⁶ *ibid.*

²⁷ Conway Gordon (1997). The doubly green revolution: food for all in the 21st century. p.334

²⁸ Shiva, Vandana (1992). Ecological, Economic and Political costs of the Green Revolution..p.11.

Revolution will put an end to the chemical abuse that the first Green Revolution led to, most of the research trends in biotechnology for agriculture actually point to development of herbicide resistance and pesticide resistance varieties-which in actual fact makes for use of more herbicide and more pesticide so that the plants can survive even worst abuse”.

In a report on transgenic plants and world agriculture prepared under the auspices of the royal society of London, science academies of US, Brazil, Mexico, China, INSA, TWAS, it is said: “we conclude that steps must be taken to meet the urgent need for sustainable practice in world agriculture if the demands of an expanding world population are to be met without destroying the environment or natural resources base. In particular, GM technology coupled with important development in other areas should be used to increase the production of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture, and provide access to food for small farmers”.²⁹

V.R. Gadwall (2003) has projected that alternative technology as a solution for the problems which can't be solved by traditional breeding approach.³⁰ Plant breeders can rectify problems only when there is variability available for the desired characters within the compatible species complex. Transfer of useful trait from distantly related species which do not sexually cross with the crop plant is not possible through conventional recombination breeding procedure, considering that many problems still remain unsolved and that the currently available technologies are inadequate to solve them, there is a need for alternate technologies. Recombinant DNA technology that enables movement of genes of interest across sexual incompatibility barriers is one approach plant scientists are relying upon worldwide today to find genetic solution to specific problems.

1.5.2 Public Sector Seeds Companies

Public sector involvement in the seed industry on a national scale began at the beginning of the “green revolution” with the establishment of the National Seed Corporation (NSC) in 1963, which was charged with the responsibility of promoting seed industry development

²⁹ Sharma, Manju (October 17, 2003). First Foundation Day Lecture on Regulatory Measure for Utilizing Biotechnological Developments in Different Countries.

³⁰ Gadwall V .R.(2003).

from production through processing, storage and marketing, and establishing a system of quality control. Before that, the Indian seed industry was little developed apart from a small number of private companies dealing with high value vegetable and flower seeds. In the initial years of operation, the NSC concerned itself mainly with foundation seed production and with seed certification after the enactment of Seed Act in 1966. The State Seed Corporations (SSC) were established later with support from the World Bank, initially in nine states, and later expanded to cover 13 states, for production and handling of seed in their respective states.

The role of public sector seed companies is now mostly confined to certified seeds of high volume, low value segment of high yielding varieties of cereals, pulses, and cotton with a limited presence in the high value hybrid sectors of cotton, cereals, and vegetables. Wheat and paddy seed constitutes a major share of the seeds handled by them. The NSC and SSCs work close together to coordinate procurement and sales prices as well as variety demand and supply. Their presence is considered necessary by the government to ensure the availability of reasonably priced seeds of major crops throughout the country and to make sure that private sector seed companies do not enjoy and exploit unreasonable market power.

The public sector seed companies, however, lag behind in research; they are mostly dependent on public research institutions, under the aegis of Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) for their breeder seed requirements. Based on feedback from dealers and end-users, the public sector seed companies, state governments forecast seed demand for various crops three years in advance and a requirement for breeder seeds is placed with the Government of India's Ministry of Agriculture. Using the breeder seeds supplied by government research institutes, the public sector seed companies produce foundation seeds on government farms or reliable, well-trained contract farms. These are further multiplied in contract farmers' fields next year as certified seeds for commercial distribution. If for some reasons (drought or other weather calamities) the supply of certified seeds falls short of requirements, the public sector seed companies source commercial grain from the market, upgrade the quality, and after proper testing distribute it as quality seeds.

All seed grown by contract growers for seed corporations meeting the specified standards attract a premium price over and above the commercial grain price for that crop. The premium can vary between 25 percent for cereals to over 100 percent for hybrids. In the public sector, NSC is usually the retail price setter with the SSCs following NSC prices in determining their own for similar or substitute varieties. For self-pollinated field crops, an accepted basis is to add a margin of 15 to 25 percent on production costs. For hybrid seeds of cereals and vegetables, prices to some degree reflect market trends. However, there is government intervention in the pricing of seeds produced by public sector corporations with the degree of intervention varying from state to state. Some states are now thinking of giving greater autonomy to their seed corporations to make them financially viable by allowing them to market private branded seeds, domestically produced or imported. An advantage to the government seed companies is that they have a vast distribution network and trusted brand image. The reason why they are losing market share is because seeds by private companies often outperform the publicly available varieties. Some SSCs have started their own research to evolve superior propriety hybrids.

Breeder Seed requirement of the Corporation is met through lifting of such seeds from ICAR Institutes and the State Agricultural Universities (SAUs) based on the allocation by the Department of Agriculture & Co-operation (DAC), Government of India. The total foundation seed requirement is mostly met through producing the seeds by the seed growers using the breeder seed procured from the above sources. Major portion of the certified seed were procured through production programme organized through the contract growers by NSC. Occasional out sourcing of Certified/Quality Seeds from reliable sources are also resorted to as and when such seeds required for marketing is not available from the NSC's seed production programme.³¹

³¹ National Seeds Corporation Limited, 44th Annual Report (2006-2007). p.9.

The table 1.5 shows breeder seeds supplied and the production and distribution of foundation, and certified seeds, mostly by government seed companies in metric ton.

**Table 1.5: Production of Breeder, Foundation and Certified Seed in India
(1991-1992 to 2007-2008)**

Year	Type of Seeds		
	Production Breeder Seed (in Thousand Qtls.)	Production of Foundation Seed (in Lakh Qtls.)	Distribution of Certified/Quality Seed (in Lakh Qtls.)
1991-92	34.90	3.75	57.50
1992-93	36.00	3.93	60.33
1993-94	37.00	4.06	62.20
1994-95	40.113	4.73	65.86
1995-96	43.363	4.76	69.90
1996-97	46.027	5.67	73.27
1997-98	46.135	6.84	78.79
1998-99	38.994	6.75	84.97
1999-00	51.13	4.66	87.98
2000-01	42.69	5.91	86.27
2001-02	45.54	5.44	91.80
2002-03	48.42	6.14	98.03
2003-04	61.82	6.50	108.59
2004-05	66.46	6.90	120.26
2005-06	68.64	7.40	126.75
2006-07	73.83	7.96	155.01
2007-08#	80.08	8.50	162.00

Note:# : Targets in respect of seeds.

Source: Ministry of Agriculture, Government of India.

1.5.3 Seed Industry Structure for Variety Development

Variety development (especially for self-pollinated crops) is predominantly carried out in the public sector, although in recent years there is growing private sector involvement, which focuses mainly on hybrid cereals, cotton, sunflower, vegetables, and flowers. The private sector is also actively involved in developing bio-engineered crops of cotton, oilseeds, and other crops. The ICAR, operating through 30 All India Coordinated Crop Improvement Projects (AICCIPs), five Crop Directorates, and seven National Research Centers coordinate public sector plant breeding. Basic genetic material from which new varieties are developed is available from the institutions' own resources and from the National Bureau of Plant Genetic Resources (NBPGR), through which India has established a working relationship with international agricultural research centers. ICAR's own institutes and several SAUs at

research centers located in different parts of the country and focusing on various agro-climatic zones carry out the AICCIPs.

The present arrangement in India for variety development, testing, evaluation, and release are as follows:

- i. New varieties are developed by SAUs, ICAR institutes, and private seed companies.
- ii. Varieties that show some promise are entered into the All India Coordinated Trials (AICT) operated by SAUs, ICAR institutes, and State Agricultural Departments under the auspices of ICAR.
- iii. Results of the AICT are presented at the respective Annual Workshops of participating scientists working on the particular crop, where recommendations are formulated for submission to the Variety Release Sub-Committee of the Central Seed Committee who makes final recommendations to the Agriculture Ministry on which varieties should be released and notified.
- iv. ***Transgenic Plant Varieties:*** Before their release, all genetically engineered crops/ Varieties would have to be tested for adherence to environmental and biosafety norms as per regulation and guidelines of Environment Protection Act (EPA), 1986. Seeds of transgenic plant varieties needed for research purposes can be imported through the National Bureau of Plant Genetic Resources (NBPGR). But before commercial release, transgenic crops/varieties have to prove their agronomic value for at least two seasons under the All India Coordinated Project Trials of ICAR.

Once a transgenic plant variety is commercially released, its seed can be marketed subject to seed laws. They would be required to bear a label indicating their transgenic character. The performance of a transgenic plant variety in the field will be monitored for 3-5 years by the Ministry of Agriculture and the department of agriculture of the relevant state.

Transgenic varieties would be protected under PVP legislation in the same manner as nontransgenic varieties. All such seeds imported into the country will be required carry a declaration and a certificate from the competent

authority of the exporting country, certifying their transgenic character. If the seed or planting material is a product of transgenic manipulation, its import will be allowed only with the approval of the Genetically Engineered Approval Committee (GEAC).

1.5.4 Private Sector Seed Companies

Easing of government regulations in the late 1980s spurred enormous development within the seed industry by attracting several foreign seed companies to India. While some of them (like Cargill) entered through joint venture partnerships with Indian seed companies, some others already had a presence in India through affiliate companies (like Hindustan Lever, now Unilever). They identified potential crops for hybridization and started research and development activities. Typically they concentrated on hybrids, mainly corn, cotton, sunflower, vegetables, and flowers (more recently on rice), and they now account for a major share of commercial production of these seeds in India. The basic reason for the private sector's focus on these crops is that it involves low production volume and higher margins. Concomitantly, they had little interest in developing self-pollinated crops, which involve high volume and low margin and are more prone to piracy in the absence of an effective Plant Variety Protection regime in India. Furthermore, there is no significant government intervention in the pricing of these hybrids, and the Indian seed regulations permit marketing of truthfully labeled seeds. Currently, some 500 hybrids of field crops and vegetables are being marketed, as truthfully labeled seeds, mostly by private seed companies.

The private seed sector now comprises some twenty or so large players (with sales turnover exceeding Rs.200 million), several medium companies (sales turn over between Rs. 200 million and 20 million), and a large number of small, unorganized players (sales turnover less than Rs.20 million) with local presence.

The private seed industry is now undergoing a transition following the Indian government's focus on biotechnology research, as a means of increasing agricultural production and also driven by trends in the domestic and world seed market. Intensifying international competition, increasing R&D costs, and the complexity of biotechnology have lead to

increased consolidation of the Indian seed industry with several of the large and medium companies merging or being taken over by multinational seed companies. Most large multinational seed companies now have their presence in India (either as a joint venture or with 100 percent equity) with their main focus on biotechnology. These include Monsanto, Bayer CropScience, Syngenta, Advanta, Hicks-Muse-Tate, Emergent Genetics (merged in Monsanto in the year 2005), Dow Agro, Bioseed Genetics International Inc., Tokita Seed Co, and Nunhems Zaden BV.

Another factor attracting international seed companies to India is the country's varied agro-climatic conditions and abundant skilled and unskilled labor, as seed production, particularly hybrid seed production, is highly labor intensive. Private seed production is largely centered around Bangalore for vegetable crops and Hyderabad for field crops, particularly cottonseeds. The emergence of these two seed production centers is due to ideal climatic conditions, better infrastructure, the technology and research leadership, and the expertise of the two regions' seed farmers in manipulating crops for perfectly synchronized flowering. The initial focus of many of these companies has been cottonseed, for which genetically modified (Bt.) hybrids have already been approved by the Indian government for commercial cultivation, with other bio-engineered crops in the pipeline. Most of these companies have licensing agreement with Monsanto for the Bt. gene; some are trying to develop their own Bt. technology, legally or illegally.

The seed industry is represented at the national level by two associations "The Seed Association of India" based in New Delhi and the "Association of Seed Industries" based in Mumbai. Recently, a third association called All India Crop Biotechnology Association (AICBA) was formed with members from mostly hybrid seed producers and multinationals like Monsanto and Dow Chemicals.

1.5.5 Public-Private Sector Cooperation

Cooperation between private sector seed companies and public research institutes under ICAR, SAUs, and the International Crop Research Institute for Semi-Arid Tropics (ICRISAT), supported by the Consultative Group on International Agricultural Research

(CGIAR), is growing. Public sector breeder seeds are available free of charge to private seed companies with no strings attached. The AICT annual workshops provide venues to private sector seed companies to assess what is available with public research institutes. Under the “consortium” model with ICRISAT, private companies can jointly fund research that results in publicly available parental lines, which they often cross with in-house genetics to produce proprietary hybrids. ICRISAT recently introduced a live-in campus for private sector researchers to use the institutions’ facilities and expertise. ICRISAT is focusing more on private sector partnerships for funding reasons and also because of private companies’ effectiveness in getting the research result out to farmers. ICRISAT is currently reviewing its policy of keeping all research in the public domain and is considering licensing/royalties/exclusive rights. Private companies can also fully fund research at SAUs for exclusive rights on the results and/or hire professionals and researchers as consultants, although the degree of cooperation varies from state to state.

1.6 Gene revolution and transformation of Indian seed industry

After 1990’s we have an alternative known as ‘Biotechnology’ which has some answers to the Green Revolution externalities and unanswered questions of Green Revolution. As gene revolution proclaim of following:

- i. Pest resistance
- ii. Solution of salinity and alkalinity
- iii. Nutritional improvement e.g.; Golden rice with vitamin A gene (World Bank Gain Report).
- iv. Tolerance to environmental stress; etc.

The entry of foreign player in Indian seed industry comes through collaborations and joint ventures through Indian private sector companies. After approval of GEAC, GM Cotton; Indian seed industry is taking a new shape which is unknown. Indian Seed Industry's preparedness is one of the issues which have been enquired in this research. Before GEAC approval; a seed company named Navbharat seed³² sold genetically modified seed by cross-breeding with its existing hybrid seed. This product was a success in the market and in the agricultural field but ethically and legally it was crime. Such kind of scenario speaks of

³² Business world, 2003.

volatile and unknown behavior of market. To understand all these, multidirectional study is required from systematic manner. Our research is one of such initiative.

1.6.1 Agricultural Biotechnology Structure of the Indian Seed Industry

Although the Indian seed market is one of the largest, it is almost exclusively supplied by locally produced seeds. Farmers retain seed of major food crops (wheat, rice, sorghum, millet, corn, and pulses) and commercial crops for many years, and the largest volume of seed trade involves local exchanges of established self-pollinating varieties. The seed replacement rate in most crops is very low, with the exception of cotton and some vegetables. The use of hybrid seeds is mostly confined to cotton, and to some extent to corn, millet, sunflower, and few vegetables. However, awareness about the high yield and quality of produce from hybrid seeds, attracting farmers to switch over to hybrids, is growing.

The Indian seed industry used to be dominated by public sector seed companies. However, following the easing of government regulations and the implementation of a new seed policy in 1988, the private sector seed companies have started playing a major role in seed development and marketing. More recently, the government's decision to use biotechnology as a means of achieving food security has attracted several leading biotechnology-focused multinational seed companies to India. The composition of the seed industry, by volume of turnover, has reportedly reached a ratio of 60:40 between the private and public sectors.

1.7 A Case Study of Cotton Crop

Cotton is the focal point through which the interdependent relationship among agriculture, agro-biodiversity, the environment, culture, economics, science, poverty-alleviation and employment may be clearly assessed in post TRIPS regime. The present study is concerned to find out a way to understand the relationship between science and society, through cotton improvement and breeding programme.

Cotton is the most important natural textile fiber, as well as cellulosic textile fiber, in the world, used to produce apparel, home furnishings, and industrial products. Worldwide about 40% of the fiber consumption in 2004 was cotton. Cotton is grown mostly for fiber but it is

also a food crop (cottonseed) - the major end uses for cottonseeds are vegetable oil for human consumption; whole seed, meal, and hulls for animal feeds; and linters for batting and chemical cellulose.³³

The cotton crop is particularly prone to damage from insects and pests. It is attacked by about 150 species of insects (Venugopal, 2004). Among the important pests are jassids (*Amarasca bigutulla*), aphids (*Aphis gossypii*), white fly (*Bemesia tabaci*), spotted bollworm (*Earias vitella*), pink bollworm (*Pectiniphora gossypiella*) and American bollworm (*Helicoverpa armigera*). The Central Institute of Cotton Research estimates that about half of the cotton output is lost to insect pests³⁴.

Severity of the pest problem makes cotton cultivation, the largest market for pesticides. Even though cotton's share in total cultivated area is less than 5%, its share in total pesticide use is between 40 to 45%³⁵. In central and southern India, cotton growers typically use 12-15 sprays per season while in Punjab 6-10 sprays are accepted practice. Pesticide use is particularly heavy in irrigated cotton area. In Maharashtra, the leading cotton growing state, more than 70% of irrigated cotton area is treated with pesticides. The corresponding figure for unirrigated area is 60% (Venugopal, 2004). Despite the heavy reliance on pesticides, cotton growers often find them to be ineffective partially or totally. This is because some of the cotton pests such as the American bollworm and white fly have developed resistance to most of the insecticides used to control them (Birthal, Sharma and Kumar, 2000).

1.7.1 Cotton Sector: Species and Varieties

Research on cotton has emphasized the development of varieties and hybrids with resistance to pests. About 150 varieties and hybrids have been released during the last 50 years. Out of these about 30-40 are under large scale cultivation although about 20 varieties and hybrids account for more than 50% of production (Alam, 2004; Santhanam and Sundaram, 1999).

³³ Wakelyn et. al. (2006) p.1.

³⁴ Venugopal, (2004) pp 200.

³⁵ Venugopal, (2004) pp 222.

Cotton fibers are seed hairs from plants of the order Malvaceae, tribe Gossypium, Botanically there are four principal domesticated species of cotton of commercial importance: *hirsutum*, *barbadense*, *arborescens*, and *herbaceum*. Thirty three species are currently recognized; however all but these four are wild shrubs of no commercial value. Each of the commercially important species contains many different varieties developed through breeding programs to produce cottons with continually improving properties (e.g. faster maturing, increased yield, and improved insect resistance) and fiber with greater length, strength, and uniformity.³⁶

Asiatic or old world cottons (*Gossypium arboreum* & *G. herbaceum*) and American cottons (*G. hirsutum* and *G. barbadense*) are the four cultivable cotton species. *G. Barbadense* is also known as Egyptian cotton and Asiatic cottons are commonly referred to as *desi* cottons. In India, *G. Arboreum* and *G. hirsutum* are the principal species that are cultivated. *Desi* varieties and, in particular, *G. Arboreum* are known for their drought tolerance and resistance to sucking pests. On the other hand, American cottons usually have long and extra long staple and better spinning potential (higher counts) than *desi* cottons.

Hybrids have been developed between varieties of the same species and these are called intra-specific hybrids. Across species, 'inter-specific' hybrids have been produced between the American cottons or between the local or landrace cotton varieties. As local cottons are diploids while American cottons are tetraploids, fertile hybrids with one local parent and another American parent are not possible.

1.7.2 Cotton Breeding in the Public and Private Sector: A Short Chronology

India was the first country in the world to commercialise cotton hybrids. The first cotton hybrid H-4, was *intra-hirsutum* (i.e., both parents are *hirsutum*s) and was produced by Dr. C. T. Patel in 1970 at the Surat agricultural experiment station of the Gujarat Agricultural University. In 1972 an inter-specific (Female - *hirsutum* X male -*barbadense*) cotton hybrid (Varalakshmi) was released by the University of Agricultural Sciences at Dharwad, Karnataka.

³⁶ Wakelyn et al (2006) p.1.

Generally speaking, *intra-hirsutum* hybrids do better than *intra-arboreum* hybrids with respect to fibre quality and yield potential. The inter-specific tetraploid hybrids (cross between *hirsutum* and *barbadense*) have excellent properties in terms of fibre length and spinning counts. But, they usually do poor in rainfed conditions as the *G. barbadense* parent in such hybrids is highly prone to moisture stress. Further, they are also susceptible to sucking pests. On the other hand, diploid hybrids (cross between *arboreum* and *herbaceum*) are well adapted to drought conditions and are resistant to sucking pests.

A historical summary of popular public sector varieties and hybrids is given in Appendix-I.a. This indicates the breadth of public sector research in developing cotton varieties and hybrids for different states and agro-climatic zones. Public sector research has emphasized high yielding, medium and long staple *intra-hirsutum* hybrids for states in the central zone (Gujarat, Maharashtra and MP), long staple cultivars and inter-specific tetraploids (*hirsutum* x *barbadense*) for states in the south zone (Andhra Pradesh, Karnataka and Tamil Nadu) and inter-specific desi cotton hybrids (*herbaceum* x *arboreum*) for the rainfed areas of Gujarat and Maharashtra. It is also clear that the late 1970s and early 1980s was an active period where the public sector released many location-specific hybrids. These hybrids were in turn based on previous public sector research as one of the parents was usually a local popular cultivar (Bhale, 1999). However, hybrids for states in the north zone (Haryana, Punjab and Rajasthan) were released only in the 1990s.

While India is the largest producer of hybrid cotton seed (Alam, 2004), hybrid cotton production is extremely labour intensive. The male flower had to be separated from the female by tying it up - a process known as hand emasculation. This is very labour intensive. The use of male sterile lines through cytoplasmic male sterility or genetic male sterility has reduced the costs of hybrid seed production. It has also increased purity by avoiding self pollination. The first such hybrid was developed in 1978 under the name Suguna through the use of genetic male sterility. Since then, other public sector hybrids that have been developed through the use of cytoplasmic genetic male sterility include PKVHy 3 and PKVHy 4. However, most hybrids in India are still produced through the process of hand emasculation.

Appendix-I.b. sketches a history of private sector hybrids. Private sector hybrids are also called proprietary hybrids and we shall use these two terms inter-changeably. The box confines itself to the hybrids that have been successful. The first private sector cotton hybrid was MECH 11 commercialized by Mahyco in 1979. Mahyco's most successful cotton hybrid was MECH 1 released in 1982. This was developed using the genetic male sterility system. Hybrids from other firms were released in the 1990s. As can be seen from Appendix, the number of firms releasing private hybrids picked up in the second half of the 1990s. The successful private sector hybrids are usually *intra-hirsutum* hybrids serving the major markets of Maharashtra, Gujarat and Andhra Pradesh. It is only in recent years, private firms have also released local hybrids and inter-specific long staple hybrid cotton with a *G. Barbadosense* parent. It is expected that as extra long fiber begins to command a premium in the cotton market, inter-specific hybrids will become more popular.

From the chronologies of public and private sector products, it is easy to see that while the hybrid breeding effort was initiated and sustained in the public sector for the first 20 years, the private sector has made rapid gains since then. There are several factors that could have played a role in the rapid development of the private sector hybrids in the 1990s. First, this can be seen as a process of technology diffusion and learning. Many of the private sector firms that have their own hybrids today entered the cotton seed business by marketing and producing public bred hybrids. *[Indeed, the leading cotton seed firms continue to market public bred hybrids even though they derive insignificant revenues from it.]* Furthermore, the private sector has relied heavily on retired public sector breeders to lead their research effort. Second, once the private sector was able to evolve a successful model of hybrid development, production and release, they were also quick to spot the market opportunities left unexploited by the public sector. In particular, the private sector focused on early duration hybrids with good fiber quality. The early duration hybrids appealed to farmers in rainfed areas anxious to minimize their exposure to weather risk. By comparison, the public sector hybrids were middle to late duration crops. Third, as selling one's own proprietary hybrids offered much greater margins than marketing public bred hybrids, private firms reallocated their resources accordingly. On the other hand, the public sector seed corporations were unable or unwilling to invest in the marketing effort to compete with public bred hybrids.

The 1990s were also the decade of economy wide reforms. In particular, the removal of industrial licensing requirements, small scale industry reservation and restrictions on foreign direct investment significantly eased entry into the seed industry. It is hard, however, to relate these reforms in a direct fashion to the dramatic growth of private hybrids in the cotton seed industry. The major impact that might have been expected would have been the entry of foreign seed companies. While this happened to a limited extent, none of the foreign seed companies that came in were global leaders in cotton. However, it is possible that the threat of such entry might have induced some R&D expenditures by the incumbent firms. Capital market reforms have favourably impacted the access of Indian firms to long term capital at global interest rates (which are significantly lower than in India). However, none of the Indian seed firms have used this route as most of them are still closely held private firms.

1.7.3 Bt. Cotton: The New Product

Bt. cotton is a radical departure from conventional plant breeding. *Bacillus thuringiensis* is a soil borne bacterium toxic to insect pests and safe to higher animals. It widely used as a bacterial insecticide. *Cry* genes from the bacteria determine the action against pests. These have been transferred by genetic engineering techniques to different plants (maize, cotton, vegetables) to confer resistance to pests. Bt. cotton offers resistance to an important pest, the American bollworm (*Helicoverpa amigera*), which has developed resistance to all the commonly used insecticides in the country (Kranthi and Kranthi, 2004).

In India, Bt cotton was first released through three hybrids belonging to Mahyco. It contained a Bt gene *cry I Ac* owned by the U.S. firm Monsanto and branded by it as Bollgard. In India, Monsanto has formed a joint venture with Mahyco called Mahyco Monsanto Biotech (MMB), which has the license to use the *cryIAc* gene. (*Monsanto has taken a 26% equity stake in Mahyco*). MMB also markets the transgenic Mahyco hybrids. MMB has sub-licensed the Bt. gene to other seed firms as well. In 2004, Rasi Seeds offered a transgenic variety while in 2005, Ankur Seeds and Nuziveedu Seeds also received commercialization approval for their Bt cotton hybrids.

Along with these officially approved Bt varieties, there is an illegal Bt hybrid that was first discovered in Gujarat in November 2001. This is Navbharat 151 distributed by Navbharat seeds based in Ahmedabad. It is illegal because it has not received biosafety clearance from the government. Despite prosecution, the plantings of illegal Bt cotton has spread across Gujarat and to other parts of India, notably Punjab.

1.7.4 India and GMC³⁷

India is one of the largest cotton growing countries in the world, where 60 million people are impacted by cotton, reported 54,000 farmers growing 50,000 hectares of Bt. cotton in 2002. Five years later in 2007 the Bt. cotton area has soared to 6.2 million hectares grown by 3.8 million small and resource poor farmers. Notably, more than 9 out of 10 farmers who grew Bt. cotton in 2005 also grew it in 2006 and similarly for 2006 and 2007 - this confirms the trust and confidence of farmers in Bt. cotton after experiencing its superior performance in their own fields. For the third consecutive year, India has reported the highest proportional increase of any biotech crop country in the world with an impressive gain of 63% in 2007. The reason for the spectacular growth in Bt. cotton is that it has consistently delivered unprecedented benefits to farmers and to the nation. Bt. cotton has increased yield by up to 50%, reduced insecticide sprays by half, with environmental and health implications, and increased income by up to US\$250 or more per hectare, which has contributed to social benefits and the alleviation of their poverty. At the national level, increased farmer income from Bt cotton in 2006 was estimated at US\$840 million to US\$1.7 billion, production has almost doubled, and India, which used to have one of the lowest cotton yields in the world, is now an exporter rather than an importer of cotton.

India's Minister of Finance recently cited the success of Bt. cotton and advocated that "It is important to apply biotechnology in agriculture - what has been done with cotton must be done with food grains. The success achieved in cotton must be used to make the country self sufficient in rice, wheat, pulse and oilseed production." Mrs. Aakkapalli Ramadevi, is a woman subsistence farmer from Andhra Pradesh, who laboriously tills 3 acres (1.3 hectares), and is typical of a small and resource-poor farmer in India who has benefited from Bt. cotton.

³⁷ ISAAA Brief 37(2007). Global Status of Commercialized Biotech/GM Crops:2007. pg. v.

Before the advent of Bt. cotton she said “The yields were very low and we used to incur losses, so we were perpetually losing money - to sum it up, we were badly off and unable to afford anything properly”. After planting Bt. cotton for two years she says, “Finally, cotton cultivation has actually turned profitable.”

A study conducted in 2006 of 9,300 Bt. cotton and non-Bt. cotton households in 456 villages in India reports that women and children in Bt. cotton households already have slightly more access to social benefits than non-Bt. cotton households. Compared with women in non-Bt. cotton households, women in Bt. cotton households report slightly more antenatal visits and assistance with births at home, and their children have higher school enrollment and a higher proportion vaccinated. The story of Bt. cotton in India is remarkable. With political will and farmer support in place, adoption is projected to continue increasing with Bt. cotton plantings escalating from the current 66% to 80% or more. Coincidentally, new biotech products such as Bt eggplant, an important food and cash crop that can benefit up to 2 million small and resource-poor farmers, is in advanced large scale field trials, with expectations of approval in the near term.

1.7.5 Review

In the cotton sector, India’s yields lag far behind international levels. India therefore needs quality seeds that can deal with the complex production problems posed by pests and insects. Further, cotton cultivation in the leading cotton growing states is mostly rainfed. Plant breeders have responded to these challenges by producing medium to long staple higher yielding hybrids most suited for Maharashtra, Andhra Pradesh and Gujarat. The research and commercialization effort was initiated and sustained by public sector research for close to two decades. Since the early 1990s, however, the private sector has released many successful hybrids. The rapid rise of the private sector cannot be attributed to any single policy change. Rather it seems to be the result of learning by doing through the process of marketing public-bred hybrids and the market opportunities left unexploited by public-bred hybrids.

1.8 Rationale for conducting the market research

The multiplier effect of Green Revolution not stopped at agricultural betterment rather than it percolated to the social behavior of farming community in term of buyer behavior and created new market for new types of product. This market was not only created for the agri-product but also for lifestyle product giving impetus to new type consumerism creating new segment of consumers whose demand and preference were new. The basic cause of ‘surplus produce’ which brought farming community ‘some extra money’ & enhanced their ‘purchasing power parity’ was ‘*Hybrid Seed*’. This increase in Purchasing Power created demand and transformed Indian farmers ‘wants’ into ‘need’. Hence we see that a single input has such a larger impact on the economy. To understand that what are the key factors which influence ‘new technology’ and Seed Industry as a whole and the key drivers of this technology insights has been taken from Porter’s Model³⁸, which differentiated stakeholders for industry analysis.

The unanticipated rapid rate at which discoveries and their applications in biotechnology have unfolded has stressed the capacity of society - more specifically, our agricultural research and educational institutions - to absorb and adjust to change. We are challenged by pressing decisions, opportunities, and problems that we face now and will continue to face in the future. Competition from abroad impels us to devise and use new technologies that can improve the efficiency and quality of Indian agricultural production. An overview of how the agricultural research system is responding to biotechnology and how it might prepare for future opportunities is the base of investigation of this thesis.

Indian agriculture has achieved its preeminence through innovation and substitution of knowledge for resources. Yet technological innovations cannot revitalize Indian agriculture unless farm business management, farm policy, Department of Agriculture, Agricultural Universities, extension services, and private sector businesses that serve agriculture are innovative. Indian farmers can take the lead in adopting new biotechnologies. These technologies should emphasize maximizing economic yield rather than total production. Such technologies become increasingly important as the competition increases.

³⁸ Porter

The adoption of new technologies has improved the efficiency of agricultural production practices. Agricultural systems throughout the world continue to adopt new and better technologies that enable them to become more efficient and competitive in developing new markets and capturing old markets for their agricultural products. The future leadership and competitiveness of the Indian agricultural enterprise is dependent on the health and effectiveness of the agricultural research system in the country and its ability to translate better technologies into practice. Research must make Indian farming a more profitable, reliable and durable business able to compete in both domestic and international markets. Innovation is crucial to enhance productive efficiency and environmental acceptability. Biotechnology is the key to this innovation.

1.8.1 Purpose of present research

Present research deals with technological transition brought by biotechnology. With the help of biotechnology, the genetic nature of seed itself has been manipulated leading to new product development with the help of technological innovation. In its essence the research enquiry is looking at the companies, the marketplace, and the competition to determine how the new product opportunity will fit into the overall industry strategy. New product development is a business venture³⁹. Being an explorative research the dissertation also tries to ponder deep into various questions raised by Eric S. Grace⁴⁰ (1997) like:

- i. Environmental safety:
 - a. Will genetically altered organisms upset the balance of populations in natural ecosystems?
 - b. Will modified organisms transfer their altered genes to wild relatives or reduce biodiversity?
- ii. Social and economic effects:
 - a. What effects will biotechnology have on the business of farming around the world?
 - b. Will patent laws give control of key crops to a few large companies?
- iii. Ethical and moral issues.

³⁹ Annacchino, (2003) p.4

⁴⁰ Grace (1997)

- iv. Regulatory issues: Do current regulations give enough protection to farmers, consumers' live stock, and the environment?
- v. With control of seeds and agricultural research held in fewer hands, the world's food supply is increasingly vulnerable to the whims of market maneuvers. Corporate control and ownership of seeds - the first link in the food chain - has far-reaching implications for global food security.

Hence the investigation had been done to understand the potential of Biotechnology in the realm of Indian Seed Industry.

1.9 Overview of the Chapters

Chapter I deals with Seed Industry vividly at Global and Local scenario. Structure of existing format of Indian seed Industry has been mentioned with reference to economic, political and technological environments. It gives the broad introduction and outline of the growth and development of Indian seed industry, present state of public and private sector, and an outline of the business environment scenario and changing trends. In addition, an attempt has been made to provide a brief introduction to the phenomenon of technology transition.

The diverse knowledge streams, the actors and drivers of technology transition are mentioned in **Chapter II** which is based on theme based review of literature. The chapter provides an overview of conceptual framework from many streams of knowledge. Through existing knowledge and scientific examination of reasons interwoven to bring business environment in purview of strategy and structure; with basic variables like science, technology, research and development, new product development and elements of marketing will have direct influence on industry's structure. Research Gaps evolved as upshot of review of literature leads to formulation of research questions, hypotheses and research objectives which have been investigated in the thesis.

In view of the new technology i.e. Biotechnology and its ramification on the seed industry, there was a necessity to design new frame of methodology for pursuing this study because the nature of the actors and drivers of the Seed Industry and their dependency on many streams of knowledge required a new approach of investigation. **Chapter III** explains the step by step

evolution and synthesis of research process and research framework for hypotheses testing and research objectives.

Chapter IV tried to interpret data and finding from one set was triangulated with other to bring out facts. Being ongoing phenomenon, it was necessary to understand the forces which are the cause of technology transition occurring in the Indian Seed Industry. Triangulation gives flexibility of interpreting archival data and primary data.

Chapter V scans the legal and policy environment in which the seed industry exists and the Indian policy structure for seed and biotechnological related issues juxtaposed with International policy initiative. The chapter provides a basis for understanding, analyzing and implementing legal systems that can properly balance the public and private interests in agricultural biotechnology inventive contribution. The chapter investigates the possible effect of Plant Breeders' Rights, Plant Variety Protection Act & Farmers Rights with respect to the Indian farmers and Indian Seed sector.

Chapter VI brings out the R&D commercialization and its influence in agricultural sector and its manifestation in seed industry.

Chapter VII brings out the science and technology environment for Seed Industry. Scientific churn leading and ramification of biotechnology in agricultural sector in general and seed industry in particular. The form of Genetically Modified Crops is probed in this chapter.

Chapter VIII concludes with suggestions for Indian seed industry, policy makers, academia and future researchers in this field. The study explores ramifications of other product portfolio of seed market which uses biotechnology. Observing the magnanimity of change brought by biotechnology, its ramification can be felt in other industries using biotechnology; the present study framework can be emulated for them too. Historically it was observed that new technology was accelerator of economy and every recession was overcome by new technological breakthrough; e.g. Green Revolution and Information Technology.

Chapter IX sums up with recommendations of the dissertation.

The reference and bibliography and appendix are given at the end of the dissertation.

References:

1. Annacchino, Marc A. (2003). *New Product Development: from Initial Idea to Product Management*. (New York: Elsevier Science & Technology Books).
2. Borloug, Norman (1999). *Verdens Brod [The world's bread]. Politiken [Denmark], November, 27. Cited in: 'Pinstrup-Andersen, Per and Schioler, Ebbe (2001). Seeds of Contention: World Hunger and the Global Controversy over GM Crops*. (New Delhi: Oxford University Press).
3. Conway, Gordon (1997). *The doubly green revolution: food for all in the 21st century*. (London: Penguin), p.334
4. Desai, D. K. and Hari Prakash (1973). *Indicators of Change in Indian Agriculture 1961-1971. In, New Opportunities in Changing Agriculture*. (Ahmedabad: Centre for Management in Agriculture, Indian Institute of Management), pp.11-35
5. Jha, Dayananth (2003). *Agricultural R&D in India: Growth, Equity and Institutional Challenges*. In "India's Agricultural Challenges: Reflection on Policy, Technology and Other issues. pp.171-195.
6. Gadwal, V. R., (2003), The Indian Seed Industry: Its history, current status and future. *Current Science*, 84 (3), pp 399-406.
7. Grace, Eric S. (1997). *Biotechnology Unzipped Promises and Realities*. (Washington: Joseph Henry Press).
8. Government of India (2009), *India 2009*, (New Delhi: Ministry of Information & Broadcasting).
9. IRRI press release (October 29, 2004). Asia New Rice Revolution
10. Kotler, Philip (2003,). *Marketing Management*, 11thed. (New Delhi: Prentice-Hall of India Private Limited).
11. Kotler, Philip and Gary Armstrong (1999), *Principles of Marketing* 8th ed., (New Delhi: Prentice-Hall of India Private Limited), p.4.
12. McDonald, Malcolm and Ian Dunbar (2004), *Market Segmentation: How to do it, How to profit from it*; (Oxford: Elsevier Butterworth-Heinemann), p.9.
13. Misra, S.K. and V.K. Puri (2007), *Indian Economy - Its Development Experience*, (Mumbai: Himalaya Publishing House).

14. Government of India (2007), *India 2007: A Reference Annual*, (New Delhi Ministry of Information and Broadcasting), p. 64.
15. National Seeds Corporation Limited. 44th Annual Report 2006-2007.
16. Rai, Mangla and B. Prasanna (2000), *Transgenic in Agriculture* (New Delhi: Directorate of Information and Publication of Agriculture. Krishi Bhawan, ICAR publication, Pusa).
17. Randhawa, M.S. (1982), *A History of Agriculture in India [Volume-IV]* (New Delhi: Indian Council of Agricultural Research), pg:iv.
18. Ravinder, Reddy Ch., V.A.Tanapi, P.G. Bezkorowajnyj, S.S. Navi and N. Seetharama (2007), *Seed System Innovations in the semi-arid Tropics of Andhra Pradesh* (Patancheru: International Livestock Research Institute (ILRI), ICRISAT, Andhra Pradesh, India).
19. Regal, P.J. (1994), Scientific Principles for ecologically based risk assessment of transgenic organisms, *Molecular Ecology*, 3:5-13.
20. Rudrappan, D. (2003). Globalisation and Crisis in Indian Agriculture – A Review. In, “*Alagh, Y.K. (editor). Globalisation and Agricultural Crisis in India* (New Delhi: Deep & Deep Publication in association with Indian Economic Association) p. 42.
21. Sahai, Suman (2004). Is Agbiotechnology Suited to Agriculture Agriculture Production in India? In *India’s Agricultural Challenges: Reflection on Policy, Technology and Other Issues*. pp. 161-170. [courtesy genecampaign]
22. Schell (1993). Plant Biotechnology: State of the Art in Developed nations and relevant Safety consideration. In African Regional Conference for International Conference on Safety in Biotechnology. Held during 11-14 October 1993 Harare, Zimbabwe. MEBO Environmental Consultancy, Netherlands, pp.23-29.
23. Sharma, Manju (October 17, 2003) First Foundation Day Lecture on Regulatory Measure for Utilizing Biotechnological Developments in Different Countries. TASS, IARI, New Delhi.
24. Shiva, Vandana (2002), *Globalization of Agriculture, Food Security and Sustainability*: In “Vandana Shiva and Gitanjali Bedi (editors). *Sustainable Agriculture and Food Security*” (New Delhi: Sage Publication), pp. 11-70.

25. Shiva, Vandana (1992). *Ecological, Economic and Political costs of the Green Revolution*: In, "Towards Hope: An Ecological Approach to the Future. editors: Shiva, Vandana; Seabrook, Jeremy; Hilliges, Gunther; Baxi, Upendra; Goldsmith, Edward and Ekins, Paul". INTACH. pp. 1-18.
26. Swaminathan, M.S. and Ikeda, Daisaku (2005). *Revolutions: to green the environment, to grow the human heart* (A dialogue between M. S. Swaminathan, Leader of the Ever-Green Revolution and Daisaku Ikeda, Proponent of the Human Revolution), (Chennai: East West Books (Madras) Pvt. Ltd.).
27. Wakelyn, Phillip T., Noelie R. Bertoniere, Alfred Dextex French, Devron P. Thaibodeaux, Barbara A. Triplett, Roussell Marie-Alice, Wilton R. Goyners(Jr.), J. Vincent Edwards, Lawrence Hunter, David D. McAlister and Gary R. Grenple, (2006), *International Fiber Science and Technology: Cotton Fiber Chemistry and Technology* (New York: CRC Press).
28. Young, A.L. (1994), "The Scientific Method", *Biotechnology*, 12:432.

Chapter II: Review of Literature

2.1 Rationale

Historically, it was observed that new technology gives impetus to the economy. At the same time, new technology generates many logical arguments and counterarguments. ‘Slow acceptance of a new technology can be caused by issues of price, immature technology, or simply the human tendency to resist change’¹.

The dialectic in terms of ‘for’ and ‘against’ lead to epistemology of ‘thesis’ and ‘antithesis’ culminating to equilibrium and acceptance. Last two decades has shown the tremendous development in the field of biotechnology. Technological expansion of biotechnology in tangible form is being harness to solve many unsolved problems for example ‘human insulin²’ produced by bacteria or ‘cell culture³’, and ‘tissue culture⁴’ technique used to propagate many endangered plant species. Recent development in life sciences juxtaposed with the concurrent market interdependence has paved way for a new frontier of unexplored market which is biotech industry.

Biotech industry ramifies into many other sectors directly or indirectly because of its inherent scientific nature which is based on manipulation of genetic make-up. This manipulation is also termed as genetic engineering in scientific literature. Agriculture is also one of the sectors where application of genetic engineering has started. Recent use of Genetically Modified Crop (which is also called as Genetically Modified Organism⁵) is the extension of the above mentioned scientific phenomena.

Business Management phenomenon juxtaposes new product development based on biotechnology which has its own implications on Indian seed industry. This is an ongoing phenomenon. Technology environment is directly influenced by path breaking discoveries in the field of life sciences where biotechnology is the causative agent. Genetically Modified

¹ Bergeron and Chan2004. p.8.

² Bergeron and Chan2004. p.1.

³ NCERT 2003 pp.191-216

⁴ ibid. pp.179-190

⁵ Nill, 2002 p.112.

Crop (GMC) is also one of the path breaking technological outcomes. GMC as a new product portfolio is a shot in the arm of the seed industry. In the first chapter, we have briefly explained the growth and spread of seed industry at international and national level. Dynamics of market economy is dependent on the performance of the product (i.e. Genetically Modified Crop) and acceptance by end-users (farmers). Hence, many actors and drivers are part of technology and product supply chains in explicit and implicit manner.

To have the bird's eye view in the selected area of research enquiry, theme based literature review is chronologically done. Some of the key issues which lead to this approach are as mentioned below:

- a. Development of scientific knowledge juxtaposing the importance on scientific ramification.
- b. Technological expansion of biotechnology.
- c. Supply chain interface of existing product portfolio and the New Product:
 - i. Technology supply chain.
 - ii. Product supply chain.
- d. Movement of technology in the rural market.
- e. Tentative implication of the new technology on the ecology.
- f. Safeguarding the consumers from product failure and adulterated or spurious seeds.
- g. To understand or to know if the problem could be traced back to scientific development of biotechnology, R&D, ecology, stakeholders etc.
- h. To understand what the activist trying to highlight and the need for a strong opposition to GMCs beyond the activist dimension.
- i. Theoretical stage i.e. stakeholder's perspective.

Relating the basic cause and to find certain links between the above mentioned. Based on all this the following broad area of knowledge is considered to complete the circle:

- i. Indian seed industry and its structure
- ii. Strategy
- iii. New product development
- iv. Development in biological science

- v. The potential of biotechnology
- vi. Role of seed
- vii. Genetically Modified Crop
- viii. Cotton sector
- ix. Bt. cotton
- x. Intellectual Property Right
- xi. Science, Innovation, Technology and R&D
- xii. Rural market and marketing

The overall linkage can be abridged as:

“Science-innovation-R&D-technology-NewProductDevelopment-commercialization”.

2.2 Development in Science

In the year 1838 and 1839, M.J.Schleiden and T. Schwann⁶ established the identity of vegetable and animal cells. They proved that the cell is the basic structural unit of living organisms. In 1959, Charles Darwin published his fundamental work, *On the Origin of Species by Means of Natural Selection*⁷. This completed the development of evolutionary ideas over a whole century and formed the basis for new ideas and modern biology. The philosophical significance of this discovery was that it revealed the dialectical character of natural developments in a particularly succinct form. In the last century, the development of the capitalist mode of production and the productive forces of capitalism were made rapid progress in the technology and natural sciences. These were developed particularly for those sciences that were linked more or less intimately with industry (Engels)⁸. However, in the late Twentieth century, biology has acquired the most dominating role. We are now heading towards a situation where knowledge of biology and the resulting technological innovations will give rise to the most unbelievable changes in the content of life and remarkably influence the living pattern, in general.

⁶ NCERT 2003, Text Book of Biology Class XI, p. 138.

⁷ *ibid.* p.46

⁸ Engels, p: 6

J.D Bernal⁹ (1961) emphasizes three potent influences of Modern Biology in the areas of medicine, agriculture and biological industry. According to him, the new agricultural revolution puts a premium on aspects of real agriculture science such as agrobiolgy, agrochemistry and agrophysics. Agricultural research has already quadrupled yields; it can bring about distributive justice when it is applied by institutions and people with the required expertise and component to socio-economic equality. Development of soil science and ecology should determine the best use of land. The use of fertilizers in multiplying yields should be combined with fertilizer industry that is cost effective with an equitably distributed marketing network. Finally, the long battle with disease of animals and plants has to be definitely won and the product of the land kept for human beings and not for insects. Through detailed biological studies it now seems likely that perennial plague of locusts could be finally eradicated from the world. The world can not afford the time where the peasant, however, hardworking and traditionally skilled he may be, was illiterate and incapable of understanding science. It should be evident that the farmers and the agricultural scientists, they may be both the same, but in reality it is not. Farmers toil in the field and produce agro-product which is the outcome of the basic 'input' i.e. the nature of the seed. The scientists, on the other hand works in laboratories for the quest of truth based on facts and findings generated within the boundaries of laboratory, which inturn contributes to the macrocosm of knowledge.

According to Rahman and Chowdhury (1980),¹⁰ "Scientific knowledge created new intellectual horizons which enabled man to question the accepted beliefs, as well as, established objectives, purposes and goals of systems. The technology developments seriously affected societies by changing means of production and relationship between man and man. The technology created as a result of the twin developments of science and technology on the one hand and the economic theories and philosophies on the other, reduced man to a number and a cog in the machinery of production and his creative capabilities could only be judged by the number of items produced in a given time and his effort valued on that basis". Published literatures during 1960s, 1970s and 1980s shows that machines were synonyms of 'production' and 'technology' means more of mechanization. Then process improvement

⁹ Bernal, J.D., 1961 p:971-972

¹⁰ Rahman and Chowdhury 1980p.viii.

based on efficiency and efficacy of machine was the purpose of technology. Contrary to that, Green Revolution taught that productivity can be increased by changing the 'nature of the seed'. Thus, hybrid seeds became the synonyms of Green Revolution and it was also dependent on many other technologies and it was 'input' intensive technology.

2.3 Role of Seed

Increased production of agricultural crops depends not only on the development of higher-yielding varieties of seeds but also on the efficiency of the systems available to ensure that these seeds reach the farmers on time (Mumby 1994). The objective of seed technology is to protect biological entity, namely the embryo in seed (Cowan 1973). The focus of seed technology, however, is on the second component, namely the supporting or food storage tissue in the seed.

The improved seed plays many roles in agricultural production (Desai et.al. 1997, Agrawal 1980, Feistritz 1975). Seed technology plays the following major roles:

- i. It is a carrier of new technologies,
- ii. It is a basic tool for secured food supply,
- iii. It is the principal means to secure crop yields in less favorable production areas,
- iv. It is also medium for rapid rehabilitation of plant and agriculture species following natural disaster.

When we talk of Evergreen Revolution, perhaps genetic engineering and genetically modified crops may be the future determinants of Indian agriculture. A pertinent issue, which we face according to Sir Monty Finniston (1985), is the question of entrepreneurial risks in an industrial society. He argues that "no simple solution to this problem has been found. The term, 'market forces', is a semantic expression which covers the successes and failures of technological developments, which depends as much on the qualities of those who champion innovation and invention as they do on the market". There are, however, great risks in established products or ventures, and these are becoming even more worrisome (issue of

concerns) as industry based on advanced technology grows more complex in content and integration into society.

2.3.1 Literature available on Seed Industry: A glance

The available literature includes a long list of seed sector organizations, both public and private. However, only a small portion of such literature relevant to the present research is being discussed.

The literature on developing country seed markets has mostly emphasized the appropriate roles for the State and the market (for instance, Jafee and Srivastava 1994; Pal and Tripp, 2002; Pray and Ramaswami, 1991; Singh, Pal and Morris 1995). Work has also been done on seed regulation and what is appropriate for developing countries (Tripp 1997). Investigations of market structure issues are not that many in management research. Tripp and Pal (2000) found that brand recall was weak among pearl millet farmers in Rajasthan suggesting that brand loyalty is not an entry barrier to this market. Pray, Ramaswami and Kelley (2001) showed that during the early 1990s - a period marked by a rapid rise in R&D spending by private seed firms - the market structure became more competitive (as measured by concentration ratios). Shiva and Crompton's (1998) survey of the seed industry in India leads them towards a different conclusion. They forecast that the seed industry is likely to "coalesce under the control of a few large companies with foreign interests." They argue that displacement of open-pollinated varieties by hybrid seed, the decline of the public sector, private sector promotions and advertising strategies, plant variety protection laws and transgenic crops are all factors that will make it difficult for small companies to compete in the seed industry. Vandana Shiva¹¹ (2002) stated that patent on seeds affect food security by forcing farmers to pay royalties for seeds, thus increasing the cost of production and hence the price of food.

In an international context, Morris¹² (2002) reviews the impact of globalization on national maize seed industries. While Morris does not define globalization, he considers economic

¹¹ Shiva, Vandana (2002)

¹² Morris, M. L. (2002), pp 209-212.

deregulation, domestic market reform, trade liberalization, privatization of State industries and the implementation and enforcement of intellectual property rights as the processes associated with globalization. The outcome of these processes has been an increase in the market share of private firms in markets once dominated by public sector organizations. While Morris acknowledges that a greater role for private firms would have increased the efficiency of the seed system in certain aspects, he also points out that this process has been accompanied by higher seed prices (relative to grain prices) and market concentration. In many countries, the largest three companies control as much as two-thirds of the market.

Morris (2002) posits a 'life cycle' theory of seed industry development consisting of four stages. The first stage is a subsistence farming system. The second stage sees a formal seed system that is dominated by a public sector. The private sector begins to play a role in the third stage where they do plant breeding work, and produce and distribute seed under quality standards. In the final stage, the industry is dominated by a few large private firms that are largely those that operate globally.

Tripp and Pal¹³ (2001) concluded that the new emerging company finds it difficult to sell its product in market due to already established other company brand. They found that even in area where the use of private hybrid seed is extensive while farmers could recall the branded seed or the companies' hybrid. This is possible because companies invest resources more in advertising company brand rather than research and communication information about the varieties. The illiteracy in presence where as private sectors are effectively marketing with great success.

Rao¹⁴ (2001) stated that farmers faced the problems of lack of technical guidance, foundation seeds availability of labor and delays in certification. The traders reported that unhealthy competition existed in seed marketing and they are negatively affected by the entry of multinational companies into the domestic seed business. The study also suggested that

¹³ Tripp and Pal

¹⁴ Rao, G.V.K. (2001).

foundation seed technical guidance and quicker certification system should be provided to the small companies and farmers.

Asokan and Choski¹⁵ (1998) in their study stated that the slow growth of industry is due to lack of vibrant policy for research and development in the sector and marketing regulation. He suggested that government needs a vibrant policy measure and both public as well as private industry need proper seed marketing regulations and pre demand forecasting for breeder seed is essential. An efficient marketing information system must be developed by the seed companies to ensure easy and effective flow of information from marketing department so that seed is multiplied in decentralized manner at the farm fields.

Pandey¹⁶ (1994), in her paper, stated that among developing countries, India occupies a prominent place with respect to the development of hybrid seeds. The initial impetus for introducing hybrids comes exclusively from the government. But after the new seed policy on seed development (1989) led the involvement of the private seed companies in India. For a long hybrid seed was not without criticism due to environmental concerns (due to fertilizer pesticides, and disease etc). She adds that some regions of the country have refused to grow the new hybrid seeds probably because they were using their own traditional alternatives. She concluded her paper stating that the traditional seed development methods have also shown good results, provided that they follow the proper seed handling process.

William Lesser (1987) has a comprehensive approach and stated that overall seed patents are anticipated to provide moderate private and social benefits at moderate costs. This is especially true if public seed breeding remains a competitive force in the industry¹⁷.

Ulynovky (1981) mentions that the first Institutionalization of seed market started with cotton seed in Nagpur with seed loan. But the distress to farmer was not because of seed price rather than price determinant of final produce. He further mentioned about the state of affairs in the following words “Bombay cotton data on the state of the cotton market also testified to the

¹⁵ Asokan and Choski (1998).

¹⁶ Pandey, B. (1994).

¹⁷ Lesser, William (1987).

deep crisis of this commercial crop, which was of such importance to India considering the importance of the sale of cotton for peasant farm, the Bombay chronicle wrote that the peasant did not suffer as great losses from low prices of wheat, rice, and so on as from low ones for cotton. This was because the peasant retained a large proportion of food products for himself, while he sold all his cotton in order to pay the government land tax and purchase essentials, and since the price of cotton was well below average costs, the producer was not left with enough money to pay tax or satisfy his normal requirements. The peasant was on the verge of total ruin as a result of the extremely low cotton prices”¹⁸.

2.4 The Potential of Biotechnology

‘Biotechnology’ is a difficult term to define since the harnessing of any biological process to human aims and desires could justifiably be called biotechnology. However, the revolution in our understanding of the molecular mechanisms underlying the processes of life, in particular our understanding of DNA, the prime genetic material, has resulted in the ability to manipulate those mechanisms to our requirements. This new-found knowledge and ability is loosely termed biotechnology¹⁹.

The power of biotechnology is no longer a fantasy. Biotechnology is the use of technologies based on living systems to develop commercial processes and products. These include the techniques of recombinant DNA, gene transfer, embryo manipulation and transfer, plant regeneration, cell culture, monoclonal antibodies, and bioprocess engineering. Using these techniques, we have begun to transform ideas into practical applications. For instance, scientists have learned to genetically alter certain crops to increase their tolerance to certain herbicides. Biotechnology has also been used to develop safer vaccines against viral and bacterial diseases such as pseudorabies, enteric colibacillosis (scours), and foot-and-mouth disease. Yet, we have barely scratched the surface of the many potential benefits the tools of biotechnology will bring.

¹⁸ Ulyanosvsky, Rostislav (1981). page74-75 & 210-211.]

¹⁹ Morris and Bruace(2000) p.13.

Biotechnology offers new ideas and techniques applicable to agriculture. It offers tools to develop a better understanding of living systems, our environment and ourselves. Yet, advancement will take a serious commitment of talent and funds. Biotechnology offers tremendous potential for improving crop production, animal agriculture, and bioprocessing. It can provide scientists with new approaches to develop higher yielding and more nutritious crop varieties, improve resistance to diseases and adverse conditions, or reduce the need for fertilizers and other expensive agricultural chemicals. In animal agriculture, its greatest immediate potential lies in therapeutics and vaccines for disease control. Bioprocessing is the use of living systems or their components to create useful products that offer opportunities to manufacture new products and food, treat and use wastes, and use renewable resources for fuel. Biotechnology could also improve forestry and its products, fiber crops, and chemical feed stocks.

Biotechnology encompasses many factors, not just research, but includes policy, networking and management²⁰.

2.4.1 Conceptual theory of Genetically Modified Crops (GMCs)

Plant breeding, the movement of desirable traits between plants by the use of the traditional Mendelian techniques, has played a major role in modern agriculture by providing plants with increased disease resistance and higher yields. However, there are inherent problems with this method. For example, it may take as long as ten to fifteen years, to introduce, select and establish a particular trait into a commercial cultivar and very often, some trait of agronomic importance are impossible to introduce by conventional techniques. In addition, breeding for disease resistance has been complicated by the continuing emergence of “new” pathogens which eventually overcome the “resistant” variety.²¹

Genetic engineering promises to accelerate the breeder’s efforts in obtaining plants with an increased resistance to virus, herbicides, and insects (Fraley et. al. 1988)²². Insect-tolerant plants are an example of how genetic engineering has increased the gene pool available to the

²⁰ Maredia and Erbisch (1998). p. 49.

²¹ Luis Destefano-Beltran et. al (1991). p. 24

²² Fraley et. al. (1988). pg: 283-298.

breeder. Traditionally, breeders relied on the existence of alternative characteristics found among plants of the same or closely related species. By using the insect toxin gene of *Bacillus thuringensis* (Bt.) researchers have opened new doors for crop improvement.

GMCs are produced using scientific techniques that enable the alteration or transfer of genetic material across living cells and organisms. This aims at engineering particular trait or characteristic. Some of the potential benefits of GM crops include improved productivity (by the way of higher yields and lower input costs), more sustainable production, lower adverse externalities (e.g., from pesticide use), and expansion in the range of products available for consumption. Concerns have also been raised, however, over the potential for adverse effects of producing and consuming GM crops, including risks to human health, harm to the environment, further concentration of supply and for some unacceptable ethical implications.

2.4.2 Risks involved with GM Crops

By applying the tools of modern molecular biology, it is possible to produce genetically engineered organisms tailored to particular uses. After laboratory development, field trials of transgenic (or any novel, introduced) products involve the potential for an adverse effect after release into the open environment. The inherent danger to ecosystems and/or human health must be assessed and managed through risk assessment protocols. Over the past decade, the use of agricultural products modified through biotechnology has moved beyond the laboratory stage. Specific protocols have been developed for these products. Many crops grown from genetically altered seeds are widely marketed, and engineered microbes for agricultural use are widely available. Microbes are used for other environmental purposes, especially for bioremediation. Although engineered microbes for bioremediation are not widely available, general use of natural microbes, alone or as members of a consortium, is common.

Consider the following description of the framework for risk assessment as a methodical progression via three main steps²³. (Adapted from G. Hall, 1995).

- i. Identify potential hazards.

²³ G. Hall (1995). Genetically Modified Organisms, A Guide to Biosafety. G.T. Tzotzos, ed., CAB International, Oxon, UK.

- ii. Estimate the probability that a hazard will cause actual harm (i.e., the risk) by assessment of exposure to the hazard and its consequences, and by assessment of the level of risk by consideration of the magnitude of harmful consequences and the likelihood of their realization.
- iii. Select and assign appropriate containment and control measures (also termed risk management).

2.4.3 Types of hazards

The potential for hazard of biological materials can be divided into the four categories viz. infectious, allergic, toxic and environmental hazards. Of these, infectious and environmental hazards, are the results of the continuing growth of the organism to produce the undesirable effect. Allergic and toxic effects may or may not involve concurrent growth of the organism. The 1986 Organisation for Economic Co-operation and Development (OECD) publication “Recombinant DNA Safety Considerations” (p. 27), categorizes biohazards as:

- i. Infection hazard - the potential for disease in man, animals, and plants following exposure to the living organism or virus;
- ii. The toxic, allergenic or other biological effect of the non-viable organism or cell, its components or its naturally occurring metabolic products;
- iii. The toxic, allergenic or other biological effect of the product expressed by the organism;
- iv. Environmental effects.

The challenge for researchers is to obtain enough data to answer these questions with confidence. As has been the case in terrestrial field trials, the goal with regard to transgenic will be to balance environmental and public health concerns against the potential benefits of responsible scientific and commercial applications of this new technology.

2.5 Genetic Resources: Biodiversity, Biotechnology and Biosafety

Fundamental changes are occurring in how, for whom, and by whom genetic resources are used. International Food Policy Research Institute (IFPRI)’s research addresses the economic incentives to use genetic resources efficiently and equitably in biotechnology research and biodiversity conservation; the social and institutional structures that affect the choices of

farmers, gene bank managers, biochemists, and scientists; and the implications of their choices for developing countries. Researchers are focusing on how biotechnology could meet the needs of the poor, including where biotechnology may not be necessary, or may even be detrimental.

The nature of the genetic resources generated by scientific research has changed, and so are the rules for conducting research. The rise of proprietary technologies owned by large seed companies is restricting the access of public institutions to the tools they need and raises serious questions about the extent to which new agricultural technologies will contribute to the elimination of hunger and poverty. A few developed countries with strong intellectual property protection supply the key technological developments used in biotechnology, but the demand comes from farmers and seed companies in many poor countries of Africa and Asia.

Devising policies that encourage transactions between rich right holders and poor right users is critical if the poor are to benefit from proprietary technologies. IFPRI research on technology innovation addresses changing intellectual property markets in developing countries, effects of contractual arrangements on access to technology, and research partnerships between public and private sectors in developed and developing countries. Other research on biotechnology products is identifying the complementary investments to ensure that benefits from these technologies are realized, including those that address farm-level impediments to adoption, the design of appropriate biosafety regulations, and intellectual property regimes.

IFPRI is also analyzing the impact of attitudes toward and policies on Genetically Modified (GM) crops on world markets, especially in developing countries. Researchers have reviewed evidence on GM food safety, and are conducting assessments of the likely costs and benefits of crop biotechnology products that hold promise for food-insecure people. In 2002, IFPRI partnered with the International Plant Genetic Resources Institute (IPGRI) to initiate research on biodiversity conservation emphasizing on-farm conservation of cultivated crops in their places of origin and off-farm conservation in breeders' collections or gene banks. With IPGRI, IFPRI is implementing a set of empirical studies in countries with a range of crops,

farming systems, and income levels. Farmers' rights crux is to save seed from harvests, to claim ownership over varieties as do off-farm plant breeders, and to be rewarded for the use of their plant genetic resources by others - are being analyzed as incentives for conservation.

International Food Policy Research Institute (IFPRI) collaborates with ISNAR on the USAID-funded program for Biosafety Systems, which promotes full involvement of the agricultural sector in making regulatory decisions. This program is based on new models for regional collaboration, biosafety capacity building, and policy roundtables on GM crop safety. The future of smallholder farming depends on efficient and equitable food systems.

2.6 Industry Structure and Strategy

In the words of Barr (2004)²⁴: “As our knowledge of strategy has evolved, however, we increasingly recognize that it is as much the differences between firms as the similarities across them that are important to advantage (Barney 1991; Wernerfelt 1984). Further, we have come to view strategy as an inherently social creation; one that develops through the interactions of people (most frequently managers) with one another (Geletkanycz & Hambrick 1997; Lovas & Ghoshal 2000) and with the environment (Greve 1998; Korn & Baum 1999). For example, while we may know that unique and complex resources can be used to create competitive advantage in the marketplace, we do not understand how those resources evolve, what makes them unique, or how they are integrated into strategy to create sustainable advantage (Kazanjian & Rao 1999; Zajac 1992). It is this more socially oriented, contextually situated view of strategy that demands a more qualitative approach to strategy research”.

2.7 Issues Related to Intellectual Property Right (IPR)

Research and development have three major strategic goals in any organization. Their purpose is to contribute to the existing businesses by allowing the organization to defend market and product positions, to support sales growth and to expand existing business. Research fundamentally generates intellectual property for the organization. If the activities of the research element are directed properly, the intellectual property will have tangible value on the balance sheet. This asset will be eventually used to develop new products.

²⁴ Barr, 2004, p. 165-167.

Salazar²⁵ et. al. (2007) viewed “current farmers’ breeding goes beyond the gradual selection in landraces and includes development and maintenance of major new farmers’ varieties that are increasingly uniform. This case is particularly seen in South-East Asia. Modern varieties developed in the formal sector have simply replaced landraces as the source of diversity, but have not abolished farmers’ breeding practices. Interpretations of the new international agreements on plant genetic resources should protect the development of modern farmers’ varieties. However, ensuring recognition of collective innovation, allowing access to relevant germplasm sources for farmers’ breeding activities, keeping materials freely available, and arranging for effective benefit sharing, all form major challenges”. This paper proposes a new protective measure “origin recognition rights”.

Erbisch and Velazquez (1998)²⁶ stated that usually, IPR is protected by one of three legal theories: copyrights, trademarks or patents. These theories demonstrate that IPR are private rights. They have been created to ensure protection against unfair trade practice. Owners of Intellectual Properties (IP) are granted protection by a state and/or country, under varying conditions and periods of time. This protection includes the right to: (i) defend their rights to the property they created; (ii) prevent others from taking advantage of their ingenuity; (iii) encourage their continuing innovativeness and creativity; and (iv) assure the world a flow of useful, informative and intellectual works.

The violent opposition from non-governmental organizations (NGOs) and farming communities in some parts of country raises the issue against IPRs especially, on plant breeders’ rights and farmer’s right. The major problem in the implementation of farmers’ right is differential approach towards the property. The IPR on seeds to farmer does not make any sense to communities where seed is the property of the community and does not belong to any individual²⁷.

²⁵ Salazar, Rene; Louwaars, Niels P. and Visser, Bert (2007). pp 1515-1528.

²⁶ Erbisch and Velazquez (2006), p. 4.

²⁷ Arunachalam, V.2001.

“As an institution Intellectual Property laws has two purposes; the protection of individual rights and the promotion of general welfare. These two purposes exit in tension and this tension is the source of intellectual conflict”²⁸. New patent and IPR regime up to some extant ignore the contribution of traditional farmers and artisans for the conservation of nature and natural resources. In case of agriculture, most of the varieties are developed by the genetic resources conserved by the resources poor gene rich informal innovators. But scientific advance involves the collaboration of both past and present generation.

New IPR regime emphasizes on the individual ownership of invention: which is against the Mertonian ethos of science. “The communism of scientific ethos is incompatible with the definition of technology as ‘private property’ in a capitalistic economy²⁹”. Property rights in science are against the second ethos of science. This difference is because finding of science are a product of person (scientist) with social collaboration and community³⁰. The relationship between science, and society may be examined at two levels: (a) First from the stand point of nature of activity of science itself, (b) Second from the stand point of relationship between science and society; that is why science is affected by social forces and manners in which science influences society. The ethos of the social institution of science is taken to include universalistic criteria of scientific validity and scientific worth, thus involving values easily integrated with the values of a free society in which it is men's capacities and achievements which matter, not their ascribed status or origin. From the sociological point of view, the place of science in the totalitarian world is largely the same as that of all other institution except the newly dominant state”³¹.

“In the post 1990 globalization era, the traditional autonomy of science and its rules of the game - it’s either, in short challenged by the external authority”. It may be argued that the external authority may be transnational corporation and State.

²⁸ Evanson, R. E. and Puntam, J. D. (1987, May). Institutional Change in Intellectual Property Rights. American Journal of Agricultural Economics, Vol.69.No.2. pp.403-409

²⁹ Merton. R,K, Science and Social Structure. The Free Press, New York .p. 612

³⁰ Ibid. p. 612

³¹ Merton. R,K, Science and Social Structure. The Free Press, New York .p. 609

2.7.1 Patent Issues

Vandana Shiva (1999) captured the sense of outrage about the role of these corporations in the making of the Trade-related Aspects of Intellectual Property Rights (TRIPS) Agreement when she said: “the TRIPS Agreement of General Agreement on Tariffs and Trade (GATT) is not a product of negotiations. It has been imposed by transnational corporations on the citizens of the world, by manipulating the governments of industrialized countries. The framework for the TRIPS Agreement was conceived and shaped by the Intellectual Property Committee (USA), Keidanren (Japan) and UNICE (Europe)”³².

Barton³³ (1998) explores the intellectual property issues involved in traditional breeding and in moving from natural material to the improved lines that are marketed themselves or used as parents of a hybrid. The research highlights the access to unimproved germplasm and the implications of the United Nations Convention on Biological Diversity. He talked about relevant forms of intellectual property protection as applied in USA which includes the plant variety protection (PVP) system, the regular patent system and trade secrecy. Further, he brought out the relationship between intellectual property and biodiversity.

Maredia and Erbisch³⁴ (1998) talks of the integrated approach to IPR capacity building which includes the following: (i) awareness creation; (ii) human resource development; (iii) institutional development; and (iv) information access. They further emphasized, “proper awareness of biotechnology-related issues must be created nationally. Since the IPR issues are closely tied in with the use and management of biotechnology, nations must create proper awareness among the general public, policy makers, scientists and administrators”. Further they ascertain that large investments in new biotechnologies have been made by the private sector in developed countries. While many of these promising new biotechnologies reside in industrial countries, they may offer new ways in which developing countries could enhance their agricultural productivity. These technologies are often proprietary in nature and must be managed in a different way from non-proprietary technologies. In the past, technologies

³² Shiva, Vandana (1999). p.158.

³³ Barton, John H. (1998) p.19. The inter-relationships between intellectual property and biodiversity are vividly explained in pages 19-21.

³⁴ Maredia, Karim M. and Erbisch, Frederic H. (1998). p.50.

developed by the public sector were freely exchanged, particularly agriculture-related technologies such as crop varieties and germplasm.

About policy changes and foreign direct investment, Ganguli³⁵(1998) states: with the declaration in 1991 of intent to open up the Indian economy, significant changes have been initiated in Indian economic and industrial policies. Two changes that have had immediate impact on the agriculture, foods, drugs/pharmaceutical sectors are as follows:

- a. Hybrid high-yielding seeds, tissue culture propagation of elite plant materials, biofertilizers and biopesticides are classified as industrial activities.
- b. Bulk drugs involving use of recombinant DNA technology, and bulk drugs requiring in vivo use of nucleic acids as active principles and formulation based on use of specific cell- or tissue-targeted formulations, would require compulsory licensing.

These have already set the scene for development of biotechnology based industries in India. Extensive national debates on various issues related to IPR and the Indian Patents Act 1970 have also taken place in the last few years. These have helped to enhance the level of patent literacy considerably. The first impact has been on the amount and type of foreign direct investments that have flowed into India since 1991.

The patent provides benefit to innovators by rewarding them but it also excludes others for its use. So it provides example of rights to excludes. “Patents proclaim exclusive rights of use and, often, non-use³⁶”. Patent holders want to maintain secrecy of its invention due to motivation of more economic incentives. “The institutional conception of science as part of the public domain is linked with the imperative for communication of findings. Secrecy is the antithesis of this norm; full and open communication its enactment³⁷”.

Scientists are divided into two schools of thoughts, one group is in favour of voluntary disclosure of their invention for serving humanity by means of informed citizenry to advance the status of masses; but the other group wants to maintain secrecy. But, it is argued that

³⁵ Ganguli, Prabuddha (1998) p.142

³⁶ Merton, Robert K.(1968) Social Theory and Social Structure, The Free Press, New York. p.612

³⁷ Bernal. J.D, The Social Functions of Science. p.150-151

“science flourishes and scientist make progress in an atmosphere of free enquiry or free interchange of ideas with the continued mutual stimulation of active minds working in the same or related fields. Any imposition of secrecy in science is like application of a break to progress”³⁸.

Modern technology has both fruitful and adverse impact on commons. It depends on the State and society how to use the scientific advancement for upliftment of the masses. Biotechnology revolution may be analyzed in this context. This technology may free India from hunger and malnutrition, but there is also threat for commercialization of developing countries agri-market and also monopolization of production by transnational corporation. But so far policy issues concerned biased view for fulfillment of desire of anyone stakeholders can not solve the problems of our masses. Science is a dynamic force of social change, though not always of changes foreseen and desired. But science has social consequences also³⁹.

In the word of Primrose⁴⁰ (1987), “recent advances in biotechnology have created many public policy and legal issues. A number of the most relevant are discussed here: patents, deliberate release of recombinant organisms, ethical and legal aspects of gene therapy, legal implications of DNA fingerprinting, biological warfare, and the future of biotechnology in third world countries. Scientists often find the practice of industrial law confusing; they are used to constructing theories based on the (supposed) rational examination of facts. Lawyers also examine facts but they interpret them within the framework of existing law. Unlike new theories, new laws are not created instantly and final acceptance comes only after months or years of courtroom debate. Reaching a final decision can take years. Nowhere is this clearer than in the field of patent law. Even though a patent examiner permits a patent to be issued, his decision may be challenged in the court of law by a third party may deliberately infringe a patent in the belief that the patentee would lose his case if he chose to defend his patent rights in a court of law”.

³⁸ Merton, Robert K.(1968) Social Theory and Social Structure, The Free Press, New York. p.150-151

³⁹ Ibid. p. 585

⁴⁰ Primrose, S. B. (1987). Modern Biotechnology. Blackwell Publications, p.187.

2.8 Policy Initiatives and Indian Seed Industry

Brahmi⁴¹ et. al. (2004) states that Indian PVPER Act appears to be effective *sui generis* system providing a balance between plant breeder rights along with Farmers' Rights and researchers' rights in view. The impact of the Indian *sui generis* system will be felt only after is effective implementation, and ultimately, it can secure the national food and nutritional security. But still there is a need for appropriability between all the acts.

Ramaswami⁴² (2002) observed that the changing structure of seed industry is due to new technologies and stronger intellectual property right. He stressed that the small part of work is necessary for market forces, transnational companies, and patents of biotechnology itself to fair equitable growth of industry respect to farmers concerns.

Reddy and Yadav⁴³ (2001) in their paper, based on the existing literature on consequence of Genetically Modified Crops and its impact on food security and food safety in the context of Genetically Modified Crop, WTO and TRIPs, concluded that the GM crops with adequate safety measures and regulations would be needed for proper adoption of technology transfers.

Singh⁴⁴ et. al. (1999) argued that country like India where no Indian domestic small firms can compete with the giants MNCs in any respect. They suggested that government supports should be needed in a big way in research and development and development of biotechnology. So that our scientists can be able to develop indigenous local biotech varieties and get their patented rights without delay.

Sindhu⁴⁵ (1999) stated that implication to the Indian agriculture under the shadow of new IPR and strong patent regime may prove harmful. He argued that taking liberty of some relevant extension is necessary because most of the third world countries own less than one percent of world patent grants. The system is quite clearly most unequal and unjust of all the relationship

⁴¹ Brahmi, Pratibha; Saxena, Sanjeev and Dhillon, B.S. (2004).

⁴² Ramaswami, B., 2002.

⁴³ Reddy and Yadav, 2001.

⁴⁴ Singh A Singh and Singh, 1999.

⁴⁵ Sindhu, 1999.

between the developed and developing countries. It has been quite absurd to comprehend that the same law can be made suitable for countries with unequal level of development.

2.8.1 Policy Linkages to strategy and structure

Hitt et. al. (2004)⁴⁶ mentioned in their study that the degree of regulation is one of the important industry level variables in strategic management.

2.8.2 Agricultural Science and Technology Policy

The process of technical change is a phenomenon which is difficult to unravel. For the present purpose, four components can be distinguished at a theoretical level. The development of new technical possibilities, the application of new methods of production and of new products, the diffusion of technical knowledge, and the diffusion of applications. Even a nation's technology policy is based on global explanation and in this sense, it being aimed at welfare in the broad sense of the satisfaction of wants.

While the WTO agreements do not regulate the use of biotechnology per se, their rules can have a profound impact on the use of the technology for both commercial and non-commercial purposes. Wüger and Cottier (2008)⁴⁷ seeks to identify the challenges to international trade regulation that arise from biotechnology. Their contribution examine whether existing international obligations of WTO members are appropriate to deal with the issues arising for the use of biotechnology and whether there is a need for new international legal instruments, including a potential WTO Agreement on Biotechnology. They combine various perspectives on and topics relating to genetic engineering and trade, including human rights and gender; intellectual property rights; traditional knowledge and access and benefit sharing; food security, trade and agricultural production and food safety; and medical research, cloning and international trade.

The quantitative restrictions has been removed at the time when hundreds of farmers are committing suicides in Punjab, Andhra Pradesh, Karnataka, Maharashtra and in different

⁴⁶ Hitt et. al. (2004) p.14.

⁴⁷ for detail please see : Wüger, Daniel and Cottier, Thomas (2008).Genetic Engineering and the World Trade System: World Trade Forum. Cambridge University Press.

other parts of the country, some of them are being forced to sell their kidneys and other body parts due to increased cost of production, the subsidies are being withdrawn from the agricultural inputs, forcing more and more small and marginal farmers to get trapped under debt burden, the FCI is withdrawing from its primary responsibility of food procurement because it is found as ecologically and financially unsustainable and therefore, the government is planning to totally privatise the storage and procurement of food grains. This has led to a deep crisis in our food and farming systems and further pauperization of our farmers⁴⁸.

2.9 Science & Philosophy of Science

Any legitimate scientific theory will make predictions. A scientific theory will not be rejected just because it cannot explain particular observations or results from a particular experiment. Kuhn (1970) argues that for a new theory to replace an old theory two conditions must be satisfied

- i. There must be serious cracks in the old theory, i.e. important facts that the old theory does not explain.
- ii. A new theory must be available.

Why replace a theory, even one that has evident flaws, unless something better is available with which to replace it?

There are further issues:

- a. When observations or an experiment give results that are contrary to a well established theory, is it the theory or the experiment that is mistaken? There may have been a flaw in the experimental procedure.
- b. Flaws in experimental procedure are especially common when one is working at the limits of experimental technology. It may be at these limits that theory has its most extreme test.
- c. Often, a small modification to the theory may be enough to accommodate a newly discovered anomaly.

⁴⁸ Shiva2002

- d. Scientists may be so deeply wedded to the existing theory that they refuse to accept the new theory. This is particularly likely if the new theory is itself incomplete, i.e. many of the theoretical details have not been worked out.

2.10 Innovation, Technology and R&D

Kitcher (2001) drawing a distinction between science and technology states that it thus undermines the idea that technology is the appropriate focus of moral appraisal, leaving science as pure. The evidence for scientific claims is always insufficient, so that our decisions about what to believe are always crucially affected by moral, social, political, and religious values.

2.10.1 Innovation

Schumpeter⁴⁹ noted that “innovation itself is being reduced to routine. Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways”. In 1950’s Drucker (1954) said, “any business enterprise has two - and only these two - basic functions: innovation and marketing.” Innovation is the act of developing a new processor product and introducing it to the market. It is essentially an entrepreneurial act, whether it takes place in a start-up firm, a large organization, a not-for-profit, or a public-sector agency. Innovation means change: sometimes radical change. Innovation generally stems from the purposeful search for opportunities. “Drucker (2002) identified that opportunities for innovation exist both within and outside a company or industry. Opportunities internal to a company include unexpected events, incongruities in processes or between expectations and results, process needs, and changes in the marketplace or industry structure. Opportunities external to a company include demographic changes, changes in perception, and new knowledge”.

Strategic management has profound importance for innovation as Dosi⁵⁰ et al. (1988) suggest, ‘strategic management may and does orient market position and learning trajectories in the long term’.

⁴⁹ Schumpeter 1942 p.132

⁵⁰ Dosi et al. 1988. p.7.

2.10.1.1 New Knowledge

New knowledge or technology is one of the strongest forces for innovation. Opportunities are being explored in the fields of genomics and nanotechnology. These technologies and systems will develop even further as consumers continue to demand new and innovative products and immediate access to information, goods and services.

2.10.1.2 Management Innovation

Innovation must be seen as a process occurring within an organization, not a single event. This process can be managed. In general, the process follows five stages:

- i. Idea generation,
- ii. Initial screening,
- iii. Review,
- iv. Seeking sponsorship, and
- v. Sponsorship and commercialization.

At each of these stages the organization's culture must be designed to support the innovation process.

Recognition of demand is a more frequent factor in innovation than recognition of technical potential (Meyers and Marquis 1969). Before 1970's market demand was the dominant influence upon the innovation process, "calling forth" innovation in market economies. But both demand and supply side influences are crucial to understand the innovation process (Mowery and Rosenberg 1979). Technological innovation can alter the competitive status of firm and nations⁵¹. Research shows that the best way for companies to achieve competitive advantage is innovation (Rugman. and Hodgetts 1995).

2.10.2 Technology

In traditional neo-classical growth theory technical change is "simply" modeled with a shift in the production function that represents the adoption of a more productive technology. But as Ayres (1962)⁵² argued, "technology is essentially an autonomous , self sustaining process,...

⁵¹ Roberts, Edward B. 1988.

⁵² Ayres (1962). pg. 125-54.

the potential for fruitful discoveries will be enhanced in a receptive environment”. In similar vein, Fagerberg and Verspagen (2002)⁵³ note, “technology catch up is not a question of replacing an outdated technological set with new one, but to continually transform technological, economic and industrial structures.”

Technology draws heavily on scientific advances and the understanding gained through research and development. It then leverages this information to improve both the performance and overall usefulness of products, systems, and services. In the context of a business, technology has a wide range of potential effects on management:

- i. Reduced costs of operations
- ii. New product and new market creation.
- iii. Adaptation to changes in scale and format.
- iv. Improved customer service.
- v. Reorganized administrative operations.

Annacchino⁵⁴, (2003) discussing about the technological fit with respect to new product development highlight following pertinent issues:

- a. Internal fit: are all elements of the business equipped to handle the technology?
- b. External fit: Is the technology right for the market place?
- c. Is the cost of this technology on the appropriate learning and cost-reduction curve?

The issue of application development requires technological engagement with the customer, in addition to commercial engagement. This is where the basic building blocks of technology embodied in the product are available for redistribution and reconfiguration into different products altogether, from the factory perspective; however, they are an on-target solution to the customer’s problem. An example of this reconfiguration of features is to think of the original part as a “toolbox of technology”. Both development and manufacturing that can be

⁵³ Fagerberg and Verspagen (2002).

⁵⁴ Annacchino, (2003) p.176.

used to solve different customer problems in different applications⁵⁵. The identification of market opportunities that are on target with the product launch plan, as well as identifying new opportunities for small changes in the product configuration. The market development aspect gives true definition to the term engagement of the customer. It is most effective when the customer is an active participant in the communication between the sales force and themselves.

Michael Porter is one of many business analysts who believe that technology is one of the most significant forces affecting business competition. In his book *Competitive Advantage* (1985), Porter noted that technology has the potential to change the structure of existing industries and to create new industries. “The job of technology is to provide competitive advantage. That advantage derives partly from the inherent attributes of technology at a given stage of maturation, but also from the characteristics of competition and from effective integration with other capabilities in an enterprise (Steele⁵⁶)”. It is also a great equalizer, undermining the competitive advantages of market leaders and enabling new companies to take leadership away from existing firms.

According to Bromley (2004), a permanent fusion of science-or natural philosophy-and inventions that had previously been essentially independent activities, devoted to the understanding and the mastery of nature, respectively.

2.10.2.1 Science and Technology

Science and Technology are an integral part of culture; they act as instruments of social evolution. Throughout history, society has promoted knowledge in order to meet human requirement and to solve problems. Looking back, we find a dynamic interaction between knowledge and its application to social problems similarly, the impact of social needs and requirements have led to the generation and development of technology⁵⁷.

⁵⁵ Annacchino, (2003) pp.464-465.

⁵⁶ Steele, Lowell W.(1991, Jul-Aug). “Needed: New Paradigms for R&D”; *Research Technology Management* Vol-34, No.-4

⁵⁷ Rahman and Choudhary 1980 p.iii

2.10.2.2 Technology as a Strategy for Market Competition

Zahra⁵⁸ et. al. (1999) in their research article '*Exploiting the dynamic links between Competitive and Technology strategies*' discussed about Technology-Strategy relationship for market success. They stated that 'the dynamic (dyadic) perspective of technology management recognizes the importance of formal technological initiatives as well as prospecting.' They summarized three perspectives which bring connection between competitive and technology strategy. The first espouses a hierarchical view in which a company's competitive strategy and internal capabilities jointly determine its technological choices. The second perspective views technology as a subset of organizational resources and one of several vital strategic weapons a company can use to pursue its competitive goals. And the third perspective that builds on the dynamic interplay between a company's competitive strategy and technology. The article concludes by discussing the implications of the dynamic perspective for executive action, highlighting industry forces that may impact the dynamic strategy-technology relationship.

Iansiti and West⁵⁹ (1997) ascertain that a company's approach to technology integration must fit its capabilities and local culture.

Porter⁶⁰ (1985) sees technology as an important element that should have its own strategy. He defines technology strategy as "a firm's approach to the development and use of technology" and suggests that: "Technology strategy must address three broad issues:

- a. What technologies to develop?
- b. Whether to seek technological leadership in those technologies?
- c. The role of technology licensing."

He then describes the link between technology and corporate strategy by identifying four generic corporate strategies and a matching set of technology strategies (page 173). While Porter views technology as important, he does not pursue the subject in great detail. According to his view technology strategy is derived from overall corporate strategy.

⁵⁸ Zahra, Shaker; Sisodia, Rajendra and Matherne, Brett (1999). pp 188-203.

⁵⁹ Iansiti Marco and West, Jonathan in HBR on Managing High-Tech Industries (1999) p.7. (First Published in Harvard Business Review, May-June 1997).

⁶⁰ Porter (1985). *Competitive Advantage*. pages: 176, 177.

Prahalad and Hamel (1990)⁶¹ intensify the interest in technology by introducing the concept of “core competencies.” They subtly expand the view of technology from a broadly described feature whose importance is determined by its support of the corporate mission, to a specific source of corporate uniqueness. According to the authors, core competencies are the collective learning of the organization, especially how to coordinate diverse production skills and integrate multiple streams of technology. The concept of core competencies, with its implied link to technology, has become one of the dominant concepts in mainstream strategic literature. According to Prahalad and Hamel, technology and corporate strategy are seen to co-determine one another. After the concept of core competencies was popularised, Hamel and Prahalad (1994) published a book entitled *Competing for the Future*. From the consumer concern with competitive advantage that dominated the literature in the preceding decade, the emphasis now reached forward in time urging managers to secure a ‘foothold in the future.’ By comparison to earlier works on strategy, *Competing for the Future*, strikes an almost new dimension. “We had to conclude that some management teams were simply more ‘foresightful’ than others. Some were capable of imagining products, services, and entire industries that did not exist and then giving them birth”⁶². Further: “the future is to be found in the intersection of changes in technology, lifestyles, regulation, demographics, and geopolitics”⁶³. In *Competing for the Future*, Hamel and Prahalad repeatedly emphasize technology foresight as part of an overall awareness of the future and as a dominant ingredient in strategy formation. They substantiate the views of those who see technology as having a dominant role in corporate strategy.

2.10.3 Research and Development (R&D)

Lee & O’Neill (2003)⁶⁴ in their study brought out the relationship between ownership concentration and R&D investment.

⁶¹ Prahalad and Hamel 1990 p.82

⁶² Hamel and Prahalad 1994 p. xi

⁶³ *ibid.* p. 95

⁶⁴ Lee and O’Neill, 2003

The Frascati Manual (OECD, 1993)⁶⁵ classify R&D into three distinct type: basic research, applied research and experimental development. The primary objective of basic research is to acquire, new knowledge of the underlying foundations of observable phenomena.

2.10.3.1 Agricultural research and development (R&D)

While global investment in agricultural research by the private sector is increasing with growth in developing country markets and the emergence of new technologies, complementary public sector investment is stagnating or declining in many developing countries. Spielman⁶⁶(2007) argues that the changing roles of the public and private sectors in generating new scientific knowledge may adversely affect the diffusion of explicitly pro-poor technologies-technologies that are simultaneously yield enhancing and poverty-reducing. Comparing historical evidence from the Green Revolution with recent evidence from the emerging era of agricultural biotechnology, this review argues that a more pluralistic international system for agricultural research will be more responsive to poverty only if the strategic leadership role of the public sector is strengthened, certain research functions are reallocated to the private sector, and new policy and organizational mechanisms are used to stimulate pro-poor research in and for developing-country agriculture.

Tripp⁶⁷(2002) states that the growth of private sector participation in agricultural research has serious implications for pro-poor technology development, but there are other factors that must be considered. New plant varieties are not the only things standing between resource-poor farmers and secure livelihoods, and institutional strengthening is also necessary. In addition, the current state of public agricultural research is cause for concern. It is not clear how many effective public-private partnerships can be formed; the public sector needs a much clearer definition of its targets and priorities; and funding strategies for national and international agricultural research must be overhauled. He further concludes that advances in private agricultural research are contributing to increasing polarization in access to technology. It is important to focus attention on the needs of resource-poor producers and the role of public research.

⁶⁵ OECD, 1993

⁶⁶ Spielman, David J. (2007) pp 189-204.

⁶⁷ Tripp, Robert (2002) pp.239-246.

The system that produces technological advances in agriculture-is changing rapidly. New ways of financing, managing, and organizing agricultural R&D; changes in the biological sciences; and the proprietary nature of the agricultural sciences are affecting how well national and international R&D systems can meet global food needs. IFPRI monitors these changes with research on public and private-sector roles in agricultural R&D, the impact of biotechnology advances, the effects of stronger intellectual property rights on agricultural research and gene banks, and ways to measure the impact of agricultural R&D on poverty, agricultural growth, and the environment.

2.11 New Product Development

Ofek⁶⁸ (2008) states that launching new products is perhaps the most prevalent way for start-up firms to establish themselves in a market and is a common strategy for incumbent firms to retain their industry position and grow top line profits. To reap the rewards from new product introductions, the characteristics of the new product must first be conceived, developed, and ultimately sold in the marketplace. While new products hold the promise of greater profitability, the process from start to finish is costly, time-consuming, and fraught with uncertainties.

Mentioning about distance between the company (and its infrastructure) and its customers, Thomke and Von Hippel⁶⁹ (2002) observe: “in a nutshell, product development is often difficult because the ‘need’ information (what the customer wants) resides with the customer, and the ‘solution’ information (how to satisfy those needs) lies with the manufacturer”.

According to Kotler⁷⁰ (2000) every company must develop new products. New-product development shapes the company’s future. Replacement products must be created to maintain or build sales. Customers want new products, and competitors will do their best to supply them. Each year over 16,000 new products (including line extensions and new brands) are introduced into groceries and drugstores. A company can add new products through acquisition or development. The acquisition route can take three forms. The company can buy

⁶⁸ Ofek, Elie (2008). p. 49.

⁶⁹ Thomke and Von Hippel (2002) p.5.

⁷⁰ Kotler, Philip (2000) p. 328.

other companies, it can acquire patents from other companies, or it can buy a license or franchise from another company. The development route can take two forms. The company can develop new products in its own laboratories. Or it can contract with independent researchers or new-product-development firms to develop specific new products.

Citing 'Booz, Allen & Hamilton', Kotler⁷¹ (2000) has identified six categories of new products:

- i. New-to-the-world products: New products that create an entirely new market.
- ii. New product lines: New products that allow a company to enter an established market for the first time.
- iii. Additions to existing product lines: New products that supplement a company's established product lines (package sizes, flavors, and so on).
- iv. Improvements and revisions of existing products: New products that provide improved performance or greater perceived value and replace existing products.
- v. Repositionings: Existing products that are targeted to new markets or market segments.
- vi. Cost reductions: New products that provide similar performance at lower cost.

Less than ten percent of all new products are truly innovative and new to the world. These products involve the greatest cost and risk because they are new to both the company and the marketplace. Most new-product activity is devoted to improving existing products.

New product development is a business venture⁷². To effectively evaluate the fit of a new product, it is necessary to understand the company's overall product strategy⁷³. Answering to the question, "how does the new product development solve a customer's need/problem?" he stated that New Product Development is the basis for a marketing plan. Effectively answering this question will directly tie the customer's need into the product concept. The pathway is the

⁷¹ Kotler (2000) p. 328

⁷² Annacchino, (2003) p.4

⁷³ Annacchino, (2003) p.3.

sales presentation. It relates to the customer and how the solution to their problem or need is embodied in the product. The question leads to the investigation of following factors⁷⁴:

- i. Large versus small companies
- ii. Public versus private
- iii. Technology developer versus pure manufacturer
- iv. Product offering, which is commodity versus service
- v. Profitable versus not profitable
- vi. Availability of cash
- vii. Competitive nature of the 'deal'
- viii. Perception in the marketplace
- ix. Perception of weakness
- x. Limiting factors on one firm in the deal
- xi. Recoverability index for both companies should a deal go bad

Iansiti and West⁷⁵ (1997, 1999) argue, “in many industries, superior technology integration—the approach used to choose and refine the technologies employed in a new product, process, or service is key to achieving superior R&D productivity and speed, and superior products”.

2.11.1 Scope of Product Line

To identify the product's positioning, the markets served the breadth of the product line, and the number of versions. The size and rating performance requirements in terms of market segments, and identify the scope of how the product will satisfy the market demand. Companies need to take care to of the specific in identifying how selected versions address specific segments⁷⁶.

⁷⁴ *ibid.* p.71.

⁷⁵ Iansiti Marco and West, Jonathan in HBR on Managing High-Tech Industries (1999) p.1. (First Published in Harvard Business Review, May-June 1997).

⁷⁶ Annacchino, (2003) p.137.

2.11.2 Life cycle management of a product

Several factors can be used to evaluate the degree of success or failure. Fundamentally, outside of the strategic initiatives, a new product development is supposed to generate funds to the corporation at a rate that far exceeds the rate of funds consumption⁷⁷.

In the traditional product life cycle there are three distinct phases of the product life cycle (i.e., emergence, growth, and decline). The emergence phase is the start of the new product's business. The volume is low, and the product is embryonic in its market share. The second phase is the growth phase, where planned volumes are achieved. The third phase is the decline if left untended, the company will lose market share and volume will drop off. Generally at this point the company is no longer competitive in that specific market segment. Ideally, at the time when volume is stabilized and the company is enjoying good profit margin and good volume, the project to replace the product with an updated or next-generation.

Jansiti and West⁷⁸ (1997, 1999) ascertain that Product Life Cycles have shortened dramatically, forcing companies to develop and commercialize new technologies faster than ever. As a result, the advantage now often goes to the companies most adept at choosing among the vast array of technologies and not necessarily to the companies that create them.

Licensing is the most common method of transferring technology⁷⁹.

2.12 Impact of Globalisation on Indian Agriculture

Following are the effects of globalization on Indian Agriculture⁸⁰:

- a. Transnational corporations may dominate the seed market and this will have its baneful effects on the peasants of poor country.
- b. Protection of Plant Breeders Rights under globalization will have its adverse effect on farmer's traditional rights to develop and sell seeds.

⁷⁷ ibid p.176.

⁷⁸ op.cited. p.2

⁷⁹ Erbisch, Frederic H. and Fischer, Andrew J. (1998). p.31.

⁸⁰ Rudrappan, p. 46

- c. The commitment on the removal of input subsidy may lead to deceleration of crop output leading to untold miseries among the resource poor farmers specifically in developing countries.

Bhalla & Singh (1996)⁸¹ raised some serious concern over the impact of GATT on Indian Agriculture which may lead to serious political economy issue. One of their propositions was towards sustainable growth which can be achieved if the policy initiative also focuses the small and marginal farmers. One important area of concern referred in their study is ‘the process of intellectual hegemony’. Their apprehensions towards provisions like intellectual property rights (IPR), Trade Related Intellectual Property Right tend to legalise the intellectual hegemonic tendency of the developed capitalism. These will make indigenous research costly and accelerate the process of accumulation of knowledge in the advance countries and multinationals. Policies related to inputs like fertilizers, pesticides and seeds will be area of larger concern.

2.13 Rural Market and Rural Marketing

Kashyap⁸² (2003) concludes that rural people have evolved systems of selling and communicating that have served them well for centuries. Corporate marketers have not used that these platform effectively, so far.

Ranganathan (2003) argue that the right marketing strategy for the rural market is to balance the conflicting dimensions of ‘availability’ on the one hand and ‘affordability’ on the other.⁸³

2.14 Questions evolved from review of literature

- i. What drives agricultural research? Is it a need generated within the industry?
- ii. Who determines what is driving agricultural research? Is it ‘technology push’ seeking to employ research through the development of techniques and materials looking for applications, or ‘market pull’ in which the need is identified by industry which then seeks a solution through research?

⁸¹ Bhalla, G.S. and Singh, Gurmail (1996).

⁸² Kashyap, Pradeep (2003, July). Revolution-in-waiting. Praxis, Business line. p.8.

⁸³ Ranganathan, C. K. (2003). p.24.

- iii. How closely is the research matched to the need? Who decides and how are the two brought together? Who monitors this decision and the provision of solutions through research?
- iv. What is unique about the product or technology that will be desired and accepted by the marketplace at this particular juncture in time and space?⁸⁴
- v. Who ensures effective use of funds, time, labour and facilities, and who monitors this? Is there any accountability involved? How are the objectives for the research set and who sets them? Who sets the objectives for the funding agencies and are the objectives based on requirements in the real world, perhaps in industry, or to serve a pressing need and, as such, recognized as being essential? Are the objectives influenced by the needs, aspirations or requirements of the scientists? Or are they politically driven, perhaps to satisfy a demand from the public, to gain parliamentary popularity, or for so called political correctness? They may even be strongly influenced by what is thought to be popular or trendy.
- vi. How GMCs are the proponent of the structural change? Is it possible for any technology based product to bring out macro-change in Industry; how? Does this product is able the solve 'need-gap' or it is the 'want-creation' of Industry? What is the trend of the market: demand pull or supply push?
- vii. Does GMCs are safe?
- viii. What should be the response of Indian Seed Companies on the new product technology (Biotechnology based seed)?
- ix. What should be the direction of agricultural research and what is the changing dimension of Indian agriculture under the auspices of TRIPS?
- x. Whether the new IPR regime will be able to enhance the scientific and technological capability to cope up with the emerging technological, social and legal problem?
- xi. The question of concern is that IPRs provides incentive and motivation of carrying out better research for the benefit of the society. Have they only monopolized patents for private sector? There are some important questions that are often debated in various platforms; but there is again polarization of opinions.

⁸⁴ Annacchino, (2003) p.4.

2.15 Research Gaps

- i. The effectiveness of large companies in supplying cheaper inputs in village market of small size needs study⁸⁵.
- ii. The impact of IPR on seed price is quiet unknown, with the most important assumption being as obvious increase in seed price and other agrochemicals. But as far the increase in seed price is compensated by the increase in the productivity and increase in the relative stability of prices, there is a little room for apprehension of its adoption by the farmers.
- iii. Terminator gene seeds such as those developed by the Monsanto Company, as MNC have to be purchased every year and they cannot be conserved as seed for next crop⁸⁶.
- iv. Why some firms in a given industry respond quickly to the moves of a competitor while others delay response to that same move, and why some firms seem to be in continuous battles with one another while others in the industry play a more cooperative game?⁸⁷
- v. There is opportunity of extension of Biotechnology developed technology to proliferate in other seed portfolio.
- vi. Till now the organization structure is being seen from human capital, machinery, process, and product point of view and R&D was a separate entity mostly autonomous. For the first time R&D influence on Industry structure is being studied.
- vii. R&D as a strategy for Indian seed industry is being studied in this research.
- viii. The main aim of R&D is to improve yields and reduce cost of production by optimal use of inputs or both as well as for creating human welfare⁸⁸.
- ix. Private companies in Indian seed industry earlier used to procure the improved seed from the government institution; but now they are developing new product based on their in-house R&D.
- x. The impact of more active participation of private sector seed industries have to analyse at several dimensions. The proponents are in favour of that due to timely availability of quality seed but opponents argued research in the public interest will be severely affected. This may provide a good example of conversion of public good into private good. According to International Rice Research Institute (IRRI) report- “the main worry is that

⁸⁵ Alagh, 2003, p: xvi.

⁸⁶ Rudrappan, p. 50

⁸⁷ Barr, 2004, p.179.

⁸⁸ Mukherjee and Pal, 2003, p. 91.

[Plant Variety Protection] and [Intellectual Property] legislation, if not properly handled, may restrict the free exchange of the genetic material or seeds, needed by scientist to develop to new high yielding varieties”⁸⁹.

- xi. Transnational company’s entry to the Indian seed sector is not being studied.
- xii. Globalization of agriculture and the acquisition of IPR for plant breakthrough in genetic engineering and the seed industry has unparalleled potential for growth and prosperity. These events and developing scenario, however raise several apprehensions which need to be studied.
- xiii. Analysis of policy initiative taken by government of India for safeguarding the interest of all the stakeholders under the obligation of new IPR regime in crop variety development and improvement programme.
- xiv. Scientific experts have been concerned about genetic manipulation and its effect on Biosafety and Biodiversity.
- xv. The ethical issues faced by seed companies marketing the GM Crops are likely to vary based on their particular technology, product focus and stage of development. Some examples of ethical issues that firms are facing as they progress from research to bringing products to market include:
 - a. Who owns genetic information? Is it socially equitable and feasible for commercial companies to own genetic information? Does this unfairly inhibit academic research? How do companies respond to those who claim that no one should patent and sell genetic information? What consent, if any, do companies using this information need from individuals and communities?
 - b. How should seed companies producing biotech product (GM Crop) price their products in Indian economy, to ensure that they can justify the major research costs and risks, and still provide the maximum access and benefit to Indian Farmers?
 - c. How does a company manage the inherent conflicts of interest in its GM- product that it intends to market? At what stage should it be obliged to disclose publicly the results of its research, including negative findings?
 - d. What are the economic, social, and health implications of the move toward GMCs? Will individuals and society be able to afford it?

⁸⁹ Benbrook, Rachel C. (2000). [www.grain.org assessed on 18th June 2007].

- e. How can the benefits of genomics and biotechnology be extended to other crops?

2.16 Formulation of Research Hypotheses

From this chapter we have constructed some arguments which in turn transcend to hypotheses further:

Argument No. 1: Farmers worried about raising enough capital to survive and to see if GM technology works and help them to earn more from their field.

Argument No. 2: Private seed companies in India are too small. These companies worry about from where to get a product (technology) to market specialized product (GMCs).

Argument No. 3: GEAC guidelines implementation, adherence and outcome.

Argument No. 4: GMC are better than pre-existing seeds. Whole business is about helping people.

Argument No. 5: The opponents of GMC argues that the real impact to expect from genetically engineered crop is not how it might feed poor, but how it will expand the wealth of Trans Nationals poised to enter the seed market in India. IPR may be seen as a key component of this strategy to monopolies the seed market and business of countries like India.

2.16.1 Research Hypotheses

The Research Hypotheses are:

Hr1: GM crops provide higher yield, improve pest control, provide drought resistance, reduce dependence on chemical fertilizer, short growing season. Therefore it is better for overall economy; society.

Hr2: Indian market has the potential for GM product.

Hr3: Farmers get more choice.

Hr4: Genetically Modified Crop has positive impact on socio-economic status of farmer.

Hr5: Structure of Industry changes in response to market.

2.16.2 Null Hypotheses

H01: GM crops do not fulfill the promises as proclaimed; like higher yield, improve pest control, drought resistance, reduce dependence on chemical fertilizer, short growing season. Therefore it is not better for overall economy; society.

H02: Indian market does not have the potential for GM product.

H03: Farmers choices are limited.

H04: Genetically Modified Crop do not make any difference on socio-economic status of farmer.

H05: Structure of Industry does not change in response to the market.

2.17 Formulation of the Research Objectives

The theoretical analysis of present study is based on the various interlinked issues of science, technology and ‘society in the form of market’. This undertaken study is an attempt to know the relationship between science and market in new global regime. How the tools of sciences like IPR and Patent influences scientific community and commons like farming community is the major concern of present study. The objective of this Research is to study the outcome of these steps:

- i. To develop a model to see impact on stakeholder.
- ii. Nature of Structural transition of Indian Seed Industry and its impact on stakeholders.
- iii. Developing strategy to structure and compaternity of Indian Seed Industry vis a vis its Multi National Company (MNC) counterparts.
- iv. To explore the various factors that affects and influence agricultural research like, technological environment, economic environment, political environment and market forces.
- v. The fears are expressed that due to emergence of transgenic technology, there may likely to have a chance that it will fall under the control of the biotechnological Industry. This is argued that Trans- national corporate are aiming to capture huge market in Indian seed sector, where farmers still save seed from their harvest for planting the next season. The best way to do this to use science to stop the reproductive capacity of plant (by using terminator gene) or use law to patent the plant, so no one can commercially exploit it without permission of concerned authority.⁹⁰
- vi. To analyze the condition of Indian agriculture in respect to New Intellectual property rights and impact of WTO in context to IPR on agricultural R&D, seed sector, biotechnology and biodiversity.

⁹⁰ Benbrook, Rachel C. (2000). [www.grain.org assessed on 18th June 2007].

- vii. To focus, how far Indian market has potential for new product range of products, which are the outcome of this new concept i.e., Biotechnology; since genetically modified crops are capturing global acceptance.
- viii. To focus, how the concept of Genetic Engineering is going to be accepted by Indian Customers as solution for their agricultural problem? Indian farmers' perception about this product in terms of consumer behavior.
- ix. To develop a strategy for analyzing science, society and technology and market dynamics to address the concern of environment.

2.17.1 Research Objectives

- i. To study the market potential for Genetically Modified Crop (GMC).
- ii. To assess the impact of GM technology on Indian Seed Industry⁹¹.
- iii. To assess the impact of GMC on Indian Seed Market.
- iv. To analyse the acceptance adoptability of GMC by Indian farmers and their perception towards new technology and buyers' behaviour.
- v. To suggest a strategy to link scientific and technological aspects for the changing market dynamics brought by Biotechnology.
- vi. To outline the future direction of Indian Seed Industry in the context of IPR regime, WTO, Technology change.

⁹¹ Note: More than 300 seed companies exist in India.

References:

1. Agarwal, R. L. (1980), *Seed Technology* (New Delhi: Oxford and IBH Publication Co.).
2. Alagh, Y. K., ed. (2003), *Globalisation and Agricultural Crisis in India* (New Delhi: Deep & Deep Publication in association with Indian Economic Association), p. xvi
3. Annacchino, Marc A. (2003), *New Product Development: from Initial Idea to Product Management* (Elsevier Science & Technology Books).
4. Asokan, S.R. and Chokshi, S. N. (1998), “Challenges of Marketing Seeds in India” *Indian Journal of Agriculture Economy*, Vol. 53, No.3, p.376.
5. Barr, Pamela S. (2004), *Current and potential importance of qualitative methods in strategy research*, In: *Research Methodology in Strategy and Management Volume 1*. Eds: David J. Ketchen Jr. and Bergh D. Donald (Oxford: Elsevier Ltd.), pp.165-188.
6. Barton, John H. (1998), *Acquiring Protection for Improved Germplasm and Inbred Lines*: In “Intellectual Property Rights in Agricultural Biotechnology, Erbisch, F. H. and K. M Maredia eds.” (Oxford: CAB International), pp.19-30.
7. Basant, Rakesh (1997), “Technology strategies of large enterprises in Indian industry: Some explorations”, *World Development*, Vol.25, No.10:1683-1700.
8. Benbrook, Rachel C. (2000). Rice research losing the patent bottle. *The Grain*, Volume 1 March 31st 2000. [www.grain.org assessed on 18th June 2007].
9. Bergeron, Bryan and Paul Chan (2004) *Biotechnology Industry: A Global, Economic and Financing Overview* (New Jersey: John Wiley& Sons).
10. Bernal. J.D, *The Social Functions of Science*.
11. Bhalla, G.S. and Gurmail Singh (1996), *Impact of GATT on Punjab Agriculture* (Chandigarh: Institute for Development and Communication).
12. Brahmi, Pratibha, Sanjeev Saxena, and B. S. Dhillon (2004), “The Protection of Plant Varieties and Farmers’ Rights Act of India” *Current Science*, Vol. 86, No.3, pp. 292-298.
13. Bromley, D.A. (2004), “Technology policy”, *Technology in Society* 26, pp.455–468
14. Cherry, John P. and Harry R. Leffler (1984), ‘Seed’, In: “R. J. Kohel, and C.F. Lewis, eds, Cotton (Number 24 in the Series AGRONOMY)”. Published together by American Society of Agronomy, Inc.; Crop Science Society of America, Inc. and Soil Science Society of America. Wisconsin, USA; pp: 511-569.
15. Cowan J. R. (1973), “The Presidential address”, *Seed Agro. Journal*, Vol.65, pp.1-5

16. DeLancey, Craig (2006). Action, the Scientific Worldview, and Being-in-the-World 356. In Dreyfus, Hubert L. and Wrathall, Mark A. (editors). *A Companion to Phenomenology and Existentialism*. Blackwell Publishing, Oxford, pp:356-376.
17. Desai, B. B., P. M. Kotecha and D. K. Salunkhe (1997), *Seeds Handbook: Biology, Production, and Storage* (New York: Marcel Dekker Inc.), p.5.
18. Dosi, G., C. Freeman, R. Nelson, G. Silverberg and L. Soete, eds. (1988), *Technical Change and Economic Theory* (London: Pinter).
19. Drucker, Peter F. (2002), "The Discipline of Innovation: The Innovative Enterprise", *Harvard Business Review*, (August), pp. 95-103.
20. Drucker, Peter F. (1954), *The Practice of Management*, (Harper & Row).
21. Engels, Frederick (1976, reprint), *Dialectics of Nature*, (Moscow Progress Publishers), p.6
22. Erbisich, Frederic H. and Andrew J. Fischer (1998), *Transferring Intellectual Properties*, In "Intellectual Property Rights in Agricultural Biotechnology; Erbisich, F. H. and K. M. Maredia, eds." (Oxford: CAB International), pp. 33-48.
23. Erbisich, Frederic H. and Carlos Velazquez (1998), *Introduction to Intellectual Properties*, In "Intellectual Property Rights in Agricultural Biotechnology; Erbisich, F. H. and K. M. Maredia," (Oxford: CAB International), pp. 3-18.
24. Evanson, R. E. and J. D. Puntam (1987), "Institutional Change in Intellectual Property Rights", *American Journal of Agricultural Economics*, Vol.69, (May) No.2. pp.403-409
25. Fagerberg, J. and B. Verspagen (2002), "Technology-gaps, innovation-diffusion and transformation: An Evolutionary Interpretation", *Research Policy*, Vol 31; pp.1291-1304.
26. Feistritz W.P. (1975), "The role of seed technology for agriculture development", *Seed Science Technology*, Volume 3, pp. 415-429.
27. Fraley, R.T., S.G. Rogers, R.B.Horsch, G.M. Kishore, R. Beachy, N. Tumer, D.A. Fischhoff, X. Delannay, H.J. Klee and D.M.Shah (1988). *Genetic Engineering for Crop Improvement*, In: "Chromosome Structure and Function. Edited by Gustafson, J.P. and Appels, R" (New York: Plenum), pp: 283-298.
28. Ganguli, Prabuddha (1998), *India*, In "Intellectual Property Rights in Agricultural Biotechnology. Editors: F.H. Erbisich and K.M. Maredia", (Oxford: CAB International), pp.129-150.

29. Gordon, Peter Eli (2006), *Realism, Science, and the Deworlding of the World*. In Dreyfus, Hubert L. and Mark A. Wrathall, *A Companion to Phenomenology and Existentialism*, (Oxford: Blackwell Publishing), pp. 425-444.
30. Hamel, G. and C. K. Prahalad (1994), *Competing for the Future*, (Cambridge: Harvard Business School Press).
31. Hindley, Brian (1970), *Industrial Merger and Public Policy* (Westminste: The Institute of Economic Affairs (Hobart Paper 50)).
32. Iansiti, Marco and Jonathan West (1999), *Technology Integration: Turning Great into Great Products*. In: "HBR on Managing High-Tech Industries" (Oxford: Harvard University Press).
33. J.D. Bernal (1965), *Science in History (Vol-3: The Natural Sciences in our Time)*, , 3rd ed., (Penguin Books, (Published by all India People Science Network on arrangement with Trustees of Bernal Estate)), pp. 971-972.
34. Kadowaki, Shunsuke (2006). *Ontology, Pragmatism, and Technology*, In: Dreyfus, Hubert L. and Mark A. Wrathall eds., *A Companion to Phenomenology and Existentialism* (Oxford: Blackwell Publishing), pp. 464-477.
35. Kashyap, Pradeep (2003), "Revolution-in-waiting. *Praxis: Business line's Journal on Management*, Volume 4, Issue 2 (Managing Rural Markets) (July), pp. 6-11.
36. Koontz, Harold and Weihrich (2004), *Essentials of Management: An International Perspective*, (New Delhi: Tata McGraw Hill).
37. Kotler, Philip (2000), *Marketing Management Millenium Edition*, 10th ed. (New Jersey: Prentice-Hall).
38. Lesser, William (1987), "The Impact of Seed Patents", *N.C.J. Agr. Eco.*, 9:37-48
39. Luis Destefano-Beltran, P. Nagpala, K. Jaeho, and J.M. Dodds (1991), *Genetic Transformation of Potato to Enhance Nutritional Value and Confer Disease Resistance*, In "Molecular Approaches to Crop Improvement, Dennis, Elizabeth S. and Danny J. Llewellyn, eds." (New York: Springer-Verlag Wien), p.24.
40. Maredia, Karim M. and Frederic H. Erbisch (1998), *Capacity Building in Intellectual Property Management in Agricultural Biotechnology*, In "Intellectual Property Rights in Agricultural Biotechnology, Erbisch, F. H. and K. M. Maredia, eds." (Oxford: CAB International), pp. 49-61.

41. Merton, Robert K. (1968), *Social Theory and Social Structure*, (New York: The Free Press).
42. Meyers, S. and D.G. Marquis (1969), *Successful Industrial Innovation*, (Washington D.C: National Science Foundation).
43. Mowery, David C. and Nathan Rosenberg (1998), *Paths of Innovation: Technological Change in 20th-Century America*, (UK: Cambridge University Press).
44. Morris, Peter C. and James H. Bryce, ed. (2000), *Cereal biotechnology*, (Cambridge: Woodhead Publishing Limited & CRC Press).
45. Morris, Michael L. (2002). *The Development of the Seed Industry Under Globalization*, In: “Bigman, D., ed. Globalization and the Developing Countries: Emerging Strategies for Rural Development and Poverty Alleviation” (Wallingford: CABI Publication), pp. 201-218.
46. Mowery, D. and R. Rosenberg (1979), “The influence of market demand upon innovation: a critical review of some empirical studies”, *Research Policy*, Volume-8, pp.102 – 153.
47. Mukherjee, Tanusree and Pal, Chaitali (2003). *Globalisation and Crisis in Indian Agriculture – A Review*. In, “Alagh, Y.K.,ed.: Globalisation and Agricultural Crisis in India (New Delhi: Deep & Deep Publication in association with Indian Economic Association), p. 91.
48. Mumby, G (1994), *Seed Marketing*, (Rome: FAO (Research Series 114)).
49. NCERT (2003), *Biology: A Textbook of Class XII. National Council of Educational Research and Training (NCERT)*, 1st ed., (New Delhi: Government of India).
50. NCERT (2003), *Biology: A Textbook of Class XI. National Council of Educational Research and Training (NCERT)*, 1st ed. (New Delhi: Government of India).
51. Nill, Kimball R. (2002), *Glossary of Biotechnology Terms*, 3rd ed., (Boca Raton: CRC Press LLC).
52. Ofek, Elie (2008), *Competitive positioning through new product development. p. 49*. In: “Christoph H. Loch and Stylianos Kavadias. Handbook of New Product Development Management”, (Oxford: Butterworth-Heinemann & Elsevier).
53. Pandey, B. (1994), “Hybrid Seed Controversy in India”, *Biotechnology and Development Monitor*, No. 19, pp. 9-11.

54. Prahalad, C. K., and G. Hamel (1990), "The Core Competence of the Corporation", *Harvard Business Review*, 168 (3), 79-91.
55. Prahalad and Hamel (1990), p. 82.
56. Primrose, S. B. (1987), *Modern Biotechnology*, (London: Blackwell Scientific Publications).
57. Porter, Michael E. (1985), *Competitive Advantage* (New York: The Free Press).
58. Rahman, A. and P. N. Chowdhury, eds. (1980), *Science and Society* (New Delhi: Centre of R&D Management, CSIR).
59. Ramaswami, Bharat (2002), "Understanding the Seed Industry: Contemporary Trends and Analytical Issues" *Indian Journal of Agriculture Economics*, Vol.57, No.3, pp 417-429.
60. Ranganathan, C. K. (2003, July), "Case Study: The making of Chik", *Praxis: Business line's Journal on Management*, Volume 4, Issue 2 (Managing Rural Markets). pp. 22-27.
61. Rao, Krishna G. V. (2001), "Production and Marketing of Cotton Seed in Andhra Pradesh – problems and prospects", *The Indian Journal of Agriculture Economics*, Vol. 57, p. 483.
62. Reddy A. and I. P. S. Yadav (2001), "Transgenic Plant and Seed Industry in India", *Indian Journal of Agriculture Economics*, Vol.57, No.3, p.490.
63. Roberts, Edward B. (1988), "Managing Invention and Innovation", *Research Technology and Management*, Volume 31, Number 1(Jan.-Feb.).
64. Rothermund, Dietmar (1993, 2nd edition), *An Economic History of India: from Pre-Colonial Times to 1991*, (London: Routledge), pp.127-162.
65. Rudrappan, D. (2003), *Globalisation and Crisis in Indian Agriculture – A Review*, In, "Alagh, Y.K. (editor). Globalisation and Agricultural Crisis in India (New Delhi: Deep & Deep Publication in association with Indian Economic Association) pp. 41-52.
66. Rugman, Allen M. and Richard M. Hodgetts (1995), *International business: A Strategic Management Approach* (New York: McGraw-Hill).
67. Salazar, Rene, Niels P. Louwaars and Bert Visser (2007), "Protecting Farmers' New Varieties: New Approaches to Rights on Collective Innovations in Plant Genetic Resources", *World Development*, Vol. 35, No. 9, pp.1515–1528.
68. Santhanam, V. (1976), *Cotton* (New Delhi: Indian Council of Agricultural Research).
69. Schumpeter, J. A. (1942), *Capitalism, Socialism and Democracy* (New York: Harper & Row).

70. Shiva, Vandana (2002), *Globalization of Agriculture, Food Security and Sustainability*. In: Sustainable Agriculture and Food Security, (New Delhi: Sage Publication), pp.11-70.
71. Shiva, Vandana (1999), *Appropriation of indigenous knowledge and culture*, In: “Intellectual property, Drahos P. ed. ”, (Aldershot: Ashgate).
72. Siddhu, M.S. (1999), “Impact of Intellectual Property Rights on the Indian Seed Industry”, *Indian Journal of Agriculture Economics*, Vol.54, No.3, pp. 370-386.
73. Singh, A.; A. Singh and A. Singh (1999), “Trade Related Intellectual Property Rights, Biotechnology, Biodiversity and Indian Agriculture”, *Indian Journal of Agriculture Economics*, Vol.54, No.3, p. 380-386.
74. Sir Monty Finniston (1982), “Technology: The Future Determinant of Society”, *Technology In Society*, Vol.4, p.8
75. Spielman, David J. (2007), “Pro-poor agricultural biotechnology: Can the international research system deliver the goods?” *Food Policy* 32, pp. 189-204.
76. Sundaram, V., A. K. Basu, K.R. Krishna Iyer, S.S. Narayanan and T.P. Rajendram (1999), *Hand Book of Cotton India*, (Mumbai: Indian Society for Cotton Improvement (ISCI), Central Institute for Research on Cotton Technology (CIRCOT)).
77. Robert Tripp (2002), “Can the public sector meet the challenge of private research? Commentary on ‘Falcon and Fowler’ and ‘Pingali and Traxler’”, *Food Policy*, 27, pp.239–246.
78. Thomke, S. and Von Hippel, E. (2002) “Customers as innovators a new way to create value”, *Harvard Business Review*, April, pp.5-11.
79. Thomson, Iain (2006), *Environmental Philosophy*, In “Dreyfus, Hubert L. and Mark A. Wrathall, eds., A Companion to Phenomenology and Existentialism”, (Oxford: Blackwell Publishing), pp.445-463.
80. Tripp, S. and S. Pal (2001), “The private decline of Public crop varieties: Rice in Andhra Pradesh”, *World Development* pp.113-117.
81. Ulyanosvsky, Rostislav (1981), *Agrarian India between the World Wars: A study of Colonial-Feudal Capitalism*, (Moscow: Progress Publishers), page.74-75 and 210-211.
82. Wüger, Daniel and Thomas Cottier (2008), *Genetic Engineering and the World Trade System: World Trade Forum*, (Cambridge: Cambridge University Press).

83. Zahra, Shaker; Rajendra Sisodia and Brett Matherne (1999), "Exploiting the dynamic links between Competitive and Technology strategies", *European Management Journal* 17, pp.188-203.
84. Zahra, Shaker. A (1996), "Technology strategy and financial performance: Examining the moderating role of the firm's competitive environment", *Journal of Business venturing*, 11, pp.189:219.

Chapter III: Methodology

3.1 Rationale

There are wide varieties of miscellaneous sources that can generate new product ideas. It is not necessarily important to remember where the new product ideas come from, as it is to evaluate and screen suitable ideas, lock onto them, and execute the best choices. Some of the miscellaneous sources are inventors, patent counsel, university laboratories, government licensing offices, industrial consultants, marketing research firms and periodical digests relating to industries.

Various stakeholders like farmers, state agriculture extension departments, dealers, government research institutions, state agricultural universities, seed companies, private research institutions, peoples' representatives, etc. have contributed to the process of taking 'bacillus thuringiensis (Bt) technology' (based on biological sciences)¹ from lab-to-land with respect to their interests, motivations and circumstances. This study tries to look at the pattern and contexts of interaction between the different actors that has led to the adoption of Bt. Cotton in India in general and Andhra Pradesh and Maharashtra in particular. It has enabled the identification of a common ground for all the stakeholders in terms of enhancing their cotton yield through the new Bt. technology. This has further helped to identify those who supported the adoption of this technology, to know what motivated them to support this technology and finally how this latest technology is bringing noticeable change in market and industry.

Indian Seed Industry's successive stages of technological² transition, from 'Green Revolution' to 'Gene Revolution', bring an unexplored area of current market based techno-legal-

¹Burnham and Anderson (1998) p27. Giving an overview of Stochastic Models in the Biological Sciences the authors states "Models are useful in the biological sciences for understanding the structure of systems, estimating parameters of interest and their associated variance-covariance matrix, predicting outcomes and responses, and testing scientific hypotheses. Such models might be used for "relational" or "explanatory" purposes or might be used for prediction".

²Desai 2002p.7: There appear to four key shifts in the context of marketing which relate to the postmodern condition:

- The speed of change and the impact of technology.
- The constant need to innovate.
- The increase in marketing literacy among consumers.
- The fluidity of categories of identity.

& Desai 2002 p.57-62.

environmental issues. These issues are being raised while biotechnology's role in agriculture is observed through the induction of 'Bt. cotton' seed in Indian Seed Market. Scientific community and seed companies proclaimed that Genetically Modified Crops like Bt.cotton have 'potential' to solve certain agriculture related problem. But, the concerns raised by scientific community have led a section of it to oppose this technology. In such a scenario, science related policy initiatives and regulatory role is also in formative stage which seeks its logical and analytical frame based on recent advancement in science and science based technology. The market is directly dependent on these 'potentials' and 'concerns'. This existing dilemma in the market is unique in the Indian seed industry. The Seed industry is now looking up on science for the answers. Simultaneously, market economy and policy makers are also looking up on science for future course of actions. Therefore the scientific environment is an important component on which the Indian Seed market is dependent on. The above mentioned paradox is interpretative and leads to new paradigms brought by genetically modified crops. This needs a qualitative inquiry by using interpretative, qualitative approach which brings the entire dynamics of the structural transition in Indian Seed Industry.

3.1.1 Key Factors of the Research:

With afore mentioned background, this research deals with different stakeholders of the Indian Seed Industry namely the end-users of technology & the consumer at the end of the supply chain in seed industry (Farmers), Innovators of the technology – the idea generator and developer of the new product (Scientists), middle players who placed in between the innovator and end-user: the proponent and propagator of the technology (Seed Industry) and International laws and regulation as legal framework (External Factors).³ This research has enormously benefited from the ideas of Michael E. Porter and his model has been used as a tool for industry's environment analysis.

³ Policy initiatives are still at different stages of formulation. Because the impact or outcome in term of 'potential' & 'concerns' are unknown. Even 'technology' as strategic decision mainly revolves round the literature as outcome of 'Information Technology' revolution or technologies related to improvement of either process or product of manufacturing sector which outcome is 'tangible goods'. In this research technology's success depends on measuring high degree of intangible outcome like 'gene-expression' and fulfillment of the purpose of 'foreign' gene-expression in the host organism. The outcome of gene-expression (the product of Biotechnology's tool) is reduction of the use of pesticides and control of pest as proclaimed by Monsanto [An transnational company- proprietor of the technology which hold patent of this technology] in the case of Bt. Cotton seed sold as different brand name by many private companies in India under the logo 'bollgard'.

3.1.2 Literature Based Substantiation

In 1990, Hambrick described the field of strategic management as an adolescent. He called for a commitment to generalism, use of multiple methods, more theory testing, use of dynamic models and data and making realistic assumptions about managers and organizations. Several of his suggestions were realized (e.g. more theory testing, use of multiple methods) at least to a degree and others are beginning to be more common in strategic management research (e.g. use of dynamic models and data).

Hitt et. al. (1998)⁴ recommended the integration of both quantitative and qualitative approaches in strategic management research. Hitt et. al. (2004)⁵ further go on saying, “ultimately, strategic management research serves two purposes: to advance the level of theory in the field and to provide useful normative advice to practicing managers”. In their words: *“there are two primary activities in the research process. Research Questions relate to the types of hypotheses that are being asked. We focus on two specific content topics, strategic change and contingency theory. The other primary activity is Data collection. Topics that we address include sampling, statistical power, and the need for a broader geographic (international) focus. Next, we discuss three secondary activities in the research value chain. For Measurement, we review current practices regarding reliability, validity, and other aspects of construct measurement. Under the heading of Analysis, we cover potentially significant problems associated with endogeneity. Finally, Application offers suggestions for improving general processes associated with empirical strategic management research. These topics are interrelated as implied by the value chain concept. The outcome of this value chain of research should be enhanced knowledge and understanding as shown in the figure. Thus, we attempt to explain some of the more important interrelationships in the discussions in each section”*. Their proposed model is shown in figure 3.1:

⁴ Hitt, Gimeno and Hoskisson, 1998, 6-44.

⁵ Hitt, Boyd and Li 2004, p.5

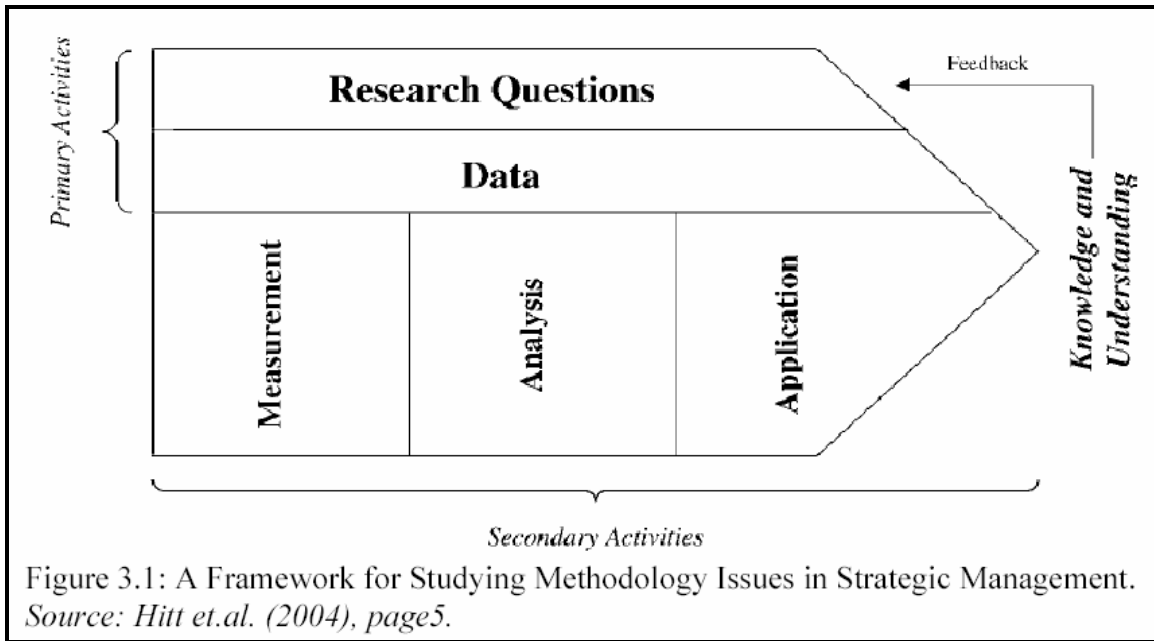


Figure 3.1: A Framework for Studying Methodology Issues in Strategic Management.
 Source: Hitt et.al. (2004), page5.

Ketchen⁶ & Bergh's edited book 'Research Methodology in Strategy and Management' gives direction to the researchers who are investigating strategic management issues. Many scholars (Venkatraman and Tanriverdi, 2004; Greve and Wiersema,2004; Barr, 2004; Slater and Atuahene-Gima, 2004; Dalton and Dalton 2005, Miller, 2005; John, 2005;Gnyawali and Tyler, 2005; Ghosal, 2006; Miles and Snow, 2006; Molina-Azorin,2007; Yip, Hult and Bink, 2007) have categorically put forward the idea of new direction to Strategic Management Research. The necessity of empirical research and theoretical model testing based on quantitative and archival data source is being highlighted in their discourse. This necessity also highlights the use of multiple methodologies for hypotheses testing. Barr (2004) in 'Current and Potential Importance of Qualitative Methods in Strategy Research' highlights the features of Qualitative approach in detail and deals with the methodology to handle the enquiry related to Strategy. Molina-Azorin (2007) shows the direction of using multiple methods in strategic research. Triangulation method used by Yip et. al. (2007) shows direction to pursue strategic and management enquiry.

⁶ Ketchen and Bergh (2004, 2005, 2006 and 2007). Research Methodology in Strategy and Management volumes: I, II, III and IV.

3.2 Defining the stakeholders

The industry's stakeholders are individuals, groups or organizations that affects and are in turn affected by the industry's decisions and actions. Depending on the specific industry, stakeholders may include Governmental agencies, social activist groups, NGOs, self-regulatory organizations, employees, shareholders, suppliers, distributors, media and the community in which the industry is located. The companies that constitute the industry tend to develop their views of stakeholders and stakeholder management over a time in reaction to events that unfold throughout the industry's history.⁷

The word 'stakeholder' for the investigation in this thesis is derived from Michael Porter's work on strategy. The rationale behind selecting this word and Porter's model is that, in the business strategy studies, it can be used as a tool for Industry analysis. Available literature sources show that research in the streams of technology, R&D, innovation, science policy had been done independently or by combining one or two of the above mentioned variables. Supply-side of understanding based on science and technology based on existing research literatures emphasizes on process of new product development. Any new technology and its manifestation to the many streams of knowledge need a newer approach to study. The constraint of existing methodologies leads to design a new approach. This new approach was necessary to interlink many stream of knowledge, to bring clarity and integrate with the stream of management research.

Thus, this work would aim at exploring some of the overlooked areas in the existing knowledge concerned with Indian Seed Industry. Therefore, the study was broadly fragmented into following steps:

- a. Understanding of new technology and its impacts.
 - i. Fusion of Technology: Existing and Embedment.
 - ii. Post Fusion and the Emergence of Genetically Modified Crops (GMCs).
- b. The Process of New Product Development based on biotechnology.
- c. Supply-Demand Functioning: Consumer Responses

⁷ Rodgers and Gago, 2004; Heath and Norman,2004.

d. Analyzing different Stakeholders

- i. *Farmer*: The end-consumer.
- ii. *Scientist*: The innovator of technology and the interpreter of science respectively.
- iii. *Industry*: The supply side based on industry's preparedness & capacity building.
- iv. *Government*: The regulator.
- v. *Civil Society*: NGOs, Pressure groups, Farmer's Association, etc.

The phenomenon⁸ of technological transition brought by biotechnology leads to a new epistemology of management. This, in turn, redefines the structure and strategy of Seed Industry in India. Hence, an extensive literature review⁹ was done to select the methodology for research so that facts and findings can be accepted within the realm of the knowledge. Many approaches are considered here to reach a rational conclusion. Customized research design and research tool for different stakeholder leads to incorporation of many ideas from many streams of knowledge which are being dealt with in the later pages of this chapter. Utmost care has been taken while selecting methodologies; wherever required, necessary logical reasoning is being given to reduce ambiguity. It was necessary to orchestrate the methodologies in synergetic form to bring out the convergence for the purpose of research investigation and this process has been done under the guidance of experts.

⁸ (Denscombe,2004)As an approach to social research, phenomenology is sometimes presented as an alternative to positivism. When a simple dichotomy is called for, phenomenology has been useful for some writers as an umbrella term covering styles of research that do not rely on measurement, statistics or other things generally associated with the scientific method. In direct contrast to positivism it is seen as an approach that emphasizes:

- subjectivity (rather than objectivity);
- description (more than analysis);
- interpretation (rather than measurement);
- agency (rather than structure).

Its credentials as an alternative to positivism are further reinforced by the fact that phenomenological research generally deals with people's:

- perceptions or meanings;
- attitudes and beliefs;
- feelings and emotions.

⁹ Literature Survey for Methodology was done to choose appropriate methodology for this research. At the end of the chapter reference is given. Literature mentioned in the reference for this chapter in particular was used as insight to select appropriate tools and methods for different stakeholders. It was necessary to select this methodology to bring linkages which influences technology integration for new product development. This study was a study of an ongoing phenomenon.

3.3 Significance of the methodology

The purpose of this research is to understand an ongoing phenomenon of technology transition brought by biotechnology in Indian Seed Industry, which in turn changing basic nature of the product, i.e. 'Seed'. Therefore, different data-set and information from heterogeneous sources are used to undertake this study. These information are stratified into four broad segments to facilitate the research enquiry. They are given in the following order:

- i. Genetically Modified Crops: GMC and related trends and the debate about genetic modification. The required information has been collected from a wide variety of sources as follows.
 - a. Government Reports and Statistics,
 - b. Newspaper Reports and Features in Magazines and Surveys,
 - c. Website Material Available on Internet,
 - d. Literature from Lobbying Groups and Charitable Organizations.
- ii. To identify, explain and investigate issues surrounding particular aspects of agriculture like; increasing yield, enhancing environmental protection, securing the livelihoods of the rural population and so on.
- iii. This research explores how the underlying philosophy of inclusiveness of the views, needs and desires of the supposed beneficiaries of 'scientific research into agricultural systems' and empower people in the macro decision-making.
- iv. To examine the multiplier impact of technology from stakeholders' perspective and the potential of 'how this genetic engineering is shaping the current structure of seed industry'.

3.4 Study Design and the Process of Selection of Different Methodology

3.4.1 The Customer

To understand who the customer is, following logical approach has been followed:

- a. Technology buyer – Seed industry buying Bt. Technology from Technology developer.
- b. Input Buyer – Farmers buying seed from market. Farmers are the customer and end – user of the technology because the 'developed technology' is being sold as the 'technological solution for the farmer's problem'.
- c. Output Buyer – Buyers of the produce of farmers.

Research tools used to collect data are:

- i. *Direct customer surveys:* Surveys are a valuable tool to engage a customer to solicit feedback and to obtain information in a directed manner.
- ii. ¹⁰*Focused group discussions:* This method allows multiple-person input and prompts discussion to generate ideas (Some of these were recorded¹¹).
- iii. *Competitors Analysis (Within industry/inter-company):*
 - a. What the competitors are doing towards new product development (GMC).
 - b. To monitor competitive product development activities.
- iv. *Company dealers and representatives:* Company dealers & representatives can give feedback on customer ideas. They can also voice their views about the product. However, this medium had been evaluated in the light of supply chain of Indian Seed Industry, where the money changes hands.
- v. *Top management:* The decision of Top Management is valuable, as it influences the product development.

3.4.2 Seed Industry Supply Chain

Farmers - The end-stakeholders of the seed industry supply chain who decides the fate of product:

Sample plan: Selected from different districts of Andhra Pradesh and Maharashtra based on geographical importance.

Survey tool: Field Survey based on structured questionnaire, Focus-Group Interview, Recording and field notes.

Questionnaire was designed to do farmer survey based on the following:

- a. Customer's expectation from product (Consumer behavior).
- b. Awareness, understanding, expectation and implementation of technology.
- c. Gap between industry and customer in terms of customer expectation and industry delivery considering different elements of marketing (Consumer's awareness).
- d. To evaluate the causes of success or failure of technology.
- e. To understand the socio-techno-legal framework.

¹⁰ Kotler and Armstrong, 2005,p.113.

¹¹ Desai,2002 p.40-42.

Format of evaluating customer survey:

- a. Stratified into four-segments based on land- holding.
- b. Based on the ‘Expectation’ of end-consumer’s ‘needs and wants’.

Expected outcome from customer (farmer) survey:

- i. Yield Analysis; whether the technology is delivering what it proclaims.
- ii. Where customer needs help?
- iii. Success vs. Failure of ‘technology based product’; ‘in the court’ of customer.
- iv. Key Success Factor.
- v. Consumer behavior, etc.

Scientists (Innovators):

There is an inherent tension between openness to new ideas and the criticism by which the scientific research process insists (or should insist) on exposing new ideas. There are general principles and methodology specific to particular disciplines. The thesis focuses on these general principles and methodologies, and *qualitative inquiries*¹² in particular, thus avoiding attempts at rigid prescription of acceptable scientific procedure. In order to discuss research, the plan includes:

- i. examination of existing knowledge,
- ii. decision based on scientific inquiry which transcend to ‘innovation’ and ‘technology’ which in turn becomes the cause for ‘new product development’¹³,
- iii. ways to seek answers of scientific facts,
- iv. analysis of the research data, and
- v. subsequent outcome based on the responses.

Sample plan (Scientists selected from the organizations):

- a. Seed Industry: Indian and Transnational companies (TNC).
- b. Government Research Centers and Universities.
- c. International Organizations.
- d. Civil Society.

¹² Patton, 2002, p.512.

¹³ Kotler and Armstrong, 2005, p.274.

Survey tool: In-depth interview¹⁴ based on semi-structured questionnaire and discussion with scientists working in the field related to Genetically Modified Crops.

Questionnaire was designed to elicit the following:

- a. Scientific dimension of the ‘Technology’.
- b. Evolution of the technology based ‘new product’ i.e. ‘the new seed’.
- c. Awareness, understanding, expectation and implementation of the technology.
- d. Gap between “*Innovator-Industry-Customer*” in terms of customers expectation and industry’s delivery. This is in consideration to the need of the technology by attempting to answer the key issue i.e., ‘whose need’.
- e. To map environmental implication as perceived by scientists based on Genetically Modified Crops.
- f. To bring out scientific aspect of ‘*Socio-Techno-Legal*’ concerns and ethical aspects related to the technology.

Format of evaluation: Respondents are stratified into four segments as mentioned in target range.

Expected Outcome:

- a. To bring facts from the practitioners to answer the ‘issues’ related to technology & opportunities and constraints of the 'technology based product'.
- b. Whether the technology is delivering what it 'intends to do'.
- c. Potential of the Genetically Modified Crops.
- d. Suggestions and solutions for seed industry based on scientific reasoning in terms of ‘Gap’ and ‘Capacity Building’.

The seed industry:

The study is being done to assess the macro-environment¹⁵, consisting of factors with the potential to affect the nature of seed business segment; business environment with elements more likely to relate to an individual company. Industry analysis is being done to analyze the

¹⁴ Wrenn et.al.,2002.p.180-200; Desai 2002, p.1-10.

¹⁵ Kotler and Armstrong, 2005,p.65.

specific change brought by the new technological-environment¹⁶ within the seed industry. Interpretation is based on the outcome pattern of consumer survey, and findings are based on the Scientist's opinion. The design will act as a bridge between creator and the end-user of the technology.

Elements of this survey are based on the following factors:

- a. Nature of industry.
- b. Industry Delivery of the product.
- c. Awareness, understanding, expectation and implementation of the technology.
- d. Gap between the Industry and the Customer in terms of customer expectation and Industry Delivery considering different Elements of Marketing.
- e. Evaluate the success and failure of the technology.
- f. Technology Transfer.
- g. Seed Industry's Supply Chain :
 - i. Supply Chain of the Technology.
 - ii. Supply Chain of New Product i.e., a Genetically Modified Crop (Bt. Cotton seed).

Sample Plan:

Selected from public enterprises, private and transnational companies.

Survey Tool:

Interviews, discussion with top management and employees who are involved in the product development, field notes, newsletters and the database sent by different companies were used.

Format of evaluation:

- a. Stratified Seed Industry: MNC vs. Indian; Government set up vs. Private Seed Companies; Area of Geographical dominance; Company having niche product portfolio etc.
- b. To know industry preparedness and to understand the 'Expectation' of farmer.

¹⁶ Ibid. p.82.

- c. Whether the industry is prepared to handle the innovative technology. Issues like Mergers, Acquisition, Licensing etc.
- d. 'Socio-Techno-Legal' constraints in front of the technology.

Expected Outcome: To find gaps and to bring out any changes in the structure.

Policy Initiatives:

This is based on 'Risk Assessment and Management'¹⁷ and legal information. Time to time modification in legal and regulatory framework shows the important role of State in contextual framework. Juxtaposing the regulatory framework according to the time reveals 'how Government initiatives give the direction and re-shape the Industry' per se.

Purview:

- a. National Laws/Rules/ Acts which directly or indirectly influence decision making process with respect to biotechnology based product (i.e., GMCs) in the context of seed industry.
- b. International policy initiatives which influence and provide guiding principles for the above mentioned.

Ingredients:

- a. Governing Laws for seed companies
- b. Patent Laws
- c. International laws
- d. International Treaties where India is one of the signatories

¹⁷Haimes,2004, p36. 'Risk assessment and management is a process that must answer the following set of questions [Kaplan and Garrick, 1981; Haimes 1991]':

What can go wrong?

What is the likelihood?

What are the consequences?

What can be done and what options are available?

What are the associated trade-offs in terms of all costs, benefits, and risks?

What are the impacts of current decisions on future options?

a. Organizational failures are major sources of risk.

b. The perception of risk and its importance in decision making should not be overlooked.

c. Risk management should be an integral part of technology management, leading to multiple objective trade-off analysis.

d. The expected value of risk leads to erroneous results when used as the sole criterion for risk measurement.

Also, risk of extreme and catastrophic events should not be commensurate with high-probability/low-consequence events.

Purpose for using legal framework: First, to emulate Porter's Strategic model. Second, this model gives scope to understand regulatory push or pull in technological failure or success. Third, to scan the dynamics of the environment in which the seed industry functions.

3.5 Data Sources

Primary Data collection is done using following ***research tools***:

- i. Structured Questionnaire,
- ii. In-depth Interviews based on Semi-structured Questionnaire,
- iii. Focused Group interviews.

Data inflow was from ***secondary sources***:

- i. Research Journals (from the field of Science, Management and Social sciences).
- ii. International Service for the Acquisition of Agri-biotech Applications (ISAAA) Database.
- iii. International Food Policy Research Institute (IFPRI) Database.
- iv. Newsletters published by various organizations.
- v. Annual reports.
- vi. Conference and Seminar proceedings.
- vii. Books.
- viii. Media Reports.

3.6 Different Stages of the research process:

Stage One:

Beginning of the research work: Literature survey was done based on segregation of 'issues' and 'concerns', related to the seed industry. Question formulation for research was based on literature survey and discussion with different stakeholders. Based on these, tentative Questionnaires were designed. 'Research framework' and 'Research synopses' were approved. Questionnaires were validated with the help of experts in the respective fields. Pilot testing was initiated before field level study.

Stage Two:

Pilot testing phase I: Structured Questionnaires were designed and pilot testing was done for three scientists, Seventeen Farmers, Two NGOs and two seed companies. The above were approved and launched for full-fledge survey.

Stage Three:

Setbacks/Hurdles by using structured questionnaires. Explanation:

- i. One hundred twenty questionnaires were sent by post and email to the scientific community. Response rate was zero.
- ii. Thirty five questionnaires were sent by post and email to the selected companies in seed industries. Response rate was zero
- iii. Questionnaire designed for farmers had limited response because of language barrier.

Stage Four:

Why – Why analysis and its justification:

- i. Scientific community was not ready to express their views in written or recorded form. They were tight-lipped on the GMCs to avoid controversies. [Strong apprehension and withdrawal was observed among the scientists working in government institutions and officials working in agriculture department. Everyone refused to go on record or give any information in written form].
- ii. Seed companies did not want to divulge information in written and recorded form especially when information was required on GMCs and the issues related to R&D and finance in particular.
- iii. Civil-society had their own arguments which had heated the debate in media.
- iv. The technology was new and the debate is in public discourse.
- v. Unknown fear factor towards the use of tape-recorder or questionnaire.

Stage Five:

Need for New approach and Second pilot study

Current methodological framework is the outcome of second pilot study where:

- i. Scientists were interviewed in person. Tape-recorder interviews were restricted. Questionnaires were refused by all the scientists, which led to use the open-ended in-depth interview based on issues related to ‘concerns’ and ‘potentials’.
- ii. Company representatives divulged information, but with the condition of confidentiality. Finance related issues were sensitive areas to be answered by these representatives. They gave generic answers and were more interested to talk about product portfolios.
- iii. Small and marginal farmers had a sense of fear from progressive farmer. Some of the issues are dealt in detail in later chapters.

Stage Six:

New methodology, Final Data Collection, data analysis and compilation:

Sampling technique: Purposive¹⁸ sampling selected.

Nature of Research:

The study is *exploratory*¹⁹ in nature because numerous types of data from different sources had limited the application of parametric study based on random sampling. But *Geographical*²⁰ aspects are taken care of while collecting data. Couple of in-depth and focus group interviews are recoded whose content is directly used for data-analysis. This leads to use of simple statistics wherever necessary. Name of the ‘*knowledgeable key informants*’²¹ are not cited since some of them who shared their experiences and views requested not to be quoted. Though necessary at certain places changed name are being used to remove ambiguity. Code of ethics was strictly followed to keep the anonymity and confidentiality of all the respondents. For comprehensibility, case study²² method is used wherever required. Hence, this research can be understood as exploratory research, based on qualitative and

¹⁸ **Cooper and Schindler** 1999 p.245: A nonprobability sample that conforms to certain criteria is called purposive sampling There are two major types – judgment sampling and quota sampling.

¹⁹ **Kotler and Armstrong** 2005, p.102: “Marketing Research to gather preliminary information that will help define problems and suggest hypotheses” & p.116; **Cooper and Schindler** 1999, p131, 134 -141.

²⁰ Benchmark Soils of Andhra Pradesh; NSS&LUP, Nagpur.

²¹ **Shortell and Zajac**1990, p.828–829 : They observed, “using knowledgeable key informants’ perceptions of an organization’s strategic orientation is a valid approach in measuring strategy.”

²² **Barr** 2004,p.172-174 ;**Yin**2003; **Hamel et al.**1993,p.v : ‘case study must locate the global in the local’...A case study is an in-depth study of the cases under consideration, and this depth this depth has become another feature of the case study approach...case studies employ various method which includes interviews, participant observation and field study. Researcher’s observation has its own importance in case study approach.

quantitative information by using a mix of methodologies to explain an ongoing phenomenon. 'Triangulation'²³ is being used for final interpretation to conclude and recommend the outcome of the thesis. The necessity of using triangulation is to bring out interlinkages between various stakeholders, since multiple methodologies, empirical study and policy²⁴ perspective is being used in this thesis.

Blends of methodological tools are used to elicit different kinds of information-sets from heterogeneous sources. These methodological tools are part of dissimilar methodologies gathered from the existing literature on research methodology. This in turn synthesized the methodological approach for this thesis and is mentioned at the end of this chapter²⁵. Hence, a composite methodology has been framed. This framing was necessary to have a bird's eye view of the issues as sequel of 'Review of Literature' i.e., previous chapter of this thesis and for theory construction as proposed outcome of this research. Being an exploratory research, this thesis is leaving many unanswered questions to be investigated further as the upshot of this research. At the end cross-checking of all the information were necessary and therefore every statement and variable have been attempted to be cross-checked with either published source or with sample survey. Wherever cross-checking was not possible, researcher has probed into deeper science and published articles in reputed journals of various streams as investigation to reach near truth. This was only possible through Triangulation methodology.

²³**Jick** 1979, p602-611; **Flick**1998, p 229-231; **Patton** 2002, p.247: “*Triangulation* strengthens a study by combining methods. This can mean using both qualitative and quantitative approach. The four basic type of triangulation are; first, *data triangulation*, the use of a variety of data sources in a study; second, *investigator triangulation*, the use of several different researchers or evaluators; third, *theory triangulation*, the use of multiple perspectives to interpret a single set of data and; fourth, *methodological triangulation*, the use of multiple methods to study a single problem or program”, & p.555-559; **Denzin and Lincoln** 2003, p8, “Qualitative research is inherently multimethod in focus. However, the use of multiple methods, or triangulation, reflects an attempt to secure an in-depth understanding of the phenomenon in question. Objective reality can never be captured. We can know a thing only through representations. Triangulation is not a tool or a strategy of validation. The combination of multiple methodological practices, empirical materials, perspectives, and observers in a single study is best understood, then, as a strategy that add rigor, breadth, complexity, richness, and depth to any inquiry”; **Flick**, 2004, p178-183; **Gorard and Taylor**, 2004, pp 42-57. “Triangulation between the evidence produced by different research methods is thought to be a simple and common form of combining methods. Various reasons have been advanced for the use of combined methods triangulation, including increasing the concurrent, convergent and construct validity of research, the ability to enhance the trustworthiness of an analysis by a fuller, more rounded account, reducing bias, compensating for the weakness of one method through the strength of another, and in testing hypotheses”. **Molina-Azorín**, 2007 p37-74.

²⁴ **Pablo** 2008, p.333: “It improves the quality research”. [*Researcher's note: Triangulate with qualitative and quantitative data, in turn give deeper insight about the drivers of technological environment prevailing in Indian Seed Market at the time of research*]

²⁵ Reference: Methodology (at the end of this chapter).

This thesis work ideally represents the distillation of knowledge from the field of marketing with the perspective of new product development whose driver is biotechnology; an ongoing phenomenon, which is redefining and reshaping the Indian Seed Industry.

3.7 Scope and Limitations of the Study

Some of the scopes are:

Technological environment has its own implication on the seed industry. The study is ‘New Product Development technology centric research’ and its implication for single industry. Different linkage and diverse kind of dataset is being used to reach near truth. Biotechnology is a new field and its manifestation is being used as inter-disciplinary study which gives complete features of Technology. Unlike technologies used during Green Revolution, Genetic Engineering techniques allow specific genes to be copied into a plant. Because the scientists know a great deal about the genes they are working with, it’s easier for them to ‘track’ the genes, understand their effects and eliminate unwanted side effects long before the plants are used in field trials or grown commercially. Scientists’ opinions have been discussed in detail as scientist being one of the stakeholders. Scientific discovery as a by product of R&D efforts, juxtaposed with IPR issues and WTO; vis a vis Indian Seed Industry is the central theme of the study. Because, the Genetic Engineering is reconfiguring product at the ‘central dogma of life: the DNA’; in cascading effect the technology has immense potential to ramify from seed industry to agro-based industries by reconfiguring the basic nature of products after products.

The following are the limitation of the research:

- i. The research is limited to the state of Andhra Pradesh and Maharashtra. These states are the important producer of cotton. Other states too grow cotton.
- ii. Due to organizational constraints and confidentiality requirements of the respective companies Financial statements were not made available, therefore R&D expenditure of different companies was collected from the archival source like annual report published by Government of India.

- iii. Non availability of population data about number of farmers growing cotton crop, random sampling and stratified random sampling could not be used. This in turn restricted the research based on purposive sampling.
- iv. Considering the sensitivity of data flow advance statistical tool has not been used. In the case of question related to refugia, primary data is used as it is. Any use of stastical tool will distort the finding.
- v. Indian farmers don't keep account of investment incurred so they give their tentative answer. In a focus group study done in village it was observed that the big or progressive farmers were talking and others were just silent or accepting what ever told by these big farmers.
- vi. At village level big farmers play multiple roles: money lenders, input (like seed, pesticide and fertilizer) seller output buyer, etc.
- vii. None of the organizations had provided Financial Statement.
- viii. None of the private seed company had provided Balance Sheet.
- ix. Because of unavailability of financial data any kind of '*Product Cost Analysis*' and R&D evaluation became impossible therefore archival data is being used.
- x. The IPR is a very complex issue and understanding it in a short term is very difficult task. Most of post WTO debate is based on the genetically modified crops and Pharmaceuticals sector, so there is unavailability of study materials regarding cash crops like cotton crop. Bio-patent particularly plant patent is very new issue for Indian research and development organization so lack of study materials about concerned subject is obvious. Institution and organization which acts as nodal agency for patents and intellectual property rights are at nascent stage, so up to some extant, they are also not capable of providing adequate and exact information and data. Lack of resources and multiple nodal agencies as actors also cause some problems to fulfill the academic ethos of present study. However, an honest and unbiased effort has been made to understand the issues and present a crystal clear picture of the concerned study.

References:

1. Aswathappa, K (2000), *Essentials of Business Environment*, 7th ed. (Mumbai: Himalaya Publishing House).
2. Barr, Pamela S. (2004), *Current and potential importance of qualitative methods in strategy research*, In “Research Methodology in Strategy and Management Volume 1, David J. Ketchen Jr. and Bergh D. Donald, eds.”, (Oxford: Elsevier Ltd.), pp.165-188.
3. Benchmark Soils of Andhra Pradesh [Technical Report]. NSS&LUP, Nagpur.
4. Benchmark Soils of Maharashtra [Technical Report]. NSS&LUP, Nagpur.
5. Boddewyn, J. (1966), “A construct for Comparative Marketing Research”, *Journal of Marketing Research*, Vol.3 (May), No.2, pp. 149-153.
6. Burnham Kenneth P. and David R. Anderson (1998), *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*, 2nd ed., (New York: Springer-Verlag).
7. Chandler, Jon and Mike Owen (2002), *Developing Brands with Qualitative Market Research* (London: Sage Publications).
8. Chrzanowska, Joanna (2002), *Interviewing Groups and Individuals in Qualitative Market Research*, (London: Sage Publications).
9. Clarke Jr., Edmund M., Orna Grumberg and Doron A. Peled (2000), *Model Checking*, (Cambridge: The MIT Press).
10. Conlisk, John (1969), “Neoclassical Growth Model with Endogenously Positioned Technical Change Frontier”, *The Economic Journal*, Volume: LXXIX, (June) pp.348-362.
11. Cooper, Donald R. and Pamela S. Schindler (1999), *Business Research Methods*, 6th ed., (New Delhi: Tata McGraw Hill Publishing Company Limited).
12. Cox, Howard and Simon Mowatt (2004), “Consumer-driven innovation networks and e-business management systems”, *Qualitative Market Research: An International Journal*, Volume 7, Number 1, pp.9-20.
13. Cyert, Richard M. and Kenneth D. George (1969), Competition, Growth, and Efficiency, *The Economic Journal*, Vol.-LXXIX (March), page.23-41.
14. Denscombe, Martyn (2004), *The Good Research Guide: for small-scale social research projects*, 2nd ed. (England: Open University Press).

15. Denzin, Norman K. and Yvonna S. Lincoln, eds. (2003), *Collecting and Interpreting Qualitative Materials*, 2nd ed. (Thousand Oaks: Sage Publications).
16. Denzin, Norman K. and Yvonna S. Lincoln, ed. (2003), *Strategies for Qualitative Inquiry*, 2nd ed. (Thousand Oaks: Sage Publications).
17. Desai, B.B., P.M. Kotecha and D.K.Salunkhe (1997), *Seeds Handbook: Biology, Production, Processing, and Storage*, (New York: Marcel Dekker Inc.).
18. Desai, Philly (2002), *Methods beyond Interviewing in Qualitative Market Research* (London: Sage Publications).
19. Elifson, Kirk W., Richard P. Runyon and Audrey Haber (1990), *Fundamentals of Social Statistics*, , 2nd ed. (New York: McGraw Hill Publishing Company).
20. Ereaut, Gill (2002), *Analysis and Interpretation in Qualitative Market Research*, (London: Sage Publications).
21. Fleiss, Joseph L., Bruce Levin and Myunghee Cho Paik (2003), *Statistical Methods for Rates and Proportions*, 3rd ed. (New Jersey: John Wiley & Sons).
22. Flick, U. (1998), *An introduction to qualitative research: Theory, method and applications* (London: Sage Publication).
23. Flick, Uwe (2004), *Triangulation in Qualitative Research*, In: “A Companion to Qualitative Research, Uwe Flick, Ernst von Kardorff and Ines Steinke, eds.” (London: Sage Publication), pp. 178-183.
24. Gupta, S.P. (2001), *Statistical Methods* (New Delhi: Sultan Chand & Sons).
25. Gorard, Stephen and Taylor Chris (2004), *Combining Methods in Educational and Social Research* (London: Open University Press).
26. Hambrick, D. C. (1990), *The adolescence of strategic management, 1980–1985: Critical perceptions and reality*. In: “Perspectives on Strategic Management, J. Fredrickson, ed.” (Cambridge, MA: Ballinger), pp. 237–253.
27. Haimes, Yacov Y. (2004), *Risk Modeling, Assessment, and Management*, 2nd ed. (New Jersey: Wiley Interscience).
28. Haimes, Y. Y. (1991), *Total risk management*, *Risk Analysis* 11(2), 169-171; Cited in: “Haimes, Yacov Y. (2004), *Risk Modeling, Assessment, and Management*, 2nd ed. (New Jersey: Wiley Interscience), p.36.”

29. Hamel, Jacques, Stephane Dufour and Dominic Fortin (1993), *Case Study Methods (Qualitative Research Methods Volume 32)* (Newbury Park: Sage Publications).
30. Harriss-White, Barbara (2005), *India's Market Society: Three Essays in Political Economy* (Gurgaon: Three Essays Collective).
31. Hartwig, Frederick and Brian E. Dearing (1979), "*Exploratory Data Analysis*" *Sage University Paper on Quantitative Applications in the Social sciences 07-016*. Sage Publications, Beverly Hills and London. Cited in: Hitt, Michael A.; Boyd, Brian K. and Li, Dan (2004). The state of strategic management research and a vision of the future. In "Research Methodology in Strategy and Management Volume 1. Editors: David J. Ketchen Jr. and Bergh D. Donald" (Oxford: Elsevier Ltd.), pp: 1-31.
32. Heath, J., and W. Norman (2004). "Stakeholder Theory, Corporate Governance and Public Management: What Can the History of State-Run Enterprises Teach Us in the Post-Enron Era?", *Journal of Business Ethics* 53, No.3, pp.247–266.
33. Heaton, Janet (2004), *Reworking Qualitative data* (London: Sage Publications).
34. Hill, Jimmy and Terri Scott (2004), "A consideration of the roles of business intelligence and e-business in management and marketing decision making in knowledge-based and high-tech start-ups", *Qualitative Market Research: An International Journal*, Volume 7, No.1, pp.48-57.
35. Hitt, Michael A., Brian K. Boyd and Dan Li (2004), *The state of strategic management research and a vision of the future*, In "Research Methodology in Strategy and Management Volume 1. Editors: David J. Ketchen Jr. and Bergh D. Donald", (Oxford: Elsevier Ltd.), pp: 1-31.
36. Hitt, M. A., J. Gimeno and R. E. Hoskisson (1998), "Current and future research methods in strategic management", *Organizational Research Methods*, Vol.1, pp.6–44.
37. Homburg, Christian, Harley Krohmer and John P. Workman Jr. (1999), "Strategic Consensus and Performance: The Role of Strategy Type and Market-Related Dynamism" *Strategic Management Journal*, Vol.20, No.4 (Apr.), pp 339-357.
38. Imms, Mike and Gill Ereaut (2002), *An Introduction to Qualitative Market Research* (London: Sage Publications).
39. Jick, T. D. (1979), Mixing qualitative and quantitative methods: Triangulation in action, *Administrative Science Quarterly*, 24, pp.602–611.

40. Joglekar, Prefulla and Morris Hamburg (1989), "Industry concentration and Allocation of Resources to Basic Research", *Management Science*, Vol.35, No.2 (Feb.), pp.208-225.
41. Kaplan, S., and B. J. Garrick (1981), *On the quantitative definition of risk*, *Risk Analysis* 1(1), 11-27; Cited in "Haimes, Yacov Y. (2004), *Risk Modeling, Assessment, and Management*, 2nd ed., (New Jersey: Wiley Interscience). p.36".
42. Kaynak, Erdener, ed. (1986), *World Food Marketing Systems* (London: Butterworths).
43. Ketchen Jr., David J. and Bergh D. Donald, eds. (2004), *Research Methodology In Strategy and Management Volume 1* (Oxford: Elsevier Ltd.).
44. Ketchen Jr., David J. and Bergh D. Donald, eds. (2005), *Research Methodology In Strategy and Management Volume 2* (Oxford: Elsevier Ltd.).
45. Ketchen Jr., David J. and Bergh D. Donald, eds. (2006), *Research Methodology In Strategy and Management Volume 3*, (Oxford: Elsevier Ltd.).
46. Ketchen Jr., David J. and Bergh D. Donald, eds. (2007), *Research Methodology In Strategy and Management Volume 4* (Oxford: Elsevier Ltd.).
47. Kohls, Richards L. and Joseph N. Uhl (2002), *Marketing of Agricultural Products*, , 9th ed. (New Delhi: Prentice-Hall of India Private Limited).
48. Kotler, Philip and Gary Armstrong (2005), *Principles of Marketing*, 11th ed. (New Delhi: Prentice-Hall of India Private Limited).
49. Levin, I. Richard and S. David Rubin (1999), *Statistics for Management*, 7th ed. (New Delhi: Prentice Hall of India Private Limited).
50. McNiff, Jean and Jack Whitehead (2006), *All You Need to Know About Action Research* (London: Sage Publications).
51. Mehta, P.L. (2001), *Managerial Economics: Analysis, Problems and Cases* (New Delhi: Sultan Chand & Sons).
52. Misra, S.K. and V. K. Puri (2006), *Economic Environment of Business*, 4th ed. (Mumbai: Himalaya Publishing House).
53. Molina-Azorín, José F. (2007), *Mixed Methods in Strategy Research: Applications and Implications in the Resource-Based View*, In: "Research Methodology In Strategy and Management Volume 4, David J. Ketchen Jr. and Bergh D. Donald, eds.", (Oxford Elsevier Ltd.), pp.37-74.

54. Moutinho, Luiz, ed. (2006), *Advances in Doctoral Research in Management – Volume 1*, (Singapore: World Scientific Publishing Co. Pte. Ltd.).
55. Moutinho, Luiz, ed. (2008), *Advances in Doctoral Research in Management – Volume 2*, (Singapore: World Scientific Publishing Co. Pte. Ltd.).
56. Pablo, Amy L. (2007). *Using policy capturing to understand strategic decisions – concepts and a mergers and acquisitions application*, In: “Research Methodology Strategy and Management Volume 4, David J. Ketchen Jr. and Bergh D. Donald, eds”, (Oxford: Elsevier Ltd.), pp.319-342.
57. Patton, Michael Quinn (2002), *Qualitative Research and Evolution Methods*, 3rd ed. (Thousand Oaks: Sage Publication).
58. Perlesz, A. and J. Lindsay (2003), “Methodological triangulation in researching families: making sense of dissonant data”, *International Journal of Social Research Methodology*, 6(1), pp.25–40.
59. Phillips D.C. (1987), *Philosophy, Science and Social Inquiry: Contemporary Methodological Controversies in Social Science and Related Applied Fields of Research*, (Oxford: Pergamon Press).
60. Qayum, Abdul and Kiran Sakkhari (2003), *Did Bt. Cotton Save Farmers in Warangal? A season long impact study of Bt Cotton – Kharif 2002 in Warangal District of Andhra Pradesh*, (Hyderabad: AP Coalition in Defence of Diversity, Deccan Development Society).
61. Shortell, S. M., and E. Zajac (1990), “Perceptual and archival measures of Miles and Snow’s strategy types: A comprehensive assessment of reliability and validity”, *Academy of Management Journal*, 33(4), pp.817–832.
62. Thanulingam, N. (2000), *Research Methodology*, (Mumbai: Himalaya Publishing House).
63. Todo, Yasuyuki and Koji Miyamoto (2006), *Knowledge Spillovers from Foreign Direct Investment and the Role of Local R&D Activities: Evidence from Indonesia*, In: *Economic Development and Cultural Change* (The University of Chicago), pp.173-200.
64. Ramana, V. Venkata, *Diversification Programmes and Strategies of Indian Industries*. (Osmania University: University Publications and Press).
65. Rodgers, W., and S. Gago (2004), Stakeholder Influence on Corporate Strategies over Time, *Journal of Business Ethics* 52, No.4, pp.349–364.

66. Uppal, J.S., ed. (1983), *India's Economic Problem: An Analytical Approach*, 3rd ed. (New Delhi: Tata McGraw-Hill Publishing Company Limited).
67. Wardle, Judith (2002), *Developing Advertising with Qualitative Market Research* (London: Sage Publications).
68. Whitehead, Jack and Jean McNiff (2006), *Action Research Living Theory* (London: Sage Publications).
69. Wrenn, Bruce, Robert Stevens and David Loudon (2002), *Marketing Research: Text and Cases* (New York: Best Business Books).
70. Yin, Robert K. (2003), *Case Study Research: Design and Methods (Applied Social Research Methods Series Volume 5)*, 3rd ed. (Thousand Oaks: Sage Publications).

Chapter IV: Consumer's Response and Data Interpretation

4.1 Introduction

In the context of agriculture, India has released its first Genetically Modified Crop (GMC) in 2002 after five contentious years of rigorous testing and debate on the same. In 2002, Bt. cotton was available only in three legal commercial seed brands, produced through collaboration of Mahyco (Maharashtra Hybrid Seeds Company: the company providing hybrid cotton seed) and its partner and partial owner i.e. Monsanto (the St. Louis based biotechnological transnational company providing the gene construct). The seeds were "Bt." versions of established hybrid brands namely: MECH-12, MECH-162 and MECH-184. Bt. cotton has been cultivated in several states of India for the last seven years. The impact of the new seed (genetically modified crop, GMC), in terms of cost and benefit, for the farmers is elaborately discussed in this chapter. But on the *sales* performance, Monsanto reported sales of 72,000 packets¹ in 2002; 2,30,000 packets in 2003; in 2004, when four Bt. hybrids were available, sales jumped to 1.3 million packets, leading Monsanto to proclaim that not only GM seeds were the fastest adopted agricultural technology in history, but Indian cotton farmers were the world's fastest adopters of the technology. However, year of 2005 was the real breakthrough year; with the number of Bt. cotton seed brands sprouting up to 20 in numbers, sales jumped to 3 million packets nationwide.

With the advent of private companies in the agricultural sector, there has been a noticeable change in the decision making process of the farmers. The process of interaction between farmers and the seed industry has become more direct and dynamic. This type of technology intervention and change in relations in the agriculture sector requires preparation by the government and a sound guidance system for farmers. The assumption here is; a coherent technology should have positive socio-economic impact on the farmers. The technology's impact can be manifold, some are subject to natural science enquiry and some are subject to

¹ Packet: a packet is of 450gms of Bt. cotton seed meeting the sowing area of 1 acre.

market and industry enquiry. This study is a market enquiry in terms of the economics of the Bt. cotton and its effect on the Consumers (farmers²).

4.1.1 Goal

The goal of the research is to understand the strategy and structure of the seed industry in general and the process of adoption of Bt. cotton and its overall impact on farmers in Andhra Pradesh and Maharashtra states of India in particular. As a new product, Bt. cotton being the first Genetically Modified Crop (GMC) approved in India for large scale cultivation, can pave the way for other types of genetically modified crops. The basic unit of life, i.e., 'gene' has been manipulated to develop this new product where bacterial gene is inserted in the crop's gene, to protect it from insect. The new genetically modified crop will not only exhibit the characteristics of cotton plant but also produce the bacterial toxin, which will protect the plant from harmful insect. The entire concept is outcome of biotechnological manifestation in new product development. All these features lead to ongoing phenomenon which links research laboratory, market and consumers with one thread. Hence, the study outlines the structure of the industry and traces the preparedness of Indian Seed Industry thereof.

4.1.2 Objectives

The broad objectives of the study are:

- i. To understand the cost/benefit of Bt. cotton especially in the rainfed areas of Andhra Pradesh and Maharashtra because cotton is usually grown in rainfed regions of India.
- ii. To study the mechanisms used in influencing the farmers for adopting Bt. cotton.
- iii. To examine the interface between the government, other stakeholders and farmers on Bt. cotton.
- iv. The study, further seeks to find out the effect of Bt. cotton cultivation and potential for GMC.

² Consumer: Here the consumer is the farmer cultivating cotton. (Names of the farmers are kept confidential to maintain the research ethics and as pledged in questionnaire. Wherever necessary pseudo-name and place is being used).

4.1.3 Methodology

The study used a mix of qualitative and quantitative research methods. The purpose of the study was not only confined to collect data, but the process itself was meant to probe the farmers about the understanding of the cost/benefit analysis of Bt. cotton and its possible impact on health, environment and so on; from the consumer's perspective.

The main research tool used for obtaining data was field survey using a set of questionnaires, which were administered farmers in different States and panned interviews and interaction. First, there was a general discussion, on Bt. cotton, that made the farmers aware of other's observations in the field. The other research methods included focused group discussions, field visits, in-depth interviews with the farmers and participant observation. To get an understanding of Bt. cotton and related impacts in the selected villages, meetings were conducted and discussions held and respondents were profiled based on their usage, consumption and preferences.

4.1.3.1 Data collection

Primary data was obtained from six districts, three each, of Andhra Pradesh and Maharashtra Viz. Adilabad, Nizamabad, Khammam and Nanded, Hingoli and Yawatmal. In these districts of both the states majority of the farmers are dependent on rainfed agriculture. Villages where, most of the farmers are involved in cotton cultivation and that too using Bt. cotton were prioritized for the study. However, accessibility of the villages and the farmers, cultivating Bt. cotton, to the researcher also played an important role in the selection of the respondents for the study.

4.1.3.2 Total Sample Size

Total Districts: 6

Total Mandals/Taluks: 18

Total Villages: 98

Total Farmer Respondents: 533, (Breakup in Table 4.1 and Figure 4.1)

Total Seed Retailers: 17

Total Seed Distributors: 5

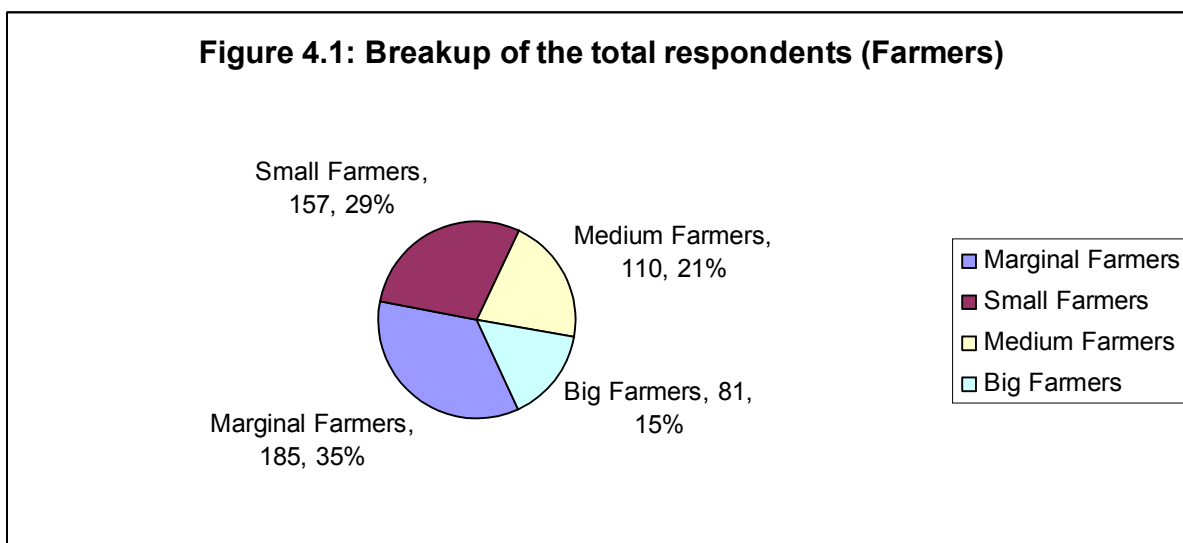
Cotton Ginning Mill: 2

Cotton Oil Mill: 1

Table 4.1: Breakup of Total respondents (Farmers) from Andhra Pradesh and Maharashtra

Type of Farmers	Land Holding Range	Number of Respondents		
		Andhra Pradesh	Maharashtra	Total (%)
Marginal Farmers	1-5 Acres	100	85	185 (34.7%)
Small Farmers	6-10 Acres	73	84	157 (29.5%)
Medium Farmers	11-20 Acres	41	69	110 (20.6%)
Big Farmers	21 acres and above	25	56	81 (15.2%)
Total Respondents		239	294	533(100%)

Source: Sample Survey



Source: Study findings

4.2 Consumers' Response from Andhra Pradesh

Total representation of farmers from Andhra Pradesh based on survey

Total District: 3

Total Mandal: 7

Total Villages: 51

Total Respondents: 239

Table 4.2: Breakup of respondents (Farmers) from Andhra Pradesh

Types of Farmers	Land Holding Range	No. of Respondents (percentage of total)
Marginal Farmers	1-5 Acres	100 (4.89%)
Small Farmers	6-10 Acres	73 (30.54%)
Medium Farmers	11-20 Acres	41 (17.15%)
Big Farmers	21 acres and above	25 (10.46%)
		Total: 239 (100%)

Source: Sample Survey

4.2.1 Case A: Consumers' Response from Nizamabad District – Andhra Pradesh

District: Nizamabad

Mandal: Bodhan

Village: Kandurki

Total Respondents: 41

Table 4.3: Breakup of respondents (farmers) from Nizamabad District

Type of farmers	Land Holding Range	No. of Respondents (%)
Marginal Farmers	1-5 Acres	9 (21.95%)
Small Farmers	6-10 Acres	12 (29.27%)
Medium Farmers	11-20 Acres	14 (34.15%)
Big Farmers	21 acres and above	6 (14.63%)
		Total: 41 (100%)

Source: Sample Survey

Out of 41 farmers, 19 (46.34%) had only dry land, who practiced rainfed agriculture and 22 (53.66%) had some facility for irrigation.

Cropping Pattern:

Kharif: Paddy, Toor Dal, Urad Dal (Black gram), Soyabean and Cotton.

Rabi: Jowar, Wheat, Kardi, Sunflower.

Summer: Groundnut and Sugarcane.

Cotton Seed Brand cultivated by the farmers who participated in sample survey:

Prominent Bt.cotton seed brands year-wise³:

Before 2005: Chamatkar (land race), 44(land race), 46Barik (landrace, local name), Brahma (Hybrid), Banni(Hybrid).

³ Inferred from the farmers' responses.

2005-2006: Zero Bt. (spurious Bt. cotton seed), Rasi Bt.

2006-2007: Rasi Bt., Brahma Bt. and Banni Bt.

2007-2008: Rasi Bt., Brahma Bt. and Mallika Bt.

Cotton Seeds prices:

Price of Bt. cotton seed brands in year 2005-2006: Rs.1850 for Bt. cotton; Rs.1000 for zero Bt. (spurious seed).

Price of Bt. cotton seed brands in year 2006-2007: MRP was Rs.750 but farmers paid the price range varying between Rs.775 to Rs.1250 for established brands.

Price of Bt. cotton seed brands in year 2007-2008: Rs.750 (All the farmers purchased at MRP). This is due to availability of many Bt. cotton seed brands in the market which in turn led to stability.

Inferences:

The survey was conducted at only one village i.e. Kandurki. Some of the findings are following:

- i. **Issue of Refugia:** In the year 2005-2006, all the farmers sowed Refugia for 2-line to 3-line; even for spurious Bt. cotton seed. In the year 2006-2007 when all the farmers were using branded Bt. cotton seed they used 1-line to 2-line on Refugia. In cropping season 2007-2008 none of the farmers sowed Refugia.
- ii. **Productivity:** Prior to 2005 the average production of cotton was 2-4 Quintals per acre. In the year 2005-2006 the yield ranged from 3-5 Quintals per acre. In the year 2006-2007 the enhanced yield ranged from 3-7 Quintals per acre. Farmers have bumper yield in the year 2007-2008 when the yield ranged from 6 Quintal to 11 Quintal per acre.
- iii. **Brand Loyalty:** Farmers of this village used only three brands for cropping in the year 2006-2007.

Table 4.4: No. of cotton seed brand grown by individual farmer (Nizamabad District)

No. of cotton seed brand	No. of Farmers (%)
One Brand of Bt. cotton seed growers	19 (46.34%)
Two Brand of Bt. cotton seed growers	22 (53.66%)
Source: Sample Survey	Total Farmers: 41 (100%)

- iv. 100% of the farmers mentioned 'yield' as the primary criteria for selection of the seed as their responses. Therefore, it can be inferred that the farmers' only expectation was 'yield' from any seed.
- v. All of them bought Bt. cotton seed from private retailers. For seed of other crops they bought from Government supply or used their own farm saved seed of 'desi' or land race varieties.
- vi. All the farmers consulted retailers if the purchased seed did not give yield as proclaimed by the seed company. None of them complained in any consumer fora or filed legal cases.
- vii. All the farmers responded 'yes' for reduction of pest problem and reduction in pesticide use.
- viii. ***Number of times pesticide used:***
Before 2005, farmers were spraying pesticides 4 to 7 times for landrace (desi variety) variety of cotton seed and 8 to 14 times for the best hybrid varieties of cotton seed. Farmers sowing Bt. cotton seed in ***the cropping season 2005-2006*** sprinkled pesticide 0 to 2 times; for ***the cropping season 2006-2007*** sprinkled 3 to 5 times pesticide in the field and for ***the cropping season 2007-2008*** sprinkled 4 to 9 times pesticides in the field.
- ix. Easy availability of Bt. cotton seed of many brands from increasing number of seed companies and reduction of prices, has removed spurious seed problem out of market since cropping season 2007-2008 onwards.
- x. Bt. cotton seed has completely removed landrace and hybrid seed, from sowing pattern.
- xi. All the respondents were unaware about the issue of labeling, Government policy and laws.
- xii. For any problem in the field all the farmers consulted local seed retailer only, for solution.

4.2.2 Case B: Consumers' Response from Adilabad District–Andhra Pradesh

District: Adilabad

Mandal: Tanuur

Villages: Javala, Kalali, Kharbala, Tondala

Total Respondents: 71

Table 4.5: Breakup of respondents (Farmers) from Adilabad District

Type of farmer	Land Holding Range	No. of Respondents (%)
Marginal Farmers	1-5 Acres	12 (16.90%)
Small Farmers	6-10 Acres	19 (26.76%)
Medium Farmers	11-20 Acres	23 (32.39%)
Big Farmers	21 acres and above	17 (23.95%)
Source: Sample Survey		Total: 71 (100%)

Out of 71 farmers, 39 (54.93%) had only dry land, who practiced rainfed agriculture and 32 (45.07%) had some facility for irrigation.

Cotton Seed Brand cultivated by the farmers in sample survey:

Prominent Bt.cotton seed brands year-wise:

Before 2005: Chamatkar (land race), 44(land race), Brahma (Hybrid), Banni (Hybrid).

2005-2006: Zero Bt.(spurious Bt. cotton seed), Rasi Bt.

2006-2007: Rasi Bt., Brahma Bt., Mallika Bt., Banni Bt., Fusion Bt. Super Maruti (KDCHH-441), Ajith Bt.

2007-2008: Rasi Bt., Brahma Bt., Mallika Bt., Fusion Bt.

Cotton Seeds prices:

Price of Bt. cotton seed brands in year 2005-2006: Rs.1850 for Bt. cotton; Rs.900 to Rs.1150 for spurious Bt. cotton seed.

Price of Bt. cotton seed brands in year 2006-2007: MRP was Rs.750 but farmers paid the price range varying between Rs.800 to Rs.1400 for established brands.

Price of Bt. cotton seed brands in year 2007-2008: Rs.750 (All the farmers purchased at MRP). This is due to availability of many Bt. cotton seed brands in the market which in turn led to stability.

Inferences:

The survey was carried out in only one mandal and four villages. The following findings are observed:

- i. **Issue of Refugia:** In the year 2005-2006, all the farmers kept refugia for 2-line to 3-line; even for spurious Bt. seed. In the year 2006-2007, when all the farmers were using branded Bt. cotton seed they used 1-line to 2-line. In cropping season 2007-2008 none of them kept any refuge around their Bt.cotton-fields.
- ii. **Productivity:** Prior to 2005 the average production of cotton per acre was 2-4 Quintals per acre. In the year 2005-2006 the yield ranged from 3-5 Quintals per acre. In the year 2006-2007, the enhanced yield ranged from 3-7 Quintals per acre. Farmers had bumper yield in the year 2007-2008, when the yield ranged from 6 Quintal to 11 Quintal per acre.
- iii. **Brand Loyalty:** Farmers of this village use seven Bt. cotton seed brands for cropping in the year 2006-2007.

Table 4.6: No. of cotton seed brand grown by individual farmer (Adilabad District)

No. of Brands	No. of Farmers (%)
One Brand of Bt. cotton seed growers	25 (35.2%)
Two Brand of Bt. cotton seed growers	36 (50.7%)
Three Brand of Bt. cotton seed growers	13 (18.3%)
Four Brand of Bt. cotton seed growers	7 (9.9%)
Five Brand of Bt. cotton seed grower	1 (1.4%)
Source: Sample Survey	Total Farmers: 71 (100%)

- iv. It can be inferred that the farmers' only expectation was 'yield' from any seed. Since 100% of the respondents (farmers) answered the same.
- v. All of them purchase Bt. cotton variety seed brand from private retailers. For other crops' seed they purchase from Government authorized supply or use their farm saved seed.
- vi. All the farmers consult the retailers, if the purchased seed varieties don't give yield as proclaimed by the seed company. None of them complained in consumer forum or taken any legal action.
- vii. All the farmers responded 'yes' for reduction of pest problem and reduction in pesticide use.

- viii. Number of time pesticide used:
Before 2005, farmers were spraying pesticides 4-7 times for landrace and 8 to 14 times for the best hybrid cotton seed field. In the *cropping season 2005-2006* farmers sowing Bt. cotton seed sprinkled pesticide 0 to 2 times; for the *cropping season 2006-2007* farmers sprayed 3 to 5 times pesticide in the field and for the *cropping season 2007-2008* farmers sprayed 4 to 9 times pesticides in the field.
- ix. Easy availability of Bt. cotton seed of various brands have removed spurious seed problem out of market.
- x. Bt. cotton seed has completely removed landrace and hybrid seed from sowing pattern.
- xi. All the respondents are unaware about the issues of labeling, Government policies and laws formulated for them.
- xii. For any problem in the field all the farmers consulted local seed retailers for immediate solution.

4.2.3 Case C: Consumers' Response from Khammam District-Andhra Pradesh

District: Khammam

Mandal: Burgampahada, Bhadrachalam, Dommugudem, Kuknur, Ashwapuram

Villages: Vapalgada, Poonvaram, Gurrampadu, Vellurpadum, Askapuram, Laxmipuram, Tekulcheruva, Cherusingaram, Krishnasagar, Mothe, Irrevedi, Irrevedi Kothuru, Burgampahar, Sanjeev Reddipalem, Upusakha, Jinnapadu, Ravulpurm, Pinnapakapetinagar, Anjanapuram, Ganpabaram, Urpure Bhawangiri, Aligudam, Pedaravigudam, Burguvaya, Velleru, Sridhara, Tandipaka, Nadigudam, Maradubaka, Nimalgulam, Chirvalu, Ramkrishnapuram, Urpure Bhawangiri, Pallamadu, Pushmapalli (Pallamadu and Pushmapalli are major Bt. cotton growing area), Upperu, Kalyanpuram, Chintriala, Anandpuram, Kruapalli Koturu, Tomalacheruvu, Venkatapuram, Ramchandrapuram and Mandikunta.

Total Respondents: 127

Table 4.7: Breakup of respondents (Farmers) from Khammam District

Types of Farmers	Land Holdings Range	No. of Respondents (%)
Marginal Farmers	1-5 acres	79 (62.3%)
Small Farmers	6-10 acres	42 (30%)
Medium Farmers	11-20 acres	4 (3.1%)
Big Farmers	21 acres and above	2 (1.6%)
Source: Sample Survey		Total:127

Out of 127 farmers, 69 (54.33%) had only dry land, who practiced rainfed agriculture and 58 (44.7%) had some facility for irrigation.

Cropping Pattern:

Kharif: Paddy, Jowar, Maize, Redgram, Other pulses (Green gram and Blackgram as Green Manure), Sugarcane, cotton, seassamone, chillies.

Rabi: Paddy, Groundnut, Maize, Tobacco (Virginia and local), Pulses (Blackgram, Greengram) seassamone, Cow pea, Sun hemp.

Cotton Seeds brands cultivated by the farmers in sample survey:

For the year 2006-2007: Sigma Bt., Banni Bt, Mallika Bt., Tulsi117 Bt., Ajith Bt.555, PCH-2270 Bt., CH3001 Bt., TCHH4Bt., Encounter Bt., J.K Durga Bt., Saraswati Bt.

For the year 2007-2008: Ajit, Nuziveedu, Mahyco, Tulasi, Krishidhan, Ankur, Prabardhan, Nath, Nirmal.

Cotton Seeds prices:

Price of Bt. cotton seed brands in year 2005-2006: Rs.1750.

Price of Bt. cotton seed brands in year 2006-2007: Rs.750

Price of Bt. cotton seed brands in year 2007-2008: Rs.750 and Rs.950.

Price of Govt. variety cotton seed (Narshimha) in year 2006-2007 and 2007-2008: MRP was Rs.150 but Selling Price in the market was Rs.100 to Rs.110.

Price of Non-Bt. cotton seed brands in year 2006-2007&2007-2008: MRP was Rs.400 to Rs.450 but Selling Price in the market was Rs.300 to Rs.350.

Inferences:

The survey was conducted at five mandals and forty-six villages. Some of the findings are following:

- i. **Issue of Refugia:** In the year 2005-2006, all the farmers kept refugia for 2-line to 3-lines; even for spurious Bt. seed. In the year 2006-2007 when all the farmers were using branded Bt. cotton seed they used 2-line.
- ii. **Productivity:** Prior to 2005 the average production of cotton per acre was 3-11 Quintals per acre when hybrid seeds predominate cropping. In the year 2005-2006 the yield ranged from 3-10 Quintals per acre even though Bt. cotton was adopted in the large scale. In the year 2006-2007 the Bt. cotton seed yield ranged from 8-12 Quintals per acre for rainfed fields and 12 to 14 Quintals per acre for irrigated fields. The lower limit of yield has increase by two to three times although the upper limit of yield has increased too. Brand Banni Bt failed in the year 2005-2006 cropping season. In the cropping year 2005-2006 upper limit of the yield for Bt. cotton has decreased slightly.
- iii. **Brand Loyalty:** Farmers of this district and fifty-one villages used eleven Bt. cotton seed brands for cropping in the year 2006-2007.

Table 4.8: No. of cotton seed brand grown by individual farmer (Khammam District)

No. of Brands	No. of Farmers (%)
One Brand of Bt. cotton seed growers	63 (49.6%)
Two Brand of Bt. cotton seed growers	42 (33.1%)
Three Brand of Bt. cotton seed growers	21 (16.5%)
Four Brand of Bt. cotton seed growers	0 (0%)
Five Brand of Bt. cotton seed grower	1 (0.8%)
Source: Sample Survey	Total Farmers: 127 (100%)

- iv. All the farmers responded that 'yield' is the only expectation which they have from any type of seed.
- v. All of them buy Bt. cotton seed from private retailers. For other seeds they buy from Government supply or use their farm saved seed.
- vi. Most of the farmer complained to the agricultural officer if the purchased seed does not give yield as proclaimed by the seed company. Some of them complained in consumer forum.

- vii. All the farmers responded ‘yes’ for reduction of pest problem and reduction in pesticide use.
- viii. Number of time pesticide used:
Before 2005, farmers were using sprinkling pesticides 5-8 times for landrace and 10 to 19 times for the best hybrid cotton seed field. In the *cropping season 2005-2006* farmers sowing Bt. cotton seed sprinkled pesticide 2 to 3 times; for the *cropping season 2006-2007* farmers sprinkled 3 to 4 times pesticide in the field. It was observed that agriculture officers had played very important role in educating farmers about Bt. technology and reduction in pesticide use.
- ix. Bt. cotton seed has completely removed landrace and hybrid seed from sowing pattern.
- x. All the respondents were unaware about the issue of labeling.
- xi. Many of the big farmers had shown interest in Government policy and laws which was known to them through the concerned agriculture officers.
- xii. For any problem in the field all the farmers consulted local seed retailer and agriculture officer for solution.

4.3 Consumers’ Response from Maharashtra

Total representation of farmers from Maharashtra based on survey:

Total Districts: 3

Total Taluks: 11

Total Villages: 47

Total Respondents: 294

Table 4.9: Breakup of respondents (Farmers) from Maharashtra

Type of Farmer	Land Holding Range	No. of Respondent
Marginal Farmers	1-5 Acres	85
Small Farmers	6-10 Acres	84
Medium Farmers	11-20 Acres	69
Big Farmers	21 acres and above	56
Source: Sample Survey		Total:294

4.3.1 Case A: Consumers' Response from Hingoli District-Maharashtra

District: Hingoli

Taluk: Basmath

Village: Wai

Total Respondents: 42

Table 4.10 : Breakup of respondents (Farmers) from Hingoli District

Types of Farmers	Land Holding Range	No. of Respondent (%)
Marginal Farmers	1-5 Acres	26 (61.9%)
Small Farmers	6-10 Acres	10 (23.8%)
Medium Farmers	11-20 Acres	4 (9.5%)
Big Farmers	21 acres and above	2 (4.8%)
Source: Sample Survey		Total: 42 (100%)

Cropping Pattern:

Kharif: Paddy, Jawar, Cotton, Soyabean, Moong Dal, Urad Dal.

Rabi: Jawar, Wheat, Toor Dal.

Cotton Seed Brand cultivated by the farmers in sample survey:

Year 2005-2006:

Hybrid (Price Range: Rs. 350 to 450): JK666, Tulsi, Banni, Sakti, Maruti, Yashoda, Dharti

Land Race (Price: Rs 350): Mahabeej-44

Bt.cotton seed (Price Range: MRP Rs.1750): Rasi Bt. and Maruti Bt. (available to the farmers Rs.1850 to Rs.2200)

Spurious Bt. cotton seed (Price range: Rs 700 to 1000): Gabbar, Sandocot, Maharana.

Year 2006-2007:

Market was predominant with only Bt cotton Brands: MallikaBt, Banni Bt, Prabardhan 102, 144Bt, Tulsi Bt, Brahma Bt, Ankur 651 Bt., Ajit 155 Bt, Rasi Bt, Mahyco Bt, Ganesh Bt., Yashoda Bt.Maruti Bt.

Inferences:

The survey was conducted at only one Taluk and one villages. Some of the findings are following:

- i. **Issue of Refugia:** In the year 2006-2007, 40 out of 42 farmers kept refugia of 2 lines and 2 farmers had not kept any refugia. In cropping season 2007-2008 none of the farmers are keeping refuge.
- ii. **Productivity:** In the cropping year 2005 -2006 the range of cotton yield per Acre was 4 Quintal to 20 Quintal. In the year 2006-2007 the yield ranged from 8 to 20 Quintals per acre. Top limit being same at 20 Quintal per acre it was observed that the bottom line of the yield had shifted from 4 to 8 Quintals which is double after Bt. cotton adopted by all the farmers in the village.
- iii. **Brand Loyalty:** Farmers of this village used thirteen Bt. cotton brands for cropping in the year 2006-2007.

Table 4.11: No. of cotton seed brand grown by individual farmer (Hingoli District)

No. of Brands	No. of Farmers (%)
One Brand of Bt. cotton seed growers	10 (23.8%)
Two Brand of Bt. cotton seed growers	17 (40.5%)
Three Brand of Bt. cotton seed growers	3 (7.1%)
Four Brand of Bt. cotton seed growers	2 (4.8%)
No Response	10 (23.8%)
Source: Sample Survey	Total Farmers: 42 (100%)

- iv. It can be inferred that the farmers' only expectation was 'yield' from any seed (100%).
- v. All of them bought Bt. cotton seed from private retailers. For other seeds they buy from Government supply or use their farm saved seed.
- vi. All the farmers consult retailers if the purchased seed don't give yield as proclaimed by the seed company. Big and Medium farmer consult Agriculture Officer for problems in the field along with consulting other farmers and seed retailer. Big farmer complained in consumer forum for failure of seed.
- vii. All the farmers responded 'yes' for reduction of pest problem and reduction in pesticide use.

- viii. Number of time pesticide used:
Before 2005, farmers were spraying pesticides 4-7 times for landrace and 11 to 20 times for the best hybrid cotton seed field. In the cropping season 2005-2006 farmers sowing Bt. cotton seed sprayed pesticide 1 to 3 times; for the cropping season 2006-2007 farmers sprayed 5 to 8 times pesticide in the field.
- ix. Easy availability of Bt. cotton Seed of various brands has removed spurious seed problem out of market in the year 2006- 2007.
- x. Bt. cotton seed has completely removed landrace and hybrid seed from sowing pattern.
- xi. All the respondents were unaware about the issue of labeling, Government policy and laws. But all the farmers were aware about crop insurance and none of them preferred to take crop insurance.

4.3.2 Case B: Consumers' Response from Nanded District-Maharastra

District: Nanded

Taluk: Dharmabad

Villages: Bannali, Atkur and Chikna

Total Respondents: 63

Table 4.12: Breakup of respondents (Farmers) from Nanded District

	Land Holding Range	No. of Respondent (%)
Marginal Farmers	1-5 Acres	20 (31.7%)
Small Farmers	6-10 Acres	16 (25.4%)
Medium Farmers	11-20 Acres	14 (22.2%)
Big Farmers	21 acres and above	13 (20.6%)
		Total: 63 (100%)

Source: Sample Survey

Out of 63 farmers, 33 (52.38%) had only dry land, who practiced rainfed agriculture and 30 (47.61%) had some facility for irrigation.

Cropping Pattern:

Kharif: Sugarcane, Paddy, Cotton, Soyabean, Moong Dal, Urad Dal, Toor Dal, Chilli

Rabi: Jowar, Wheat, Gram, Kardi, Til, Sunflower.

Summer: Groundnut

Cotton Seed Brands cultivated by the farmers in sample survey at Nanded District:

Year 2004-2005:

Hybrid (Price Range: Rs. 350 to 400): JK666, Tulsi, Banni, Sakti, Maruti, Hema, Tulsi,
Banni, Brahma, Ankur, J.K. Durga

Land Race (Price: Rs.300): H-4, 468, Mahabeej-44

Bt.cotton seed (Price: Rs.1750): Mahyco.

Year 2005-2006:

Bt.cotton seed (Price Range:Rs. 1750- 2200): Market was predominant with only Bt cotton Brands: MahycoBt., Banni Bt, Rasi-2, and spurious Bt commonly named 'Zero Bt'

Year 2006-2007:

Bt.cotton seed (MRP was 750 but available to the farmers at the Price Range: Rs. 800-1100). Market was predominant with only Bt. cotton Brands: Banni Bt, Mahyco 9 Bt., Brahma Bt, Ankur 651 Bt., Ajit 155 Bt, Rasi Bt, Mahyco Bt, J.K Durga Bt., JK-666 Bt., Ankur-651 Bt., Ganga Kaveri Bt., Mahashakti Bt. Mallika Bt., Vishwanath (NCEH-2R) Fusion Bt. of Nath Seeds, Super Maruti (KDCHH-441) of Krishidhan Seeds,

Year 2007-2008:

Bt.cotton seed (MRP was 750 but available to the farmers at the MRP). Market was predominant with only Bt. cotton Brands: Banni Bt, Mallika Bt., Mahyco 9 Bt., Brahma Bt, Ankur 651 Bt., Ajit 155 Bt, Rasi Bt, Mahyco Bt, Ankur-651 Bt., Ganga Kaveri Bt., Mahashakti Bt., Vishwanath (NCEH-2R) Fusion Bt. of Nath Seeds, Super Maruti (KDCHH-441) of Krishidhan Seeds. Hence, it was observed that the Price of Bt. cotton seed brands in year 2007-2008 had stabilized at Rs.750 (field survey findings shows that the farmers purchased Bt. cotton seed at MRP). This is due to availability of many Bt. cotton seed brands in the market which in turn led to stability.

Year 2008-2009:

Bt.cotton seed (MRP was 750 and available to the farmers at the MRP). Market was predominant with only Bt. cotton Brands: Mallika Bt., Brahma Bt, Ankur 651 Bt., Rasi-2 Bt., Mahyco Bt, Ankur-651 Bt., Super Maruti Bt.

Inferences:

The survey was done at only one Taluk and three villages. Some of the findings are following:

- i. **Issue of Refugia:** In the year 2005-2006, all the farmers kept refugia of 2-lines to 4-line. In cropping season 2006-2007 most of the farmers are kept Refugia of 2-line. In cropping season 2007-2008 none of the farmers are keeping refuge.
- ii. **Productivity:** In the cropping year 2004 -2005 the range of cotton yield per acre was 2 Quintal to 4 Quintal. In the year 2005-2006 the yield ranged from 2 to 8 Quintals per acre in the year 2006-2007 the yield ranged from 4 to 8 Quintals per acre. In the year 2007-2008 the yield ranged from 7 to 11 Quintals per acre. In the year 2008-2009 the yield ranged from 8 to 22 Quintals per acre. It was observed that the bottom limit of the yield had shifted from 2 to 8 Quintals which is quadruped by the cropping year 2008-2009; after Bt. cotton adopted by all the farmers in the village.
- iii. In the cropping year 2006-2007, two farmers left cotton cultivation because of lower yield. Both of them were marginal farmers.
- iv. **Brand Loyalty:** Farmers of this village used thirteen Bt. cotton brands for cropping in the year 2006-2007.

Table 4.13: No. of cotton seed brand grown by individual farmer (Nanded District)

No. of Brands	No. of Farmers (%)
One Brand of Bt. cotton seed growers	27 (44.3%)
Two Brands of Bt. cotton seed growers	14 (22.9)
Three Brands of Bt. cotton seed growers	7 (11.5%)
Four Brands of Bt. cotton seed growers	9 (14.7%)
Five Brands of Bt. cotton seed growers	3 (4.9%)
Six Brands of Bt. cotton seed grower	0 (0%)
Seven Brands of Bt. cotton seed growers	1 (1.6%)
No response	2 (3.3%)
Source: Sample Survey	Total Farmers: 63 (100%)

- v. 100% respondents' expectation was 'yield' as basic quality from any seed.
- vi. All of them bought Bt. cotton seed from private retailers. For other seeds they use to buy from Government supply or use their own farm saved 'desi' variety of seed.
- vii. All the farmers consulted retailers, if the purchased seed don't give yield as proclaimed by the seed company. Big and Medium farmer consult Agriculture Officer

- for problems in the field along with consulting other farmers and seed retailer. Big farmer complaint in consumer forum for failure of seed.
- viii. All the farmers responded 'yes' for reduction of pest problem and reduction in pesticide use.
 - ix. Number of time pesticide used:
Before 2005, farmers were spraying pesticides 4-7 times for landrace and 9 to 17 times for the best hybrid cotton seed field. In the cropping season 2005-2006 farmers sowing Bt. cotton seed sprayed pesticide 0 to 3 times; for *the cropping season 2006-2007* farmers sprayed 3 to 7 times pesticide in the field, for *the cropping season 2007-2008* farmers sprayed 5 to 9 times pesticide in the field, for *the cropping season 2008-2009* farmers sprayed 4 to 19 times pesticide in the field.
 - x. Easy availability of Bt. cotton Seed of various brands have removed spurious seed problem out of market in the year 2006- 2007.
 - xi. Bt. cotton seed has completely removed landrace variety and hybrid seed variety used in sowing pattern.
 - xii. All the respondents were unaware about the issues of labeling, Government policies and laws. All the respondents are aware about crops insurance but none of them adraft for practical crops insurance.
 - xiii. Big and Medium farmers complained to Agricultural officer if any problems related to seed occur. Small farmers complained to retailer and sometime they get back the replacement for seed. Marginal farmers did not initiate any action.

4.3.3 Case C: Consumers' Response from Yawatmal District-Maharastra

District: Yawatmal

Taluks: Kerapur, Pandav Kauda, Kedapur, Kelapur, Maregaon, Yawatmal, Ner, Babulgaon, Ghatanji

Villages: Sonbardi, Moregaon, Choupan, Wagoli, Sorlundi, Sai Kheda, Kinni, Umri, Khungra, Hapoli, Khergaon, Pimpri Road, Chalbardi, Ballarpur, Tilank Takri, Botony, Mangru, Waghapur, Lasina, Kini, Warud, Both, Sonewadona, Pimpri, Hatgaon, Uttarwadhona Manikwada, Asola, Brahmanwada, Sonkhan, Gondhali, Madni, Sukali,

Karalgaon, Galwa, Rani Amravati, Pimpadgaon, Rajegaon, Titwi, Rajurwadi,
Mandwa, Wasri Tanda, Rajapeth, Narayanpeth.

Total Respondents: 189

Table 4.14: Breakup of respondents (Farmers) from Yawatmal District

Type of Farmers	Land Holding Range	No. of Respondents (%)
Marginal Farmers	1-5 Acres	39 (20.6%)
Small Farmers	6-10 Acres	58 (30.7%)
Medium Farmers	11-20 Acres	51 (26.9%)
Big Farmers	21 acres and above	41 (21.7%)
Source: Sample Survey		Total: 189 (100%)

Out of 189 farmers, 58 (30.7%) had only dry land, who practiced rainfed agriculture and 131 (69.3%) had some facility for irrigation.

Cropping Pattern:

Kharif: Paddy, Cotton, Soyabean, Moong Dal, Urad Dal.

Rabi: Jowar, Wheat, Pulses, Vegetables, Groundnuts.

Annual Fruit: Orange

Cotton Seed Brands cultivated by the farmers in sample survey:

Year 2005-2006:

Hybrid (Price Range: Rs. 350 to 450): Mahbeej, Ganga Kaveri, Tulsi, Banni, Brahma, Sigma, Prabardhan, Ankur 651

Land Race (Price: Rs 350): Mahabeej-44

Bt.cotton seed (Price Range:Rs. 1750 to 1850): Rasi Bt., Mahyco Bt.(12, 162, 184, 6301), Banni Bt, Mallika Bt., Ankur Bt.651.

Spurious Bt. cotton seed (Price range: Rs 700 to 1000): Illegal Bt Raja Rani, Illegal Bt Don, Illegal Bt Balaji, Illegal Bt Hema, Illegal Bt Gautam, Illegal Bt, Illegal Bt Shiva-1, Illegal Bt Ganesh, Illegal Bt Bhagya

Year 2006-2007:

Market was predominant with only Bt. cotton Brands: Mallika Bt, Banni Bt, Prabardhan 102, 144Bt, Tulsi Bt, Brahma Bt, Ankur 651 Bt., Rasi Bt, Mahyco Bt., Brahma Bt., Sigma Bt.,

Fusion Bt. Price of Bt. cotton seed brands in year 2007-2008 stabilised at Rs.750 (field survey findings reveal that all the farmers purchased Bt. cotton at MRP). This is due to availability of many Bt. cotton seed brands in the market which in turn led to stability.

Inferences:

The survey was conducted at only nine Taluks and forty four villages. The following findings are observed:

- i. Issue of Refugia: In the year 2005-2006, all the farmers kept refugia even for spurious Bt. cotton. In cropping season 2006-2007 All of the farmers were keeping refugia ranging between 1-line to 2-lines.
- ii. Productivity: In the cropping year 2005 -2006 the range of cotton yield per acre was 2 Quintal to 12 Quintals for Bt. and non Bt. In the year 2006-2007 the yield ranged from 6 to 17 Quintals per acre for Bt. cotton seed. Bottom limit of yield increased to 6 Quintals which are three times more and top limit of the yield had shifted from 12 to 17 Quintals after Bt. cotton adopted by all the farmers in the village.
- iii. Brand Loyalty: Farmers of these villages used thirteen Bt. cotton brands for cropping in the year 2006-2007.

Table 4.15: No. of cotton seed brand grown by individual farmer (Yawatmal District)

No. of Brand grown by individual farmer	No. of Farmers
One Brand of Bt. cotton seed growers	34 (17.9%)
Two Brand of Bt. cotton seed growers	136 (71.9%)
Three Brand of Bt. cotton seed growers	17 (8.9)
Four Brand of Bt. cotton seed growers	2 (1%)
Source: Sample Survey	Total Farmers: 189 (100%)

- iv. 100% consumer expectation was ‘yield’ as basic quality from any seed for buying decision.
- v. All of them buy Bt. cotton seed from private retailers. For other seeds they got from Government authorised supply or use their farm saved seed.
- vi. All the farmers responded ‘yes’ for reduction of pest problem and reduction in pesticide use.

- vii. Number of time pesticide used:
Before 2005, farmers were using sprinkling pesticides 7 to 15 times for the best hybrid cotton seed field. In the cropping season 2005-2006 farmers sowing Bt. cotton seed sprinkled pesticide 2 to 3 times; for the cropping season 2006-2007 farmers sprinkled 4 to 7 times pesticide in the field.
- viii. Easy availability of Bt. cotton seed of various brands have removed spurious seed problem out of market in the year 2006- 2007.
- ix. Bt. cotton seed has completely removed landrace and hybrid seed from sowing pattern.
- x. Apart from 7 (3.7%) farmers, all the respondents were unaware about the issues of labeling, Government policies and laws. All the farmers are aware of crops insurance but none of them go for practical crops insurance.

4.4 Conclusions

Productivity:

Table 4.16 presents state wise area and productivity of cotton in India between 2003-04 and 2007-08. The total area under cotton has increased from 7.6 million hectares in 2003-04 to 9.4 million hectares in 2007-08. The average yield of cotton crop per hectare also increased significantly during this period. The average yield of cotton, per hectare increased from 399 Kgs in 2003-04 to 567 Kgs in 2007-08. This shows that the increase in production area and yields are largely attributed to the increased use of Bt. (*Bacillus thuringiensis*) cotton hybrids (a shift from traditional hybrids to Bt. cotton hybrids) and favourable climatic conditions. Findings from the case studies shows that only 273 (56.52%) out of 483 respondents (farmers) had some facility of irrigation and rest 218 (45.13%) of farmers had only dry land. Observation during field survey reinforce that irrigated land use for cropping for paddy, sugarcane, pulses, vegetables etc. whereas non-irrigated rainfed land use for millets and cotton types of crops. In such circumstances minimum range of cotton yield had increased in all the districts selected for study.

**Table 4.16: State-wise Area and Productivity of Cotton
(Area in lakh hectares and yield in kgs per hectare)**

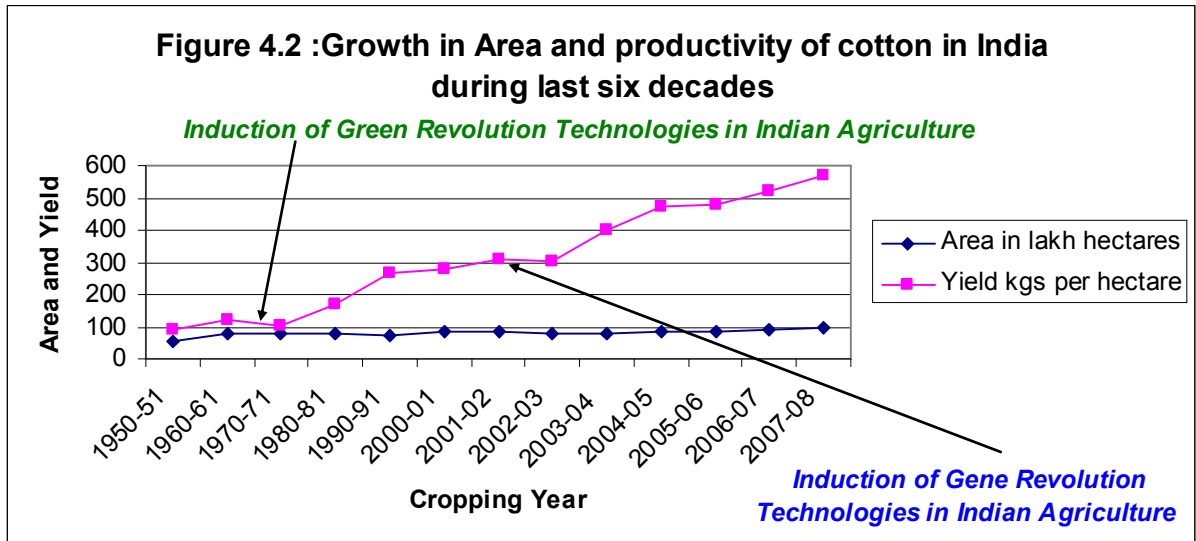
	2003-04		2004-05		2005-06		2006-07		2007-08	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Punjab	4.52	389	5.09	551	5.57	610	6.07	672	6.04	619
Haryana	5.26	372	6.21	424	5.83	379	5.30	481	4.83	563
Rajasthan	3.44	452	4.38	427	4.71	397	3.50	437	3.39	451
North total	13.22	399	15.68	466	16.11	464	14.87	549	14.26	560
Gujarat	16.47	516	19.06	651	19.06	794	23.90	733	24.22	786
Maharashtra	27.66	191	28.40	311	28.75	213	31.07	273	31.94	330
Madhya Pradesh	5.91	565	5.76	472	6.20	494	6.39	505	6.30	567
Central total	50.04	342	53.22	450	54.01	450	61.36	477	62.46	531
Andhra Pradesh	8.37	557	11.78	469	10.33	527	9.72	630	11.38	687
Karnataka	3.13	228	5.21	261	4.13	268	3.78	270	4.02	338
Tamilnadu	1.03	619	1.29	725	1.40	568	1.00	850	1.19	714
South Total	12.53	480	18.28	428	15.86	472	14.50	551	16.59	605
Others	0.51	333	0.68	250	0.79	215	0.71	239	1.08	315
TOTAL	76.30	399	86.86	470	86.77	478	91.44	521	94.39	567

Source: Cotton Advisory Board (<http://www.cotcorp.gov.in/statistics.asp#area>, dated: 18/6/2009)

**Table 4.17: Area, Production and productivity of cotton in India during
last six decades**

Year	Area in lakh hectares	Production in lakh bales of 170 kgs	Yield kgs per hectare
1950-51	56.48	30.62	92
1960-61	76.78	56.41	124
1970-71	76.05	47.63	106
1980-81	78.24	78.60	170
1990-91	74.39	117.00	267
2000-01	85.76	140.00	278
2001-02	87.30	158.00	308
2002-03	76.67	136.00	302
2003-04	76.30	179.00	399
2004-05	87.86	243.00	470
2005-06	86.77	244.00	478
2006-07	91.44	280.00	521
2007-08	94.39	315.00	567

Source :Cotton Advisory Board



Source: Study findings

Table 4.17 and figure 4.2, highlight the productivity of cotton in India during last six decades during 1950 to 1980, when farm saved seed and land race varieties were commonly sown, at that time initial hybrid varieties introduced by government, the yield increased from 92kg/hectare from 1950-51 to 172kg/hectare in 1980. With the participation of more number of private seed companies and more hybrid varieties released thereafter, there was a leap in cotton production when yield per hectare rose from 172 kg/hectare in 1980-81 to 267kg/hectare in 1990-91. Thereafter the productivity increase to 308kg/hectare by the year 2001-2002, this increase was slow and productivity saturated and a minute decline was observed in the cropping year 2002-2003. Year 2002-2003 was also marked the introduction of first GMC i.e. Bt. cotton in India. Afterwards there was a substantial increase in cotton productivity, within three years the yield increased from 302kg/hectare in the cropping year 2002-2003 to 470kg/hectare in the cropping year 2004-2005 (the increase in productivity was 167 kg/hectare). Further the productivity increased to 567kg/hectare in the cropping year 2007- 2008. These findings lead to a logical conclusion that within six years of the launch of Bt. cotton (new product, i.e. a type of GMC), the productivity increased from 302kg/hectare to 567kg/hectare, i.e. an increase of 265kg/hectare. This increase is phenomenal within a time duration of just six years as compared to what was achieved in five decades, the six years registered the same growth due to use of biotechnology in cotton productivity. This illustrates the success story of the potential of Biotechnology in the field of agriculture.

Secondary use of cotton seed:

**Table 4.18: Availability of Cottonseed for Processing in India
(2001-2002 to 2003-2004 and 2005-2006 to 2007-2008)**

Items	2001-2002	2002-2003	2003-2004	2005-2006	2006-2007	2007-2008
Cotton Production (lakh bales)	158	140	167.5	241	280	310
Cottonseed Production (@333kg/bale) (lakh tonnes)	52.61	46.62	55.77	80.25	93.24	103.23
Retained for Sowing & Direct Consumption (lakh tonnes)	11.3	10	11	13.00	13.00	13.00
Marketable Surplus (lakh tonnes)	41.31	36.62	44.77	67.25	80.24	90.23
Production of Washed Cottonseed Oil (lakh tonnes)	4.13	3.66	4.77	7.40	8.83	9.92

Source: East India Cotton Association and All India Cottonseed Crushers Association.

Table 4.18 gives broad breakup of cotton seed production and its processing. Cottonseed is an important source of vegetable oil and protein but despite the value of these products, the price of cotton is based on the spinning value of the fibers that develop as elongations of the surface cells in the seed coat. From the field survey it was observed that cotton seed oil, used for human consumption and after extraction of oil cotton seed cake used for cattle feed. Cotton seed oil also has various industrial uses and used as raw material for soap manufacturing. Cotton seed and its direct and indirect consumption by human and animal do need scientific evaluation of Bt.cotton seed oil and its toxicological findings. The scientific study of toxicology and its various aspects are necessary and vital for the welfare of human being because the basic change in the form of 'genetic manipulation' has been done to cotton plant which is directly and indirectly influencing human food chain.

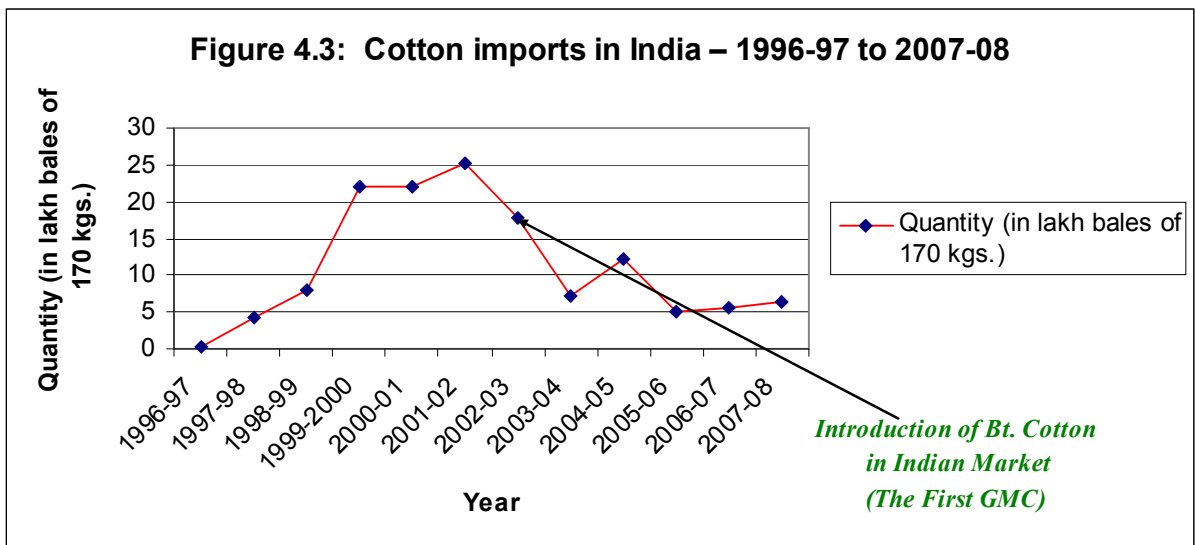
Import of cotton by India:

Table 4.19 and figure 4.3, shows the cotton import by India in last decade. Cotton being a cash crop brings money to farmers. Increase in cotton productivity also save valuable foreign exchange for the country. After the introduction of Bt. cotton (The First GMC) to the Indian agriculture, India's dependency on cotton imports has declined.

Table 4.19: Cotton imports in India – 1996-97 onwards

Year	Quantity (in lakh bales of 170 kgs.)	Value (Rs./Crores)
1996-97	0.30	56.42
1997-98	4.13	497.93
1998-99	7.87	772.64
1999-2000	22.01	1967.92
2000-01	22.13	2029.18
2001-02	25.26	2150.01
2002-03	17.67	1789.92
2003-04	7.21	880.10
2004-05	12.17	1338.04
2005-06	5.00	695.77
2006-07	5.53	752.29
2007-08	6.50	986.33

Source: Cotton Advisory Board for Quantity figures



Source: Study findings

From figure 4.2 and figure 4.3, it is inferred that new technology induction has increased productivity of cotton and reduced the import of cotton by India.

Issue of Pricing:

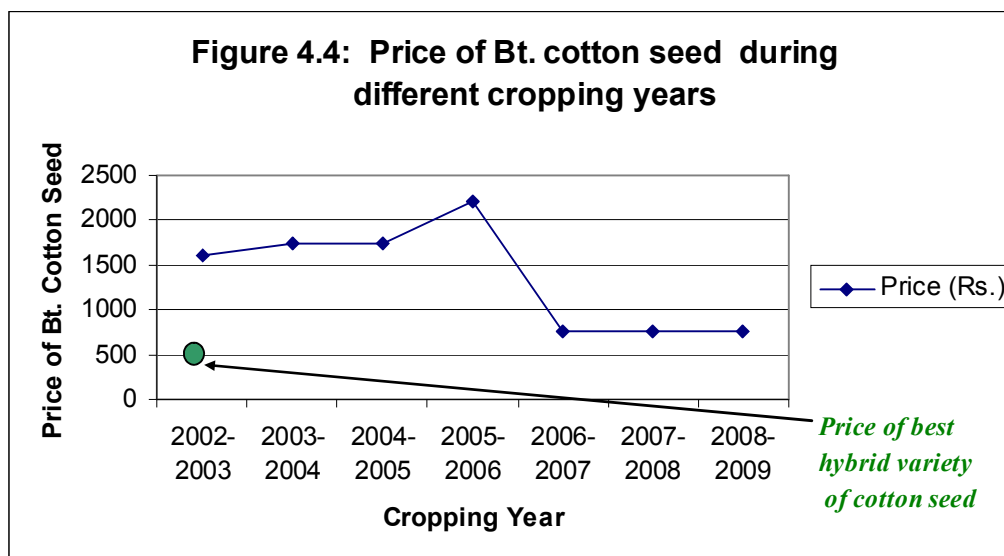
In the initial years of product (Bt. cotton) launch by ‘Mahyco-Monsanto Biotech Limited (MMB)’, the price of Bt. cotton was Rs.1600; in the cropping year 2002-2003, when best hybrid varieties of cotton crop in market priced at only Rs.400 for a packet of 450gms of seed. Table 4.20 shows skimming pricing in monopoly market. Monsanto through its joint venture company ‘Mahyco-Monsanto Biotech Limited (MMB)’ has sublicensed its ‘Bt. technology’ to several seed companies in India in subsequent years and availability of these companies’ Bt. cotton seed brands in market shows skimming pricing in oligopoly market. After government intervention through MRTP Act and entry of more than 20 brands of Bt. cotton seed by several companies, the price stabilized at Rs.750 in oligopoly market; still farmers were paying more than the MRP to procure Bt. cotton seed because the demand was more than supply. By the cropping season 2007-2008, farmers were purchasing the Bt. cotton seed packet at MRP, which shows the equilibrium of demand and supply and market behaved as perfect competition.

Table 4.20: Pricing of Bt. Cotton

Cropping Year	Price of Bt. cotton seed per packet (450 gram) (MRP* in Rs.)
2002-2003	1600
2003-2004	1750
2004-2005	1750
2005-2006	2200
2006-2007	750
2007-2008	750
2008-2009	750

Source: Sample Survey & Interviews with farmers, retailers and industry practitioners.

*Including all taxes and levies.



Source: Study findings

Table 2.20 and figure 4.4, implies that at the beginning new products launched in the existing market used the skimming pricing strategy. After the government’s intervention the price stabilized to a fixed price, forced by law and agreed by the seed companies.

As regards Sub-licensing:

Monsanto through its joint venture company Mahyco-Monsanto Biotech Limited (MMB)’ sublicensed its ‘Bt. technology’ to several seed companies in India. Under the sublicense agreement, MMB permitted sub licensees to use its ‘Bt. technology’ by paying fixed ‘trait value’ (another name for royalty) on each packet of seed they sold in the market. Sub licensees have to pay this royalty as long as they use MMB’s Bt. technology. In the initial years MMB fixed trait value at Rs.1250 on each packet of seed (450 grams) and subsequently reduced it to around Rs.100 in 2006-07 after Monopolies and Restrictive Trade Practices Commission directed the company to reduce the trait value and different state governments in India put the tag on maximum selling price of Bt. cotton seed in the market at Rs.750 per packet. After the intervention of the central and state governments, MMB reduced the price of a 450 gram seed packet to Rs.750 in 2006-2007.

Issue of Pesticide consumption:

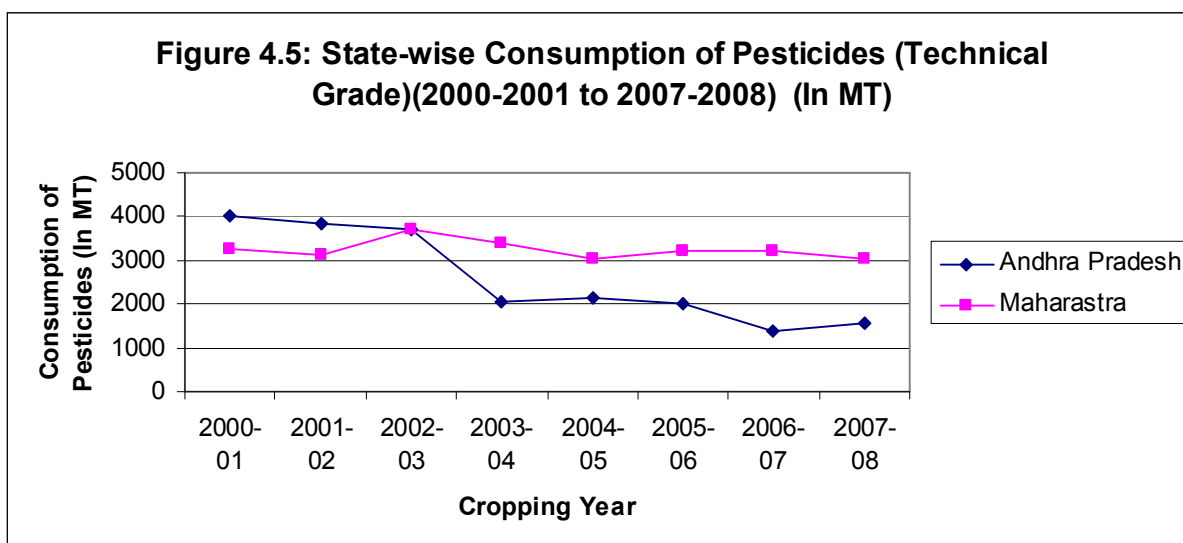
When the question regarding pesticide consumption and number of times pesticide used in the individual farmer’s field was posed to the farmers, the response was similar in all the districts

in the selected sample. Overall perception of the respondents was that there was reduction in number of times pesticide sprayed and a gradual reduction in bollworm problem in their cotton fields. This implies that the overall pesticide consumption has decreased by adoption of Bt. technology in India. Hence, this proves that Bt. technology reduces pesticide related pollution. However, it is also observed that the number of times spray of pesticide increased during the cropping years 2006-2007 and 2007-2008; this is due to the problem of sucking pests. Simultaneously, it was also observed that for getting more yields many farmers had increased the pesticide spray in the field even though it is not necessary. Therefore, this trend needs to be taken seriously and educating the farming community by using mass media towards this issue needs urgent attention of government, NGOs and seed industry.

Table No 4.21: State-wise Consumption of Pesticides (Technical Grade) in India (2000-2001 to 2007-2008) (In MT)

State	Years							
	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Andhra Pradesh	4000	3850	3706	2034	2135	1997	1394	1541
Maharashtra	3239	3135	3725	3385	3030	3198	3193	3050

Source: Ministry of Statistics and Programme Implementation, Govt. of India.



Source: Study findings

Table 4.21 and figure 4.5, shows a decline in demand of pesticide consumption. The remarkable decline in pesticide consumption from 3706 MT in the cropping year 2002-2003

to 1394 MT in the cropping year 2006-2007 and further partial increase to 1541 MT in the state of Andhra Pradesh reinforces the observations made during the primary survey at field level. From the state of Maharashtra the pesticide consumption declined from 3725 MT in the cropping year 2002-2003 to 3193 MT in the cropping year 2006-2007 and further partial decreased to 3050 MT again reinforced the findings of the primary survey. The findings conclude that the microcosm is being reflected as macrocosm both in term of primary survey and secondary data.

Issue of Bt. cotton plant after final harvest:

When question like: ‘What do you do with Bt. cotton plant after harvesting’; posed to farmers. Their response was similar in all the area selected for field survey. After final harvest farmers leave the plant in field for drying. At this stage they allow animals to graze the field. After drying up they either burn it in the field or use it as fuel for cooking.

Issue of Product choice/substitute:

Bt. cotton seed had completely removed landrace varieties and hybrid varieties of cotton seed from sowing pattern.

Seed Replacement:

As regards the seed replacement, the responded opined differently in terms of seed selection for different crops. For cash crop like cotton, all of them buy seed in every cropping season whereas for the seed of crops like paddy, pulses, sunflower and soyabean they buy from government agencies. Some farmers do buy seeds from private retailers too for the trial looking for higher yield. It was observed during focus group interviews that in the first year of sowing of hybrid seed of paddy, Pioneer Seed company, yielded very good harvest but farm saved seed from same harvest has not yielded as per expectation of the farmer and yield was low in subsequent years.

For crops like Jowar, farmers used their own farm saved ‘desi’ seed; such type of crop was being grown where other crops were not possible, as Jowar is considered inferior crop against paddy or cash crop. Seed companies argue that their hybrid varieties of Jowar could yield

better than farm saved seed of this crop, but farmers do not buy seed of crops like Jowar from open market. Hence, for private seed companies, large share of profit comes from portfolio like 'cotton seed'.

This shows a unique kind of consumer behaviour in terms of Indian farmers. According to farmers' response, when they grow landrace (which is also called 'desi variety' or 'gaurang' in local term) varieties; the minimum yield is sure in extreme climatic conditions like draught seasons. The other advantage of using 'desi' variety of crops seed is that it is not highly dependent on agricultural farm inputs like fertilizers and pesticides. Therefore, the risk of growing this type of crops seed is minimum and with assured minimum yield. Hybrid seed of crops, even though they give high yield, the perceived risk is also more in terms of biotic and abiotic stress.

In all the area surveyed, it was observed that farmers grew a mix of seed varieties: farm saved desi varieties, hybrid seed purchased from private seed companies and government authorized shop where agricultural universities improvised seeds are sold. This creates a unique pattern of consumer behaviour where farmers use different type of available seeds as 'portfolios' with moderate risk to have optimum yield. This type of pattern has created all together unique supply system of seed demands with distinct role to all suppliers in this industry. Understanding the specific needs of the farmers also creates an enormous potential observing the consumer behaviour. This behaviour also becomes hurdle in the path of seed replacement.

Seed Supply System:

Table 4.22 and 4.23 shows the supply side of seed industry. From primary survey it was observed that Bt.cotton seed portfolio is monopolized by private seed companies leading to oligopoly market. Private seed companies play a leading role in the supply of seed of crops like cotton, soybean, sunflower, paddy whereas government play leading role in supply of the seed of crops like cereals, pulses, oilseeds. Private seed companies have monopoly over cotton and vegetable seeds portfolio.

Table 4.22: Crop-wise Availability of Certified/Quality Seed with Various Agencies in India (Kharif, 2007)

Crop	Availability				(Qty in Qtls.)
	NSC	SFCI	SSC	Others	Total
Paddy	170664	55758	959577	2640897	3826896
Maize	17672	1133	28152	440001	486958
Jowar	8060		28884	133879	163323
Bajra	5058		44457	179006	228521
Ragi	950		10019	16794	27763
Urd	13487	4589	42877	49355	110308
Moong	3821	3696	49645	72267	129429
Arhar	4094	7200	27598	126159	165051
Cowpea	360	0	500	6952	7812
Moth	300	695	1932	2997	5924
Groundnut	18314	2814	83947	99060	1099135
Till	687	0	4445	12053	17185
Sunflower	708	0	2920	45655	49283
Castor	1976	120	11072	42191	55359
Niger	0	0	130	165	295
Soybean	78482	11614	652140	948120	1690356
Cotton	347	5759	40359	202993	249458
Jute	12382	0	24393	42827	79602
Others	2374	3379	22138	39130	67021
Grand Total	339736	96757	2035185	5100501	8459679

Abbr. : NSC : National Seeds Corporation.

SFCI : State Farm Corporation of India.

SSC : State Seeds Corporations.

Source : Rajya Sabha Starred Question No. 534, dated 11.05.2007.

Table 4.23: Share of Public Sector in Making Available/Supply of Certified/Quality Seeds in India (2005-2006 to 2007-2008)

Year	(In Lakh Quintal)			
	Govt. Agencies		Private *	
	Quantity	%	Quantity	%
2005-06	73.67	52.43	66.84	47.57
2006-07	79.62	53.73	68.56	46.27
2007-08	111.59	57.43	82.72	42.57

Note : * : Including Multinational Companies.

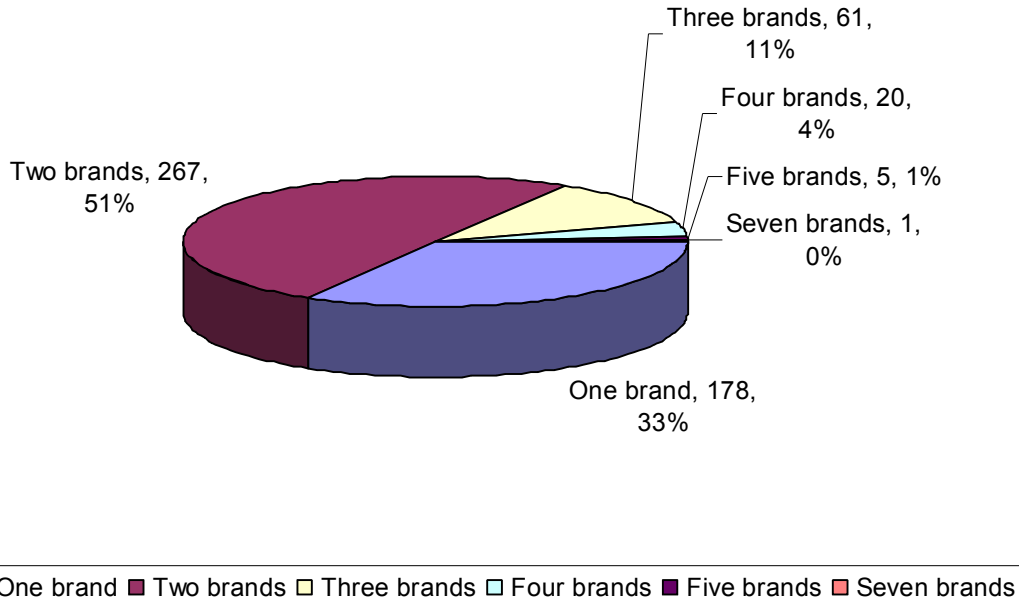
Source : Rajya Sabha Unstarred Question No. 553, dated on 23.11.2007.

Regarding Advertisement Tactics:

Table 4.24: Breakup of the Number of Respondents (Farmers) growing, number of different brands of Bt. cotton in their individual fields

Number of Brands	Breakup of Respondents (Farmers) from different districts						Total Respondents (% of total respondents)
	Nizamabad	Adilabad	Khammam	Nanded	Hingoli	Yawatmal	
One	19	25	63	27	10	34	178 (33.46%)
Two	22	36	42	14	17	136	267 (50.2%)
Three		13	21	7	3	17	61 (11.46%)
Four		7	0	9	2	2	20 (3.75)
Five		1	1	3			5 (0.93%)
Six				0			0 (0%)
Seven				1			1 (0.18%)
Source: Sample Survey							Total: 532 (100%)

Figure 4.6: Number of Respondents (Farmers) growing, number of different brands of Bt. cotton seeds in their individual fields



Source: Study findings

From the field survey, focus group interview and researcher’s observation it was observed that “Big (private seed companies call them progressive farmer) farmer’s name” was used by a seed company through publishing his name and showing information about him and arranging field visit to his farm; for advertisement of new product (new seed) by private seed

companies in India. Big farmers have multiple roles in village: influencer, opinion leader, opinion maker, money lender, agriculture-input seller, agriculture-output buyer and so on. All seed companies target these influential (Big) farmers' field for trial plot where demonstration crop by seed companies are sown. Being resource rich, these farmers can take better care of trial plot or demonstrated trial field for cultivation of 'new seed'. As it was inferred by case studies that 'yield' was the only parameter for 'buying decision making process'; performance of the seed on the parameter of 'yield' becomes very important to be in the market. This leads to use of these 'Big Farmers' plot for showcasing seed companies' new product. ⁴

'Word of mouth'⁵ is the silent rule of the Indian seed industry. Since, 'yield' is the only criteria on which farmers' buying decision depends; this logically concludes that Indian farmers are not brand loyal and they keep experimenting with different brands (as shown in Table 4.24 and represented by figure 4.6) in search of 'yield'. It was also observed that farmers are growing multiple brands of multiple companies in search of 'yield'. This experimental nature of Indian farmers, make the seed market very dynamic and volatile.

⁴ Note: the paragraph's conclusion is based on focus group interview, field observation.

⁵ Note: Inference based on the farmer's response collected during field survey; where all the farmers responded that they are influenced by friends or relatives for initial buying decision with regard to Bt. cotton seed.

Chapter V: Policy and Regulatory Framework

5.1 Introduction

After 1990, globally a major change occurred in all types of international trade and several changes are still occurring to accept the challenges, opportunity and threats under the obligation of WTO/TRIPS¹. This has also affected Indian agricultural sector in several dimensions. A new era of debate is initiated at different levels of society about biopiracy, biosecurity, traditional knowledge, biotechnology and Intellectual Property Rights (IPRs). Keeping these issues in mind, a comprehensive study of policy framework has been done to understand several factors and its implication on agricultural sector.

Biotechnology is arguably one of the most contentious issues in Indian Seed Industry today. Its proponents contend that it is the beginning of a 'gene revolution' that will vastly improve the agriculture as the green revolution did during 1970s and 80s. Critics, on the other hand, believe that the perceived benefits of biotechnology are outweighed by the potential risks posed to environment and the people through genetic modification and the ownership of life through patenting. Once a transgenic plant has been developed, it must be marketed if it is to prove the value to its creators. In globalize market economy, the development of a marketing strategy is likely to require consideration of legal questions, for both intellectual property rights and environmental regulation can be used to achieve competitive advantage and market exclusivity.

The coming into force of IPRs and agreement on agriculture is far from consensus. Developing countries like India are facing a tough battle against time, safeguarding their natural resources under changing global environment. This situation has arisen after establishment of the World Trade Organization w.e.f. 1st January 1995, of the several World Trade Organization (WTO) agreements; its agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) is of great significance for most developing countries

¹ TRIPs or Trade Related Intellectual Property Rights are of the agreements signed at the end of Uruguay Round of GATT negotiations in 1995. It sets our minimum standards of IPR protection that each country belongs in to the WTO is expected to provide. According to Article 27 of TRIPs, member states are required to allow patents for any invention "where the product or process, in all fields of technology" Microorganism and microbiological processes are to be provided protection through patents. In the case of plant varieties, countries have choice.

since ratification by member countries implies important change in their respective intellectual property laws. It is very important to mention that, at the time of signing of the WTO agreements, IPR laws in developing countries were in nascent stage in comparison to developed countries, whose laws or institution are at par with the TRIPS agreement. By the enactment of TRIPS, the IPR became an issue of debate between developed and developing countries. The word like 'life patent' and 'plant variety protection act' emerged in front of developing countries for the first time. Patent on life (Bio-patent) is not new for developed countries but in case of developing countries it is new one. The question was in front of developing countries is to accept the TRIPS in which suitable manner that will fit for their needs and requirements. After global acceptance of WTO agreement, the dimension is totally changed in case of life science industry like agriculture and pharmaceutical sector. The mechanism and instrument of life patent has negligible presence in developing countries. Most of the debate after TRIPS agreement focused on pharmacy sector and biotechnological revolution in plant science. The concepts of traditional knowledge, bio-piracy, biosecurity and food security of country like India in new global regime have to be analysed. India has large number of crop varieties having diverse centre of crop diversity and its climate is suitable for different types of crop and herbs. Therefore, concerns are expressed that the new liberalized regime might have some impact on rich genetic heritage and bio-wealth of India.

The study of the Indian seed industry in the light of the technological innovation like GMC brought by biotechnology has great significance. Increasing Public - Private sector partnership and protection regime definitely has some socio-economic impact on larger farming community and the Seed Industry. Existing legal policy framework has been studied to understand the complexity inbuilt because of multiple regulatory initiatives at international and national context, which has been highlighted in this section of study. This chapter briefly explores these legal issues that are associated with marketing transgenic plants, and touches on the likelihood that these legal doctrines will encourage a concentrated market structure in the agricultural biotechnology industry of which Seed Industry is a segment. This chapter is only a research initiative to juxtapose International and Indian regulatory framework which explicitly and implicitly ascertain role of policy environment on Genetically Modified Crops marketing in global market in general and India in particular. This chapter first introduces the

international intellectual property system. It then describes the traditional form of plant intellectual property protection, known as plant breeder's rights or plant variety protection (PVP), and next the contemporary use of the regular or utility patent system. It further considers the less formal legal protection methods of trade secrecy. It finally turns to a brief discussion of those biosafety issues that affect marketing and trade.

5.1.1 Methodology

This chapter based on the critical evaluation of Rule, Acts, National policy and international laws etc.² and discussion arising from that by triangulating to some of the outcomes of previous chapters of this dissertation. Juxtaposing national regulatory framework with international brings out the influence of global regulatory initiative on Indian agriculture. This chapter investigates the possible effect of Plant Breeders' Rights, Plant Variety Protection Act & Farmers Rights (PVPA & FRs) with respect to the Indian farmers and Indian Seed sector.

The enquiry is based on the archival source obtained from various organizations like Indian Council of Agriculture research (ICAR), Department of Biotechnology (DBT), Department of Scientific and Industrial Research (DSIR), Council of Scientific and Industrial research (CSIR), research and press release of IRRI, ISAAA, IFPRI, FAO, Monsanto, Syngenta etc. Economic survey of India and Hindu survey of Indian agriculture is done for theoretical Knowledge. An interdisciplinary approach had been adopted to know the various features of IPR in Agriculture.

5.2 International Regulatory Framework (WTO Agreements Related to Agriculture)

The WTO agreement consists of 29 individual legal texts, covering a wide range of subjects from agriculture, textile and clothing and services to government procurement, rules of origin and intellectual property and environmental and sustainable development concerns. Added to these are more than 25 ministerial declarations, decisions and understandings. The agreement on agriculture (AOA) having 21 articles forms a part of the final act.³

²See Appendix Policy.

³ Sompal (2002)

Agreements on Agriculture (AOA)

The long term objective of the AOA is to establish a fair and market oriented agricultural trading system. A reform process should be initiated through the negotiation of commitments on support and protection and through the establishment of strengthened and more operational effective GATT rules and disciplines. It also undertakes to provide for substantial progressive reductions in agricultural support and protection sustained over and agreed period of time, resulting in correcting and preventing the restrictions and distortion in global agriculture markets. Broadly there are four areas under the AOA, whereby member countries are required to adhere to commitments and one other area the agreement of on Trade Related Aspects of Intellectual Property Rights (TRIPS). These are:

- i. Market Access
- ii. Domestic Support Measures or the Aggregate Measures of Support (AMS)
- iii. Export Competition or Subsidies
- iv. Sanitary and Phyto Sanitary Measures and
- v. TRIPS

Agreement on Sanitary and Phytosanitary Measures

The Agreement recognizes that Members have the right to adopt or enforce measures that are necessary to protect human, animal or plant life or health. This right is subject to the condition that such measures should not act as a means of arbitrary or unjustifiable discrimination between Members as a disguised restriction on international trade.

Agreement on Technical Barriers to Trade

The Agreement is for the establishment of international standards and conformity assessment system in packaging, marking and labeling, so as to ensure that technical regulations and standards, and procedures for assessment of conformity with technical regulations and standards do not create unnecessary obstacles to international trade. No country should be prevented from making provisions to ensure the quality of its exports, or for the protection of human, animal or plant life or health, of the environment, or for the prevention of deceptive practices.

5.2.1 Evolution of Structure and System based on International Intellectual Property System

Intellectual property as the name indicates is the creation of human, the product of imagination, of mind or of objective thinking.⁴ Intellectual Property Rights (IPRs) confer on the owner a monopoly of production and distribution of products in a specified territory for given period of time along with social obligation of disclosing information. IPR are of different types like, trademarks, industrial design, copyrights, plant variety protection, geographical indicators and patents.

Intellectual property rights are designed to create incentives for innovation. They permit a right holder to prohibit others from practicing the protected technology for a defined period of time, and thus assist the right holder in obtaining a proprietary position and some form of monopoly rent. This special economic return is intended to encourage the inventor to invest in research and development. Moreover, in the regular patent system, known in many countries as the ‘utility patent system’, where the inventor is required to disclose the details of his or her invention in order to obtain protection. This disclosure becomes a starting point for others to conduct research, and the patent incentive becomes a way of encouraging inventors not to protect their inventions by maintaining them secret.

Intellectual Property Rights (IPRs)⁵ are granted so that they can stimulate inventions by providing inventors with monopoly⁶ (over the commercial exploitations of his/her idea for fixed duration). It is government assurance to innovators by granting monopoly over production and marketing. This becomes a particularly important concern when IPRs regime is expected to the biological domain. It shows that before the advent of modern technologies in the agricultural sector, inventions based on living organisms⁷ were considered as natural and obvious discoveries that could rarely be copied and did not warrant and protection or

⁴ Gupta, A.K. (1999).

⁵ IPRs are legal instrument which provide protection to inventions such as manufacturing process, product design, plant variety, computer programme, publications and music. Broadly it can say that IPRs are legal right granted by government authorities to control certain products of human intellectual effort and in genuity (OECD 1999) P – 12 as cited is FAO legislates study, 85)

⁶ Gadgil, M. and Utkash, G. (1999).

⁷ Like the breeding of new varieties through hybridization, back crossing and selection cannot be copied.

patents⁸. In agriculture the use of patents is mostly to protect inventions relating to agricultural chemical such as pesticide and fungicides. But they are now being used increasingly to protect inventions in the filed of agricultural biotechnology products.

The actual workings of the systems are subject to significant economic dispute. There is strong evidence that adoption of a PVP system in the United States increased private sector plant breeding. And it is quite clear that an intellectual property system is essential for pharmaceutical products, where there are substantial research and product approval costs as well as long product lifetimes, and imitation is relatively inexpensive. In other industries, however, intellectual property is frequently regarded as less useful in encouraging innovation, and the existence of broad and fundamental patents may do little more than create significant conflict among companies.

The intellectual property regimes themselves are national rather than international (save in the special cases of European regional regimes) and are territorial. It is the international understanding that a plant variety protection certificate or patent confers exclusivity within a country's territory and nowhere else. Thus, one cannot infringe a United States patent by one's activities within India. This is an extremely important point to remember when learning of an extremely broad patent issued in the United States or Europe; the patent may simply not be relevant to the foreign researcher. The most important point tempering this territoriality is that countries to import a product that infringes the relevant intellectual property right or one that is made by means of a process that would infringe the national right if carried out within the country. The exact scope of this process-oriented protection varies from country to country. In most countries, it is only the direct product of a patented process that cannot be imported; generally regard it as infringement of the national intellectual property system.

The various international treaties, e.g. (UPOV, 1978) and (UPOV, 1991), for plant variety protection and the Paris Convention (1979) for regular patents assume and accept this

⁸ Patent provides the strongest protection to intellectual property. They enable the patent holders to exclude all other making, importing, selling or using the intentions in countries where it is patented. In order to be patent able on inventions in countries must satisfy certain. Criteria of novelty, non-obviousness, utility or industrial applications. In other words the inventions have to be novel, not obvious and useful.

territoriality. Their primary object is to create reciprocal rights: in return for a reciprocal commitment from other parties, each party gives the nationals of other parties the same rights as its own nationals to obtain intellectual property protection in its system and to enforce these rights in its own country. Many countries are parties to these agreements. The result is that a breeder or inventor can obtain essentially global coverage, but, in order to do so, must file for protection within the systems of each country. Although it is ultimately necessary to make the more expensive filings in each significant market country, this system can delay the point at which these decisions must be taken, thus permitting the decisions to be taken on a more informed basis.

Finally, the Uruguay Round brought a new international standard to intellectual property protection. The treaties described above incorporated some, but relatively weak, minimum standards of protection that had to be satisfied by a member country's intellectual property system. The Uruguay Round's Agreement on Trade-Related Aspects of Intellectual Property Rights, Including Trade in Counterfeit Goods (TRIPS, 1993) establishes more severe standards, particularly in the biological area. Its Article 27 states that "patents shall be available for any inventions, whether products or processes, in all fields of technology," but permits members to "exclude from patentability" inventions whose exploitation must be prevented "to protect public or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment." Finally, the Article permits members to exclude from patentability "plants and animals other than microorganisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof." Articles 65 and 66 give countries a number of years (up to 10 years for the least developed countries) to bring their systems into compliance. Countries are now moving to comply with this requirement; if they do not do so, they can be subject to trade sanctions under the World Trade Organisation's dispute settlement system (World Trade Organisation 1993).

There is an intense debate over what is and effective sui generis system as it is open to interpretation. The wide spread sui generis system for plant variety protection is established by UPOV⁹ of which presently, two versions are available vide supra table - 5.1. The main difference between the two is that the 1991 version provides greater protection to PBR holders. Two aspects of these versions are particularly relevant to the breeders' exemption and the farmers' privilege. The 1991 version of UPOV has been especially criticized as unsuitable for adoption by developing countries. This is because this version gives the breeder much greater control over plant varieties, without exception, which were available in the 1978 version. The companies, which are to share with developing countries benefit arising from bio-diversity, also criticize UPOV for the lack of obligation. It is argued that the UPOV's criteria over eligibility for protection is biased in favour of organized for development or maintenance of cultivars. UPOV only provides for strong breeders' right suited to developed countries where the functions of grains and seed production are divided between the farmers and the breeders respectively. There are again discretions available to member of WTO and countries that are not member of other IPR agreements. Developing countries like India where more than half of the seed supply is ensured by farm saved seed and exchanges of seeds from fellow farmers therefore, it requires an innovative piece of legislation looking beyond UPOV. Without such legislations the Indian farmers will be deprived of seeds to plant their next crop.

⁹ Unions international pour la protection des obtentions végétales (UPOV). The first UPOV act was drafted in 1961. Principally by industrialized government seeking to provide protection for plant breeder is his or her own and overseas market's the UPOV later revised in Act adopted in 1972, 1978, 1991. See details in intellectual property rights in plant varieties, international legal regimes and policy options for national government, FAO legislature study, 85.

Table 5.1: Comparison of UPOV, 1978 Act and 1991 Act

SUBJECT	UPVO 1978 Act	UPOV 1991 Act
Minimum scope of coverage	Increasing number of genera or species required to be protected, from five at time of accession, to 24 eight years later.	Increasing number of genera or species required to be protected, from 15 at time of accession, to all general and species 10 years later (5 years for member states of earlier UPOV Act).
Eligibility Requirements	Novelty, distinctness, uniformity and stability	Novelty, distinctness, uniformity and stability.
Minimum exclusive rights in propagating material	Production for purposes of commercial marketing; offering for sale; marketing; repeated use for the commercial production of another variety.	Production or reproduction; conditioning for the purposes of propagation; offering for sale; selling or other marketing; exporting ; importing or stocking for any of these purposes.
Prohibition on dual protection with patent	Yes, for same botanical genus or species	No.
Breeders exemption	Mandatory, Breeders free to use protected variety to develop a new variety	Permissive, but breeding and exploitation of new variety “essentially derived” from earlier variety require right holder’s authorization.
Farmer’s privilege	Implicitly allowed under the definition of minimum exclusive rights.	Allowed at the option of the member state within reasonable limits and subject to safeguarding the legitimate interests of the right holder.
Minimum term of protection.	18 year for grapevines and trees: 15 years for all other plants.	25 years for grapevines and trees; 20 years for all other plants.

Sources: FAO Legislative study Volume 85, 2005.

Till recently, developing countries like India considering the PBRs system, but knowledge about its socio-economic implications is still meager. So far, there are only a few studies carried out in USA¹⁰ & India¹¹. PBRs have several socio-economic impacts on farmers because the development of transgenic involves the rights related to transformation technology, selectable marker employed, the target gene promoter, and the regulation protein etc are very important to industry segments. The current restructuring of the seed industry is being technology driven and influenced by IPRs issue Winner will be those companies who are able to deal with IPRs issue effectively and can quickly bring new quality products, in the

¹⁰ Wijk Joren Van, 1995.

¹¹ Madhav Gadgil & Ghate Utkash 1999.

market. Keeping all these in background India has to design her own version of legal and policy framework.

5.2.2 Plant Variety Protection in International Context

Most developed countries enacted plant variety protection (PVP) legislation in the period since the Second World War. A number of developing countries are now adopting parallel legislation in order to comply with the requirements of the Uruguay Round to protect plant varieties. Such legislation, also known as “plant breeders’ rights,” provides an intellectual property system adapted to the needs of traditional plant breeders and is designed to give these breeders an increased incentive to develop new varieties while respecting the traditions of breeding. Under the treaty, all countries that ratify it must agree to facilitate access to their plant genetic resources for food and agriculture. In turn, those involved will share-in a fair and equitable way-the benefits arising from the use of these plant genetic resources.

The protection is by means of a certificate granted, most typically by an office of the Ministry of Agriculture (rather than by part of the national patent office), upon receipt of a relatively simple and inexpensive application. The certificate entitles its holder to be the exclusive marketer of the relevant variety, and also of the product of the variety. This right may, of course, be licensed to others. The certificate does not, however, prevent others from using the variety in efforts to breed further varieties.

The PVP laws are generally adopted in accordance with an international treaty, e.g. (UPOV, 1978 or 1991), after the French language acronym for the International Union for the Protection of New Varieties of Plant. Under the older versions of this treaty, e.g. (1978), countries were required both to allow use of protected materials for breeding of additional new varieties, and to allow farmers to reuse their harvest for seed purposes. Article 15 of the new (1991) version, came into force in 1997, permits countries to allow farmers to reuse seed, but does not require them to do so - most countries opted to allow such reuse. In addition, Article 14 of this new version adopts a concept of “essentially derived variety,” designed in part because of the rise of biotechnology. A breeder remains free to use a protected variety and to make any change in such a variety, but is subject to the rights of the owner of the initial

variety if that change is so small as to leave the new variety “essentially derived.” Examples listed in this Article are varieties made “by the selection of a natural or induced mutant, or of a somoclonal variant, the selection of a variant individual from plants of the initial variety, backcrossing, or transformation by genetic engineering.” Thus, if a biotechnologist uses an existing protected variety as material within which to insert an agronomically important gene and markets the resulting material, the biotechnologist would infringe the rights of the owner of the protected variety. Normally, this problem would be solved through a license under which the biotechnologist and the breeder share the profits available from giving the farmer the benefit of both the high quality background material and the new gene.

Another important aspect of the new version of UPOV is strong protection for harvested material from plants. Article 14 of UPOV (1991) gives the certificate holder rights over “harvested material, including entire plants and parts of plants, obtained through the unauthorized use of propagating material of the protected variety... unless the breeder has had reasonable opportunity to exercise his right in relation to the said propagating material.” It also permits member countries to make similar arrangements with respect to “products made directly from harvested material.” This article thus protects the holder of a certificate in a market country against the import of material grown elsewhere, perhaps quite legitimately as if the certificate holder had not obtained protection in the country of origin. And the certificate holder’s rights extend to any part of the plant, whether useful for propagation or not, and, depending on the national law, extend to products from the plant. The likely implication, in an era of high-technology agriculture in high-value crops, is that breeders will seek to gain consumer recognition of their brand, and use PVP protection in market countries to seek to limit competition and imports and to command and protect a premium price. Licensing rights can thus be used to protect against imports of materials, even though the materials may have been legally grown in a country where they are not protected.

Although the above analysis should make it clear that the biotechnological breeder must take PVP into account, it is also clear that PVP does not provide adequate protection for a firm which has expended significant resources in identifying an important gene, transforming plants, and perhaps obtaining regulatory approval for use of the gene. Under PVP, another

breeder can purchase the protected material, cross it with his or her own material, and develop a new variety that includes the gene. This is in no way an infringement of PVP rights, but it clearly significantly decreases the market value of the gene. The company that wants to make and protect a significant investment in a new gene must find other means of protection.

5.2.3 Trade Related Aspects of Intellectual Property Rights (TRIPS)

The agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is an international treaty by the world trade organization (WTO), which sets down minimum standards for most form of intellectual property (IP) regulation within all member countries of the world trade organization.

Each country has its own law to regulate patents and its infringements can be proceeded against as per the law of that country alone. The patent owner gets the right to enforce the law. Article 27 of the TRIPS agreement provides that the WTO member state shall provide patents for any invention, either a product or process provided that they are new involve inventive step and are capable of industrial application. Thus, before a patent can be granted it should be shown that the invention is novel and useful; and not so obvious to anyone interested in this subject. It should also be capable of practical implication. The American law insists that the protected subject must be useful and British law will grant a patent only if the invention is capable of industrial application. The latest trend is to apply the Swedish principle under which a patent can be granted for discovery hitherto unknown application even in respect of an already popular product.

The coming into force of WTO agreement involving TRIPS has brought both opportunities and threat to the developing countries, though convergences of opinion on these aspects exist. It is argued that the TRIPS agreement has changed the international governance of Intellectual Property Rights (IPRs) radically. TRIPS have sought to establish enforceable universal minimum (and high) standards of protection and enforcement. TRIPS has incorporated provisions from many existing international IP agreements, introduced new obligations and higher protection standards by mandating extension of patentability to virtually all fields of

technologies recognized by the developed country patent regime and by prolonging the patent protection.

TRIPS agreement did not require us to patent seeds. However we could have to establish an effective system “sui generis” for protections of plant varieties seed and other form of propagation material that is suitable to our own requirement.¹² The proponents of the TRIPS agreement argue that it will provide free trade era calls for effective protection of wealth of developing countries. Some also argue that there is also possibility of reshaping of agricultural institutions and organizations meant for research and development activities due to the new global scenario. For the welfare state, the concern is to feed overgrowing population to maintain food and nutritional security and the judicious use of new technology in our own frame with the fulfillment of international mechanism of IPR is the major task for economist, agronomist, social scientist and all other concerned. The science and technology has changed the scenario of hunger problem in India up to some extent. This was due to adoption of high input responsive technology. This technology has some geo-political and socio-economic consequences.

Traditional concepts of factors of production are also changing in the time of liberalized economy in case of agriculture and allied activities. The role of knowledge as potential contributor to production is increasingly being recognized, thus assuming the status of a factor of production. Not only gathering and or generation of information and technology, but its effective protection is also vital in new order of international relation and multilateral trade in agriculture.

Although TRIPS is difficult to interpret with respect to some of these issues, it is not at all clear that even the more recent of these laws comply with the TRIPS requirement that patents shall be available “for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application, Article 27. Although most of these countries will almost certainly seek to comply with the TRIPS agreement, they will often do so through adoption of some form of PVP, to

¹² Sui generis mean of its own kind of system of protection.

satisfy the requirement of a sui generis system for plants, and may seek to avoid changes in their patent legislation.

5.2.4 WTO & QR's

As per the WTO Agreement on Agriculture (AOA), the member countries - both developed and developing - are obliged to gradually open up their agricultural sectors to world trade by removing all the trade distortions. As signatory to the GATT Agreement, India is committed to implement various agreements and provisions pertaining to AOA. These include the commitments on (a) domestic support, (b) market access, (c) export subsidies and (d) an agreement on Sanitary and Phyto-sanitary issues.

With regard to market access, all the existing quantitative restrictions and non-tariff barriers (NTBs) are to be replaced by the 'equivalent tariff barriers' [bound tariff rates (BTRs)] during the transitional period, i.e. from 1st January 1995 to 31st December 2004. According to AOA, the unweighted average reduction of bound rates must be 36 percent (24 percent for developing countries) with a minimum cut of 15 per cent for each commodity (10% for developing countries) over a period of six years (10 years for developing countries) for developed countries. Least developed countries are not required to reduce tariff. The minimum market access quota is to be expanded to 5% of the total domestic consumption with effect from 1st January 2005. However there are certain protection provisions in the form of safety trigger, custom duties, anti dumping clauses and countervailing duty rights.

Quantitative Restriction's (QRs) were being maintained ever since 1947 on Balance of Payments (BOP) grounds under the General Agreement on Tariffs and Trade (GATT) to which India was a signatory. India participated in the 7-year long Uruguay Round Negotiations (1986-1993) which culminated in the signing of the Uruguay Round Agreement in April 1994 and became a founder member of the World Trade Organisation (WTO), which came into being in January 1995. India subscribes to all the WTO Agreements, but continued to maintain QRs on BOP grounds as per the provisions of Article XVIII-B of GATT.

5.2.5 The Regular Patent System

The patent itself includes both a description of how to practice the invention and a statement of claims, which precisely define the exclusive rights conferred by the patent. In evaluating the possibility of infringement, it is these claims that must be consulted, not just abstracts describing the general area of the invention - some of the criticisms that have been made of plant biotechnology patents have been made without consideration of the scope of the actual claims. Obtaining a patent is both slower and more expensive than obtaining a PVP certificate; expenses of global coverage can easily rise high. Patent enforcement is typically by private suit before a court rather than an administrative agency and the process is dependent on the initiative of the patent holder rather than of an agency.

5.2.5.1 Important differences among national systems

India has been more concern with the issuance of patents in agriculturally-related areas. Many countries have, in fact, prohibited patents on food and agricultural products or on portions of living things. They may, however, permit patents on certain of the processes to make these products. For example, developing country laws like, that of India, prohibits any patent on “a method of agriculture or horticulture” or on “any process for the medicinal, surgical, curative, prophylactic or other treatment of human beings or any process for a similar treatment of animals or plants to render them free of disease or to increase their economic value or that of their products.”

5.2.5.2 Typical coverage of actual patents

There are two politically controversial issues here of particular importance. One is the idea of a patent on a natural gene or protein. Many actors of Agri-business system, particularly in developing countries, object to such patents, typically on grounds that the isolation and sequencing of a gene amounts to a discovery rather than an invention, that portions of living organisms should not be patented at all, and that the patenting of such materials amounts to an appropriation, typically by a developed-country researcher, of something that in rights belongs to a developing country that may have been the source of the material, The concern is closely related to concern about the protection of developing countries’ genetic resources and the desire to use these resources as a basis for obtaining greater access to biotechnology, a

concern reflected in the Convention on Biological Diversity (1992)¹³. The response of the biotechnology industry is that such patents are crucial to the encouragement of research in both agricultural and medical biotechnology. Moreover, there is a basis for satisfying the technical requirements of patent law, because the fact that the nucleic acid or protein is isolated or purified means that it is different from what is found in nature and is therefore novel.

The structure of the claims, which reach isolated versions of the gene or protein, protects the patent holder against use of the gene by another biotechnologist, but leave anyone free to use and breed with organisms containing the gene naturally. In light of this logic, patents on genes and the proteins for which they code are available in most developed countries; as the examples noted above, however, show, some developing countries, however, exclude natural genes from patent coverage, and thus prohibit at least the first of the claims cited above. The carefulness of this distinction effort suggests the difficulty that may arise in interpreting national legislation that excludes the patentability of parts of natural organisms. At the same time, it appears very likely that an exclusion that reaches genes violates the TRIPS agreement, which, as noted above, requires coverage of inventions in all fields of technology, and excludes only whole organisms from patentability.

The second politically controversial point relates to the claims on transformed plants and their progeny. Such claims are essential to obtain effective control of agricultural biotechnology using the gene, and to keep a third party from crossing the inserted gene into a different variety and marketing that variety. With these claims a breeder is much more protected than under the PVP system. Nevertheless, in many countries the legal system prohibits the patentability of living organisms themselves, and such exclusion is consistent with TRIPS if there is provision for sui generis (PVP) protection. Thus, these claims will not always be available. Note, however, that in India, it was possible to reach the same result effectively by

¹³ The Convention on Biological Diversity, known informally as the Biodiversity Convention, is an international treaty that was adopted in Rio de Janeiro in June 1992. The Convention has three main goals:

- a. conservation of biological diversity (or biodiversity);
- b. sustainable use of its components; and
- c. fair and equitable sharing of benefits arising from genetic resources.

claims on the process of transformation, which can be enforced against the unpatentable - but infringing - products of the process (which has changed now to product patent).

5.2.5.3 Trade Secrecy and Material Transfer Agreements

Arguably, the most important mechanism of protecting biological materials is not a statutory intellectual property system, but rather the trade secret system, which is a combination of legal principles of contract law and legal principles against misappropriation of another's information. Trade secret protection is required by Article 39 of the Uruguay Round TRIPS Agreement, which covers "undisclosed information," and is already accepted in many countries. The contractual component recognises and encourages private enforcement of contracts designed to protect information, e.g. confidentiality agreements between a firm and its employees. And the misappropriation components protect the holder of a trade secret against, for example, one who comes into the laboratory and secretly copies laboratory notebooks or steals genetic material.

An important context for application of these trade secret principles in contemporary biotechnology-based breeding is in exchange of genetic materials and information - which, in a commercial situation, is most wisely done through a "material transfer agreement" (MTA) between the donor and the recipient of the material. Such an MTA is simply a contract, formalised under relevant national contract law principles, providing for an allocation of rights in the materials. The precise terms will vary from case to case, but may, for example, permit the recipient to use the material only for research purposes, require the recipient to negotiate a royalty arrangement should it identify commercial applications for the material or a product derived from it, seek to disclaim any supplier liabilities or warranties with respect to the quality or biosafety of the material or to whether or not use of the material infringes a third party patent, require return of the material and everything derived from it after a particular time, and require consultation before filing of any patent application or presentation of any academic article based on the material. Clearly, one of the most important and difficult issues is how far the supplier's rights should run under such an agreement. If, for example, a particular purified protein is supplied, should the donor's rights run to a gene coding for the

protein; a probe to identify such a protein; a homologous gene in a different organism. The need, of course, is to agree in advance.

The precise terms of these agreements will vary from context to context. Universities exchanging material at the relatively basic scientific level are most likely to allow the material to be used freely for research but with a protection for their interests should there be a commercial application. The private sector may exchange material only after a careful negotiation that actually sets royalties or profit shares in resulting inventions and varieties. Developing countries, with an interest similar to that of universities, may seek to protect a right to a share of profits in the material - and their concerns clearly become significant in any situation in which biotechnology is done with materials derived from such countries. Unique opportunity emerged from agreements between public and private players in the agricultural biotechnology area, for example the collaboration between IIT Kharagpore and JK Seeds based on biotechnology based agricultural product.

5.2.6 Biosafety and Product Labeling Considerations

Biosafety considerations are important part of marketing, for the commercialization of genetically-modified crops. Assuming that a firm complies with local biosafety requirements in its research and production, there will still be biosafety-based questions as to whether the product can be exported into other markets. These will relate to both consumer acceptance and environmental protection.

Two points deserve particular attention at this time. *First* is the current international negotiations are placing the international biosafety regime in direct and close relationship - and possibly conflict - with the international trade regime. Under the Convention on Biological Diversity (1992), a working group is developing a Biosafety Protocol, which will probably require an international shipper of "living modified organisms," to obtain "prior informed consent" from the importing country before shipping products to that country. The precise scope and terms are not yet clear, nor is the timing. Depending on the way it is implemented, certain requirements of this concept may be in violation of the World Trade Organisation's Phytosanitary Code (1993), which restricts the use of technical standards as

non-tariff trade barriers and - in very rough summary - requires that these standards be scientifically based. The evolution of this Biosafety Protocol is extremely important for trade in agricultural products derived from transgenic plants. The *second* point to note is that consumer countries are considering the imposition of labeling requirements. There are certainly circumstances in which such requirements are clearly justifiable, as if an allergenic protein is transferred from one organism to another where it might not be expected by a consumer. Similarly, there are circumstances in which marketing can take advantage of the features inserted into an organism and labeling is desired by the producer, as in the marketing of non-spoiling fruit. However, it is possible that countries may sometimes impose a broader range of labeling requirements to identify the use of genetic engineering in the product.

5.3 Regulatory Environment in India

The Ministry of Agriculture within the following legislative framework determines overall policy with regard to the seed industry.

The Seed Act, 1966 and Seed Rules, 1968

The Seed Act enacted in 1966, the Seed Rules framed under this Act and notified in 1968, and amendments from time to time provide the basic regulatory structure to ensure seed quality control. The Act provides for compulsory quality control of seed of any notified kind and variety; voluntary certification of seed of any notified kind or variety; and truthfully labeling of seeds. The Act specifies the function of various regulatory bodies associated with the industry as well as rules for notification of new varieties, specifications of minimum limits of germination and purity, regulation of sale of seeds, certification, labeling, etc.

This was the first initiative towards the structural framework of Indian Seed Industry in terms of ‘product specification and quality control’.

Seed (Control) Order, 1983

A Seeds (Control) Order was issued in 1983 under the Essential Commodities Act of 1955, which required seed dealers to obtain a license valid for three years in order to operate, grants the Controller powers to regulate the sale and distribution of seed and provide additional

power to the seed inspectors. This order shows that how the ‘State’ intervention stated in terms of ‘monitoring and control measure’.

Plant Variety Protection and Farmers’ Rights Act, 2001 & Rules

To address concerns about the lack of effective intellectual property rights in the seed industry, the GOI enacted legislation in August 2001 named, “Plant Variety Protection and Farmers' Rights Act, 2001,” This legislation provides for the establishment of a “Protection of Plant Varieties and Farmers' Right Authority” to implement the Act. Under the new legislation, farmers will continue to enjoy their traditional rights to save, use, exchange, share, and sell the produce of the protected variety with the only restriction that the farmer will not be able to sell branded seed of the protected variety for commercial purpose. The legislation contains several of the contentious issues such as the compulsory acquisition of parental material of a variety and granting production license to a third party to produce proprietary variety when there is a shortage of such seeds.

New Seed Legislation, 2002

The purpose of formulating New Seed Legislation was to replace the existing Seed Act, Rules, and Seeds (Control) Order, 1983. This legislation was aimed at regulating the quality of seeds for sale, imports, and exports. Various stakeholders reviewed the draft bill. The salient features of the legislation are:

- i. Compulsory registration of all varieties being offered for sale by National Seed Board (NSB), to be constituted by the government
 - Registration to be valid for fifteen years for annual and biennial crops and 18 years for long duration perennial crops.
 - Registration of genetically engineered crops subject to clearance under the Environmental (Protection) Act, 1986. [This clause raises the debate over GMCs].
- ii. Selling, bartering, importing/exporting of seed of any transgenic kind/variety subject to declaration to this effect.
 - Non-registration of a kind/variety of seeds containing any technology (including genetic use restriction technology and terminator technology), which is harmful, or potentially harmful.

Registration of existing varieties on the basis of three years of agronomic performance data to be submitted by the applicant

- iii. Registration of new/exotic varieties only provisionally for two years Registration of all seed producers and seed processing.

Declaration of information on adaptability and expected agronomic performance by the breeder.

NSB to decide the seed standards, to appoint private/public seed certification agencies and to formulate rules for compensation to farmers in the event of a crop failure due to defective seeds.

Exemption of farmers seed from the Seed Act and allowing them to save their own seeds and market it without branding.

National Seed Policy, 2002

The National Seed Policy, 2002, is expected to lay the foundation for comprehensive reforms in the seed sector. This will entail significant changes to the existing legislative framework in order to stimulate varietal development in line with market trends and to introduce advanced scientific knowledge (including biotechnology) to meet farmers' needs.

Other Rules, Law & Acts:

Phytosanitary Regulations [The Destructive Insects and Pests Act, 1914 & Plants, Fruits and Seeds (Regulation of Import in India) Order, 1989]

This Act and Order regulate the import into India of agricultural products including plants and seeds. Salient features are:

Prohibit import of seeds for sowing and planting materials without a valid permit

- a. Clearance of consignments subject to inspection, fumigation, disinfection, and disinfestations as the case may be under official supervision
- b. Imports not permitted unless accompanied by an official Phytosanitary Certificate

Biodiversity Act, 2002

Being a signatory to the United Countries' Convention on Biological Diversity, India enacted a Biodiversity Act in 2002. The Act provides for the establishment of a National Biodiversity Authority (NBA) and State Authorities.

The provisions of the Act, which will have a bearing on seed trade, are:

- a. Person(s) who are not citizens of India would be required to take permission of NBA before obtaining any biological resource occurring in India. Foreign companies, and even Indian companies having foreign equity are included in the list of such persons.
- b. Prohibits transfer of material or research occurring in India or obtained from India unless the research is collaborative and there are agreements to this effect before the Act was commenced.
- c. Does not allow application for IPRs without permission of NBA in case the biological resource from India has been used for development of such a product.
- d. Provides for imposition of charges by way of royalty subject to terms and conditions.

Biodiversity and Biopiracy

The third world countries are rich in biodiversity. "Indian subcontinent is bestowed with great diversity in agri-horticultural crops; of this 8900 species are of ethno-botanical importance. Around 75-80 % of population of developing nations depends on this genetic wealth for their livelihood and medicinal purpose"¹⁴ Due to wide geographical and biological diversity India has been divided into 16 different agro-climatic zones, 10 vegetative zones and 10 biotic provinces.¹⁵ Concerns are expressed in many schools of thoughts that the introduction of IPR may lead to erosion of biodiversity of cultivated crop as more and more would be occupied by transgenic crop. It is argued that transgenic crop will hamper our crop genetic variability by promoting monoculture of 'single trait' specific crops.

Rules for the manufacture, use, import, export, and storage of hazardous microorganisms genetically engineered organisms or cells under the Environment (Protection) Act, 1986

¹⁴ Kamboj, V.P. (2000). p35-39.

¹⁵ Ghosh, S. K. (). p196-205

All genetically engineered crops/varieties will be tested for environment and bio-safety before their commercial release. Bio-safety guidelines and regulations are formulated by the Department of Biotechnology (DBT) in exercise of powers conferred to it through “*Rules for the manufacture, use, import, export, and storage of hazardous microorganisms genetically engineered organisms or cells*” formulated under the *Environment (Protection) Act, 1986* and issued by the *Ministry of Environment and Forests in 1989*. Imports and exports of bio-engineered products are also governed by these rules.

Quantitative Restriction and India

India has bound all its agricultural tariffs under the WTO Agreement on Agriculture. The tariff bindings in agriculture range from 0% for primary products to 150% for processed products and 300% for edible oils. In case of a number of cereals, most of which are on negative list of imports, India has bound rates of 0%. India had recently re-negotiated bound duty for some agricultural items such as rice and milk under GATT Article XXVIII.

In spite of increasing debt and continuing BOP vulnerability, the WTO-IMF working in tandem forced India to remove its BOP cover to restrict imports by the year 2003 on the basis of a dispute initiated by US, with the European Communities, Canada, Australia, Switzerland and New Zealand joining in. However, with the artificial improvement in the BOP position, some members of the WTO disputed India's justification on need to continue QRs on imports for BOP reasons. In May 1997, India presented a plan for elimination of these restrictions on imports over a period of 9 years, which was considered at consultations held in the Committee on Balance of Payments Restrictions in June-July 1997. This nine year time schedule was from 1st April 1997 to 31 March 2006, divided into three phases.

While the plan generally received the support of developing countries, the developed countries felt that the phase out period was too long. Although India agreed to reduce the phase out period to 7 years, even this was not acceptable to the developed countries.

Till 31st March 2000 the quantitative restrictions were maintained on balance of payment ground on 1429 items out of which 700 items were under Restricted List, 685 items were

under SIL (Special Import License) list and there were 44 items under Canalised list. In April 1999 about 1285 items were already shifted to the open general license list.

5.3.1 Trade Related Aspects of Intellectual Property Rights and India

This Agreement is made to promote effective and adequate protection of intellectual property rights and also to ensure that the measures taken in this direction do not become an impediment to legitimate trade. It is through Article 27.3(b) of the Agreement that the subject of agriculture is brought under this Agreement.

This issue is related with IPR in agriculture, It must be realized that there has to be a comprehensive legislation or act on patenting. Its absence has cost India heavily as other countries have taken advantage of large scale patenting. India has witnessed several cases of biopiracy, due to lack of patent mechanism. India has incurred a great deal of expense by losing a large number of patents and entering into unnecessary legislation. Second, the biodiversity conservation act (BCA) and plant variety protection act (PVP) to save India's genetic resources from misuse, plunder and overexploitation and protect the rights of its farmers and researchers, have become absolutely essential. The plant variety protection act came into existence after autumn of 2001 and biodiversity act should have been introduced much earlier¹⁶.

The third equally significant aspect of IPRs is India's stand on patents which have already taken or filed by the developed countries based on our germplasm and traditional indigenous knowledge. These include Basmati rice, Neem, Haldi, and Amla or other products known to us through the traditional medical formulation. Geographical indication and appellation of origin constitute IPRS that are distinct from patents, furthermore patents can not be granted for knowledge that is already in public domain.

In India the concern for the protection of intellectual property was evident way back in the design act of 1911. Later the patenting system was modified and a comprehensive act viz., Indian patent act was passed on 1970. Prior to the agreement on TRIPS India had legal system

¹⁶ Sompal (2002).

of protection for four types of intellectual property like patent, trademarks, copy rights and industrial design. In view of TRIPS article Indian government amended 1970 patent act to incorporate issues of plant patent as well acceptance of both process and product patent in recent years.

Besides a rich biodiversity, India has an abundant wealth of agricultural ideas, techniques, products and processes. Being a country with a long and varied past many of its knowledge and practices relating to agriculture has come down through generations. These traditional knowledge and practice have found many modern applications. On the basis of India's rich biowealth, one argued that India may take benefit from TRIPS, if its traditional knowledge is documented and registered properly.

However India's rich reservoirs of the traditional knowledge and practices are under threat from MNCs and usurpation elements, which are quick to grab the opportunity to patent our knowledge and practices in western countries. India needs to put in place effective steps to protect them. Proper documentation of these knowledge and practices should be the first step in that direction.

5.3.2 Post-WTO Indian Legislation Pertaining to Agriculture¹⁷

Under the changing dimension of agriculture under auspices of TRIPS, government of India formulated different acts, legislation and amendments to compete with global counterparts so far the agricultural research and development is concerned

Protection of Plant Variety and Farmers' Rights Act, 2001

The Act is for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development new varieties of plants. This Act is to give effect to Article 27.3(b) of the Agreement on trade Related Intellectual Property Rights, India having ratified the Agreement on trade Related Aspects of Intellectual Property Rights. The Act recognizes the necessity of protecting the rights of farmers in respect of their contribution made in conserving, improving and making available plant

¹⁷ Sompal (2002) p.411

genetic resources for the development of new plant varieties. The Indian act seems to be a role model for developing world, because it provides recognition of farming community for their contribution in conservation of crop genetic resources and also providing reward system for breeders to encourage them for better research for sake of public welfare.

This act also provides a way for new institution like plant variety and farmers right authority. This act also provides a way for setting up of new gene banks for conservation of germplasm. India did not accepted UPOV model of plant variety protection but it adopted several positive elements from UPOV.

The Geographical Indications of Goods (Registration and Protection) Act, 1999

According to the Act, the term 'geographical indication', in relation to goods, means an indication which identifies such goods as agricultural goods, natural goods, or manufactured goods as originating, or manufactured in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin. In case where such goods are manufactured, one of the activities of either the production or of processing or preparation of the goods concerned takes place in such territory, region or locality, as the case may be.

The Act is for the exclusion of unauthorized persons from misusing geographical indications, add to the economic prosperity of the producers of such goods and also promote goods bearing Indian geographical indications in the export market. Unless a geographical indication is protected in the country of its origin, there is no obligation under the TRIPS Agreement for other countries to extend reciprocal protection.

The Patent (Second Amendment) Act, 2002

- i. The non-patentable aspects of the invention are specified. This includes plants, animals in whole or any part thereof, including seed varieties and essentially biological processes for the production or propagation of plants and animals.
- ii. Micro organisms per se can be claimed provided; they are not mere discovery of organisms existing in nature.

- iii. Methods for rendering plants free of diseases or to increase their economic value will be patentable.
- iv. The Act of 2002 makes it mandatory to deposit the biological material mentioned in the specification with a depository notified in the Gazette of India. The source and geographical origin of the biological material must also be disclosed in the specification.

5.4 Patent Issues in Indian context

The recent changes in the General Agreement on Tariffs and Trade (GATT) now require members of the World Trade Organization (WTO) to respect each other's IPR. In the past, public sector research in most developing countries was predominantly supported by their governments which mandated that public sector institutions freely serve society. Therefore, technologies generated by the public sector were freely exchanged for research and development purposes without entering into any kind of commercial agreements. With the advent of biotechnology, this trend is now changing. As the global community increasingly attempts to privatize the agricultural sector, and access new and emerging technologies, many national governmental policies are changing to address IPR issues. In order to build a sound IPR framework, countries must address the issue of capacity building at both the national and institutional level.¹⁸

With the growing recognition of IPR, the importance of worldwide forums on IPs is realized. Worldwide companies, universities and industries want to protect their IPR internationally. In order to reach this goal, countries have signed numerous agreements and treaties and developed organizations to oversee their applications. These agreements and treaties include the General Agreement on Tariffs and Trade (GATT), the World Intellectual Property Organization (WIPO), and the Trade-related Aspects of Intellectual Property Rights (TRIPs) treaty.¹⁹

¹⁸ Maredia, Karim M. and Erbisich, Frederic H. (1998) pp 49-50.

¹⁹ Erbisich, Frederic H. and Velazquez, Carlos (1998) page-4.

For decades, there has been an ongoing and intense debate about the appropriateness of patents for living matter. This debate was greatly intensified in the late 1990s with the convergence of three developments. First, advances in science led to a rapid increase in the number of biotechnology patents in the late 1990s, particularly in the field of genetics. Second, the international community negotiated in 1995 a new international regime for intellectual property protection through the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs Agreement). Third, international debate about ownership, control, access and benefits sharing related to global plant genetic resources heated up through a variety of negotiating venues under the auspices of the Convention on Biological Diversity (CBD). These three developments at times supported and at other times challenged the international innovation agenda that is increasingly focused on knowledge-based economic growth. The expansion of private rights to intellectual property, particularly for inventions related to composition of living matter and genetic isolates, is viewed as the foundation of knowledge-based economic growth. This has generated significant public debate. The dominant agenda generally operates on the assumption that patents are essential to the identification of research targets, the mobilization of public and private resources, the oversight of new technologies and products and the active adaptation, adoption and use of new end-products. Those supporting this extension argue that, in a period of knowledge-based growth, private investors need to have the incentive for and assurances of monopoly access to and use of their inventions. Many of these supporters firmly believe that private initiative is the only way to generate the optimal amount of investment in Research and Development (R&D) and that any resulting inequities should be handled outside the formal Intellectual Property (IP) system. Arrays of opponents challenge this expansion of private rights, arguing either that the range and scope of rights may be excessive or, in some cases, inappropriate. This issue is important for everyone involved in agri-food research and general development policy. The debate and related conflicts about access and benefits sharing do not align exclusively along a North-South axis. While many of the higher profile conflicts relate to germplasm drawn from indigenous communities in "southern" developed countries, there is rising interest and concern about how indigenous communities in Canada, the US, Australia and many other developed countries will be able to control access and share benefits related to use of their traditional knowledge and genetic resources. Similarly,

virtually all agri-food research programs in all countries depend heavily on germplasm from others - no country is self-sufficient in any major crop. Hence, how the debate unfolds and how rights are sustained or realigned will have an influence around the world.

Concerns are expressed in many quarters that the introduction of new IPR in agriculture may led to the erosion of genetic and biological diversity of many cultivated crop species as more and more would be occupied by genetically modified crops. This may result in narrowing the genetic base of different cultivated crops and in turn it may lead to uniformity of genetic base would have its implication on susceptibility to diseases and pest and spontaneous out break of biotic stresses.

The extant and degree to which IPR influences productivity increase is still to be assessed in Indian condition because it has not witnessed the cereal crops in this context. There is a chance that the commercial crops may push crops like rice and wheat in back stage due to high private sector investment in research and monopolization of seed market by transnational corporate as well as many environmental and ecological threats in many high productivity zones of the cereal crops.

5.4.1 Salient feature of Indian Version of Plant Variety Act

The Indian Plant Variety Act (PVA) induces both element of UPOV Act (earlier 1978 Act and revised 1991 Acts) any beyond with some new features vide supra in Table 5.2. It has drafted a bill (The Protection of Plant Varieties and Farmer's Right Bill, 2000) and passed it as an Act in an amended form, 2001. It has a number of provisions to protect farmers' right and introduce a mechanism for benefit sharing. The main objective is to promote the research and to protect plant²⁰ rights of both farmers and plant breeders. "...It protects plants, Plant breeders' rights to stimulate investment for research and development of new plant varieties".

²⁰ The printed version of the Act is published in the Newsletter of Seed Association of India (2001). Newsletter, vol. 15. pp 1-35,.

Table 5.2: Comparison of Indian PVA with UPOV, 1978 and 1991 Acts.

Features	UPOV 1978	UPOV 1991	Indian PVA
Minimum scope of coverage	Increasing number of genera or species required to be protected, from five at time of accession to 24 year later.	Increasing number of genera or species required to be protected, from 15 at time accession to all genera and sp. 10yrs later (5) years for member states of earlier UPOV act	All species required to be protected for 15 years
Exception to right (farmer privilege)	Farmer privilege in practice	Farmers privilege option of the 10 th reasonable limits and subjects to safeguards the legitimate interests of the right holders	Farmer right specially recognized in article 27.3 (b)
Protection period	15 years	20 years	15 years
Compulsory licensing	Not defined	Not defined	In case of public interest defined as reasonable availability of seeds and supply of export and marketing.
Breeder exemption	Mandatory, breeder free to use protected variety to develop a new variety	Permissive but breeding and exploitation of new variety “essentially driven”	Permissive
Protected material	Vegetative and reproductive propagating material, harvested material for commercial use of ornamental	Vegetative and reproductive propagating material, harvested material under particular conditions	No material required to be protected; best state must protect sufficient material to grant an IPR.
Other requirement	Those imposed by 1978 Act	These imposed by 1991 Act	These imposed by Indian own Act.

Sources: Compiled from FAO Legislative Study, Volume 85, 2005.

It also “...protects the rights of farmers in respect of the contributions made at any time in conserving, improving and making available Plant Genetic Resource (PGRs) conservation for the development of new plant varieties”. Another important and related objective of the Act is to “Promote the availability of high quality seed and planting material to the farmers”. The act has a provision to deny protection to varieties on the grounds of public morality, health and environmental concerns and exploitation of such a variety is necessary to protect public order

or public morality or human and animal, plant life and health or to serious prejudice to the environment. The special features are discussed follow.

Feature of protection

The scope of protection is to all categories of plant except microorganisms, as decided by the competent authorities from time to time. The certificate of registration issued under [section 24 or sub section 98 of (section23)] shall be valid for nine years in the case of other crops, and may be reviewed for the remaining period on payment of such amount as may be fixed by the rule on this behalf subject to the conditions²¹. For a new variety to be eligible for registration, it must conform to criteria of novelty, distinctiveness, uniformity and stability (NDUS) described in section [15 (1) - (3)]. The compulsory registration of varieties based on the agronomic performance data as specific character. (New Seed Bill, 2004)²².

Protection of “essentially driven varieties”

The PVA also covers the protection of essentially driven varieties. Thus clauses restrict the marketing of newly developed varieties if it is genetically similar to protected source variety and demands authorization from the breeder who has protected it. The Introduction of this principle of ‘essentially driven’ strengthens the protection of existing protected variety. Then the question come now how to determine the “essentially driven variety”; which needs clarification further in this context.

Community and Farmers Rights:

The term farmer’s right has been coined to recognize the rights of farmers over their contribution to conservation of crop development. It also provides for the farmers to be awarded for their contribution to preservation and improvement of germplasm and the sharing of their contribution to sharing of their knowledge on adoptive traits²³. Furthermore, farmers will also have the right to save, use, sow, re-sow, exchange, share or sell seeds of the protected variety (Chapter VI of Act) except the sale under a commercial marketing

²¹ In case tree vines, 18 years from date of registration variety in case of extent varieties 15 year from the date of the notification of that variety by the central government under sections 5 of the seed

²² Drafts of National Seed Policy and New Seed Bill 2004

²³ Geeta Rani, M, 2000

arrangement (branded seeds) [section 39(I), (I) - (iv)]. Further, the farmer have also been provided protection of innocent infringement when, at the time of infringement he farmer was not aware that he was infringing the act.

PBRs under UPOV's vide table exclude the farmer from producing and exchanging the seed material except only on the permission of the concerned breeders. Therefore, adoption of PBR the farmer's practices of seed multiplication would be illegal and can be considered as theft. But in revised Act (1991) this privilege was made optional for the member's states because of vested interested of private seed industry. It was emphasized in Indian New Seed Bill, 2004.

National Gene Fund

The act also provides a National Gene Fund, which is constituted under the Act. The fund²⁴ raises question on collection of annual registration fee, compensation and other contribution that will deposit in the fund. The fund will be applied for abusing share to benefit claimers, either individual of organization and for compensation to village communities. The fund will also be used to supporting, conservation and sustainable use of genetic resources including in-suit and ex-situ collection and build village level (panchayat level) to carry out such conservation and sustainable activities (section 45). For this our agriculture research system needs infrastructure facilities and manpower to support the programme. The reason most of farmer's are unaware about the importance of plant genetic resources even they are active conservators and protectors of resources.

Compulsory License²⁵

One area in which compulsory licenses may affect plant breeders is that of development of patents and dependence on it, which are defined as patent whose use requires that

²⁴ The benefit sharing from the breeder, annual fee payable to authority by a way of royalists, compensation provided to communities accordant to under [section 41 (sub1)] and contribution from any a national or international organization.

²⁵ TRIPS contain a complex set a rule that regulate, when state may compel patent owner to license their products and processes to governments to or to private parties. Although TRIPs agreement does not specify the grounds which justify the creation of compulsory licenses (Gervais, 1998 p. 165) into can be inferred that such licenses may be granted only to prevent "abuses which right results from the exercise of the (patent owners) ex Chinese rights" even where such abuses exist TRIPs article 31 impose further conditions upon the granting of compulsory licenses.

authorization of an earlier patent owner. Such protection regimes are restrictions on plant breeding activities where, the creation of new varieties often occurs incrementally in form of adaptations and improvements of existing varieties, as opposed to radically new innovation²⁶. Increment forms of innovations are necessary to access protected varieties. So that the government may require imposing compulsory licenses in favour of third party breeders who are unable to negotiate voluntary access to protected varieties (more in Article 31).

The Indian, scenario, the Act passed by parliament, authorities grant of compulsory license, in case of any complaints about the availability of seed of any registered variety to public at a reasonable price. The license can be granted to any person interested to take up such activities. The license provides that after the three years of registration to under take production, distribution sale of seed or other propagating material of variety [(section) 47(1)] after the implementation of Act 2001, any other which party can be granted licensed if in the companies is not fulfilling its obligation. This is ineffective mainly because of India does not have the adequate trained manpower and infrastructure to the evaluation of PBRs applications. Secondly, database of all the varieties development and released in Indian will have to compile and that it will need time and money²⁷. As per example a number of crops such as rice and wheat varieties are grown in a large part of the country and have a large degree pf genetic variable varieties and this will be a great challenge in compilation of the database. In absence of competent manpower and database to examine PBR claims, there is a fear that wrong patents may be accepted. The implications of this could be serious. It is therefore important that the building of these capabilities is given utmost priority by the state Government has taken limited step and these include the setting up of a patent cell by the ICAR at it's headquarter in 1996. The availability of patented variety under the Act is alarming situation to the research. As per literature of ICAR, patent cell only have process patent on Genetically Modified food crop varieties protected under this.

²⁶ Cited in FAO legal study 85, 2004. (See more details C.M.Intellectual property right the WTO and developing countries. In The Trips Agreement 1995)

²⁷ Alam, G. 2004.

Consideration for effective implication of Act

India has opted for a sui generis system of protection of plant varieties and has provided for farmers' right, breeders' right, researchers' right and equity concerns in the legislations. All these provision in ones legislations make it a unique Act when compared to similar legislations in other countries. Although, a few countries have provided farmers rights, other different right i.e., researchers, breeders, consumers and seed producers have not been considered elsewhere in the world. The unique Indian act also poses many challenges for effective implications. The harmonization between the interest of breeders' right (PBR) and farmers' rights (FRs) could be tough to strike. Although the Indian authority also got some success to make a balance between all rights but the efforts are not enough to make clarity and understanding.

Farmer Perspective

The act has taken care of farmers' interest [section 18C] requiring an application to provide an affidavit that newly bred varieties does not contain terminator gene. A farmer who has bred or developed a new variety shall be entitled for registration and any other protection as a breeder [section 2(j)]. It includes a farmer variety also, which may be land races or a wild relative about which farmers possess common knowledge.

The uniformity criteria in case of registrations of these varieties are difficult to ascertain. Such consideration may have to be included in DUS guidelines for testing of these varieties in future, as there could be innumerable to farmer' varieties because of traditional land race. The registration and data are scattered and some times over lapping and thus makes if enduring task to compile if at the cost of farmers' interest.

A farmer/farmer's organization claim that besides modifying the patent system to protect special land races/folk knowledge or innovations it is necessary to explore the possibilities of tailoring plant breeders' right regime to protect folk varieties. It is difficult to distinguish and protect farmer varieties from place to place, from one generation to another. Hence, it is often

difficult to distinguish one from another variety of particular crops²⁸. Furthermore, denomination and documentation is necessary.

The modern plant breeding develops varieties that have a very narrow genetic base so that these satisfy the DUS criteria prescribed for protection under UPOV's framework. It was also adopted by our draft PVPA Act. The folk (traditional) varieties are unlikely to satisfy these norms and it is very easy for private business to indulge in piracy theft. However, petty patent or confused plant breeders' right system serves to protect at least some of these varieties. Question pertaining to novelty and ownership raises further difficulties in protecting folk varieties because most of these varieties are not novel. However, these are also not registered under the Seed Act 1966, which primarily recognizes varieties, which are developed by public sector. The PVPA Act precludes protection of varieties registered under the Act, 1966. Hence, countless examples of traditional communities in India contributing to development of new varieties and saving bio-diversity are available. Some grow well under drought other withstand against pests and disease while some other such as aromatic, sticky, medicinal value and have from time immemorial allowed farmers and consumers to meet their need²⁹. Therefore, the obligation to recognize and protect the traditional and contributions made by rural societies lay with the authorities. It is in the backdrop that aspects of the Indian Sui generics PVPA act are examined.

Farmer organization and farmer [section 39 (2)] can claim compensation if a variety fails to give the expected performance under given conditions. Such a claim may have to be paid by the breeder as directed by the authority after giving due hearing to both the parties farmer and the breeder. But the breeders or private sector do not accept their obligation in fulfilling such claim properly the reason being their lack of awareness and poor infrastructure among the farmers.

²⁸ A Kaga is vernacular generic term describing various salt resistant varieties traditionally grown along the west of northern Karnataka with lot of varieties with lost of varieties from village to village assigned to name such as "Bilikaga" attractively a single base name refer to two different varieties.

²⁹ Katiyar R.P Recent advance in seed science and technology

Section 42, regarding protection to farmers for innocent infringement is also not clear as to how to define innocent infringement such a clause may not stand in the court of law in view of other law where ignorance is not a reason to have protection from legal obligation³⁰.

Introduction of PBRs will clearly have a number of positive effects on agriculture research in India. However, it must be mentioned that IPRs can also have some negative effects. If public sector institute encourage protection of their varieties more are likely to be linked to the spread of variety. The varieties, which are planted in large irrigated area, will have the high potential of earnings. This may strengthen the existing bias in research system³¹ which favours only those crops which are having commercial high value and preferably grown in irrigated area. There is an urgent need to shift the balance in favour of orphan crops (Poor men crops like millets) of dry land and small and marginal farmers. This will be a balanced approach for socio-economic development of farming community. It is therefore, needed that the R&D incentives through PBRs is not allowed to distort the research priority unduly.

The establishments of private sector are naturally looking for return on their investment support and provide incentive for their future innovations. The consolidation of seed business with the introduction of PBR in the small and medium sized domestic companies, which do not have the capability to do research, and rely on the public sector/ big companies for breeders' lines, may find it difficult to sustain in seed business. It results in cutting down the number of companies and seed price may increase. The effect of an increased seed price will be particularly serious concern to small farmers those have smallholding. They will find it even more difficult to replace old seeds that in the past. It is therefore important for government to exercise a proper price mechanism, which will be necessary for crops, which are largely grown by poor small and marginal farmers³²

Integration and implementation of different rights

There is a need for effective and integrated implementation of various new Acts/Bills concerning bio-diversity, environment safety and seed, which have some, interface because of

³⁰ Brahmi, Pratibha; Saxena, Sanjeev and Dhillon, B. S. (2004).

³¹ Alam .G. 2001

³² UNDP human development Report (Oxford university press) 2001

the common commodity that is the seed. There are several arising concerns above the New Seed Bill, 2004; Indian Agro-Biodiversity, 2002; International Biosafety Regulation and National Policy on Biotechnology Policy, 2004 the area of benefits sharing mechanism for conservers of agro-diversity and the establishment of a fund for claims of benefit sharing.

The Ministry of Agriculture, which piloted the PVPA&FR Act, has now authored the Seed Bill in which many a farmer friendly provisions of the PVPA&FR are re-written. The present seed law regime allows a foolproof patent like monopoly a hybrid seeds and transgenic hybrids and farmer unfriendly practices in the trade of low volume high value seeds. Hence, contradictions between the Seed Act and other legislations create loopholes for establishing monopoly on seeds, pirating national bio-resources, denying the farmers rights and evading public accountability.

The Biological Diversity Act (2002), dealing with conservation and access to biodiversity and the protection of plant varieties and farmers' right act along with one Seed Act may be simultaneously and effectively integrated for smooth implementation. Although, some overlapping issues have been sorted out to bring harmony between the Seed Act and the PVP&FR act in the New Seed Policy 2002 and New Seed Act 2005. But again the seed sector is the key area of development perspective so that appropriability between industry and framers are needed³³ in future development.

5.5 Pattern and Direction of Agricultural Research and Development in new IPR regime

There is also a positive argument that Introduction of IPR norms may result increased resources allocation to research. The hypothesis of IPR induced inflow of fund towards research still is to be verified. Along with the total allocation of research funds, the area of attention is also important. The possibility of channelising a lion's share of privately funded research towards high profit oriented elitist technology can not be ruled out. The oblivious opinion on the part of government will be to monitor the quality as well as the funds

³³ Pray. C. and Basent, R. 2000

allocation towards research and bring the necessary guidelines to protect the interest of farmers and breeders.³⁴

The opponents also argue that the new IPR regime under the WTO/ TRIPS auspices is more stringent than the existing one in India, encompassing more monopoly elements. This gives the innovator more incentive and protection and calls for more investment in research and development. However, its impact on developing countries like India is to be examined particularly on public sector research system.

India was a founder signatory with 23 countries for establishment of GATT (General Agreement on Trade and Tariffs) as early as in 1948 to promote and regulate international trade. However, the signing of multilateral world trade agreement by India along with 124 nation states in April 1994 transferring GATT into special significance. The world trade agreement (WTA) under the auspices of WTO includes an agreement on Trade Related intellectual Property Rights (TRIPS) according to which India as a member state, is obliged to enact and enforce a system of plant variety protection (PVP) either by patenting or by any effective *sui generis* system (an unique system of its own kind) or any combination thereof.

The conclusion of the protracted Uruguay round of multilateral trade negotiation marks a major leap forward in international trade liberalization. The final act was signed in April 1994 at Marrakech, Morocco. With this old general agreement on trade and tariffs was replaced by the new multilateral trade regime known as the world trade organization (WTO) with a membership of 136 countries as on 1st January 1995. The most avowed goal of the WTO as set out in the promoting documents is to create a fair and equitable, rule based multilateral trade system. The most appealing aspect is that the new multilateral trade regime would be transparent and non discriminatory. For the world trading community as a whole, every initiative on trade liberalization should insure rewards in the form of large and expanding market, and the greater trade flows for all participating members.

³⁴ A. Suresh and Dr. Puran Chand (2004) Trade Related Aspects of Intellectual Property Rights: An Evaluation . Kurukshetra, April 2004, pp21-26

5.6 Agricultural Biotechnology and Policy initiatives in India

There is a general recognition within India's scientific community, and even within the government, that biotechnology offers the only realistic means to achieving food security. According to the GOI's National Seed Policy, 2002, "Biotechnology will play a vital role in the development of the agriculture sector. The technology can be used not only to develop new crops/varieties, which are tolerant to diseases, pests, and abiotic stresses, but also improve productivity and nutritional quality of food."

The present regulatory structure and procedures, which have approved only one (non-food) technology after seven years of deliberations and review i.e cotton crop (Bt. cotton). Bio-engineered varieties of several crops are in various stages of development and testing, both by public sector research institutes/universities and private seed companies.

Legal aspect attached with this technology is being seen based on international laws and treaties and juxtaposing those laws with the national laws as well as their relevance with liberalization, privatization and globalization.

5.7 Technology and Regulation

It is argued that transnational corporate may usurp the third world crop genetic resources by means of new mechanism like patents. At present over 160 patents have been granted in the field of rice biotechnology worldwide, over half of them are held by 13 companies in the industrialized country. If patents on the life are accepted in Asia, rice scientist will have to pay to use genetic resources and technologies, and the bill will be passed on the framers.³⁵

The development of vitamin A - fortified golden rice,³⁶ which has been so highly, commended in western press, involved wading through no less than 70 patents, according to Dr. Peter Bayer of the University of Freiberg, one of the scientists who developed the rice. He himself is a party to a patent application on it. IRRI argued that golden rice will be available

³⁵ Benbrook, Rachel C. (2000). Rice research losing the patent bottle. The Grain, Volume 1, March 31st 2000. [www.grain.org assessed on 18th June 2007].

³⁶ Golden Rice is a transgenic variety of rice, which has genes for the synthesis of Beta-Carotene. These genes are taken from the garden favourite *Narcissus pseudonarcissus* (Daffodils) and inserted into the genome of a temperate strain of rice.

for free. After complex licensing negotiation, it might be. But that does not answer the question – ‘who will pay for it’. The big corporation keeps arguing that patents are needed to recoup their R & D costs. A little bit of charity might win them some public relation points in the short terms but it wont support their investment.

There was a Convention of Biodiversity under the UN auspices in July 1999 when the issue of TRIPS vis-a-vis the rights of farmer came to be debated. The TRIPS agreement became controversial because it recognized patents on plant developed through biotechnology using plant varieties that themselves are the result of years of cross breeding by farmers. It does not recognize the rights of communities over their intellectual resources but concentrate on the rights of individuals and companies claiming the patents as their own investment.

Many a times it is argued that interest of Indian farmer will not be hampered due to new IPR regime since majority of Indian farmers use farm saved seeds. In the new regime, farmers are completely free to use farm saved seeds of a protected variety for growing subsequent crops on his own land or on leased land or for traditional exchange in the village community. Once he converts into commercial seed sector, he is not permitted to sell the seeds of protected varieties without prior permission and he can be booked for breaching the IPR norms in that case.

5.8 Impact of New Technology and IPR on Agricultural R & D

Due to adoption of TRIPS under WTO obligation, the research and development pattern in agriculture has affected by several factors. Liberalization, globalization and free market access system have several impacts on Indian agricultural research and development and food security. Agricultural R & D in the India owes its origin as well as present status lo public sector. After enactment of WTO and new seed policy in year 1988 several changes has occurred and still occurring like emergence of private sector, multinational corporate and company merger in agricultural sector.

The study by Adede³⁷ (2001) concludes that patents are obviously bad for poor countries. They are largely the preserve of western multinational companies, allowing them to establish monopolies, drive out local competition, divert research and development away from the needs of poor countries and force up the price of everything from seed to software. Further adding to this view, the study of Raju (2004)³⁸ shows that though TRIPS Agreement prescribes the maximum standards that will substantially increase the degree of harmonization of intellectual property, it does not provide a uniform law. Even the protection is on a universal scale leaving considerable room for national laws to define a number of important aspects. The idea of patenting itself was creation of the industrialized countries for protecting their intellectual creations. The developing countries like India were always on the receiving end.

Pal and Bayerlee³⁹ (2003) analysed the historical perspective of research and development in agriculture and told that “nearly 30 years ago, a global consensus emerged that developing countries must target 1-2 % of agricultural GDP for agricultural research and that the government must lead this in view of the very limited private sector presence”. They also revealed that the economic reforms of last 10-15 years encouraged private sector participation in agricultural research and development.

Jha (2003) accepted the changing pattern of market demand in agricultural research and came to conclusion that economic liberalization and integration with the global market has changed this basic premises, economic efficiency has become the new mantra and regional and global comparative advantages is the new route to future agricultural and economic growth. This will demand major adjustments in resource allocation and production patterns.⁴⁰

Malik and Jafar (2005) revealed that with structural adjustment and liberalization, public research institutions-are under pressure to become involved in income generating activities. Revenues from licensing or royalties, or from provision of services, could therefore become

³⁷ Adede, A. O. (2001).

³⁸ Raju, K. D. (2004).

³⁹ Pal and Bayerlee (2003)

⁴⁰ Jha (2003)

important for those institutions, which until; now have made their "innovation" freely available to both public and private sector. The need for public sector research in agriculture will remain despite the private sector assuming a growing role. They also emphasized that the introduction of IPR system may even facilitate a more rational public /private division of biosecurity roles.⁴¹

Harbir Singh⁴² (2002) analysed that more proprietary controls in research tools and uncertainty in the limits of ownership make the conduct of agricultural research all the more difficult by requiring complicated negotiations. He asserted with example of use of golden rice variety involves clarifying user license for over 70 patents.

5.9 Implications for commercial companies

Patents have enormous implications for the strategy of a breeder seeking to protect new innovations and ensure access to its market. Certainly, it will sometimes be possible to devise a combination of technology and patent coverage that leads to an exclusive ability to fill at least a niche market and to protect one's proprietary position within that market. This possibility - and the ability to build consumer recognition for specific varieties - suggests that maintenance of proprietary position may become nearly as important in agricultural biotechnology as in medical biotechnology. From this perspective, the acquisition of a patent on a gene and plants transformed with it offers a very valuable incentive for research and the investment needed in product approval; this is the context in which the patent system is likely to work to benefit innovation.

Nevertheless, the sheer bulk of very broad and very basic patents creates significant barriers to marketing of biotechnology products. The of patents covering fundamental research and transformation methods and covering broad species ranges show how difficult it is likely to be to operate without risking infringement litigation⁴³. Probably some of the patents would be struck down during litigation, but the expense of litigation is itself a significant problem for

⁴¹ Malik and Jafar (2005)

⁴² Singh, Harbir (2002).

⁴³ Bossche, Peter Van den (2005). page 133 and 162. For detail, see "The Law and Policy of the World Trade Organization: Text, Cases and Materials. Cambridge University Press, Cambridge".

many companies. Just as there is a concern in ensuring that one has a strong proprietary position, there is a concern in ensuring that one will not be sued. It is therefore necessary to obtain a careful legal opinion examining the possibility of infringing a variety of possible patents before it is safe to invest large sums in developing a new biotechnology derived variety.

To avoid litigation, one may seek license rights from the relevant companies, e.g. those holding rights over transformation methods, specific promoters, specific genes, and specific plant categories, as well as the holders of plant variety protection over the variety that is genetically transformed, in order to be able legally to participate in important agricultural markets. These rights are likely to prove expensive. A typical commercial evolution in such a situation is for firms to enter cross-licenses, under which each firm permits its cross-licensee to use certain of its own basic technologies in return for the right to use the cross-licensee's basic technology. In this context - and the point is extremely important for a company's intellectual property strategy - it may be as important for the company to obtain patents that others are likely to infringe as to obtain patents to protect its own proprietary position. It is patents that everyone in the industry needs that are the basis for entering into the cross-license structure or for use as a counter threat to protect oneself from suit.

Clearly there is a risk, not just that these broad and basic rights will complicate life for agricultural biotechnology firms but that they will lead to concentration in the industry. It is after all, the larger firms that have the greater resources for litigation, the larger patent portfolios, and that may be able to obtain the best cross-license arrangements. Certainly, concentration is occurring in the industry, as with Monsanto's acquisitions of Emergent and joint venture with Mahyco i.e. Mahyco Monsanto Biotech (MMB).

5.10 Government of India intervention

- i. The Genetic Engineering Approval Committee (GEAC) permission for field trial.⁴⁴

⁴⁴ Field Trial of GM Crops only after GEAC Approval, Rules Apex Court. The Financial Express - May 2, 2006 (see appendix policy)

- ii. To bring down the prices.⁴⁵

5.11 The Debate

In the current context Intellectual Property Regime is a legal concept which stands on the foundation of Rights of the Inventor as an individual or as a group which excludes others rights in favour of the inventor for a stipulated period. As a principle it is aimed at motivating the culture of new inventions by providing the incentive of exclusivity.

The origin of debate started with the inclusion of TRIPS in GATT, developed countries emphasized that TRIPS should be added to GATT because LDCs were imitating the innovations of developed countries. LCDs on the other hand stressed that TRIPS should not be added to GATT because it will lead to an alarming increase in the prices of biotechnology based product on one hand and will cause harm to infant high-tech industry on the other. Ultimately TRIPS was added to GATT treaty at the end of the Uruguay round of trade negotiation in 1994. Developed countries further stressed that establishing strong Intellectual Property Rights would actually benefit the developing by encouraging foreign investment, the transfer of technology gearing domestic R&D. India initially opposed the TRIPS agreement of WTO and refused to comply with its provision earlier. The reason was that The Indian Patent Act of 1970 has continued to govern the IPR Regime. By being a signatory member of WTO, India had to agree to comply with its provisions.

The major difference between Green revolution and Gene revolution is the new protection regimes and exploitation of Plant Genetic Resources (PGRs)⁴⁶. The processes and methodologies used in modern agriculture, science and technology raise level issues because it's proprietary natures⁴⁷ and increasingly subjected to intellectual property rights (IPRs) protection along with the product. This is the most debated issue in agriculture, IPRs specially, patent, plant breeders rights, copy rights and plant variety protection systems, farmers rights, and "sui generis" system along with the bio-diversity issues which are major concern to Indian agricultural scientists, traders, policy makers and politicians. The question

⁴⁵Regulator tells Monsanto to cut GM Seeds Prices (see appendix policy)
http://agbios.com/sabp_main.php?action=ShowNewsItem&id=7517AFP - May 12, 2006.

⁴⁶ Rai, M. and Prasana, B, (2000).

⁴⁷ Alam, Gayour (2001).

is how to safeguard our bio-wealth farmer interest as well as breeders rights as cultivars developed by him. Secondly, how can we make profits from all the above by striking the balance among them? On the other hand, global concern is drifting agriculture into commercialization, which has led to future concern for free access of germplasm, trade related aspect and conservation issues raises on free movement of PGRs. Our traditional communities have made enormous contribution to conservation and improvement of germplasm and land races, which are the main sources of material used in modern plant breeding. The farming communities have also developed techniques and management practices, which are central to modern farming, furthermore, the bio-resources and traditional knowledge developed and preserved by these communities are the most valuable new material in biotechnology based research. At present, no international accepted system to protect traditional knowledge exists. In such an ineffective system it is easy for industry in developed countries to use the bio-resources originating in the developing countries without compensation.

Supporters of IPRs point out that developments in biotechnology⁴⁸ have changed this situation dramatically because, biotechnological inventions require substantial investment and its processes and products can be easily copied. Therefore, the industry sector think that the absence of a grant of exclusive rights over those products, so called free riders,⁴⁹ could be misused. The policy goals of granting IPRs to Plant varieties are grounded principally on an instrumentalist approach⁵⁰ to IPRs. This is true both for patents and plant breeders' rights. It is argued that without IPRs the investor would not have incentive to invest in the creation of information or to disclose the invention. Due to free rider problem there may be under investment in seed sector. Patents are means to solve the free rider problem by providing the inventors with a legal right to his /her inventions for a specified period and ensuring that other can not copy his / her invention.

⁴⁸ Some economic survey have predicted that biotechnology alone would account for up to 50-60 percent of global economic control is seed sector in next two or three decade.

⁴⁹ Who have not made such investments could exploit inexpensive distributes and reproduction technologies and sell other intellectual property product at a much lower price.

⁵⁰ It is philosophical approach to decision to grant IPRs it takes as its starting premises an instrumental view of intellectual property. Legal protection for the products of human intellectual effort and ingenuity is granted not because of moral commitment to compensating creators and innovators, but rather because the products they create enrich a society's culture and knowledge and thus increase its welfare. The well manifestations of this approach is found in IP clause of United State constitution (FAO legislative study. Vol. – 85), 2004.

Others argue that since patent and protection of plant variety involves granting a monopoly right to the investor there are economic costs associated with IPRs. This may lead to the diversions of resources from important aspects of research to more patentable areas. Such kind of plant breeding is increasingly being carried out by large multinational commercial establishments (in many developed western countries and some developing countries), by and large state run research institutes in few developing countries like India and China using modern technology. These provisions are likely to have a serious impact on agriculture in developing countries.

The granting of PBRs is likely to provide strong incentives to breeders to develop and introduce new plant varieties. It will also encourage the private sector to invest in research and the development of open pollinated varieties. Furthermore, it is also likely to promote the exchange of germplasm between private and public sector. However, some of the provisions of TRIPs may have negative effect on seed industry sector in developing countries ability to develop and use agricultural biotechnologies. This will especially influence advanced developing countries such as India, which have biotechnology capacity. The implication of plant variety protection and seed industry transformation is discussed below.

Food Security

Food security defines a situation in which people do not live in hunger or fear of starvation. Worldwide around 852 million men, women and children are chronically hungry due to extreme poverty, while up to 2 billion people lack food security internationally due to varying degree of poverty⁵¹.FAO define food security as “food security exist when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.”

One of the most vital issues concerned with the third world countries regarding WTO/TRIPs regime is fulfillment of the food and nutritional security. Although the countries of south are provided with rich natural resources and different varieties of crops, but due to traditional

⁵¹ FAO (2003).

mode of practicing agriculture fulfillment of the dietary requirement of their population is a daunting task. It is argued that WTO promotes commercialization of agriculture. It also provides better opportunities to modern technologies in agriculture. The emergence of biotech is major feature of global agriculture after the WTO enactment. Most of the laws of WTO are in conformity with the countries of the north.

Due to the deference in food habits of developed countries and developing countries, the dimension of food security is also differing from one part of the globe to other part. Cereal crops like wheat and Rice and millets like Jowar, Bajra and Ragi are grown and consumed in third world countries. In the fast changing economics of agriculture, the cultivable land of third world also came under commercial crops to enhance more benefit in global agri-market. The pattern of cropping is changing from food crops to cash crops and also investment in agricultural research and development is tilted more towards commercial crops. This type of situation will must have some impact on food security. The changing pattern of more thrust on low volume but high return crops may have impact on food security.

The agricultural biotechnology revolution has both positive and negative impact on the food security of third world countries. This is argued that judicious application of biotechnology may fulfill the food requirement both in quantity and quality. Colder A rice project is noteworthy example in this context. Use of biotechnology may invent trait specific varieties suitable for a particular agro-climatic region. The planner policy makers and agricultural scientist of various nations in the south and west Asia have been engaged in alleviating poverty, improving food security ,and reducing malnutrition ,by using new technologies in eco-friendly and sustainable manner. This is | also argued that the tools of biotechnology like genomics, bioinformatics, transformation and molecular breeding will provide better path for agricultural research; to maintain the food security of nation. Therefore, it is argued that, a holistic approach is needed for the agriculture sector in new IPR regime to fulfil the requirement of all the stakeholders of the society.

Dr. M. S. Swminathan (2000) argued that “we need to examine how science can be mobilized to raise further the biological productivity ceilings without associated ecological harm.

Scientific progress on farm, as an evergreen revolution, must emphasize that the productivity advance in sustainable over time since it is rooted in the principles of ecology, economics, social and gender equity, and employment generation”⁵². Technological advancement of science can solve the problem of hunger and malnutrition in third world agriculture if it is regulated in suitable manner by the welfare state like India.

The tool of IPR in agriculture like patents, geographical indicators and plant variety protection acts is likely to have some impact on food security. The impact of the provision of TRIPS on food security is yet to be analyzed. The restructuring of existing institution of agricultural research and development to fulfil the concept of food security is need of the time which is influenced by the new regime. The step is already taken by the government of India by enactment of New Seed Policy, Biodiversity Act and Plant Variety Protection act which will streamline the concept of food security.

Food security has its dimension from the international level to global level. It encompasses the production as well as the accessibility and purchasing power of the individuals. The issue of food security has its own gender dimension also. The fundamental aspect of food security is the production of sufficient quantity of quality food capable to fulfill the nutritional needs of the masses.

There is the chance that commercial crops may push the food crops to backstage due to high private research investment in cash crops as well as many environmental and ecological threats in many high productive zones of the country. Secondly, the quality parameters of food with regard to its nutritional utility. IPR may provide a better condition for cultivation of transgenic to fulfill the nutritional as well as quantities requirement of poor masses. However, it may lead to monoculture of crops which will narrow down the genetic variability and in turn led to genetic erosion of our rich agro biodiversity. In the new IPR regime monoculture of specific crops will create several other problems like insect pest resistance.

⁵² Swaminathan (2000)

Country's food production jumped from about 50MT, to over 200MT. in fifty years or so is to state the obvious. Based on requirements of between 2200-2400 kilo calories deemed necessary for leading an active life ,it is estimated that per capita per day consumption should be 425 grams of food grains, 60 grams of proteins and about 20 grams of fats. Based on this premise food grains (cereal)requirement for a billion population will be about!70-175 million tones and for a projected population of about 1.3 billion in 2020 it is likely to be about 190-195 million tones for human consumption.⁵³

There are different thoughts in counter groups about issues of the food security in the new IPR regime. Various institutional changes occurred in respect of IPR and food security. The tools of IPR like patenting, plant variety protection and geographical indication with emerging technology often debated in counteracting forces with opposite argument in context to food security. One group of thinkers often claimed that the new tools will hamper food security of the developing countries by monopolization, commodification and commercialization of resources by new legal and more protective instruments. The counter argument is that now tools will create economic incentives for scientific community that will promote them to do some greater innovation for public welfare.

N. R. Subbaram (2001) has a very positive argument about the impact of new patent amendment act and PVPFR act on food security. He stated that the legislation relating to the protection for the new plant varieties is expected to be advantageous to India, particularly in the area of food sector. This is because such legislation will encourage development of new varieties of plants, which are useful in the area of food related crops and also to protect such new plant varieties to safeguard the interest. Such an environment will have great impact in the production of food, which will result in the availability of food items in abundance, facilitating its availability at reasonable rates.⁵⁴

One group of thinker realized that the new tools of technology and IPR as a threat to food security. They asserted that the private sector, particularly a few MNCs, have invested heavily in bio-technology. As a result, a significant part of the unfolding bio-revolution is

⁵³ Taimini (2001). Vision for 21st century: Food Security in 21st century Perspective and Vision. Konark Publication, pp. 148-175.

⁵⁴ N. R. Subbaram (2001).

likely to come from the private sector. The private seed sector needs returns on its investment, which can be ensured mainly through patenting of its products, unless the government wants to compensate it through lump sum transfers. This act has at least two implications with respect to food security, first is the relative increase in prices of seed in comparison to publicly funded research and second factor is that the oligopolisation of seed market by terminator seed technology.

Traditional Knowledge

Seed is the basic input of agriculture on which whole agricultural operation, innovation and development is based. Seed plays a central role in agriculture-society-environmental interface. In the new IPR regime seed provide a debate between traditional knowledge and modern technological breakthrough. Bradford and Cohn (1998) stated that “seeds are the connection between the past and future. They contain the accumulated genetic wisdom of the past, and the potential for its perpetuation in the future”⁵⁵. This is the traditional knowledge system that saved the seeds for present generation and this is the modern emerging technology that will make its propagation and distribution more convenient for the human welfare and again for the coming generation.

One group of thinkers argued that the south Asian region is the one of the largest gene rich regions of the world and equally rich in traditional and indigenous knowledge. The rich socio-cultural heritage of the developing countries is evident in that the plant variety has always remained freely accessible to all since times immemorial.

Sharma (2000) argued that the Asia-pacific region is rich in agro-biodiversity. It is the centre of origin of several important crops including rice, sugarcane, coconut, jute and cotton, besides vegetables and other crops. The region has a gene pool for several plant species that have already been identified as ‘endangered’. With more than 47000 species of plants and two

⁵⁵ Bradford, K. J. and Cohn, M. A.(1998)

hot-spots of biodiversity, 8 % of the total biodiversity is available in the Indian sub-continent.⁵⁶

R. A. Mashelkar (1999) revealed that the issue of economics based on traditional knowledge and biodiversity is far more complex. India, with approximately 8% of the worlds biodiversity and as one of the greatest storehouse of traditional knowledge have a potential of becoming a major player in global trade in herb based formulation, medicine and products. An estimate by the EXIM bank puts the international market of medicinal plants related trades at US \$60 Billion per year growing at about 7% annually. India has only 2.5%share of the market.⁵⁷

Kamath⁵⁸ (2002) cited that 1970 Patent Act, although helped the domestic companies to grow, had negative scientific culture, which did not promote creativity. Continuing changes in the law required by TRIPS is in fact a blessing in disguise for an industry that is yet to receive its true creative potential. Laws that promote and reward creativity are to be welcomed rather than opposed.

Anil K. Gupta (2003) also emphasized that traditional knowledge system help a very large section of our society not only survive against all odds but also generate in the process, some of the products, which might have national and global market if properly developed.

Fred Powledge (1995) asserted that Rice and beans, wheat and soybeans were part of the global commons, along with air, soil, water.⁵⁹ Elenita C. Dano argued that more than 70 % of worlds biodiversity are found in only 7 % of the earths surface, namely in key centers of mega-diversity spread across Asia, Latin America and Africa.⁶⁰

Anup Shah argued that large transnational corporation like Monsanto, Du Pont and others have been investing into biotechnology in such a way that patents have been taken out as

⁵⁶ Sharma (2000)

⁵⁷ Mashelkar, R. A.(1999)

⁵⁸ Kamath, N. (2002). <http://www.users.ox.ac.uk/~edip/kamath.pdf>

⁵⁹ Powledge, Fred (1995). Bioscienc. Voi.45.No.7 (Jul-Aug.).pp440-444

⁶⁰ Dano, Elenita.C. Biodiversity, Biopiracy and Ecological Debt.

indigenous patents which have been used for generation by the local people without their knowledge or consent.⁶¹

UNCTD-ICSTD project on IPRs and sustainable development also came to conclusion that Traditional Knowledge is being widely disseminated and commercially exploited, with only a small proportion of the benefits flowing back to provider peoples and communities, raises the question of ownership. This project report also raised an important question who owns traditional knowledge, according to traditional people and communities? And who owns, according to most national legal systems and the international IPR regime.⁶²

Vandana Shiva argued that the expansion of new 'IPR' into the domain of life forms and biodiversity, and globalization of this regime TRIPS of GATT/WTO, has been an attempt to enclose the biological and intellectual commons.⁶³

Muchkund Dubey (2005)⁶⁴ stated that the provisions in the TRIPS agreement For the patenting of plant varieties, micro-organisms and micro-biological processes [article 27.3(b)] can be potentially used by multinational companies for the piracy of the bio-resources and related traditional knowledge, from developing countries. He quoted the example of basmati rice, neem, haldi, etc. He also predicted about another discriminatory aspects of the TRIPS Agreement is that it provides for higher level of protection to Geographical Indicators. South Asia has many Geographical Indicators of tremendous commercial value such as basmati rice, Darjeeling tea, etc. for which such protection is not available.

5.12 Inferences

The literature about the impact of TRIPS on Seed Industry gives a mixed opinion. A few researchers believe that product patent will result in metamorphosis of the industry while the other few appear to be not supportive of this view. WTO affected the agricultural situation of

⁶¹ Shah, Anup. Genetically Engineered Food Patents-Stealing Indigenous Knowledge.
<<http://www.globalissues.org/EnvIssues/GEFood/FoodPatents.asp>>

⁶² UNCTD-ICTSD project on IPRs and Sustainable Development, page 117

⁶³ Shiva, Vandana (2000). The Enclosure of the Commons: Biodiversity, Indigenous Knowledge and Intellectual Property Rights.

⁶⁴ Dubey, Muchkund (2005).

developing countries in different manners. After emergence of WTO in global arena, particularly TRIPS reshaped and redirected all the existing pattern of agricultural research and development, production and productivity pattern of crops as well as investment in agricultural innovation. A holistic approach is used to understand different arguments in favour and opposition of Intellectual Property Rights. Policy formulation is based on the adoption of several ideas, thoughts and expressions. The different components of science and technology may be used for the betterment of society, if they are used in judicious, efficient and equitable manner.

In the changing situation of world the issues of Plant Variety Protection have become important concerns. These rights will encourage the private sector to increase its investment in research and development. Plant Breeders' rights will clearly have some positive effect on agricultural research in India. However, it must be mentioned that IPRs can also have some negative implication on small local players, orphan crops and marginal farmers.

Considering the potential of Bt cotton many Indian seed companies have become sub licensees of MMB. It has sub-licensed the Bollgard II gene construct to Rasi Seeds, Ankur Seeds Pvt Ltd (Nagpur), Krishi Dhan Seeds Ltd (Jalna) and Emergent Genetics India Pvt Ltd, Hyderabad. These companies have incorporated the gene construct into their respective cotton hybrids. MMB has sub-licensing agreements for its Bollgard technology with 21 domestic seed players, including the five who have opted for the improved Bollgard II versions. Of the remaining, 10 companies are from Hyderabad. Others include Namdhari Seeds Pvt Ltd (Bangalore), Tulsi Seeds Pvt Ltd (Guntur), Ajeet Seeds Pvt Ltd (Aurangabad), Vikram Seeds Pvt Ltd (Ahmedabad), Solar Agrotech Pvt Ltd (Rajkot) and Proagro Seed Company Pvt Ltd (Delhi). Seven of the 10 seed companies based at Hyderabad led by Nuziveedu had formed a consortium-Swarna Bharat Biotechnics-to enter into an agreement with the National Botanical Research Institute (NBRI), Lucknow, for commercializing Bt cotton technology to combat the multinational dominance. But now all have become sub-licensees of MMB.

Although proprietary seeds have enjoyed a robust growth over the last decade and new companies have entered the market, the current situation is characterized by significant

uncertainty about future market dynamics. At the ground level, there is a substantial shift of farmer preference towards Bt. seeds as a result of which companies find it imperative to come out with Bt. hybrids. Almost all the major companies except JK Seeds have tied up with MMB (the single source for this technology) possibly enhance the monopoly of MMB licensed genes for the future as well. Significant investments have been made and firms are impatient to get to the market as early as possible when competition in the Bt. market is still weak. The uncertainties stem from the competition from illegal seeds, from other genes in the testing process and also from regulatory policies. Companies looking to enter are fearful of regulatory capture by incumbent firms.

5.13 Conclusions

Modern biological history is in a sense is a story of technology from discovery of bacteria to that of genetic engineering. The tribulations and triumph of such journey will continue in the future, has one aspect constant at its core - '*the laws that govern them*'. Technology per se is never a disputed issue but for whom and at what cost has been the issue in the ambit of governance. The biotechnology holds the promise of quickly reaching the masses as opposed to earlier technologies, which has a trickle down effect; Bt cotton is the best example of it. Such a promise and potential can only be realized with an appropriate legal regime based on a given socio-economic-cultural factors. In the ambit of technology and law, law needs to provide road map to the technology.

In India during 1980's due to the commercialization of hybrids leading to high profit margin in seed business several chemical companies including, Sandoz, Ciba-Geigy, Dupont, Monsanto and Unilever started acquiring small seed companies. But it did not work well, and again during 1990s they started diverting them towards seed and biotech business in production of Genetically Modified Crops (GMOs). The path from inception of agricultural biotechnology industry to field production of commercial products were full of obstacles, ranging from scientific and technological challenges, to legal and regulatory hurdles, to economic factors and social concerns. Slowly, the agrochemical cum-seed companies are getting into biotechnology research as the transgenic products starts entering into market, and this convergence has changed the structure of the traditional business and product pricing.

Therefore, attempts are being made to separate the value of technology from the value of seed in the form of technology premium to be paid by farmers when they purchase a product improved by biotechnology. Getting IPR in case of transgenic plant product is very easy for a company and to block the development of a produce to maximize value recovery, minimize litigation and access the technology such as Bt based insect protections in Cotton, maize etc. The new competitive strategies that is likely to focus these areas in seed industry in view of IPR and PBR. As mentioned earlier, TRIPs requires developing countries to protect the right of breeder either through patents or plant breeder right. It does not indicate the type of plant breeders' right to be used but requires that protection have to be "adequate". It provides freedom to adopt a *sui generis* system to suit their development.

The spread of new types of intellectual property protection into agricultural biotechnology and the rise of regulatory activity dealing with genetically modified organisms imply that the commercialisation of these new products will require careful legal analysis and planning, which will have to be carried out well before much of the scientific research. Because of the increase in the role and number of broad and fundamental patents, the needs are not simply the traditional ones of obtaining intellectual property protection in order to develop a proprietary position and of satisfying regulatory requirements. They are also ones of recognising that firms will be seeking to use these intellectual property and regulatory regimes to attempt to keep their competitors from marketing their products at all. These bodies of law may have the effect of increasing concentration in the agricultural technology industry, and the lowering of traditional trade barriers to agricultural products may simply permit the commercial battleground in future agriculture to move to the legal and regulatory arenas for example: Navbharat seed floated by Dr. Desai⁶⁵ (former Professor of Gujrat Agriculture University), who crossed his varietal seed of cotton with Bt. cotton seed and sold in Gujrat cotton seed market.

The responses for a company seeking to enter the industry thus involve difficult choices and strategies of seeking niches, seeking alliances, and patenting for bargaining purposes as well as for product proprietary protection. And countries seeking to encourage their firms may

⁶⁵ Dr Desai, proprietor of Navbharat Seeds. [Seeds of Disaster, Business World, 22 July 2002.]

wish to take great care in the way they define their national intellectual property and biosafety regulatory regimes and to participate thoughtfully in efforts to modify the existing international intellectual property, regulatory, trade, and competition regimes. The need of the times is that of a strong legal research orientation which needs to travel along with technological developments if not in advance. Such an effort can make law as a management tool, of rights and obligations in the interface of technology and Governance.

The New Interlinked Institutional Structure for biosafety related policies

Biosafety in India follows a three-tiered system. The ***first tier*** is the Institutional Biosafety Committee (IBSC), which oversees more than 160 institutional biosafety committees throughout the country, including all research institutions, universities, NGOs, or companies engaged in transgenic research. All experimental protocols are looked into by a group of experts. If someone wants to introduce a new technology for the benefit of human-kind, he must have confidence in the key players and scientists. At the IBSC level it is the scientist who decides what strategy is important for GMCs. The ***second tier*** is when scientists have completed their experimental work. One has to initially conduct small-scale containment experiments followed by large-scale open-field experiments. The Review Committee on Genetic Manipulation (RCGM) looks at all the details and gives permission to carry out small-scale experiments under containment in the field. Thereafter, the members of another committee, the Monitoring-cum-Evaluation Committee (MEC) visit all the sites where the experiments are conducted, collect the data, present it in terms of the actual agronomic parameters, the environmental risk factors etc. to the RCGM. The committee's report is again looked into by the RCGM. The ***third tier*** is the Ministry of Environment and Forests (MoEF), which grants permission for large-scale field trials. This doesn't imply immediate commercialization but only permission to conduct large-scale field trials. The DBT had an agreement and arrangement with the ICAR to shorten and streamline the procedure. This kind of arrangement is done by observing many countries biosafety structure.⁶⁶ The ICAR network with its agricultural universities, research institutions and All-India Coordinated Programmes, is probably better than other similar networks around the world.⁶⁷

⁶⁶ Based on the interviews of expert. Also see Chapter 7 of this thesis.

⁶⁷ Compiled from the interviews of top Directors of Research Institutes, Scientists and Beurocrates.

References:

1. Adede, A. O. (2001), *The Political Economy of TRIPS Agreement: Origins and History of Negotiations* (ICTSD, ACTS & QUNO, July 2001).
2. Alam, Ghayour (2004), *Technology Generation and IPR issues (State of Indian Farmer, A Millenium Study: Volume-5)*, (New Delhi: Ministry of Agriculture, Government of India).
3. Alam, Ghayour (2001), *Indian Agricultural Research past performance and emerging Issues* (New Delhi: Centre for Technology Studies, Ministry of Agriculture, Government of India).
4. Anderson, C., P. Baenziger, R. Barnes and R. Kleese (1994), "NIH drops bid for gene patents", *Science* (February 18), 263, p.909.
5. Arunachalam, V. (2001), "The Science behind Tradition", *Current Science*, pp.1272-1275.
6. Bossche, Peter Van den (2005), *The Law and Policy of the World Trade Organization: Text, Cases and Materials* (Cambridge: Cambridge University Press).
7. Bradford, K. J. and M. A. Cohn (1998), "Seed Biology and Technology: At the crossroads and Beyond. Introduction to the symposium on Seed Biotechnology: Application and Advance and a Prospectus for the Future", *Seed Science Research*, 8, pp.153-160
8. Dubey, Muchkund (2005), *WTO and South Asian Countries: Developing Unison. South Asian Yearbook of Trade and Development* (New Delhi: Centre for Trade and Development).
9. Eisenberg, R. (1992), "Genes, patents, and product development", *Science* 257 (August 14), p.903.
10. Erbisich, Frederic H. and Carlos Velazquez (1998), *Introduction to Intellectual Properties*, In: "Intellectual Property Rights in Agricultural Biotechnology Erbisich, F. H. and K. M. Maredia, eds.", (Oxford: CAB International), pp.3-18.
11. Evans, Phillip (1996), *Unpacking the GATT: A Step by Step Guide to the Uruguay Round*, (Calcutta: Consumer Unity & Trust Society (CUTS)).
12. Dhar, Biswajit (2002), *Sui Generis System for Plant Variety Protection option under TRIPS. A Discussion Paper* (Geneva: Quaker UNO office).

13. FAO Legislative study Vol 85, 2005.
14. Field Trial of GM Crops only after GEAC Approval, Rules Apex Court. The Financial Express - May 2, 2006.
15. Gadgil, Madav and Ghate Utkash (1999), "Intellectual Property Rights and Agricultural Technology: Linking the Micro and the Macro Scales" *Indian Journal of Agricultural Economy*, Volume 54, (July-September), No.3.
16. Geeta Rani, M. (2000), "Community gene banks sustain food security and farmers rights", *Biotechnology and Development Monitor*, Volume 41, pp. 19-32.
17. Ghosh, S. K. (2000), "Biodiversity and IPR-Ethics and Politics", *Journal of Intellectual Property Rights*, 5(4), pp.196-205.
18. Gupta, A. K. (1999), Making Indian Agriculture more knowledge Intensive and Competitive: The case of Intellectual Property Rights, *Indian Journal of Agriculture Economics*, 54(3), pp.342-369.
19. Hall, G. (1995), *Genetically Modified Organisms, A Guide to Biosafety*, In: G.T. Tzotzos, ed., (Oxon, UK: CAB International).
20. Jha, Dayananth (2003), *Agricultural R&D in India: Growth, Equity and Institutional Challenges*, In: "India's Agricultural Challenges: Reflection on Policy, Technology and Other issues", pp.171-195.
21. Kamboj, V.P. (2000), "Herbal Medicine", *Current Science*, 78(1), pp.35-39.
22. Katiyar, R.P. (2000), *Intellectual Property Right and Agriculture*, In: "Recent advance in seed science and technology, A. Gour, A. K. Vari, K. Kant and S.P. Yadav, eds", (New Delhi: IARI), pp.137-143.
23. Lesser, William (1987), "The Impact of Seed Patents", *N.C.J.Agr. Eco.*, 9, pp.37-48.
24. Malik, Kauser Abdulla and Yusuf Jafar (2005), "Intellectual Property Rights in Plant Biotechnology: A contribution to Crop Biosecurity", *Asian Biotechnology Development Review*, Vol.8, No.1, pp.7-43.
25. Maredia, Karim M. and Frederic H. Erbisich (1998), *Capacity Building in Intellectual Property Management in Agricultural Biotechnology*, In: "Intellectual Property Rights in Agricultural Biotechnology, Erbisich, F. H. and K. M. Maredia, eds." (Oxford: CAB International), pp.49-62.

26. Norton, Roger D. (2004), *Agricultural Development Policy: Concepts and Experiences* (West Sussex: Food and Agriculture Organization of the United Countries in collaboration with John Wiley & Sons Ltd.).
27. Powledge, Fred (1995), *Bioscience*.Vol.45.No.7 (Jul-Aug.). pp.440- 444
28. Pray, C. and R. Basant (2000), *Issue in Private Agriculture Research* (USDA: AER, Economic Research Service), pp.32-55.
29. Rai, M. and B. M. Prasana (2000), *Transgenic in Agriculture*, (New Delhi: Directorate of Information and Publication of Agriculture, Krishi Bhawan, ICAR publication, Pusa).
30. Raju, K. D. (2004), “WTO-TRIPS Obligations and Patent Amendments in India: A critical Stocktaking”, *Journal of Intellectual Property Rights*, Vol.9, pp.242-59.
31. Rao, Y. V. Krishna, ed. (1997), *The Impact of GATT and Economic Policy on Indian Agriculture* (New Delhi: People’s Publishing House).
32. Regulator tells Monsanto to cut GM Seeds Prices. AFP - May 12, 2006.
<http://agbios.com/sabp~main.php?action=ShowNewsItem&id=7517>
33. Sehgal, Suri (1996), “IPR driven restriction of Industry”, *Biotechnology and Development Monitor*, Vol.29, pp.19-21.
34. Sherman, Andrew J. (1999), *Franchising & Licensing: Two Ways to Build Your Business* (New York: AMACOM Books).
35. Sompal (2002), *WTO Agreement on Indian Agriculture*. In “WTO Agreement & Indian Agriculture, In: Anwarul Hoda, ed. (Delhi Social Science Press), pp.3-15.
36. Stone, R. (1995), “Sweeping patents put biotech companies on warpath”, *Science*, 268, May 5, p.656.
37. Subbaram N. R. (2001), “Patenting in food technology area: a post WTO scenario”, *Invention Intelligence*, Vol.36, No.4 (July August), pp.165-167.
38. Suresh, A. and Puran Chand (2004), “Trade Related Aspects of Intellectual Property Rights: An Evaluation”, *Kurukshetra*, , (April), pp.21-26
39. Taimini K. Brij (2001), *Vision for 21st century: Food Security in 21st century Perspective and Vision* (New Delhi: Konark Publication), pp. 148-175.
40. The Convention on Biological Diversity: <http://www.cbd.int>
41. UNCTD-ICTSD project on IPRs and Sustainable Development, pp. 117-130.

42. Wijk Joren Van (1995), "PBR creates winner and losers", *Biotechnology and Development Monitor*, Vol.23, pp.15-19.
43. Wüger, Daniel and Thomas Cottier (2008), *Genetic Engineering and the World Trade System: World Trade Forum* (Cambridge: Cambridge University Press).

Chapter VI: R&D in Agriculture and Indian Seed Industry

6.1 Introduction

The economic structure of India is characterized by, what may be described as, over population and the dominance of agricultural sector, which continues to be a major source of livelihood for the people of India. Agricultural sector is important in the Indian economy both in terms of share in the national income, as well as, for employment, though the share of agriculture in the national income has declined over the years. In 1950-51 agriculture contributed around 59% to the national income by 1960-61 it was 54%; in 1970-71 it was 48%; in 1980-81 it was 40% and in 1996-97 it was 29% (Planning Commission Reports & India 2007)¹. But its share in employment is still very high. In 1998, In addition as it is well known, this sector is also important for industrial development, because it provides raw materials to industries like Cotton, Textiles, and Jute etc. According to India² 2007 published by GOI, still 65 to 67 percent of Indian population is engaged in agriculture and allied sector. An increase in productivity can increase the income of people dependent on agriculture.

In the mid-sixties apart from introduction of high yield varieties of seeds for Wheat and Rice, public investment in agriculture too had been increased significantly, as a result of which the annual Gross Capital Formation in agriculture both public and private, combined at constant prices, rose faster than the pre-green revolution period. During the green revolution the increase in output took place mainly through the increase in the yield per hectare. Initially the HYVP was implemented in India, in 189 million hectares of area. Between 1951 and 1990 the production of two dominant food grains rice and wheat went up from 20.6 to 74.1 and 6.5 to 49.7 million tonnes respectively. The per-hectare availability of Rice and Wheat went up from 159 to 222 and 66 to 130 tonnes (Mishra and Puri 2004). The rapid growth of these seeds was the main priority of the agricultural sector in the fourth and fifth plan. During the green revolution period total food grain production showed a high trend mainly in Northwest India and in some parts of the South. The increase in output in this particular period took place due to increase in yield per hectare. Oilseed and pulses were grown as essentials during this

¹ Planning Commission Reports and India 2007.

² Ministry of Information and Broadcasting (2007) India 2007.

period. Though green revolution was concerned with a lot of new variety crops, only Rice and Wheat were very relevant in the Indian context and paid their potential concern. Another fact to be noted is that even if the growth rate of food grains seems to have improved due to the new technology, the growth performance was not smooth. There was variation in the productivity from one year to another year. In fact there has been a degradation of agricultural productivity and production in 1990s as compared to the 1980s. In the case of rice the production was 3.62 million tones, in between 1980-81 to 1989-90, but in between 1990-91 to 1998-99 it came down to 1.69 million tones. In the same period the yield per hectare of rice showed a falling trend from 3.19 million tones to 1.18 million tones. The production of all crops during the period of 1980-81 to 1990-91 was 3.19 million tones but it fell to 1.73 million tones during 1990-91 to 1998-99³.

The above discussion shows that there is need to increase agricultural production. This can be done either by increasing the area of cultivation or by increasing the yield per hectare. In 1950s and 1960s more production was possible by extending the area under cultivation. But at present, the area available for cultivation is less feasible for any increase as the forest cover in the country has already come down to a dangerously low level. The main concern thus would be to increase the production by increasing the yield within the fixed area. In such cases, agricultural research is considered as an operating factor, which can help to increase the yield, which can shift the production function upwards, as new methods of production and cultivation are developed. An increase in the income of farmers as a result of the increase in productivity, will ultimately lead to increase in the aggregate demand in the economy. Jha (2001) has pointed out that technological change through agricultural research has been an important basis of agricultural growth and its significance has become even more fundamental as land and water frontiers close and shrink. As the supply of un-used land diminishes, technological changes play an ever-larger role in increasing farm production (Baum, Tolber 1985).

R&D generates new information, which can be used to develop new processes, products and inputs. These can be exploited only if they offer distinct advantages over previous methods

³ Government of India Economic Survey, various issues.

and products. Thus the process of adoption and innovation, which links R&D with the commercial and economic system, determines the effect of R&D on people's lives and welfare (Harvey 1988). Several studies have attempted to show the impact of agricultural research on various food-security indicators (World Food Summit, FAO 1996).

In developing countries public investment is more effective rather than private sector investment (Phillip, Parday, Alston 1995, USDA 2002). Private and public investments both have different objectives. The public research investment in R&D helps the development of basic scientific knowledge and extension of the same to the public benefit. Private R&D mainly aims at marketable application, so that they can earn profit (USDA 2002). Public sector investment is important (Alston, Parday and Roseboom 1998, Byerlee 1998). Further, agricultural R&D is a kind of public good and is profitable to the society, as a whole. The investment on agricultural R&D is a long time lag, the investment on today's agricultural research will result in future, consumer or producer, and private firms can't wait for that long. So in this regard, public investment is considered essential (Alston, Parday, Roseboom 1998, Evenson, Prey, Rosegrant 1999). Yet another reason for government in agricultural R&D is due to the general market failure. As the private firms are not socially optimal, it leads to market failure (Alston 1998, Byerlee 1998). Some studies show that the private investment is increasing in agricultural sector in recent years, but this is still only a fraction of public sector funding (Pray and Umali-Deininger 1998). Private sector can only use the knowledge and technology developed by public sector (Byerlee 1998). Thus the private sector can only invest in the development of embodied technology (Pal 1995). So the private investment depends on public sector for basic research and development. Thus public investment is important into stimulating private research (Pray, Basant 2000) as well.

Capacity building is the strengthening and/or development of human resources and their institutional support structures. In agriculture, biotechnology is currently applied to improve agricultural productivity in order to feed growing populations in an environmentally friendly manner. Biotechnology encompasses many factors, not just research, but includes policy, networking and management. In order to utilize properly the new and emerging tools of biotechnology, nations must take an integrated approach and build capacity in all these areas.

Developing capacity in policy areas includes fostering experience and expertise in intellectual property rights (IPR), biosafety and commercial linkages.⁴

6.1.1 Methodology

This chapter is build based on the primary and secondary data. Since the seed companies did not want to divulge the information on R&D expenditure; secondary sources like published literature were used to build the chapter. DSIR, ICAR, IFPRI reports has been in context of sources for secondary information.

Further in understanding how seed markets may evolve in the future, it is useful to look at entry barriers and cost advantages. Therefore the end of the chapter is largely based on interviews with seed companies.

6.2 Agriculture Research and Development System in India

The involvement of a wide range of institutions helped in the separating the aspects like policymaking, funding and execution of research, since each one requires different inputs and skill. In India the Indian Council of Agricultural Research (ICAR) was restructured to allow its headquarters to focus primarily on policy and funding of research, while the decision about research execution was undertaken by different organizations operating under the ICAR. ICAR implements its research through 48 ICAR Institutes, 5 Bureaux, 30 National Research Centers, 11 Project Directorates, and 77 All India Coordinated Research Projects.⁵ Another important change made in the National Agricultural Research System (NARS) is the improvement of level and effectiveness of public research organization. Increasing efficiency and effectiveness in India means consolidation and rationalization of existing network of research stations. In India NARS the highly centralized system, such as ICAR is exploring options for decentralization, by developing full decision-making authority to its center directors.

Adequate attention needs to be given to the globalization of agricultural research, so that a country can maintain a competitive agricultural sector. In India, centers of excellence are

⁴ Maredia and Erbisch (1998). p. 49.

⁵ Source: <http://www.icar.org.in/ICARatag glance.pdf> (access on 18th May 2009)

being established for specific strategic research areas and they link themselves with the global scientific community.

India has one of the largest research systems in the world; the public sector is still under-investing in comparison to other developing countries. In the late 1990s, India invested 0.31% of its agricultural GDP in research, closely followed by China with 0.43%, but it is lower than the average of all developing countries which was 0.62%, and also lower than the intensity ratio of the industrial countries. This implies that industrial countries spend a higher amount (of 2.64%) of agricultural GDP on research, thus reflecting their higher tax base, smaller agricultural sector in relation to the economy, and often politically powerful farm lobby groups (Pal, Byerlee 2001).

6.2.1 Structure of Agricultural Research System in India

The Indian agricultural research system is considered as a large and complex one. But with time the National Agricultural System is changing in both its organizational and research form. Since independence it has made rapid changes, both in conceptualization and implementation, for an effective system. In other words the most effective and successive change in Indian agricultural research system occurred only after the post independence period.

The milestone in the National Agricultural Research System is the establishment of Imperial Council of Agricultural Research (ICAR), which was established in 1929 on the recommendations of Royal Commission on Agriculture. It has been renamed as Indian Council of Agricultural Research (ICAR). ICAR has an established mandate to guide, promote and co-ordinate agricultural research and education in the country. The re-organization of ICAR was done in 1965. This was considered as a landmark in agricultural research, as the research institutes under the ministry of food and agriculture as well as those with the commodity committees were transferred under ICAR. In the next stage of re-organization of research in the country, the research farms under state control were transferred to State Agricultural Universities (SAUs) within the respective states, as even if there were 17 SAUs the amount of co-ordination remained low. Thus the primary responsibility for

agricultural research and education was given to state but the ultimate responsibility for agricultural development lies with Centre. With this reorganization the SAUs and the ICAR became the two leading partners for agricultural research and development and education in the country. For greater autonomy, flexibility in operation and management, the ICAR was reorganized for the second time. ICAR was given the responsibility to promote agricultural research development and education in the country ICAR operated the All India Coordinate Research Project (AICRP) and National Research Project (NARP). Department of Agricultural Research and Education (DARE) was set up in the Ministry of Agriculture to provide ICAR with the required linkage and to deal with the Central and State Governments on the one hand and the International Organizations on the other hand without going through the Department of Agriculture.

The national agricultural research system of India has different components. One is ICAR in national level and state agricultural universities at state level. According to the constitution, the major responsibility of executing agricultural research and education programmes in different state depend upon particular states but the overall responsibility for agricultural development in the country lies with the central government, which provides assistance to the states in the form of both resources and personal for such activities. Besides this there are many other agencies also which undertake research and development activity. Thus the main component of the agricultural research system in India can be broadly grouped into the following categories:

- a. The ICAR system
- b. The Agricultural University System.
- c. General Universities having either faculties/colleges or strong departments in various disciplines of agriculture and allied activity.
- d. Scientific origination working in areas related to agriculture.
- e. Government department in the center.
- f. Various Ministries in the center and,
- g. Voluntary originations/private institutions participating in agricultural research activity.

The agricultural research and development comprises of ICAR, its various institutes and State Agriculture Universities (SAUs) and their various campuses and regional institutes. By the year 2009, ICAR implements its research through 48 ICAR Institutes, 5 Bureaux, 11 Project Directorates, 30 National Research Centres, 138 Substations of ICAR Institutes, 77 AICRPs/AINPs, 516 Krishi Vigyan Kendra (KVK), 41 State Agricultural Universities (SAUs) all over in the country and there is one central Agricultural University and 4 Central Universities having facility of agriculture⁶. SAUs also have Zonal research stations to address research problem for each agro climate zone. There are some non-agricultural universities or organizations that conduct agricultural research directly or indirectly such as Department of Biotechnology (DBT) Department of Science and Technology (DST) etc. Private voluntary organizations and scientific society too are involved in agricultural research and form a part of NARS.

6.3 Investment Pattern of Public R&D in Agriculture

The national agricultural research system is dominated by the public sector. Agriculture is a state subject in the constitution of India. But the union government funds major components of research system. So government investment means it includes the expenditure made by union and the state government and the union territories as well. The public funding to agricultural research and education in India is provided in block grants to ICAR and SAUs, which is determined according to the five years plans.

In the beginning of each plan, the planning commission constitutes a working group to agree on broad agricultural R&D priorities, which also assesses the financial requirements for their implementation. Recommendations of the working group are later discussed in several consultations between the Department of Agricultural Research and Education (DARE) and Planning Commission. Based on the outcome of this decision of DARE it develops its five years plan. The plan outlays for each ICAR institutes are approved by Ministry of Finance depending upon the proposed outlays and they are finally evaluated. The approved outlays are the basis for the funding of each institution during the plan period. The funds received at that

⁶ Source: <http://www.icar.org.in/ICARatag glance.pdf> (access on 18th May 2009)

plan period are called 'plan funds'. The ongoing activities of the previous plan are financed under 'non plan funds' which is funded to maintain the fixed costs.

State funding is too done in the same procedure, but from the allocation that the Planning Commission has already made to the state as part of total plan allocations to a state. The respective State governments then approve expenditure on research and education.

Figure 6.1 Major Sources of Investment in Agricultural Research & Development in India

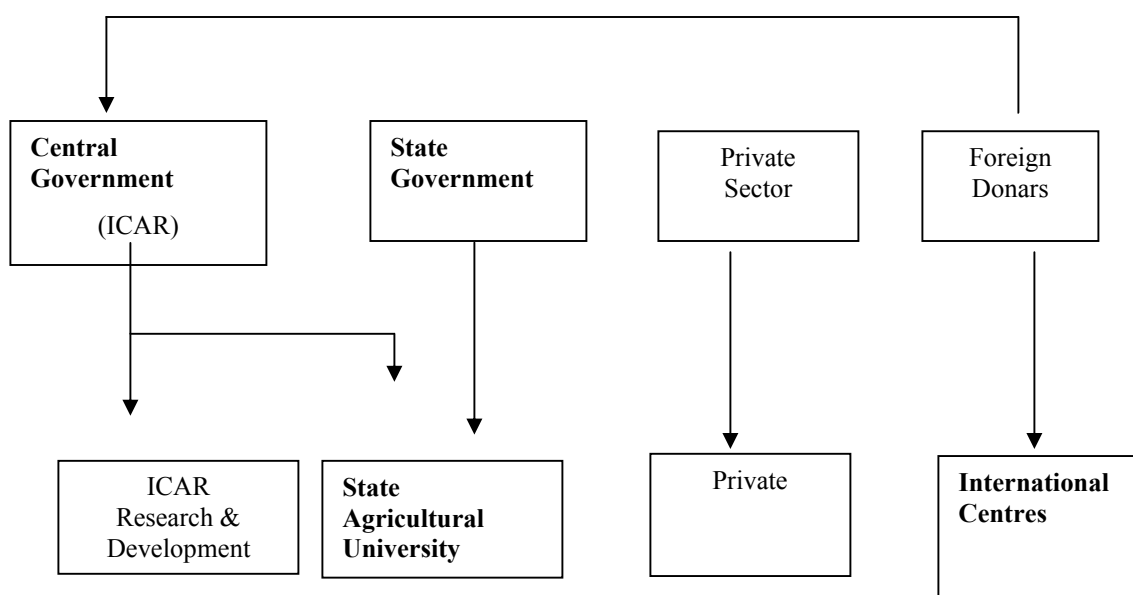


Table 6.1: Central Government Grant to ICAR (Rs. in million)

Investment	1997-98	1998-99	1999-00	2000-01	2001-02
Non-plan	3501.8	5447.67	4373.26	73355.08	7003.00
Plan	3306.70	4277.24	4550.03	5160.44	6834.00
Total	6808.50	9724.91	8923.29	12515.52	13837.00

Source: ICAR Annual Budget Books, 1997-98, 1998-99, 1999-0, 2000-01, 2001-02.

In the year 2000, ICAR was given a grant of around Rs.13 billion by the central government. ICAR also acquires loans from World Bank and international institutions. Recently for the period 1998-2003, ICAR got a loan under NATP for US\$180 million from World Bank for

research and development. ICAR too generates itself by its own revenue. The same amount it earns is used to finance competitive grants to individual scientists and organizations. But this earning of ICAR is only 3% of total budget in 2000.

Out of total public expenditure on research and development the central government provides 52%, which pass through ICAR⁷. A large proportion of ICAR funds (87%) is given to SAUs, and other part are made for external funding. In the year 2000 the state governments were provided Rs.12 billion for SAUs. The state of Maharashtra, which has 4 SAUs, claimed 14% of total ICAR grants, indicating the fact that states with higher research investment were also getting higher ICAR financial support. Similarly, the states of Andhra Pradesh, Haryana and Kerala too received higher ICAR expenditure. The funds allocated to the states are used only for the SAUs in that particular state but in the case of Uttar Pradesh, a small competitive fund is open to all research organizations located in U.P, which also includes ICAR institutes. The other source of funding is the private sector which provides around 10% for research in agriculture. But private funding for the public organizations is very negligible. Thus the establishment of Mahyco foundation for hybrid in 1995 established a research linkage with ICAR. Since the 6th plan, in the case of central government assistant, the total amount invested for ICAR, claimed nearly 3/4th of resources. With in research, focus has been on crop research, which accounted for 1/3rd of total research outlay. The share of crop research declined in eighties but was restored during 8th plan period. Since 1980, major expansion has taken place in non-commodity, resource related research, which now accounts for one third of total plan outlay for research. Educational research, which accounted for nearly 1/3rd of ICAR plan allocations in 70s, is now accounted for nearly 12%.

⁷ The other central government funding is through the Ministry of Science and Technology (DBT and DST).

6.4 Public Investment in R&D and Productivity

6.4.1 R&D and Agricultural Productivity

There is a need to increase productivity growth in agriculture in many developing countries. Even though the world's food production is increasing faster than the population growth (AO June-July 2002), many people are still undernourished in the under developed regions. The under developed countries do not have large financial resources to invest in maintenance of research, scientists and in strong agricultural research and development (R&D). Where as the developed western countries in the world gained a lot from R&D as it increases the agricultural productivity of a country. The new technology and investment in innovative practices have been the key factors in economic development of high-income countries. Investment in R&D in the case of developing countries is less when compared to developed countries. In order to attain food security, developing countries should increase their investment in R&D. Agricultural production in these countries must grow rapidly in comparison to the past decades so as to increase food production. This is possible only when the amount spent on research is increased in these countries. Investment in Asian countries is more than most of the countries in Africa yet the average level of expenditure in Asia is still below the world average.

Table 6.2 below shows that the productivity in India is much less when compared with the productivity level of other countries of the world. Also productivity per hectare for almost all crops is low when compared with some developing countries. The crop production shows that in all crops India's production was low compared to rest of the countries expect in case of Pulses. And also the crop productivity was very low in comparison with other countries. Even though Rice is the staple crop in India, the productivity of Rice is very low and ranks 51st among the rest of the countries. This shows the low productivity in India of all the crops.

Table 6.2: Place of India's Agricultural Production and Productivity

Crop	Production (in Million Tonnes)				Productivity (Kg/ha)			
	India	Rank	Highest		India	Rank	Highest	
Wheat	69.1	(3)	China	109.01	2493	(32)	Ireland	8997
Rice	82.2	(2)	China	190.10	2811	(51)	Ukraine	7444
Maize	8.66*	(9)	USA	236.60	1408	(105)	UAE	18636
Sorghum	10.50*	(2)	USA	20.39	897	(51)	France	6182
Potato	17.94*	(6)	China	46.05	16478	(51)	Ukraine	43966
Pulses	14.8	(1)	India	-	608	(118)	France	4769
Cotton	14.0	(3)	China	18.75	922	(57)	Israel	4527
Sugarcane	289.7	(2)	Brazil	324.44	65892	(34)	Peru	121361

Notes: Production figures for India are 1998-99 estimates taken from the Economic Survey. Rest of the World Production figures corresponds to the year 1996. Figures pertaining to productivity and area correspond to the year 1996. *1996 production figures used for these items. **Source:** www.cifti.com

Agricultural research is considered to be the main factor for increasing the agricultural productivity of a country. As mentioned earlier, agricultural research activity leads to innovation of new technology and new projects, along with establishment of new research institutes. The institutes carry out advanced research in agricultural sector which finally leads to increase in productivity. Besides, trying to merely increase the volume of agricultural productivity, is not the sole concern, there is also the need to increase the farmer's income by reducing the cost of production. Past evidence suggests that the Total Factor Productivity (TFC), in developing countries has shown a growth rate of 1% to 2 % per year. Research accounts for one third and one half of that growth. Some studies have revealed that there exists a high rate of return on investment in research in the agricultural sector in developing countries (Echeverria 1990 and Evenson and Rosegrant 1993).

Agricultural research has contributed immensely to the economic well being of both producers and consumers by raising the productivity. Investments in agricultural research have made possible the technological breakthroughs that led to greater food security around the world. Without these investments in agricultural research, the consequence would have been higher with the food costs causing greater food insecurity for those with low purchasing

power. Likewise, without sufficient future investments in research, the process of achieving food security, poverty alleviation and economic development will be seriously threatened. Agricultural research also has some positive effects on the environment. Most notable among them being the increased productivity, resulting in fewer marginal areas being cultivated. In India for instance with the technologies of the 1960s, farmers would need nearly 60 million hectares of additional land to produce the quantity of wheat consumed today.

Rates of return of investments on agricultural research have been impressive and are generally estimated in a range of 20% to 190 % in developing countries. A comparison across commodities indicates that rates of return in the case of maize research have been very high at 191 % in South America and 78% to 91% in Mexico. Rates of return in rice research in India and Indonesia are in the range of 60% to 65%. Rates of return of wheat research have been over 50 percent in developing countries. Even for non cultivated crops such as cowpeas, research investments have fetched good pay-offs, in the range of 60% to 80%. These high rates of returns indicate that the benefit from investment can easily justify the research costs⁸.

The table 6.3 below shows the investment pattern from 1975 to 1998 by both public and private sectors at all India level. Some studies have concluded that there is a high complementary relationship between the two types of investments (Hanumantha Rao 1994, Shetty 1990, Hanumantha Rao 1986) while some scholars have described it as an inducement effect of public investment on private investments⁹ (Rath 1989, Patnaik 1987). However the actual behavior of the two shows that after reaching the peak in 1980-81, public investment started moving downward whereas private investment continued to rise. One among the main reasons, for the fall in public sector investment, is the decline in investment in irrigation. Another explanation for this is the diversion of resources from capital account to current account to meet mounting inputs subsidies in agriculture. As agricultural subsidies increased tremendously after 1980-81 it put a massive strain on fiscal resources. Accordingly rise in subsidies is recognized as a major constraint for raising public sector investment in

⁸ (1996) "Role of Research in Global Food Security and Agricultural Development". FAO, World Food Summit, 13-17 November, Rome Italy.

⁹ Patnaik Prabath (1987), "Recent Growth Experience of the Indian Economy: Some Comments". Economic and political weekly, vol 2, No. 19-21, May.

agriculture¹⁰. The table 6.3 shows that both Total and Private Investment in agriculture is increasing whereas public sector investment is declining.

Table 6.3: Public and Private Investments in Agriculture at Current and 1980-81 Prices
(Rs.Crore)

Year	At current prices			At constant prices		
	Public	Private	Total	Public	Private	Total
1980-81	1892	2975	4867	1892	2972	4864
1981-82	2066	3381	5447	1878	2863	4741
1982-83	2275	3806	6081	1857	3008	4865
1983-84	2495	3623	6118	1843	2563	4406
1984-85	1679	5327	7006	1822	3066	4888
1985-86	2811	4771	7582	1631	3010	4641
1986-87	1901	5839	7740	1550	2810	4360
1987-88	3311	5877	9188	1580	3202	4782
1988-89	3445	6534	9979	1485	3252	4737
1989-90	3347	7661	11008	1301	3490	4791
1990-91	3628	9225	12853	1315	3761	5076
1991-92	3653	11123	14776	1135	4077	5212
1992-93	4175	13938	18113	1179	4694	5873
1993-94	4920	13788	18708	1272	4302	5574
1994-95	6022	18498	24520	1438	4806	6244
1995-96	6557	22778	29335	1250	5677	6927
1996-97	6323	25965	32288	1132	5867	6999
1997-98	5963	24969		1096	5789	6885

Source: Ramesh Chand (2000). "Emerging Trends and Regional Variation in Agricultural Investment and their Implications for Growth and Equity" Policy Paper 11. National Centre for Agricultural Economics and Policy Research.

The investment in agricultural Research and Development (R&D) can be channeled through two sources; one by the public sector and another by the private sector. Public sector investment initiates new techniques and establishes institutes. New institutions and research centers enhance the process of agricultural research activity, mainly through plant breeding. Private sector uses the techniques, to make genetically modified seeds. Major bio-

¹⁰ Humantha Rao (1994). "Agricultural Growth, Rural Poverty and Enviromental Degeration in India". Oxford University Press, Delhi.

technological research is carried out by private sector. These researches are mainly knowledge intensive and skill intensive. The research thus results in new varieties of seeds with low environmental pollution causing capacity and low cost. This study has not concentrated much on private sector research, but the main focus of the study is on the public or government investment in research.

As mentioned earlier, agricultural research in India was initiated under the colonial regime through the Imperial Council of Agricultural Research and was continued through the Indian Council of Agricultural Research. In the post-independence period the extent of ongoing research activity was not sufficient keeping in mind the requirements of the time. Hence, the need of the hour was an increased investment in agricultural research for an increased productivity. It has been specifically pointed out here that productivity in India has largely been increased through new technology obtained from four sources- Indian public research, international agricultural research centers, international technology transfers, and private research investments. (Evenson, Pray, Rosegrant 1999). The discussion of the relationship between investment on agricultural research and productivity is very important, because there is a long lag between the two. The agricultural food security challenges that India wants to achieve in the next decade essentially depend upon the investment that is made today.

Kumar and Rosegrant (1997) have underlined the importance of effective agricultural research in their work. Kumar, Rosegrant and Hazell (1995), had examined the prospects of Indian cereals supply, demand and trade using an econometrically estimated supply and demand model for India. On the supply side, production of each cereal crop is determined by input prices and total factor productivity growth, which in turn are driven by investment in research. Their study shows two trends: Continued decline in rate of growth of productivity due to continued slowing in the rate of growth of public investment, and Sustained growth in productivity at the prevailing level of the 1980s, through a recovery in public investment in agriculture. The investment intensity taken into consideration here helps in explaining about the real trend of expenditure on R&D. There are three ways to calculate the research intensity; it can be found out by taking Agricultural GDP, by taking R&D investment as a percentage of Gross Cropped Areas (GCA), and by the number of scientists. Here investment intensity

implies funding per hectare of land, which shows the amount of investment in particular states to one hectare of cultivable land. The table 6.4 below shows the relation between investment in R&D and Agricultural productivity.

Table 6.4: Growth Rate of Public Investment in R&D and Agricultural

Productivity: All India

Year	Trend Growth Rate (%)	
	Expenditure in R& D	Agricultural Productivity
1980-81to1989-90	5.91	2.85
1990-91to1999-00	4.82	2.34
1980-81to2000-01	5.30	2.80

Source: State Finances, Reserve Bank of India (Various issues 1980-2002).

6.5 Public and Private debate on investment in Agricultural R&D

Arrow (1962) points out that in an ideal world the reward for invention and research should be divorced from any charge from the users. This new knowledge is not only a public good but also has an additional feature of increasing returns to scale. Since the benefits of R&D are productively captured by the commercial world it should be publicly funded and freely available. If funded by the private agency, it is done for one's benefit or profit and doesn't benefit the society.

The objectives of the public and private sector investment are different. The public research has supported the development of basic scientific knowledge and applications that are beneficial to the general public and thus the public agricultural research system focuses on pre-technology science for agricultural and farm level technology. But in contrast, private R&D tends to focus on marketable application of agricultural chemicals and biotechnology, whereas Private sector firms are mainly profit motivated. The objective of India and most of the developing countries is to meet the demands of a huge population by attaining food security, which can be fulfilled only with the government intervention only, as the private sectors is more profit motivated.

In most of the developing countries public investment on agricultural R&D is more important since very little private investment is attracted. As such support to agricultural R&D is a traditional government objective in most of the developing countries. In agricultural research, the output is a new knowledge, or a knowledge that is embodied in new inventions. There are certain technologies in which knowledge is not embodied which can be a public good. Public good is something, which is non-rival and non-excludable and is characterized by the increasing returns in use. Generally, public good is characterized by suitable change or institutional practice.

Even after a period of rapid increase of private investment, private R&D is only 10-15% of total agricultural R&D in developing countries. This is only half when compared with the industrialized countries (Byerlee 1998)¹¹. The main reason is that the private sector depends upon the public sector investment as it uses the knowledge and methods developed in public sector. If the government withdraws from agricultural research, then the investment in agricultural research will be insufficient. The research activity is usually long-term, large-scale and risky. And the private firms in agriculture are not capable of effective research. Agricultural R&D is characterized as long term project which entails, that there exists a very long gap between research investments and its impact. An investment in R&D today will result in a better future. The benefit from today's research investment may assist the future generation of producers and consumers. The private sector, which is generally profit motivated thus doesn't wait for long term results. That leads to a under investment of private sector investment in R&D. another factor is that the investment on agriculture is huge. Hence it is not possible on the part of any single firm or an organization to take on such a responsibility. So institutions need to set up funds on a collective basis to carry out research. The above discussion shows the necessity and importance of public sector investment on R&D. Presently, one of the main concerns of many of the developing countries is to deal with the issues of the public and private investment on R&D. The policy makers have pointed out that the private sector will invest only in the development of embodied technology and areas like crop and resources management, research problems may not be addressed by the private

¹¹ Byerlee 1998

sector. Also in the absence of adequate measures for protecting proprietary material, private investment in research may not be substantial. Thus, strengthening agricultural research with adequate public investment is essential, mainly in a developing country like India.

6.6 Issues of Research and Development in Indian Seed Sector

Nearly 80 percent of agriculture research in India is publicly supported yet, research investment account for barely 0.5 percent of agricultural GDP¹². The public system has been struggling to match limited funds with burgeoning R&D needs. In this context, rational and viable objective allocations are crucial. This down turn is partly due to the relatively slow growth of real plan expenditure on agriculture since the early 1990s. The stagnation of the 1980s, which continued into early 1990s, was essentially due to decline in public sector gross capital formation. Private investment did not rise fast enough to compensate for the relative decline in state- sponsored investment. The nascent private sector accounted barely 10-15 percent in seed research. Not surprisingly effort to raise the funding have always held center stage. The R&D resources allocation seeks to examine the pattern of deployment of scientific resources in strategically on different thrust areas.

There is no single model that can be recommended for research and development in agriculture. The research effort must be on the basis of present resources and applications. It has clearly resulted in the farmers' demand and socio-economic development of farmers. The goal should be clearly focused on the problem solving, orientations basically given on the small and marginal farmers' demand.

There are certain areas where public sector agencies can exclusively play role in agricultural education, research and extension. These belong to areas of national resources conservation and efficient use of available land resources with upgradation in technology. Similarly, the area where the interests of small arid poor farmer are involved the public agencies have to play a very important role. There is considerable scope for improvement in the public sector R&D system, which has been built in this country. The in-house seed resources and others

¹² DATA Book 2003. Indian Council of Agricultural Research, Directorate of Information and Publication of Agricultur, Krishi Bhawan, New Delhi.

accounting system can be very useful for improving the efficiency of public sector R&D. Where there is a need for inflow of knowledge from abroad, it is better to have collaborations with international institutions in public domain.

In recent period the private research in India has grown rapidly since 1985. Between 1985 and 1995, private research expenditure increased significantly. Some multinational corporations (MNCs) are establishing research laboratories on some specific crop products. This is faster than public agriculture R&D, which grew at 69 percent vide in Table – 6.5. This shows the growth in food and agricultural research by private firms and government owned corporations registered by science & technology. The data showed that seed research expenditure doubled in the period 1985 to 1995.

Table 6.5: Research expenditures by private firms and state-owned enterprises (SOE), India, 1984-95

Industry	Research expenditures (1995 US dollars)		SOE in 1994-95 (%)	Increase (%)
	1984-85 Millions US\$	1994-95 Millions US\$		
Seeds	1.33	4.93	0	271
Agricultural machinery	32.70	6.48	13	75
Fertilizers	6.80	6.65	67	-2
Pesticides	9.00	17.02	15	89
Veterinary pharmaceuticals	.90	2.72	5	203
Sugar industry	.90	2.49	1	177
Food processing	1.27	10.33	1	712
Vegetable oil processing	.07	.14	0	99
Total	23.97	50.75	16	112
Public research	206.22	347.90		69

Sources: Department of Science and Technology.

R&D activities related to the seed industry are carried out in a variety of organizations in India. This relates both to private companies as well as public sector research institution. An

over view of nature and thrust areas of R&D of these organizations are discussed in this chapter.

6.6.1 Seed Research in Public Sector

The large part of seed research in India is predominately carried out by public research. Around 80 percent variety development is still in the hand of national agriculture research system¹³. After the initiation of concept that of All India Co-ordinated Crop Improvement Projects starting with maize in 1957, replication of same coordinated mission project in different crops showed significant result. More than 3073 varieties and hybrids have been released for commercial cultivars in different crops, out of which 450 varieties are on actual seed production chain. The whole seed programme revolves around the improved quality and quantity seed.

The production of Nucleus/Breeders seed development is the mandate of the Indian Council of Agricultural Research (ICAR) which is being undertaken with help of National Agriculture Research Centre (NARC), Project Directorates (of different crops like rice, wheat maize cotton and sugarcane, etc.), forty one State Agricultural Universities (SAUs) and Non-Governmental Organizations. Some international research organizations are also supporting and working in collaboration with ICAR. Institute like ICRISAT, ICGAR, CIMMYT, IRRI and IBPGR also helping in varieties improvement programme.

There are 54 breeders seed production stations for different crops including vegetable crops located in SAUs and ICAR institutes and 240 seed testing laboratories¹⁴ in different state whose seed testing capacity is about 7.24-lakh samples. But the number cannot be regarded as adequate to cater to the need of the country. The production of breeder seed has made impressive increase from 3914 quintal in 1981-82 to 738300 quintals in 2006-07¹⁵. In addition to this a good quality of breeders seed of various crops varieties are also produced by state run research station at state level. In general, production of breeder seed is higher than the indent

¹³ Various ICAR Reports.

¹⁴ Compiled from Lok Sabha unstarred question no 165 dated on 13.08.2007 (www.indiastat.com).

¹⁵ Economic Survey 2007-2008. p.167

every year. In recent past efforts are however needed because there are several mismatch seen in demand and supply of quality and quantity seeds of different crops.

For supply of certified seed, the Department of Agriculture and Co-operation established NSC in 1963. The fund is separately investing for strengthening of production chain through marketing of seed to farmers. Government again has large seed production system at centre and state level. Fourteen State Seed Corporations (SSCs) have the objectives of production of Breeder seed, Foundation seed, certified seed and labeled seeds of wide range of field crops and vegetables, preserving buffer stock and provide consultancy for seed testing and installation and operation of seed processing plants.

The real expenditures estimation of crop-wise investment is not easy task because the seed development research carried out is of heterogeneous nature. The expenditure by government is allocated under heads of Crop Science & Research Division, ICAR. The ICAR allocate funds to the concerned institute, which is independent to utilize according to their priorities. Due to this limitation no separate crop wise research allocation is presently available. Thus, some research development expenditure for technological capabilities development in the ninth plan was allocated to seed division the tune of Rs.93.44 crore.¹⁶ This fund was mainly utilized in different schemes like the National Seed Project, upgradation, strengthening of seed quality control, National Seed Bank and setting up of new seed testing laboratories and effective implementation of Plant Variety Protection Act and farmer rights.¹⁷ The investment was 26.96 and 22.38 crore invested in 2002-03 and 2003-04 respectively. The part of fund was also invested in technological capabilities generation and maintenance of National Seed Bank etc.

There is a still need to generate more human resources development in public seed research. Presently, there are 79 scientist and 200 technical personnel and 23 supporting position in various institute working under seed programme. In addition, separate unit for production of breeders seed of groundnut, sunflower and soybean have been established at 24 centers with

¹⁶ Parliamentary Standing Committee Report, Ministry of Agriculture.

¹⁷ ICAR report.

44 scientists 101 technical personnel and 23 supporting staffs engaged.¹⁸ The present technical manpower is not enough to face the challenge of shortage supply breeder seed.

6.6.2 Thrust and challenge of Seed Research and Developments.

In changing global situation the seed sector is at a crossroad. There is a steadily decline in public support for technological capabilities development. The most out-dated conventional breeding methods time-consuming technologies have failed to attain desired level due to various reasons. Also there is a lack of effective regulation mechanism for market control for a major challenge to industry. In above condition, the role of state has to be very pro-active. The poor germination percentage, seed purity and exploitation of Hybrid Vigor, infestation of disease and pest, poor Indian minimum seed standards and yield with quality are the major concerns to public research sector.

The seed health is priority area in seed programme that needs immediate attention to scientists and planners. The farmers of several states reported that some improved seeds produced by public and private sectors have not fulfilled the promised demands.¹⁹ In several states like Andhra Pradesh, Maharashtra, Karnataka, Gujarat and Madhya Pradesh farmers complained that crop failures are mainly due to infestation of disease/insect attack on improved seed.²⁰

Pulses like i.e. Gram, Mooth, Lentil, Arhar, Moong and Guar are mainly grown in dry land area where the annual rainfall is low. These crops are also the major contributing factors for socio-economic development of farmers.²¹ The study on pulses and oil seed revealed that the seed replacement rate in most of these crops in most of the states were far lower than prescribed government rate vide Table 6.6 the reasons for the gap between breeders seed, foundations seed and certified seed is the lower multiplication rate in different crop varieties, lack of early demand forecasting of the breeders seed by state. The poor infrastructure and coordination between research institutes and agencies are the serious concerns.

¹⁸ ICAR report.

¹⁹ Compiled from media reports & Judicial cases: Y. Hemantha Reddy Vs Varun Hybrid, The Business Manager, Rasi seed Pvt. Ltd. Secunderabad and others in the Court of Dist. Forom at Bellary. And six other similar legal cases.

²⁰ Various Media Report.

²¹ ARCE (2003).

Table 6.6: Distribution of Certified Quality seeds and Seed Replacement Rate (SRR) in lakh quintal.

Crop	100% Seed requirement for saturation	Distribution of Seed	Seed Replacement Achieved	SRR Suggested by Expert Group on Seed	SRR Projected for Xth Plan
		2000-01	During 2000-01		
Wheat	274.86	26.93	9.8	12	12
Paddy	135.49	24.77	18.28	20	15
Maize	12.84	3.12	24.3	33	25
Jowar	12.3	2.46	20	33	30
Bajra	3.56	1.93	54.21	33	40
Gram	46.1	1.09	2.36	15	5
Lentil	3.7	0.13	3.51	15	7
Urad	5.88	0.89	15.14	15	15
Moong	5.81	0.77	13.25	15	20
Arhar	6.85	0.58	8.47	15	10
Groundnut	103.01	5.42	5.26	15	10
Rape/Must	3.01	0.69	22.92	33	30
Till	0.78	0.1	12.82	20	15
Sunflower	1.29	0.42	32.56	33	33
Soybean	38,89	4.75	12.21	15	15
Cotton	12.77	2.64	20.67	33	33
Jute	0.85	0.26	30.58	50	30

Source: NCA, Reports, State of Indian Farmers, 2004

The Indian Minimum seed standard is also a major issue if seed for export from India was to improve to any substantial extent. The same standard for domestic market is required as quality consciousness is increasing day by day and even consumer forum have began to play on active role in the area. We need to develop demand base varieties having higher genetic purity taking experience from developed countries. This we can fulfill because India has a tremendous potential of any quantity with quality through diverse agro-climatic conditions.

The several pockets of the country also report the poor technical information network and hybrid seed production guidelines. The availability of spurious and fake seed is very serious

concern to seed sector as well as farmer. Because the large sections of farmer fail to distinguish between spurious seed and quality ones.²²

It is essential that we ensure availability of seed of superior quality in adequate quantity on timely basis as envisaged in our National Agricultural Policy 2004. The productions and multiplication of hybrid seed needs to be given a thrust of R&D incentives in seed sector to achieve desired level of seed production and distribution of any specific varieties.

In above condition without proper allocation of R&D and extension machinery support one cannot expect to achieve desired level. Government achieved some success through seed minikit programme, which became a way /means to dispose off unsold stock by some of the seed corporations as seed minikits. This had been due to the fact that under the programme, the distribution of all kind of varieties irrespective of their age/notification/years of release has been allowed. Although, there has been some modification in the programme of cereals minikit where in varieties released up to 5 to 7 year back are to be included. But in the programme of technology mission on oil seed and pulses, some older varieties, which have already become popular with the farmers and the effective implementation with full awareness about varieties and participation with private grower also help in success of programme.

6.6.3 Seed Research in Private Research

As it has been earlier discussed, large number of seed companies are engaged in seed production, distribution and marketing of seeds. Most of the medium sized companies generally multiply foundation and certified seed from breeders and foundations seed respectively obtained from the public sector organization, SAUs research stations and NSC. Their production activity is restricted to specified regions and so is their marketing network. Processing of seed is generally carried out on custom basis.

Out of them very few large (around 24 multinational and national companies) are involved in evolving new hybrid of pearl millet, soybean, cotton, maize, sunflower and vegetables. These

²² Rao,G.K.V.2001.

companies have full-fledged research division with highly qualified breeder scientists. They have its research facilities like laboratories and research farms and their own adequate processing facilities. They get the germplasm from project co-coordinators of All India Coordinated Crops Improvement Project (AICCIP), National Bureau of Plant Genetic Resources (NBPGR), International Centre for Agricultural Research in Semi-Arid and Tropics (ICRISAT), International Rice Research Institute (IRRI), Public and Private Institution in the USA, and other countries. These companies however experienced certain difficulties in acquiring germplasm both from within the country and abroad and felt that the procedures should be streamlined for the smooth delivery of the basic raw material some of those have full flagged research facilities are in advanced stage in the development of hybrids of pearl millets soybean, maize, sunflower and cotton. Lately, some are extend in-house research development with collaboration of Indian domestic seed companies.

The private seed sector make substantial in investment agricultural. A survey reported in 1985 that seventeen of the companies had plant breeding research programme with average seed sale above R&D programme. The companies were investing total Rs19.5 million or average 4 percent of seed sale on research. These companies have 31 PhDs 45 with M.Sc. degrees, Total experiment status area was 408 hectare with 24 firms an R&D field trial programme. The same survey conducted in period between 1988 and 1996 on the basis of questionnaires were sent out to approximately 160 seed companies that have link with ICRISAT and member of Seed Association of India. These included most of the major seed firms accounting 75 percent commercial seed sale and 38 percent seed sale in India using the similar methodology as in 1985. The 1996 survey cited responses from 23 firms that include all large private firms that were active in earlier survey out of which 13 firms participated in 1996 survey companies accounting for only less than 1 percent of total R&D in 1987.

Between 1988 and 1996 R&D expenditure grew from Rs, 19.5 to 155 million, which is increase of more than 800 percent. In real term gross capital formation at 1981-82 prices the increase is from Rs.13.1 million total 6.5 million, which is a growth of more than 250 percent. The survey also asked questions about other inputs of R&D efforts such as technical personnel and size of experiment station. The number of researchers increased 31 to 111 with

PhD and 45 to 140 M.Sc holder technical personal. The experimental station size also expanded from 400 over 1200 hectares. Vide in Table 6.7 Thus in every measure (Rupees investment, technical and size of experiment station) the R&D efforts seem to have tripled in a short span of about 8 years. This may be due to government incentives to private and diversification by the private companies. Others argued that this might be due to policy reform by liberalization because the two surveyed were conducted in before and after economic reform. A series of policy changes has relaxed these regulations since 1991. Several recent studies have looked at the impact of these policy changes and privatization of the industry.

Table 6.7: R&D programmes and expenditures

Measure of impact R&D	1985-86	1995-96
Selected companies	51	160
Responded companies	24	49
Number of PhDs	31	13
Number of M.Sc.s	45	140
Research station size chart	400	1200
R&D investments (Rs. million) crops	19.5	155

Sources: Pray et. al. 1991, 1997.

Study on maize seed industry concluded that existing government seed supply and contribution due to recent changes has improved the efficiency of industry. The multinational companies have new biotechnology tool and information for better marketing facilities to Indian seed industry. None of them are able to provide quantitative evidence of the impact of policy changes is responsible for private seed sector R&D as whole.

In vegetable, Indian vegetable hybrids are in a developmental stage. A study conducted for the South East and South Asia by Asian Vegetables Research and Development Centre, Taiwan (AVRDC) has highlighted that about 32 percent of the seed companies have established research and development (R&D) budget below 5 percent of their total budget, 55 percent are in range of 5 to 20 percent and only one company has a budget of above 20 percent, The allotted budget is mostly confined to developing new varieties and hybrids for

local and international market. Thirty three percent of companies have out reach programmes having sub station or branches in foreign countries.

According to study by ICAR and Agricultural University Research System about thirteen private seed companies are actively involved in vegetable R&D. Some of them have joint venture with multinational or domestic companies specializing in vegetable crop research and utilizing R&D facilities available with their overseas partners vide in Table-6.8. Few companies have created facilities for field testing and imported the germplasm from other public research organization primarily for developing F1 hybrid and few open pollinated varieties.

Table 6.8: Hybrid varieties and number of companies R&D available in market 1996-97

Crops	No of companies	No of hybrid varieties
Tomato	11	48
Brinjal	10	38
Chilli	8	27
Lady Finger	13	25
Cabbage	11	40
Cauliflower	8	21
Ridge guard	6	8
Water melon	5	13
Musk melon	2	7

Sources: Kuldip R. Chopra, Mahendra Hybrid Seeds Co. Ltd. old MIDC, Jalna India, 2004.

When we compare the data from the hybrid developed by public and private sectors it shows the significant participation of private sector as compared to public sectors in between 1995 to 1997 vide in Table-6.8.

Table 6.8: Number of private and public bred in may on crop in major crop in market during 1995-1997

Crops	1995		1997		No. of private Hybrid grow on 2% for more area.
	Private	Public	Private	Public	
Pearl millet	50	4	60	6	14
Soybean	22	4	41	5	6
Maize	57	3	67	3	12
Sunflower	47	5	35	6	10
Cotton	73	15	150	15	19
Rice	4	4	8	4	-

Source: Kuldip R. Chopra, Mahendra Hybrid Seed cotton old MIDC, Jalna India 2002.

Many of hybrids, which are accepted by the farmers, are grown on 2% area or so. The private seed companies invest in research where increased seed sales or high margin or both are expected.

6.6.4 Major Constraints in the Private Seed Sector

We also opine that the private sector should be involved more in organized seed activity research multiplication and distribution. The major constraints in participation of private sector in seed research are (i) lack of clarity on issues of protection of IPRs regime (ii) restrictions on transfer of land to private agencies for research activity.²³

Seed Industry face the problem of weak R&D, infrastructure, and technical service needed by seed companies. Because the research is capital intensive activity and returns to research could be expected after a moratorium of at least six to seven years in conventional breeding process. On the other hand benefit from research are spread over a number of years and new seeds (varieties) evolved by an agency, do not venture to invest in basic seed research.

²³ Singh, G; Asokan, S.R. and Asopa, U.S. (1990).

Similarly, restrictions on transfer of land for research activity to private companies should be done away with. At the same time sale /resale of land by the seed agencies may be banned to avoid misuse of suggested relaxation.

The risk associated with production and multiplication of seed include crop failure due to natural calamities, loss in yield due to pest /disease, low input use and deviation from recommended practices, rejection of seed due to admixture, spurious seed in market, viability and high cost of production due to unforeseen expose.

On the basis of above arguments we can say that at times of crisis while public seed agencies get the government support for research, private seed agencies have to bear the costs of carry over stock in times of market failure.²⁴

6.7 Relevance and Need for Agro-Biotechnology in Seed Sector

It is an overwhelming fact that seed dominated the realm of green revolution. The widespread increase in food production could be achieved by increasing the use of high quality seeds of high yielding varieties. The intensive input use has become more complex because of urbanization and industrialization, which has put a limit on the availability of land and water resources, as in the decades to come for availability of land, will get reduced.²⁵ Thus, more food is to be produced from less land. This requires Plant Breeders who can rectify problem in crop only when there is variability for desirable traits within compatibles species complex. The transfer of useful traits from distinctly related species, which do not sexually cross with other crops plant, is not possible through ‘conventional recombination breeding procedures’. Considering that many problems still remain unsolved and even hybrid can increase yield up to only 20 percent more than normal varieties. Although, hybrid technology achieved higher agriculture output but, it also brought several problems that the currently, available technologies are inadequate to solve. According to Swaminathan, “In the 21st century, Gene Revolution will be the guiding force behind agriculture development as Green Revolution was in 20th century”.

²⁴ Cotton crop failure in Andhra Pradesh, 1998, Report of the Research Foundation for science, Technology and Ecology.

²⁵ G.S.Bhalla. 2002

Biotechnology is emerging as one of the most innovative achievement in life science, which is influencing almost every aspect of life, and seed sector being not exception. Biotechnology is inter-disciplinary in nature. It cuts across various disciplines such as molecular biology, biochemistry, microbiology and information sciences. In other words, biotechnology is an applied science utilizing biological organism, system or process in manufacturing and service. Recognizing the potential of genetic engineering and biotechnology and its relevance to India setting up of the separate Department of Biotechnology in 1986 has given a new impetus to development in the field of modern biology and biotechnology. Because of vast availability of genetic variability²⁶, trained manpower, strong knowledge base, good network of research laboratories and well-developed base of industries like seed and Pharmaceuticals industry²⁷ the importance in the field of biotechnology in the field of great importance.

All the above opportunities of Biotechnology can prove to be a potential tool in development of seed sector that guides the future thrust of biotechnology in the field of agriculture production. Hence, we wish to present in this chapter a salient feature of investment support in biotechnology, opportunities of Agro-Biotechnology in the seed sector and various issues pertaining to transgenic research and regulation in India.

6.7.1 Investment in Biotechnology

Investment in India began with early initiatives of the government and setting up of a separate Department of Biotechnology for promoting R&D, human resource development. Since the establishment of biotechnology facilities, product and process development during financial year 1985-86 to March 2002 an investment of Rs.12.95 billion has been made. Fifty percent of this investment has been made in the last five years and the same is increasing approximately by 30 percent. In early years most of this investment was on infra structure facilities. Since 1997-98 the annual allocation for R&D is almost more then 60 percent, Agriculture and Medical research received maximum fund.²⁸

²⁶ Compendium of Environment Statistics, India 2002.

²⁷ www.dstindia.org & www.icarindia.org

²⁸ Rao, 2002

Beside the Department of Biotechnology (DBT), other government S&T Organizations such as the Indian Council for Agricultural Research (ICAR), Council for Scientific and Industrial Research (CSIR), University Grant Commission (UGC), Department of Science & Technology (DST) and other autonomous institution also support R&D programme in biotechnology. Since, in all of these organizations there is no clear-cut separate evidence for investment available to biotechnology. However, normally the contribution or sharing of cost in most of these projects is about 30 percent, and therefore, it can be presumed that the contribution by all would be around Rs.404 million since 1987-88 to Rs.1138 million in 1997-98 to Rs.2356 million in 2002-03 Biotech Consortiums India limited (BCIL). The centre is also planning to introduce additional venture capital funds in lines with its Technology Development Fund (TDF) to promote small and medium biotech enterprises,

Several states have taken their own initiatives in term of defining their own biotechnological policies to give an impetus to the industry in this sector and to biotechnology in India as a whole. Some states like Andhra Pradesh, Karnataka, Maharashtra, Kerala, Tamil Nadu and Himachal Pradesh are developing biotech parks, Several concessions are being offered to the industry in term of single window clearance, speedy customs clearance, and exemption from tax creation of funds to be used for incubations of new projects.²⁹

Private sector investment has also showed positive trend since 1995. There are no authentic statistics available in the private sector investment. The private sector do not want to disclose R&D expenditure for some unknown reason. But the expected investment in the next five years is, vide Table 6.9. The expected investment showed that the maximum contribution of Rs 1500 million was on seeds sector (GM crops). These trends are the positive indications of the huge market for the seed sector.

²⁹ www.techno-preneur.net & www.dbtindia.org

Table 6.9: Investment on biotechnology in next five years

Specific area of investment	Est. investment Next 5 year (\$ Million)
Vaccine	300-400
Seeds (Hybrids)	1500
Biopesticides	800
Biofertilizers	200
Amino acid production	700
Production of specialty biochemical	1000

Sources: biotech market research reports, 2004.

6.7.2 Agro-biotechnology opportunities in the Indian seed sector

India is the second largest food producer after China and thus, offers a huge market for agro biotechnology products. The global commercial seed markets of agricultural and horticulture seed have a value of \$30 billion worldwide. It is estimated that the market could triple to around \$91 billion, if the Asian region opens up their markets for European and United States seed companies. India's market is around 3 percent of the global seed market. Industry segments of agro-biotech contribute 60 percent of the total biotechnology growth, vide Table 6.10, dramatic increase in the annual expenditure on research by the private sector on biotechnology research is yet another indicator of increasing involvement of different stakeholders which indicates opportunities of transgenic seed. In changing global agriculture situation, rapidly decreasing land resources and low opportunities for improvement in existing crop varieties quickly shift towards transgenic, this will have major impact on the seed business.

Table 6.10: percentage Market Share of Agro Biotechnology in India

Sector	% Contribution
Agro-biotech	60%
Diagnostic & therapeutics	25%
Vaccines	15%

Source: biotech market research reports, 2004.

The growing population and increasing food demand also showed changing pattern of consumption. The actual market consumption in biotech products in 1999 was \$ 8.6 billion. It could result in a turnover of \$ 9-10 billion in the next 5 years out of which agricultural product (including seeds) contributes 29.8 percent. It will move to 30.7 percent by 2005, vide Table-6.11. This is expected due to value addition in existing products, change in traditional foods, and diversification in food basket, rapid economic development, and better markets opportunities for export, which have increased the demand of Genetically Modified Food³⁰.

Table 6.11: Consumption trend in biotechnology in year future

Biotech	Actual Consumption 1999	Future Consumption Estimate 2005	Future Consumption Estimate 2010
Human & Animal Healthcare Products	32240 (37.5)	35320 (37.6)	93540 (40.0)
Agricultural Products (incl. Seeds)	25670 (29.8)	28880 (30.7)	78720(33,7)
Industrial Products	27090(31.5)	28500 (30.3)	53590(22.9)
Other Biotech Products	1040(1.2)	1300(01.4)	7940 (3.4)
Total in Rs. Million	86040(100)	94000(100)	233790 (100)

Sources: Biotech market research (figure in brackets indicates contribution in % of the total)

6.7.3 Transgenic Research in India

Despite significant advances in crop improvement, it is predicted and felt by many researchers that crop yield increases through conventional methods and will not continue progressively at the same rate of the demands. Driven by the need to achieve higher and more stable yield, several advanced techniques have been developed by the researchers to aid identification and transfer traits. These include the molecular markers³¹, DNA finger printing³² and tissue

³⁰ Alam. G. 2001

³¹ Molecular markers gene that are responsible to identification of the desired gene in desirable species

culture³³ technologies. These technologies have the capacity to allow access to gene pools that were previously too distant to be tapped through the conventional breeding or sexual hybridization.

The techniques of genetic modification, which essentially include molecular biology and Genetic engineering, provide vast opportunities to facilitate creation of new genetic variability and can effectively complement to the conventional breeding strategies³⁴. The balanced approach of conventional and molecular biology is undoubtedly a way to look forward in our effort to enhance quality and quantity of crop production. The crop plants improvement through genetic make up and exploitation of intellectual asset through genetic transformation or genetic engineering can increase farmer's income and reduce uncertainties and risks associated with production³⁵, provided, that the price of seeds is kept low. This will particularly benefit the poor and the marginal farmers.

Genetic engineering is one of the component of biotechnology which allows gene that carry instructions for particular feature to be isolated and move from one organism to another, resulting in a Genetically Modified Organism (GMO) or Transgenic(s). Transgenic is defined as "those organism with a gene or genetic construct of interest that has been introduced by molecular or recombinants-DNA technique". These exclude organisms produced by conventional breeding as well as organisms produced by chemical means. The GMOs, thus, carry transgene(s), which when integrated and expressed stably and properly confer either a new trait to the organisms or modified it which was hitherto not present (for instance, insect resistance) an enhance on already existing traits (for instance nutritional yield).

Several public institutes under the Indian Council for Agricultural Research (ICAR), Council for Scientific and Industrial Research (CSIR) besides reputed research organizations and universities actively are involved in research on transgenic vide in table 6.12 covering wide

³² DNA finger printing process by which unknown sequence of DNA can be known, through Known DNA hybridation sequences

³³ Cultivation of plant cells and tissues in vitro on artificial media or in aseptic conditions

³⁴ Clive James. 1999

³⁵ Barnes and Bread. 1992

range of crops like tobacco, rice, mustard, cotton, potato, brinjal, tomato, cabbage, cauliflower etc, most of them are under field trials and results are expected in the 2005-06.

In the private sector, Pro-Agro- PCS India Ltd. was the first company to obtain the permit from Department of Biotechnology in September 1994 to conduct controlled field trials with mustard (*Brassica Juncea*) containing *Barstar* (male sterility gene) and *Barnase* (Fertility restorer gene) gene of plant Genetic system, *Gent*, Belgium. The main aim was to increasingly productivity of the crops, the yield to which had been rather stagnant for several years. Subsequently, permits have also been obtained to conduct trials with cauliflower and cabbage since several other companies have also showed interests e.g. MAHYCO, Jalna (Bt. cotton); SPICE, Chennai (male sterility) paddy; Ankur Seed (GM cotton seed and vegetables); Rasi Seed, Tamil Nadu (Bt. Cotton) and Nicholas Piramal Mumbai, (cotton and all crops) have also obtained permits for experimentation. Some of these multinationals and domestic companies collaborated with Joint venture research with the public research institutions and at present the characters predominantly targeted by institutions carrying out genetic engineering experiment in the both public and private sector in India is insect-pest resistance, mainly using *Bt. base strategy*. Several crops including potato, cabbage, cotton and rice are being targeted for this purpose besides, effort are also being made, mainly in the private sector vide in Table-6.13, to generate transgenic in commercially important crops such as chilli, black pepper, and tomato, with resistance against *lepidopteron & coleopteran*.

The first transgenic, *Bt Cotton*³⁶ was approved in April 2002 for the period of three years by the Genetically Engineering Approval Committee (GEAC), based upon the recommendations of the Monitoring Evaluation committee (MEC), ICAR and Biosafety. After that, Rasi Seeds hybrid (*Bt. cotton*) was also approved by the committee.

³⁶ Three transgenic namely MECH 12 Bt, MECH 162 Bt and MECH 184 *Bt cotton* containing insect resistance gene (cry I Ab gene) from a soil bacteria (*Bacillus thuringiensis*).

Table 6.12: The institutes/organizations engaged in transgenic research

Institute	Crop	Transgenic	Aim Inserted	Current status
DRR, Hyderabad	Rice	Chitinase gent	Resistance to sheath blight disease	Ready for greenhouse trials
Bose institute, Calcutta	Rice	Bt. toxin gene	Resistance to Yellow Stem Borer	Greenhouse trials in progress
Delhi University, South Campus, Delhi	Mustard/ rapeseed	<i>Barnase</i> and <i>Barstar</i>	Pollination control for hybrid development	Ready for field trials.
Jawaharlal Nehru University. New Delhi	Potato	Ama- 1 gene from Amaranthus	To improve nutritional quality	Transgenic lines under evaluation under containment conditions
Central Institute of Cotton Research, Nagpur	Cotton	Bt. toxin gene	Resistance to <i>lepidopteran</i> insect pest	Greenhouse trials in progress
M/s Proagro PGS India Ltd. New Delhi	Mustard/ Rapeseed	<i>Barnase</i> and <i>Barstar</i>	Pollination control for hybrid development	Contained field trials in more than 15 locations over; open - field research trials in progress
M/s Proagro PGS India Ltd. New Delhi	Tomato	Bt. toxin gene	Resistance to lepidopteron insect pests	One season contained field trial over; further trials in progress
M/s Proagro PGS India Ltd. New Delhi	Brinjal	Bt. toxin gene	Resistance to lepidopteron insect pests	Glasshouse experiments in progress
M/s Proagro PGS India Ltd. New Delhi	Cauliflower	<i>Barnase</i> and <i>Barstar</i>	Pollination control for hybrid development	Glasshouse experiments in progress
M/s Proagro PGS India Ltd. New Delhi.	Cauliflower	Bt. toxin gene	Resistance to insect pests	Glasshouse experiments in progress
M/s Proagro PGS India Ltd. New Delhi	Cabbage	Bt. toxin gene	Resistance to insect pests	Glasshouse experiments in progress
M/s Mahyco, Mumbai	Cotton	Bt. toxin gene	Resistance to lepidopteron insect pests	Field trials In over 40 locations completed
Central Tobacco Research Institute	Tobacco	Bt. toxin genes	Resistance to Tobacco Caterpillar (<i>Spodoptera litura</i>)	One season of contained field trial completed; further evaluation under progress
Central Potato Research Institute, Shimla	Potato	Bt. toxin gene	Resistance to Potato Tuber Moth (<i>Phthorimaea opurculella</i>)	Ready to undertake glasshouse trials

Indian Agricultural Research Institute (IARI, New Delhi)	Brinjal	Bt. toxin gene	Resistance to Shoot and Fruit Borer (<i>Leucinodes arbonalis</i>)	Two seasons of field trials over; further evaluation in progress
IARI, New Delhi	Rice	Bt. toxin gene	Resistance to yellow Stem Borer (<i>Scirpophaga incertulas</i>)	Ready for greenhouse trials
IARI, New Delhi	Tomato	Bt toxin gene	Resistance to Fruit Borer (<i>Helicoverpa armigera</i>)	One season field trial over; further evaluation In progress
IARI, New Delhi	Cabbage	Bt. toxin gene	Resistance to Diamond Back Motli (<i>Plutella xylostella</i>)	Ready for green house trial
IARI, New Delhi	Tomato	ACC synthase gene	Delayed fruit ripening,	Ready for greenhouse trials
IARI, New Delhi	<i>Brassica Junea</i>	Annexin gene <i>Arabitdopsis</i>	Tolerance to moisture stress	Field trial in progress
IARI, New Delhi	Potato	<i>Osmotin</i>	Tolerance to moisture stress	Ready for greenhouse trials
Directorate of Rice Research (DRR), Hyderabad	Rice	Bt. toxin gene	Resistance to yellow Stem Borer	Ready for greenhouse trials

Source: Data mainly based on information presented by Sharma, Manju; Canak, K.S. and Ramanaiah, 2003. Agricultural Biotechnology Research in India: Status and Policies, current Science, Vol., 84, No., 3 Feb

Table 6.13: Alliances of major companies with different institutions and industries in Agriculture seed research

Major Indian Companies	Collaborating institutions/ industries	Nature of collaboration
National Dairy Development Board Around (NDDB)	Delhi Univ. Delhi	Transgenic plant development, including mustard
Cadila Pharma, Ahmedabad	IARI; DU, Delhi; IISc, Bangalore; IMT, Chandigarh; The energy Research Institute; International Centre for Genetic, Engineering and Biotechnology, Trieste Italy.	Biotech process development, Technology transfer and diagnostic Kit's development for viral disease.
Nath Seeds, Aurangabad	Biocentury Transgenic Company, China	Genetically modified cotton seeds and Technology Transfer
Maharashtra Hybrid Seeds (Mahyco) Mumbai	Monsanto, US	Equity participation and technology transfer for genetically modified seeds.
Ankur Seeds, Aurangabad	Mahyco-Monsanto India	Technology Licensing for genetically modified seeds
Rasi Seeds, Tamil Nadu	Mahyco-Monsanto, India	Technology Licensing for genetically modified seeds.
M/s Pro-Agro PGS India Ltd.	Aventis	All crops
HLL	Uniliver	All crops

Sources: Data mainly based on information presented by Sharma. Manju, Canak, K.S. and Ramanaiah, 2003. Agricultural Biotechnology Research in India: Status and Policies, current Science, Vol., 84, No., 3 Feb

Currently, India comes under top ten Bt. cotton growing countries having area of 0.4 million hectare (ISAAA 2004). A survey conducted by ISAAA³⁷ expected that India would be a global market with use of GM cotton³⁸ in coming decade. These developmental efforts in transgenic can reduce some financial losses in input management. But the developments are mainly concerned on commercial crops and crops, which are grown in irrigated area. Whereas the need is to be enhance the quality improvement in crops. However, so far due weightage is not provided to enhancement of nutritive qualities of the crops.

So the promise of transgenic research technology has largely a grey area. It can be concluded that both the public and private research organizations emphasized mainly on either on production of pest/insect resistance or abiotic stress, vide in table 6.12 and 6.13. The Low emphasis on improvement in yield and other nutritional improvement like enhanced protein and mineral was accorded proper attention. However, Institutes like University of Hyderabad, Jawaharlal Nehru University and Indian agriculture research institute are involving in development of protein rich potato and delay fruit ripening in tomato respectively this is also important to industry as well as farmers vide in tables 6.12.

However, some report from different states Andhra Pradesh, Gujarat etc on the harvest 2002 provided mixed pictures of success, and failure³⁹ respectively. Some of Non-Governmental Organizations (NGOs), farmers' organization accepted and refused to grow these crops⁴⁰. The basis of refusal of these crops is attributed to the risk associated with the *Bt. gene* and the resistance developed by gene may be turn to develop tolerance against the insect. In case of edible food crops the transgenic technology raised the question of health and environment safety (for instance Genetically modified corn crop containing *Bt-10* gene released in environment can pose threat on human or environment safety. Although Indian Biotechnology

³⁷ International service for the Aquisition of Agri-Biotechnology application

³⁸ Cotton (Bt) area has increased 400% in India, (out of 81 million hectare are approved under Bt cotton), <http://www.cgiar.org>.

³⁹ Because it does not deliver a promise high expectation and low cleverness and fanner believes that crop is not completely free from insect and difficult to justify the cost benefit analysis details in, Status of Bt. Cotton & Future of Biotechnology in India. Moyee, C.D, 2004.

⁴⁰ Thus, the issue raised on the risk of insect resistance are relevant particularly, produce (cry I Ac) gene that produce toxin in Bt cotton. Non-Bt varieties of some of other crops may thwart resistance by acting as refuge for cotton boll worm, See more detail, Stone, G.P Human Organization 63, pp 127-140.

Policy, 2004 restrict to transgenic research should not be undertaken in crops/commodities where international trade may be affected e.g., Basmati rice, Soybean or Darjeeling Tea.

The bottom line of development policy is the economic well being of the poor families, and the food security of nation, as most of populations do not get adequate food diet.⁴¹ So, our coordination of transgenic research should be based on a holistic basis. It should include not only economic aspect but also other health related aspects.

The fact is that our research system should be sensitive to the bio-diversity, conservations and socio-economic context of our composite agrarian system and resources should not be taken in crops/commodities and our national bio-diversity may not be affected. So in their pursuit of profits, transnational corporations are eager to push untested technologies and models regardless of the human, environmental and social damages they may cause. India is rapidly moving toward a cash crop economy, at the expense of self-sufficiency. Large multinational like Monsanto are also pushing the Gene Revolution (biotechnology), as the successor to the green revolution, inspite of largely unanswered questions about the impacts of such technology. There are grand yet, unproved claims that biotechnology is the answer or feeding the hungry in the world. Not only the unanswered questions are problematic, biotechnology in agriculture itself is designed so that corporations gain full control over the agricultural system from the local farmers.

Proper health and bio-safety assessment of transgenic before transfer in farmer's field must be ensured. This is mandatory under the guideline for institutes / companies engaged in transgenic research.

6.7.4 R&D priority for transgenic in the Seed Sector

As earlier mentioned, larger number of big and medium size seed companies are intensively pursuing full-fledged in-house agro-biotech research. This becomes more and more a commercial reality. Its impact on consumers as well as farmers is well recognized. There is a

⁴¹ About 24 percent all new born have impaired growth due to poor nutrition during birth out of total 33 percent of all under age of five on stunted due to iron deficiencies and other nutrient disorder disease

need to prioritize and restructure our research programme relating to transgenic research in crops, in order to maximize benefits from limited resources in areas of relevance to food, livelihood & ecological security, as emphasized in National Biotechnology Policy 2000⁴².

It will be better to prioritize in R&D activities on demand basis. The R&D work should include programmes on development of high yielding varieties, stress tolerant and high yielding variety improvement on nutritional standard of food crops through modern genetic engineering techniques.

Due to high cost of technology required for substantial investment and time to get a product commercialized it will become difficult for even large companies to pursue biotechnology research alone because of large investment needed and inevitability of using already protected gene and protocols in developing transgenic. These limitations necessitate collaborations research joint ventures at national/international level. The government of India supports Top down research project⁴³ in which the central agencies decide the research programme from top to affiliated institutes those, who are working on the same project but difference is objectives and regions. Here, it is need that no replication follows in other research centers.

Public research institutions and universities are encouraged to forge partnership with one or more companies in the private sector. The scopes of such collaborative research between advanced public institutions and prospective private companies are unlimited This kind of collaborative research creates intellectual property for the institutions involved and provides leverage to get access to technologies from other technology holders. Such types of partnership bring together public institutions and the private seed industry. In interest of all stakeholders, the evolutions of a viable system for joint ventures should be given priority.

⁴² National Biotechnological Policy 2004. Task force an Applications of Biotechnological in Agriculture by Dr M.S Swaminathan, 2004

⁴³ Example from National project iransgenic directed by the DBT/ICAR for implementation involving several agriculture universities and research station in developing virus resistance rice so the strategy should be b«scd on the other institute must involving in improvement in other related problem, The project lias also paved the way for other Improvement of rice. Through we cannot only save the money but also lime need for improvement of other useful traits. The linkage between them makes it speedy.

As biotechnology is becoming more and more commercial reality its impact on consumer as well as producer is well recognized. The GMOs is relatively new to the Indian farmers (awareness about the subject matter of technology). Therefore, it is important for government to generate / educate the farmers and consumers awareness regarding the potential benefit and possible limitation of transgenic technology in general to avoid prejudices and presumption. It is essential to stimulate healthy debate on possible risks, rather than making sweeping generalization about safety or non-safety of GMOs without verification.

6.8 Regulation and Risk with transgenic

Technological advancement in transgenic also have several challenges⁴⁴, where these technologies require to be careful about the likely impacts of GMOs. Concern over development of the ‘Terminator Technology’⁴⁵ which has been patented by US has also granted approval to the MNCs ‘Delta and Pine Company’ to commercialize the Terminator Technology. This affects the farmer’s ability to save and use the same crop seeds in future and also has some impact on natural biodiversity⁴⁶.

Therefore, the country has to be very vigilant in the context of the applications and regulations. The promotion of transgenic crop is suggested to have the following major risks:

- a. Escape of engineered gene-by-gene flow or gene dispersal.
- b. Non-target effect or ecological effects
- c. Invasiveness or weediness of transgenic
- d. Creation of super weeds and super virus
- e. Toxicity and allergenicity to human being and animals,
- f. Expansion of undesirable phenotypes traits
- g. Erosion of biological diversity.

The scientists refuted some of them on based on science-based explanations. Miller 1994 and 95 argued that transgenic organism pose no greater risk. Organisms generated by the

⁴⁴ James C. Delouche, 1999

⁴⁵ The basic premise is a desire to inhibit germination of seeds in the second generation so that seeds can be sold to farmer which will germinate to produce, but the seeds obtained by farmer from that crop will not be viable as embryo become dead.

⁴⁶ Jefferson et al., 1999

recombination DNA technique are likely to be at least, as safe as those generated by traditional methods, because despite the greater range of gene that can be transferred, genetic changes introduced by molecular biotechnology are generally better than conventional methods⁴⁷. Based on considerable amount of field-testing data on transgenic plant demonstrated that no risk are involved in releasing transgenic⁴⁸. But worldwide pressures from different NGOs raise the questions on the regulatory mechanisms.

India has three tiers regulatory systems⁴⁹ for field-testing of transgenic plant. It also needs to restructures the existing systems. Still the regulator)' mechanisms are active only on preventive and permissive level whereas, the promotional levels need to be straightforward.

An effective control and monitoring system can genuinely promote institutions, which are involved in incorporation of such gene in varieties being propagated for mass cultivation. Effective steps will have to be taken to prevent the entry of genetic material unfit for human. Illegal activities like fake spurious seed of transgenic, replication of technology through reverse engineering, has to be checked.

It is imperative that the government machinery with greater assertiveness checks such unlawful activities perpetrated by vested interest so as to ensure adequate testing and evaluation of genetically modified crops being established. There is need to address the problems, objectives and priorities on case by case for ensuring rapid growth the of seed sector.

It must be pointed out that compared to these sources devoted by large multinational agro biotech firm, India's effort is very minimal in many cases the scale of research activities are

⁴⁷ Miller and Crowley. 1994.

⁴⁸ Prins and Zadok, 1994.

⁴⁹ IBSC set up a! each institution for monitoring institute level in GMOs

-Review committee on genetically manipulation (RCGM) set up al DBT to monitor on going research activities in GMOs. A monitoring and Evolution committee MEC, comprising agricultural scientist, was constituted in July 1998 by RCGM to monitor and supervise field trials permitted by the GOVT. Genetic Engineering approval committee (GEAC) in the ministry of environment and forest has been set up to author rise large scale trials and Environment release of Genetically modified organisms. (Revised guidelines for research are in transgenic plants find guidelines for toxicity and allergccily evaluation of transgenic seeds .plants and plant parts, department of biotechnology, New Delhi 1999. Ghosh. P.K.and Ramanaiah. 2000.

sub optimal, considering the general gap of resources in India. It is also important that our research should be focused on a limited number of problems. Priority must be based on our farmers' socio-economic development point.

Finally it must be pointed out that biotechnology research in India has been focused only mainly on the problem of crops that are grown in irrigated areas. The research activities neglected qualitative traits (like enhancement of minerals, protein nutrients) and pulses oil seed and small millet have received very little attention, These crops affect the large segment of our farmers it is important that biotechnology contribute to the reduction of regional imbalances and benefit a large number of farmers.

The high costs of technology, IPRs and risk association with technology raises several issues like monopolization of the seed market, environment safety etc., there are major concerns to scientists, policy makers and farmer organizations. The Government needs an effective policy guideline that makes balance among parties concerned.

6.9 Technological dimension of Bt. Technology based on Primary Survey

6.9.1 Entry Barriers: Pre-Bt

It is commonly agreed that conventional plant breeding does not require much capital investment. Breeders, a collection of germplasm, and land for an experiment station are the principal inputs. The private sector has often hired breeders from public sector research institutions and agricultural universities. Germplasm was not mentioned as a constraint by any of the seed companies that had been interviewed. The size of experiment stations varies between 25 hectares for a modest breeding program to over 100 hectares for an experiment station spread over multiple sites. Marker assisted breeding is beginning to be important but as the cost of this technology is not prohibitive, it is unlikely to be a dominant source of technological advantage for larger companies.

Seed production is organized through contract growers and this needs to begin one year before sales commence. Growers receive an advance (about a sixth of the price of seed) and

they are fully paid by April-May. Risk is an issue because seed production is based on one-year ahead forecasts of demand (for the firm's proprietary hybrid). Cautious companies could therefore miss opportunities to become market leaders. The proprietary seed market has seen entry by a number of companies in the last decade.

6.9.2 Entry Barriers: Post-Bt.

In India, the first approvals to Bt. cotton were given to three hybrids released by Mahyco Monsanto Biotech (MMB), the joint venture between Mahyco and Monsanto. These hybrids contained the Bt. gene *cry 1 Ac* owned by the U.S. firm Monsanto. Subsequently, MMB has sub-licensed the gene to 20 other companies in India (as of April, 2005) to incorporate it into their cotton hybrids.

To the sub-licensee of the *cry 1 Ac* gene, MMB provides the gene incorporated in an American variety called Coker 312. Through routine backcrossing with the parental lines of its hybrids, the sub-licensee firm incorporates the gene into its germplasm. Hybrid seed is then produced in the usual manner. The principal investments (besides the license fee) by the sub-licensee consist of equipment that isolates DNA (through grinding and centrifugal force), tests for the presence of the Bt. protein (Elisa test), tests for tracking plant transformation (homozygosity tests using PCR) and greenhouse for contained field trials. According to several respondents, such equipment together with related essentials (such as refrigeration) and infrastructure (temperature controlled buildings with back up power) cost about Rs.5 million. Many seed firms go beyond these essentials and also invest in plant pathology labs, machines for DNA sequencing and characterization and multiple Elisa machines to be used for testing Bt. presence in seeds produced by their growers. For this reason, many seed companies reported budgeting around Rs.10 million for the biotech lab. MMB charges a licensing fee of Rs.5 million.

While Rs.15 million was a quantum jump in R&D expenses for most seed companies, the economics of such investment can be considered for a small company selling 100,000 packets annually. For a packet of seed (450 grams), MMB had fixed a trait value of Rs.1200 of which Rs.700 was paid to MMB (this is in addition to the lump sum licensing fee of Rs.5 million) and

Rs.200 to the seed dealer. If the company expects to sell the seed at Rs.1600 (the lowest price for seed among the official Bt. providers), its share of the selling price would be Rs.700 and its expected revenues would be Rs70 million. As non-Bt. hybrids sell for around Rs.400 per packet, the incremental revenues due to Bt. is of the order of Rs.30 million annually. Thus, even for a small company, the additional R&D cost due to Bt. related investments could be recouped quite rapidly provided the assumptions about expected sales and price hold.

The Bt. related investments are therefore unlikely to be a barrier to entry into the Bt. market by the companies in the branded segment. This is also borne out by the large number of seed companies that have licensed the Bt. gene from MMB.

6.9.3 Competition in the Post-Bt Scenario

Despite the conclusion in the previous section that Bt. related investments do not constitute an entry barrier, the impact of Bt. on market structure is likely to be complex. According to industry estimates, there has been a marked shift in farmer preferences towards Bt. seed. Of the total hybrid seed market of 13 million packets, industry sources estimated that Bt. seeds could account for as much as 8-9 million packets in 2005 (up from 3 million packets in 2004 season). Illegal Bt. seed was thought to account for 5-6 million packets while the remainder was legal Bt. seed.

Although about 20 companies have licensed the cry 1 Ac gene from MMB, not all of the 20 companies will have their Bt. products in the market at the same time. For instance, in the 2005 season, besides MMB, hybrids from Ankur, Rasi and Nuziveedu were available to growers. Hybrids from other companies were still in large-scale trials awaiting the biosafety regulator's approval (the Genetic Engineering Approval Committee or GEAC) or at even more preliminary stages of testing. Some of the licensees had concluded their agreement with MMB in 2005; thus they were just beginning to do backcrossing. On the other hand, Rasi's agreement with MMB dates from 1998. They did large-scale trials in 2002 and 2003 and obtained GEAC's permission to commercialize in 2004. Hence, the fact that not all firms had started their Bt. programs at the same time means that companies that got a headstart might receive the opportunities to enjoy monopoly power temporarily. GEAC's insistence on

agronomic testing (through large scale trials) favoured the companies that have already received commercialization approvals.

The case for agronomic testing relies on the need to protect poor and vulnerable growers from inferior products. Yet, growers had not shown a marked preference for hybrids that had undergone agronomic testing. Under India's seed laws, agronomic testing (by which varieties and hybrids are "notified") is mandatory for public varieties and public hybrids but is voluntary for proprietary non-Bt hybrids. Most companies have not bothered with the notification process and have relied on their own quality systems, demonstration plots and field days to build brands and push sales. In some cases, for the sake of public relations with the government and the public sector agricultural research establishment, companies submit their flagship hybrid to the notification trials but almost never waited for the outcome to market their product. [A fairly typical example was that of Vikram 9 and Vikram 5 from Vikram Seeds. They were released in 1993 and 1995 and were very successful hybrids in Gujarat till 2003. Both hybrids were also tested in notification trials and were notified in 2000 and 2002 respectively]. In the perception of seed companies, notification adds little or no commercial value. The dominance of non-notified proprietary hybrids in the cotton seed market demonstrates this amply.

The hybrids from MMB, the first company to apply for commercialization, spent 4 years in large-scale trials including two years of testing with ICAR trials. By allowing concurrent ICAR and large-scale trials (organized by the applicant), GEAC quickened the process to 2 years for Rasi, which was then reduced to 1 year for the approvals in 2005 including that of Nuziveedu Seeds. However, since then, the GEAC revised its protocol to specify that non-notified Bt. hybrids would have to spend upto 2 years in ICAR trials, thereby increasing the time before which new Bt. hybrids can come to the market.

While the entry of more Bt. hybrids brands would offer growers more choices and lessen concentration, the impacts on price would be muted. As we saw earlier, by the revenue sharing agreement with MMB, the trait value was fixed and a sub-licensee company receives Rs.700 and an increment of Rs.300 over the price of non-Bt. seed (if the Bt. seed sold at the

current market price of Rs.1600). Rs.300 is therefore the additional surplus (gross of costs due to Bt.) received by the seed company. Competition could therefore affect this quantity and it represents the maximum amount by which price could fall.

6.9.4 Competition between different Bt. genes

As of 2003, MMB's cry 1 Ac gene was the only Bt. gene that had been approved by the biosafety regulators in India. Large scale field trials had been permitted in the 2005 crop season for hybrids incorporating four other gene constructs – MMB's Bollgard II which stacks *cry 1 Ac* and *cry 2 Ab* genes, a modified *cry 1 Ac* gene developed by IIT, Kharagpur in collaboration with JK Seeds, a fusion' *cry 1 Ac/cry 1Ab* gene sourced by Nath seeds from the Chinese Academy of Agricultural Sciences and Vip genes (also isolated from Bt. bacteria) from Syngenta. These genes have undergone biosafety tests and the hybrids incorporating them have to go through the agronomic testing discussed earlier.

The competition from alternative genes could lead to a more serious impact on the seed price than the competition between hybrids with the MMB gene. This is because the alternative gene providers could target a trait value lower than that fixed by MMB. Whether this will happen and to what extent will depend on two factors: (a) The performance of these alternatives as compared to MMB's genes especially Bollgard II which promises protection not only against lepidopteran pests but also spodoptera - a rapidly emerging pest. (b) MMB's first mover advantage in sub-licensing the Monsanto genes to companies that had some of the best performing hybrids in the country. Even if the alternative gene constructs prove successful, they would not be able to combine with quality germplasm. Thus, the market for the new genes may well be limited by the contractual restrictions of the major seed firms with MMB. *[Several companies indicated that the agreement with MMB disallowed the license of genes (with insect-resistant traits) from other companies. However, they cited confidentiality reasons in declining us access to this clause.]*

6.9.5 Illegal Bt.

Illegal Bt. originated in Gujarat and is still dominant there. But it has also spilled over to Maharashtra, Punjab and Andhra Pradesh. Industry sources acknowledge that in these states, while illegal Bt. is not dominant, it is not uncommon either. Navbharat 151 is a generic name for illegal Bt. In interviews, industry observers stated that the male parent (with the Bt. gene) used in Navbharat 151 has been crossed with a variety of female lines to generate many different versions of illegal Bt., often well adapted to local environments.

In the 2005 season, illegal Bt. was priced anywhere between Rs.800 to Rs.1200 per packet. With its seemingly effective performance and its lower price, illegal Bt. was a threat to legal seed, whether Bt. or otherwise. The threat was particularly acute for non-Bt. hybrids. With legal Bt., the non-Bt market has some protection in terms of a large difference in seed price. With illegal Bt., the protection is much less. In Gujarat, for instance, the market leader Vikram Seeds lost its non-Bt. market rapidly because of illegal Bt.

The following facilitates illegal Bt.'s spread:

- a) It can be priced lower than legal Bt. because the seed value does not have to be shared with the gene supplier. Even if competition between legal Bt. hybrids improves their performance or lowers their price, illegal Bt. could compete by further lowering its price.
- b) The illegal Bt. coming out of Gujarat was regarded as being of good quality. Within Andhra Pradesh and Maharashtra, illegal Bt. was served by a large network of seed producers and distributors. Anecdotal accounts of grower experience speak of farmers receiving quality assurance from this network.
- c) Illegal Bt. generates large gains for seed dealers and seed producers and therefore can be shared with local authorities that have the power to enforce seed laws.

As against these factors, the spread of illegal Bt. can be limited by the following factors:

- i. Transactions have to be based on trust and carried out in cash. Seed dealers and producers cannot use normal banking facilities and nor can they use regular commercial channels for dealing with first time buyers (i.e., seed dealers from outside their area of operations). Illegal trade becomes difficult to carry out without kinship networks, which are geographically restricted.

- ii. Illegal Bt. is marketed without a company name and a bill of purchase. In Andhra Pradesh and Maharashtra, some illegal seeds are known by brand name such as 'Zero Bt'. But it would be difficult to build such brand (without risking counterfeiting) over geographically dispersed areas. Illegal Bt producers do not possess the formal means to communicate quality especially to growers not within their traditional areas of operation. Growers are confronted with the issue of spurious Bt. One estimate is that 30% of all seeds marketed as illegal Bt in Maharashtra is spurious (Market source).
- iii. With better gene constructs such as Bollgard II, legal Bt. will perform better than illegal Bt.

[Easy availability of Bt. cotton seed of many brands from increasing number of seed companies and reduction of prices, has removed illegal Bt. cotton problem out of market since cropping season 2007-2008 onwards...See Chapter 4: Districtwise Case Studies.]

6.10 Inferences

Growth in public spending on agricultural R&D in India has increased. At the same time, private participation in agricultural research has grown in some developed countries. Moreover, the distinction between public and private research is increasingly blurred, as public agencies are being pushed to pursue new sources of funding and develop new organizational structures to manage and allocate public research funds. Yet there is a dearth of information and policy analysis to inform and guide the institutional and policy changes that are underway or contemplated. Research is particularly lacking on public policies that can improve the funding, performance, and impact of public and private agricultural Science & Technology institutions worldwide, including their productivity, and their environmental and poverty consequences. Keeping track of these changes to compare them within and among countries and types of agencies and at different points in time is critical to keep policymakers abreast of agricultural science policy issues.

The ICAR and the Agricultural universities system have been the keystones of Indian national agricultural research system, and they will continue to play an important role in developing biotechnologies. Yet the emergence of biotechnology has brought a variety of new actors - in particular, Transnational companies (Monsanto's Bt. cotton) and private companies - into

agriculturally related research. An alliance is emerging between public sector basic science and private sector technology development (IIT- Kharagpore & JK Seeds), which should be exploited and enhanced in the area of biotechnology.

The current agricultural research system depends on basic research, applied research, technology development, and technology transfer. Basic and applied researches overlap in biotechnology to perhaps a greater extent than in traditional areas of agricultural science. In realigning the system to promote biotechnology, communication is essential among basic researchers, applied researchers, and farmers and private companies, the end users of technology. For the agricultural research system to be most effective, links among the disciplines of science that support agriculture as well as links between basic and applied research and technology development and transfer must be strengthened.

References:

1. Arrow, K. (1962), "The Economic Implication of Learning by Doing, *Review of Economic Studies*, Volume 29, (June), pp. 155-173" cited by Atkinson, Anthony B. and Stiglitz, Joseph E. (1969, September); "A New View of Technological Change"; *The Economic Journal*, Volume: LXXIX.
2. DSIR Annual Reports (1991 to 2007). Government of India.
3. Economic Survey of India, Government of India.
4. Fan, Shenggen, Peter Hazell and Sukhadeo Thorat (2000), "Government Spending, Growth and Poverty in Rural India", *American Journal of Agricultural Economics*, Vol. 82, No. 4, pp.1038-1051
5. Maredia, Karim M. and Frederic H. Erbisch (1998), *Capacity Building in Intellectual Property Management in Agricultural Biotechnology*, In: "Intellectual Property Rights in Agricultural Biotechnology, Erbisch, F. H. and K. M. Maredia, eds.", (Oxford: CAB International), pp. 49-61.
6. Ministry of Agriculture Annual Reports; Government of India
7. OECD-FAO Agricultural Outlook2006-2015, OECD-FAO (Organization for Economic Co-Operation and Development food And Agriculture Organization of the United Nations), 2006.
8. Pattnaik, Binay Kumar, ed. (1999), *Technology Transfer and In-House R&D in Indian Industry: In the later 1990s (Volume I and Volume II)*, (New Delhi Allied Publishers Limited).
9. United Nations Conference on Trade and Development, "Developing Countries in International Trade 2007: Trade and Development Index", (United Nations, New York and Geneva, 2007).
10. World Investment Report 2007: Transnational Corporations, Extractive Industries and Development", United Nations Conference on Trade and Development. United Nations, New York and Geneva, 2007.
11. World Investment Report 2005: Transnational Corporations and the Internationalization of R&D, United Nations Conference on Trade and Development; United Nations, New York and Geneva, 2005.

Chapter VII: Scientific Environment

Vs

Views of Scientists and Industry Managers

7.1 Methodology

This chapter is synthesized from primary and secondary sources of information. Content analysis¹ of the interviews of the respondents was done which have been represented in tabular form in this chapter.

7.1.1 Primary Sources

The research tool adopted is in-depth interview. Information was elicited from Scientists and practitioners from industry through in-depth interview based on open ended questionnaire. These interviews were conducted at the office of the individual concern with prior appointment and during meeting at the various seminars, symposium and workshops.

PhD Theses were used to go in-depth analysis of the Science. PhD Theses are the live research sources and their credentials are unquestioned in the realm of academics.

7.1.2 Secondary Sources

Information is used from the database sent by Syngenta, Monsanto, ISAAA, and IFPRI. Apart from these databases, information gathered from Science based Journal of repute; published books are also used at certain places to highlight the already accepted fact in the realm of scientific world and scientist community.

7.1.3 Institutions from where the respondents have been selected

Seed Industry: Companies Selected

All respondents are from top-level Management.

Multi National Companies: Monsanto and Syngenta.

¹ Content analysis is a method of systematically studying any information, or communication to measure variables. Holsti (1968) defines it as “Content analysis is any technique for making inferences by systematically and objectively identifying specified characteristics of messages”.

Indian Companies: Maharashtra Hybrid Seeds Company Limited (MAHYCO), Mumbai; Ankur, Krishidhan Seeds Ltd, Jalna; Nath Seeds Ltd., Aurangabad; Rasi Seeds (P) Ltd., Salem; Indo-American Hybrid Seeds, Banglore; J.K. Seeds, Hyderabad; Ajith Seeds; Nuziveedu Seeds Limited, Secunderabad; Tulasi Seeds, Guntur; Rallies Seeds, Patancheru; Aditya Birla Seeds Divisions, Vibha Seeds, Hyderabad.

International Organisations: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India; International Rice Research Institute (IRRI), Manila, Philippines; International Service for the Acquisition of Agri-Biotech Applications (ISAAA), Manila, Phillipines; International Food Policy Research Institute (IFPRI), New York.

NGOs: MS Swaminathan Research Foundation (MSSRF), Chennai; Centre for Sustainable Agriculture (CSA), Secunderabad; Deccan Development Society, (DDS) Zaheerabad; Navdanya, New Delhi; GeneCampagne, New Delhi; Kudumbam, Trichi; Modern Architects for Rural India (MARI), Warangal.

Central University: University of Hyderabad, Banaras Hindu University, Jawaharlal Nehru University and Delhi University.

Agricultural University: Acharya N.G. Ranga Agricultural University, Birsa Agricultural University, Pusa Agricultural University and Allahabad Agricultural University.

Research Institutions: Indian Agricultural Research Institute (IARI), New Delhi; Central Institute for Cotton Research (CICR), Nagpur; Central Institute of Research on Cotton Technology (CIRCOT), Mumbai; Centre for Cellular and Molecular Biology (CCMB) National Environmental Research Institute (NERI), Nagpur; National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Nagpur; National Botanical Research Institute (NBRI), Lucknow; National Academy of Agriculture Research Management (NAARM), Hyderabad; Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad; Lam Farm, Guntur; Central Tobacco Research Institute (CTRI) Guntur-sub station and DRR-Hyderabad.

7.1.4 Sample Size

- 2003 Survey: Total numbers of respondents were 13.
- 2005-2006 Survey (Pilot Testing Stage): Total numbers of respondents were 27.
- 2006-2008 Survey (Final Sample based on in-depth interview): Total numbers of respondents were 67.

7.2 Chronological Finding of Primary Survey

Rapid changes in knowledge and capabilities in biotechnology have presented the human race with a major dilemma, which only a few had anticipated even as recently as three or four decades ago. If we limit the discussion to the applications of biotechnology to agriculture, it becomes obvious that recent research and advances in knowledge hold enormous promise for improvements in yields, reduction of damage by pests and enhancement of qualities such as drought tolerance that can revolutionize agriculture. At the same time, genetic engineering strikes at the very core of the life at all species. This holds dangers difficult to even comprehend much less measure. India is a nation of over a billion people with ever-increasing population. It must, therefore adopt science and technology in agriculture to harness their latest breakthroughs and yet safeguard all species from the dangers of genetic changes that could jeopardize their very existence.

In recent years considerable debate has taken place on the lure and limits of biotechnology in agriculture. Understandably, there are differences across the world. The United State of America with a lead in GMC has seen the penetration of products created by genetic modifications on a significant scale in its markets. On the other hand, Europe has had an extremely cautious approach to the use of GMCs, and there is considerable resistance not only to the use of GM products but also to research, development and testing related to these materials. Developing country like India which has more or less exploited all its arable land area, have to spell out their own policies based on realities it face today and those likely to be faced in the future. Increasing agricultural yields is imperative, but so is preserving all species and protecting all forms of life.²

² Comprehend from various ISAAA, IFPRI & Media Reports. Insights from Journals like nature, current science and science books have been used to comprehend the paragraph.

India releases its first GM Crop in 2002 after five contentious years of testing and debate. In 2002 Bt. cotton was available in only three legal commercial seeds, produced through collaboration of Mahyco (the company providing hybrid cotton seed) and its partner and partial owner Monsanto (the St. Louis based biotechnological transnational company providing the gene construct). The seeds were “Bt.” versions of established hybrids MECH-12, MECH-162 and MECH-184 with launching price Rs.1050 per packet for one acre in 2002-2003 cropping season. Bt. cotton has been cultivated in several states of India for the last seven years. The impact of it in terms of cost and benefit has been mixed for the farmers. But on the *sales* performance the picture is clear. Monsanto reported sales of 72,000 packets in 2002; 2,30,000 packets in 2003; in 2004, when four Bt. hybrids were available, sales jumped to 1.3 million packets.

7.2.1 Excerpts from Responses of Scientists during 2003

The broad issues raised by the set of scientists working in agriculture related area are categorized in three broad sets, namely: Scientists working in Private Seed Companies, Scientists working in Indian Research Stations and Indian Universities and Scientists working in Indian NGO. The findings of interviews are represented as statement and variable told by scientists as it is.

Interpreted from Scientists working in Private Seed Companies

- a. The new biotechnology provides powerful tools to augment conventional plant breeding. Genetic engineering has allowed the expression of alien genes into all kinds of plants.

Interpreted from Scientists working in Indian Research Stations and Indian Universities

- a. Commendable efforts are being made at JNU (Jawaharlal Nehru University), New Delhi, to engineer protein quality by mobilizing heterologous genes such as 2S storage protein from *Amaranthus*³ into potato and rice. It has also been demonstrated that this

³ *Amaranthus* is a minor millet, widely consumed both as leafy vegetable and puffed grain; therefore, this protein has been a component of the human diet for a long time. Mobilisation of this storage protein gene from

storage protein from *Amaranthus* has higher level of the essential amino acids than those recommended by the World Health Organisation (WHO).

Interpreted from Scientists working in Indian NGO

- a. The horizontal transfer of genes into wild types, such as those for antibiotic resistance (kenamysin, hygromycin), raises important questions. New strains of viruses and bacteria may evolve because of recombination or transcapsidation. There are concerns related to the loss of biodiversity and potential contamination of gene banks owing to horizontal transfer of genes. Also new compounds synthesized may disrupt the balance of nature.
- b. The presence of antibiotic-resistance genes in the food made by transgenic plant may result in cumulative effect in which a problematic resistance to antibiotic can develop.
- c. Scientists had transformed soybean with the 2S gene from Brazilian nuts. Allergic reactions were triggered off when some people consumed the transgenic soybean.
- d. Several questions on agricultural problems can be answered using existing knowledge and experience as human beings have selected and improved crop plants by breeding/mobilizing their genetic material since times immemorial.

Broad Responses of Scientists from various institutions during 2003 are clubbed together and shown in Table 7.1.

Table 7.1: Broad Responses of segmented Scientists during 2003*

<i>Respondents & Organizations</i>	<i>Broad Area of Concerns</i>
Scientists working in Private Seed Companies	1. Biotechnology is powerful tool 2. Biotechnology takes a long time to come to fruition.
Scientists working in Indian Research Stations and Indian Universities	1. New Technology 2. No detail information, 3. They are not the creator of this technology. 4. Anti-biotic Marker.
Scientists working in Indian NGOs	1. 'Frenkenstein food', 2. Terminator Technology, 3. Antibiotic Marker

Source: Sample Survey

* Finding: Compiled from interviews

Amaranthus into other target crops through genetic engineering is expected to improve the quality of protein without any detrimental effect on human health or the environment.

7.2.2 Excerpts from Responses of Scientists during 2004-2005

Interpreted from Scientists working in Private Seed Companies

- a. Sustaining the production potential is possible by engineering plants against biotic and abiotic stresses. Sterility systems derived from alien cytoplasm by genetically engineering male sterility in crops in a non-specific manner have enhanced the exploitation of hybrid vigour. Apomixis, as an extension of hybrid technology, has offered new promise in the realization of hybrid advantage on a sustainable basis. Molecular markers are being linked to apomixis, which will facilitate marker-aided selection. A reduction in production costs by replacing costly inputs such as chemical fertilizers and pesticides is possible. Genetic modifications for better processing and storage, mechanical agriculture, and appropriate size, shape, colour, flavour, texture, taste, etc. of useful parts have opened up possibilities for a holistic approach to crop improvement and production.
- b. Genetic engineering techniques have been effectively utilized to modify the starch content in a number of crops. In the potato, over expression of the enzyme AGPase (ADP-glucose pyrophosphorylase) resulted in an increased amount of starch (Monsanto, USA). These transgenic potatoes are found suitable for making finger chips. Finger chips from transgenic potatoes fry uniformly and also consume less oil, thereby reducing the oil intake in the human diet. Similarly, 'vitamin A' contents in the diet play a major role in preventing disorders such as night blindness prevalent among large sections of the population in many countries including India. Monsanto, USA, has reported the introduction of the *beta-carotene* gene through genetic transformations in rapeseed and mustard, enhancing the vitamin A content.
- c. Protest groups and some of the NGOs may claim to speak for consumers, but in reality are only promoting themselves by theatrical ploys, rather than reflecting the consumer's interests.

Interpreted from Scientists working in Indian Research Stations and Indian Universities

- a. Policy makers, administrators, legislators, the judiciary, industry, farmers, and the media will each have to play an active role in safeguarding the society's interests by participative decision-making.

- b. In India, efforts are being made at institutes such as the Indian Agricultural Research Institute (IARI) to alter the quality of proteins in crops such as chickpea, *Lathyrus*, and mustard. The success achieved in deriving *Lathyrus* lines with very low neurotoxin levels emphasizes the power of biotechnology to improve crop quality.

Interpreted from Scientists working in Indian NGO

- a. Private companies engaged in seed/agricultural biotechnology have a major role to play by keeping up their research efforts as also by disseminating information.
- b. Private companies do need to soften their stand on the issue of royalty.

Broad Responses of Scientists from various institutions during 2004-2005 are clubbed together and shown in Table 7.2.

Table 7.2: Broad Responses of segmented Scientists during 2004-2005*

<i>Respondents & Organizations</i>	<i>Broad Area of Concerns</i>
Scientists working in Private Seed Companies	1. Biotechnology is powerful tool for crop improvement.
Scientists working in Indian Research Stations and Indian Universities	1. Biotechnology is powerful tool to improve crop quality. 2. Regulatory Effect 3. Environmental effect 4. Biosafety and economic implications.
Scientists working in Indian NGO	1. Monocropping 2. Anti Biotic Marker 3. Food Safety 4. Pricing of the product 5. Public Health 6. Environmental effects 7. public health 8. Biodiversity 9. Monopoly of market 10. Farmers choice

Source: Sample Survey

* Finding: Compiled from interviews

7.2.3 Excerpts from Responses of Scientists during 2006- 2008

Interpreted from Scientists working in Private Seed Companies

- a. No technology, including biotechnology, can survive without profit sharing. Seed sector of India cannot alone become the market; they have to have partners.
- b. Biotechnology companies are investing billions of dollars in consolidations to ensure access to the rapidly growing markets of GMCs, while investing more money in R&D. There is a definite trend towards genetically modified plants. The dependence on insecticides and pesticides will decrease so that higher yields can be realized. The public debate over the future of agricultural biotechnology is more mature as the public becomes better informed and sees more clearly the benefits and risks associated with it.
- c. Intellectual Property Right is bringing new dimension to the market. Royalty payment is truth of today's market dynamics which is re-modifying market of technology. A single gene-construct can re-orient the market. Bt. technology is able to reshape the Indian cotton crop seed market. It can be emulated to other product.
- d. New biotechnologies have begun to play a critical role in providing stability to production, either in a favourable or unfavourable agro-ecology.
- e. Transgenic plants can improve the nutritional quality of cereals and legumes by increasing the lysine (an essential amino acid) content of storage protein.
- f. The role of media must be balanced based on scientific data rather than on sensationalism. They should emphasize publishing technically correct information rather than selling more copies. The mainstream population must be involved and communicated to without hype or false hope.

Interpreted from Scientists working in Indian Research Stations and Indian Universities

- a. Biotechnology will be a very effective tool for increasing crop productivity and may replace, supplement and complement many existing agricultural practices.
- b. It is often difficult to translate laboratory research to a commercial scale or to make it reach it the farmer by oneself.
- c. On the issue of pest and insect management: "Some farmers believe that spraying more chemical pesticides gives more yields. However, chemical pesticides are a great threat

to the environmental and human health. A solution to this problem is certain as many scientists are working in this direction, particularly on *Bt. gene*. Scientists are currently using this gene to control the damage caused by various pests. However, there is a problem as this gene has been patented; one can do some basic research and can publish scientific data, but ultimately the patent holder will not allow the commercialization of transgenic crops.”

- d. IRRI is aiming to produce varieties of rice that will consume one-tenth of the water consumed by normal varieties.
- e. The power of transgenic technology has raised several issues about biosafety, the role of the private versus public sector and the need for their coming together especially in the country like India.
- f. Infrastructure and Funding is the main constraint for R&D potential, we can not match multi-national companies in term of R&D expenditure and media management.
- g. GMC’s approval and adaptation should be based on India’s need rather than multi-national companies’ dictate.

Interpreted from Scientists working in Indian NGO

- a. Social, economic, ethical and moral issues arising as a result of the introduction of transgenic plants need to be addressed.
- b. To implement effective biosafety standards in India may prove difficult though the Vardharajan Committee has put forth an effective biosafety protocol.
- c. How much farmers should be told about the new transgenic crop? How will farmers with small land holdings be able to grow transgenic crops?
- d. Under the TRIPS agreement, micro-organisms need to be patented. Plants are patented under the *sui generis* system.
- e. Private seed companies are monopolizing the seed market.
- f. GMC will reduce the biodiversity of Indian farm sector where farm saved landrace seed have prominence in cropping pattern. These indigenous farm saved seeds are the product of many years of trial and testing in farms of Indian farmers. Seeds are part of our culture.

- g. The way pest have developed resistance against modern pesticide, in similar manner they can develop resistance against GMC; then controlling them will be more difficult.

As outlined earlier the responses of scientists from various institutions was obtained during 2006-2008 which are presented in the Table 7.3:

Table 7.3: Broad Responses of segmented Scientists during 2006-2008*

<i>Respondents & Organizations</i>	<i>Broad Area of Concerns</i>
Scientists working in MNCs	1. Biotechnology is powerful tool for crop improvement
Scientists working in MNCs- Private Indian Seed Companies Collaboration	1. Biotechnology is powerful tool for crop improvement 2. Any human activity has inherent risks
Scientists working in Private Seed Companies of India	1. Biotechnology is powerful tool for crop improvement. 2. Require heavy investment to build basic infrastructure.
Scientists working in International Research Institutions	1. Ethics 2. Product labeling 3. Issue of refuge crop
Scientists working in Indian Research Institutions	1. Ethics 2. IPR 3. Biotechnology is powerful tool for crop improvement. 4. Biodiversity
Scientists working in Indian Agricultural Universities and Indian Universities	1. The technology has enormous potential. 2. IPR 3. Biodiversity
Scientists working in Indian NGO	1. Monocropping 2. Environmental effects 3. public health 4. Biodiversity 5. Monopoly of market 6. Farmers choice 7. Biosafety

Source: Sample Survey

* Finding: Compiled from interviews

7.3 Agriculture

Agriculture, or farming, is the oldest form of biotechnology. All the farmed plants that we eat today, including wheat, corn, potatoes, tomatoes, rice, and many more, were developed thousands of years ago by farmers who practiced selective breeding of wild plants. Modern science has adjusted this heritage of crop plants, but has not added anything really new to it.

More food is being grown than ever before. It has also depended on the creation of new varieties of plants, especially hybrid varieties (produced from two different plants). These are plants that can be grown in vast monocultures (fields containing only one kind of plant), and they depend on fertilizers made from fossil fuel and on pesticides, including both herbicides (chemicals that kill unwanted plants) and insecticides (chemicals that kill insects).

Agriculture has been further changed by biotechnology, especially genetic engineering. Starting in the 1990s, genetically modified crops have been grown in large amounts, especially soyabeans and corn. Genetic engineering has been controversial. Some countries, such as Japan, some African countries, and most of Europe, restrict the growing or importation of genetically modified food. Although most government and corporate scientists agree that genetic engineering is safe, critics are worried that it might hurt human health or the environment. For example, artificial genes from genetically engineered crops might get into wild relatives of those plants and alter the balance of nature.

7.3.1 Genetically Modified Foods

When an organism's genes (its genetic materials) are changed in a laboratory, the organism is called genetically modified or transgenic. Genetically modified foods are products that contain transgenic animals or plants as ingredients. Genetically modifying food sources can make them bigger, stronger, and more nutritious. Changing genes in plants can protect them against disease. It can also help them survive when exposed to herbicides (chemicals used to kill weeds and plants) and insects.

There are many uses for genetically modified foods. For example, in parts of Africa, people eat large amounts of rice. Regular rice is not very nutritious, so scientists have genetically modified rice plants. These modified plants produce proteins that give their rice extra iron and vitamins. 'Golden Rice' is one of the best examples of GMCs.

7.3.1.1 Scientific Foundations

Genes are the basic units of heredity. They are contained within a double-stranded structure called deoxyribonucleic acid (DNA). The sequence of genes contains the instructions that tell cells how to create particular proteins. Proteins are primary components of living cells. How these proteins are produced determines what traits an animal or plant will have. In nature, genes are passed from one generation to another. The genes of the parent determine which genes the offspring will have. Today, scientists can add or change genes in a lab to create animals and plants with certain traits.

Genetic engineering of crops is done by adding genes to the deoxyribonucleic acid (DNA) in plant cells. DNA is a long, chainlike molecule of genetic information. All living things use DNA to pass on traits to their offspring. Cells use DNA as a recipe-book for making the complex molecules called proteins that they need throughout life. By changing plant DNA, scientists can change the proteins that the plants make in their cells. This can change the nutritional value of the plants, their resistance to certain chemicals, their production of certain chemicals, and other qualities.⁴

Starting in the 1970s, an agricultural movement came into being that is intended to preserve soil, uses only natural fertilizers (such as decaying plant material and animal excrement), uses no chemical pesticides, and uses no genetically engineered plants or animals. The amount of organic food sold increased by about 20 percent per year from 1999 to 2006, a large increase. Most recently, biotechnology has changed agriculture by introducing antibiotics and genetically engineered organisms.

7.3.1.2 Development⁵

The idea of creating plants with specific traits is ancient, but it started as a science with the studies of an Austrian monk named Gregor Mendel (1822–1884) in the 1860s. Mendel discovered how plants passed their traits from one generation to another. Botanists (scientists who study plants) used his discovery to help them breed plants to have desired traits, such as

⁴ Chrispeels, Maarten. *Plants, Genes, and Crop Biotechnology*. Boston: Jones and Bartlett, 2003.

⁵ Ruse, Michael and David Castle, editors. *Genetically Modified Foods: Debating Biotechnology*. Amherst, NY: Prometheus Books, 2002.

sweeter fruit or extra seeds. This selective breeding took time. Scientists had to try different combinations to see which ones worked.

Scientists from three different research groups in Belgium and the United States were the first to make genetically modified plants. In the early 1980s they used bacteria to put a gene from one plant species into another plant species. One of the groups inserted a bean gene into a sunflower plant. To genetically modify an animal or plant, scientists first have to find the gene that controls the trait they want to change. Then, they separate that gene and make many copies of it in a lab. Finally, they put the copied genes into animals or plants. There are a couple ways to insert new genes in plants. The first uses a type of bacteria called *Agrobacterium* to transfer the gene. The *Agrobacterium* contains a circular piece of DNA called a plasmid. When the bacterium infects the plant, it copies its genes through the plasmid into the plant's genes. Another way to insert the gene is with a gene gun. The gun shoots tiny gold balls coated with the changed DNA into the plant's cells. Those genes then become part of the plant's DNA.

7.3.1.3 Current Issues

People who support genetically modified foods argue that they can help people who live in areas with poor growing conditions. They believe these foods can help end world hunger. Those on the other side of the debate worry about the safety of genetically modified foods. They fear that mixing genes from different species could create strange new animal and plant breeds.

Environmental groups worry that genetically altering foods could be dangerous to human health. They are not sure what effects genetically modified plants and animals might have on the people who eat them. Critics call these foods "Frankenfoods" because they have been pieced together using genes from different species.

One specific concern is that a gene might mistakenly be taken from a plant to which many people are allergic. For example, if a gene taken from a peanut were inserted into soybeans, it could cause the soybeans to produce peanut proteins. Those proteins could trigger a reaction

in anyone who was allergic to peanuts. Another worry is that genetically modified plants might breed with the plants growing around them. Then the wild plants could pick up the traits from the modified plants. This cross-breeding could create problems such as weeds that herbicides cannot kill.

Another concern is the possibility that the Bt. toxin gene could be transferred from genetically engineered plants to other species. If the recipient plant was an unwanted variety, the result could be a very environmentally hardy “super-weed,” some critics argue. Again, however, careful monitoring of engineered plants over decades has not revealed this gene transfer to be a problem. But, the possibility cannot be ruled out, and so approval of genetically engineered Bt-plants is done only after careful thought.

7.3.2 Scientific Background

A multitude of classical scientists laid the foundation for the advent of biotechnology. Louis Pasteur, Robert Koch and Gregory Mendel all contributed to the fundamentals of microbiology and genetic inheritance, respectively. These were key to enabling Francis Crick and James Watson to deduce the structure of deoxyribonucleic acid (DNA). Biotechnology is closely related to Agriculture and proven its capability by changing the genetic make up of plants. Biotechnology, “the ‘scientific’ manipulation of plants, animals and/or organisms and their products for use by man” includes breeding and genetic engineering.

Plant breeders can rectify problems only when there is variability available for the desired characters within the compatible species complex. Transfer of useful trait from distantly related species which do not sexually cross with the crop plant is not possible through conventional recombination breeding procedure, considering that many problems still remain unsolved and that the currently available technologies are inadequate to solve them, there is need for alternate technologies. Recombinant DNA technology that enables movement of genes of interest across sexual incompatibility barriers is one approach plant scientist are relying upon worldwide today to find genetic solution to specific problems.

Technology like transgenic seed and terminator technology is often debated with several facts, figures and assumption. Some have opposite argument some have positive thoughts. Schell (1993) and Young (1994) said that genetic engineering is based on the transfer of ‘defined genes’ and considerable amount of data available from field tests with transgenic plants demonstrate that no risk are involved in releasing transgenic. However, critics of transgenic technology refuted these propositions.⁶

Regal⁷ (1994) asserted that the mechanism and potential of conventional selective engineering and genetic engineering can be profoundly different. Although this does not mean that every transgenic is ecologically dangerous, some transgenic may be considered riskier than what could be produced with selective breeding, especially when an ecologically competitive host is supplemented with noble feature that may increase its competitiveness.

In a report on transgenic plants and world agriculture prepared under the auspices of the royal society of London, science academies of US, Brazil, Mexico, China, INSA, TWAS, it is said: “we conclude that steps must be taken to meet the urgent need for sustainable practice in world agriculture if the demands of an expanding world population are to be met without destroying the environment or natural resources base. In particular, GM technology coupled with important development in other areas should be used to increase the production of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture, and provide access to food for small farmers”.⁸

7.3.3 Recombinant DNA Technology

The best known set of biotechnology techniques revolves around manipulation of DNA at the molecular level, commonly referred to as genetic engineering or recombinant DNA technology. Recombinant DNA technology is based upon the discovery of special proteins called restriction enzymes that recognize certain sequences in DNA and cut the DNA strand at that point. Researchers have also discovered another type of enzyme, called ligase that can

⁶ Schell (1993); Young (1994)

⁷ Regal (1994)

⁸ Sharma, Manju (October 17, 2003). First Foundation Day Lecture on Regulatory Measure for Utilizing Biotechnological Developments in Different Countries.

reconnect severed DNA strands. These molecular tools allow splicing or recombination of DNA from different sources. The proteins expressed from such recombinant DNA can transfer desirable characteristics from one type of cell to another type of cell. However, before recombinant DNA can be expressed as a protein, it must be introduced into a cellular milieu. This is generally done by way of a vector, a DNA molecule that can move between cells and is functional in different cells. One common type of vector is a plasmid, a circular piece of DNA that is often exchanged by bacteria. Using recombinant DNA technology, a gene from a plant may be cut out of plant DNA, spliced into the plasmid, and introduced into a bacterium along with the plasmid DNA. Once in the bacterium, the plant gene on the plasmid will interact with the bacterial cell machinery to produce a plant protein.

Another common type of vector is a virus. Viruses commandeer the cellular machinery of a host by introducing their own DNA into the cell to direct the production of new viruses. Recombinant DNA techniques can splice foreign genes into viral DNA. The virus is then allowed to infect a cell of interest; the foreign gene will be introduced into the cell with the viral DNA. Usually, the viral DNA is inactivated to prevent it from taking over the cellular machinery, but the foreign gene is allowed to remain active so that the cell will produce the corresponding foreign protein. By using an appropriate virus as a vector, genes of interest may be placed into the cells of bacteria, or into animal cells in cell culture.

These methods are especially useful for transferring genes from complicated plants or animals into single-celled microorganisms. Genes that produce rare proteins from a plant, human or animal can be placed into a bacterium or yeast. This is advantageous because microorganisms grow at a tremendous rate; some have a generation time of 30 minutes or less. This means that as a recombinant microorganism reproduces, the inserted gene is also reproduced every 30 minutes. These multiple copies of the gene, contained in the many offspring of the original recombinant organism, will all be actively directing the synthesis of the desired protein. The offspring of the original recombinant organism act as millions of tiny cellular factories, producing large quantities of the protein. Consequently, proteins that occur in minute quantities in nature can be produced in large quantities through use of recombinant DNA techniques.

The application of recombinant DNA technology is always dependent upon⁹:

- i. an understanding of the target biochemical pathway or process to be altered.
- ii. the ability to isolate the genes responsible for the biochemical step, or steps, to be manipulated, and
- iii. the ability to transfer and express the genes of interest in the plant species to be genetically altered.

Therefore from the existing scientific literature it is inferred that the development of genetic engineering or biotechnology has given plant breeders an additional tool to expand genetic variability through the introduction of genetic material from related and even unrelated species. In normal hybridization programs, the chromosome complements of the two parents may be so different that fertilization is impossible, incomplete or leads to infertile offspring, or the trait desired may not be present in the variety being improved or its compatible relatives, thus limiting the ability of the breeder to achieve the desired improvements. Biotechnology has given plant breeders a tool to overcome this problem.

Successful plant improvement programs require:

- i. clearly defined objectives
- ii. adequate genetic variability
- iii. appropriate instrumentation and evaluation methods
- iv. time.

7.3.4 Scientific Evaluation of Genetically Modified Crops based on Published Literature

Genetic engineering technology has been exploited to develop disease resistant varieties. Plant disease resistance genes and defense genes have been cloned. Transgenic plants expressing these genes have been developed, and they show resistance against fungal, bacterial, and viral diseases. Genes from fungi, bacteria, viruses, insects, and human beings have been transferred to plants, and transgenic plants expressing these genes show resistance against various diseases. The use of genetic engineering technology in the development of disease-resistant plants is well discussed in its chapter on ‘Breeding for Disease Resistance –

⁹ Trevor W. Stevenson (1991). Pg 124

Genetic Engineering'¹⁰ which is based on 152 scientific research paper published in some of the best scientific reviewed journals.

Genetic engineering can also help in improving otherwise deficient essential amino acids in plant proteins. Cereals as protein sources are generally deficient in lysine and tryptophane, whereas legume seed protein to be deficient in methionine and cysteine¹¹. The aim is to alter the existing gene products to improve their nutritional and functional properties. With the use of ribozyme and antisense Ribonucleic acid (RNA) technology, it is possible to suppress/eliminate the synthesis of undesirable constituents in the seed storage proteins making them fit for human consumption. The methods used for improving the quality of proteins include:

- a. Utilization of gene encoding major storage proteins
- b. Expression of selected storage protein gene
- c. Utilization of protein quality genes from unrelated species
- d. Deletion of undesirable gene sequences to improve protein quality.

On the issue of Horizontal Gene Transfer¹² in the field, the scientific argument put forth by Hamilton et. al.¹³ (2002): 'The factors affecting possible "horizontal" gene transfer between genetically modified plants expressing antibiotic resistance marker genes and microorganisms in the environment have been extensively studied. To date, there is no experimental evidence that any antibiotic resistance marker gene from a plant has transformed a bacterium either under laboratory conditions or in the field. Most bacteria in natural environment are not competent to accept DNA. Even under laboratory condition, studies specifically designed to detect the transfer of functional marker genes from plants into bacteria have failed to demonstrate such an occurrence.' Citing various other scientific studies they further asserted that Bt. cotton is environmentally safe.

¹⁰ Vidhyasekaran, P. (2004). Concise Encyclopedia of Plant Pathology

¹¹ Shotwell and Larkins (1991). Improvement of the Protein Quality of Seeds by Genetic engineering. pg. 32-61
David, Clark (2005). Molecular Biology. Elsevier Academic Press, New York, pg. 599-633.

¹² for detail please see: Syvanen, Michael (editor) and Kado, Clarence I.(editor) (2002). Horizontal Gene Transfer. Academic Press, San Diego

¹³ Hamilton, Kathryn A.; Goodman, Richard E. and Fuchs, Roy L. (**from Monsanto Company**) (2002). pg.455

7.3.5 Bt. Insect-Resistant Crops¹⁴

Bacillus thuringiensis (Bt.) is a type of bacterium (a single-celled living thing) that has been used to control plant insect pests since the 1970s. It produces a chemical that paralyzes an insect's intestines, and the insect usually starves to death in several days. Thus, the chemical functions as a toxin (poison) to the insect. Bt. is usually sprayed on the plant's leaves or needles and is ingested by the insect when it eats the plant.

Cells use DNA (genetic information) to control their functions. Genes are pieces of DNA that tell cells how to do a particular job. The gene that tells a cell how to make the Bt. toxin can also be removed from *B. thuringiensis* and inserted into the genetic material of a target plant. The toxin can then be directly produced by this transgenic plant that now contains the Bt. gene. Plants that produce the Bt chemical (or that have been sprayed with the Bt bacteria) become resistant to the destructive feeding of insects.

7.3.5.1 Scientific Foundations

Bt. is naturally present in the soil. The ability of the bacterium to kill insects has been known since 1911, although the active compound was not discovered for decades. By 1961, Bt. was approved as a biopesticide (biological insect-killer) in the United States.

The application of Bt. to plants as a spray has several drawbacks. Because the bacterium must be eaten by the insect for the toxin to exert its deadly effect, environmental factors that reduce the concentration of the bacteria on the plant are a problem. For example, sunlight can lessen the strength of the bacteria and its genetic material, and rain can wash the Bt. off of the plant.

These problems have been overcome using genetic engineering—the process whereby selected deoxyribonucleic acid (DNA) of one organism is removed from that organism and inserted into the genetic material of another organism, in this case the species of plant that

¹⁴ a.) Fox, Jeffrey L. "Resistance to Bt Toxin Surprisingly Absent from Pests." *Nature Biotechnology* 21 (2003): 958–959.

b.) Fumento, Michael. *BioEvolution: How Biotechnology Is Changing Our World*. New York: Encounter Books, 2004.

c.) Metz, Matthew. *Bacillus thuringiensis: A Cornerstone of Modern Agriculture*. Binghamton, NY: Haworth Press, 2004.

would have been applied with Bt. spray. As the plant manufactures more DNA as part of the cell division process, the inserted Bt. gene is copied and the insect-killing chemical is produced. Thus, the plants themselves produce the Bt. toxin.

When the plant's leaves are eaten by an insect pest, the toxin is ingested. In the insect's gut, the three-dimensional structure of the Bt. protein is altered. The newly shaped toxin is now biologically active, and it destroys the intestinal tract of the insect. This chemical only has this effect on insects. Eating the toxin does not harm humans or animals.

7.3.5.2 Development

The process of genetic engineering - removing a piece of DNA from one organism and inserting it into a new organism - was discovered in the 1970s. To adapt this process for the creation of Bt. transgenic (genetically engineered) plants, scientists first identified the gene in Bt that codes for the toxic chemical. Once the gene is known, the techniques of genetic engineering can be used. The gene is removed from the Bt. genome using specialized chemicals. It is then combined with another gene that codes for a chemical that degrades a particular antibiotic. This gene combination is then inserted into plant cells, where it is taken into the plant's DNA. As the plant grows, its new cells express the chemical as directed by the transplanted gene combination. When grown in the presence of the antibiotic, the plant cells that are resistant because they produce the Bt/antibiotic resistance protein can be identified. (Not all the plants take in the transplanted DNA effectively.) These cells are selected and grown into the Bt-expressing (producing) plants.

As of 2006, this technology has been used to create Bt-transgenic corn (which is resistant to the corn borer), potatoes (resistant to the potato beetle), and cotton (resistant to the tobacco budworm and varieties of bollworm).

7.3.5.3 Current Issues

One concern associated with Bt. insect-resistant crops is the development of Bt resistance by the target insect species. Resistance is a natural process that aids an organism in surviving the challenge imposed by a lethal compound. Resistance happens when the organism's DNA

evolves in a way that makes it better able to survive whatever caused earlier generations to die. In the case of Bt., resistance is a valid concern, since insects have developed resistance to conventional insecticides in the past. Moreover, the ability of insects to develop Bt resistance has been demonstrated in laboratory studies.

However, as of 2003, such resistance had not developed in nature to any significant extent. In 2005, researchers demonstrated that plants engineered to express two slightly different versions of the Bt. toxin are even more resistant to insects than plants expressing a single type of Bt. toxin.

7.3.6 Corn, Genetically Engineered

Corn, also called maize, is a cereal grain. A cereal grain is any type of grass whose seeds are used for food. Genetically engineered corn, also called transgenic corn, is corn whose DNA (deoxyribonucleic acid, its genetic information) has been changed in the laboratory.

Corn is the largest crop grown in the United States, which also is the world's largest grower of corn. China is second, growing less than half the U.S. crop.

There are several kinds of genetically engineered corn. Two kinds of traits or abilities have been genetically engineered into corn, herbicide resistance and insect resistance. A herbicide is a chemical that kills plants, especially weeds. Farmers spray herbicides on many crops so that the crops do not have to compete with the weeds for water and soil nutrients. The most popular herbicide in the world is a chemical called glyphosate, which was invented by the Monsanto company in the early 1970s. Monsanto sells glyphosate under the trademark name Roundup. Several crop plants, including corn, have been genetically engineered to be immune to Roundup. Fields of these crops—which Monsanto calls Roundup Ready crops—can be sprayed with large amounts of glyphosate, and only the weeds will die.

Some plants, including some types of corn, have been genetically engineered to make a chemical in their leaves or other parts that is bad for some insects. The most common insect-resistant genetically engineered plants are the ones called Bt. varieties. There is Bt corn, Bt

cotton, Bt. soybeans, and so forth. “Bt.” stands for *Bacillus thuringiensis*, the scientific name of a bacterium (a very small, usually single-celled, organism). To make Bt corn, scientists took DNA from *Bacillus thuringiensis* and added it to the DNA of a corn plant. This Bt. DNA tells the cells of the corn how to make a protein that is poisonous to some insects that eat corn plants. Since these insects cannot thrive on corn that makes the Bt protein, less of the pesticide usually used against them needs to be sprayed on a Bt corn crop. However, other pesticides must still be used on Bt. corn or other Bt. crops to kill other kinds of insects that are not harmed by Bt.

7.4 The Importance of Agricultural Science and Technology Indicators

Successful innovation in agriculture depends on the provision of new and improved technologies that are well targeted; which in turn depend on well-funded agricultural research systems with appropriate research capacity and infrastructure. Current global developments in food prices and climate change further emphasize this point. Given competing demands, investments in agricultural science and technology (S&T) in many developing countries have stagnated over time despite numerous studies repeatedly linking improvements in agricultural productivity with increased investments in agricultural S&T. Furthermore, agricultural S&T systems in many countries have become increasingly complex, requiring the implementation of new organizational structures, increased participation by the higher education and private sectors, and diversification of funding sources. Quantitative information provides the foundation of our understanding of the important contribution of agricultural S&T in promoting agricultural growth. Indicators based on such information assist in measuring, monitoring, and benchmarking the performance, inputs, and outcomes of agricultural S&T systems (Spielman and Birner 2008)¹⁵. These indicators assist S&T stakeholders formulate policy, setting priorities, and undertake strategic planning, monitoring, and evaluation. They also provide information to governments, policy research institutes, universities, and private-

¹⁵ Beintema, N. M., and G. J. Stads (2008). Diversity in agricultural research resources in the Asia-Pacific region. Washington, D.C. and Bangkok: International Food Policy Research Institute and Asia-Pacific Association of Agricultural Research Institutions.

sector organizations involved in public debate on the state of agricultural S&T at national, regional, and international levels (Tijssen and Hollanders 2006)¹⁶.

7.5 Inference: Linkage between Science, Policy and Business and their practitioners' view¹⁷

If we agree that the issues involving agriculture-research are becoming increasingly complex, then it makes sense that more information, particularly accurate, thorough and objective information, will result in better decision-making. A question frequently asked in the scientific community is how scientific knowledge can more effectively be used to inform public policy and private sector decisions based on agri-business. It is clear that many of the research tools developed in academia are not fully utilized by policy-makers and agri-business managers alike. There are at least three reasons for this:

- i. the scientists who have developed them do not fully appreciate the institutional, economic and cultural constraints within which policy-makers operate;
- ii. policy-makers and agri-business managers frequently are not aware that relevant scientific research is available to them; and,
- iii. there is a disconnect between the timeframes within which scientists/researchers, agri-business managers and policy-makers operate.

There has been many concerted effort by universities to foster stronger relationships between the academic and public policy arenas. In conferences and seminar of universities issues related to 'public- private partnership' had been emphasized many times.

Understanding the institutional, economic and cultural circumstances within which policy-makers develop and implement solutions:

The professional environments of scientists, agri-business managers and policy-makers are very different. Most scientific research takes place within an academic environment where success is measured by the novelty of the research, its validity and acceptance by fellow

¹⁶ Tijssen, R., and H. Hollanders (2006). Using science and technology indicators to support knowledge-based economies. Policy Brief No. 11. Maastricht, the Netherlands: United Nations University.

¹⁷ The inference is outcome of compilation from the in-depth interviews of scientists working at different institutions like Universities, Private Seed companies, Research Institutes, and NGOs for sharing their experiences along with the interaction with other stakeholders.

academics. In contrast, political success is measured by election or appointment to office which requires policy-makers to answer to a variety of interest groups including stakeholders, constituents, the media, elected officials and the general public. But for agri-business manager they have to satisfy their consumers and ‘dividend based Quarter to Quarter result for shareholder’ is necessary to survive in market. Consequently, scientists, policy-makers and agri-business managers are guided by different types of information. Table 7.4 illustrates some of the key differences.

Table 7.4: Key Differences in Guidance between Agri-business Managers, Policy Makers and Scientists.

Scientists	Policy-Makers	Agri-Business Managers
1. Objective facts	1. Subjective Values	1. Business
2. Proof	2. Beliefs	2. Opportunity
3. Rational	3. Emotional	3. Profit
4. Measurements	4. Perceptions	4. Reality
5. Incremental Progress	5. Deadlines and Crises	5. Consumer satisfaction

Source: Sample Survey

*Finding: Comprehended from interviews

While scientists must judge the quality of their research by its technical strengths, policy-makers must also consider the social acceptability and financial feasibility of a proposed solution to a problem. As a result, scientists can be frustrated when what appears to be the “correct” answer based on scientific values is overlooked for a more politically acceptable solution.

Furthermore, scientific development of useful products and services for agri-business managers requires an understanding of the context in which the products and services will be used. A scientist, whose view is strongly influenced by the boundaries of his own experience, will fail to appreciate the practical needs of an agri-business manager doing business in the “real” world. This disconnects results in a research product that is not useful, and therefore not used, by the agri-business manager.

Most policy-makers, famous scientists included, operate within a “decision space.” This is the range of realistic options available to a policy-maker or manager to resolve a particular

problem. A time has come that effective policies must be scientifically valid, economically viable, and socially acceptable. Among their considerations is whether they have the legal authority to initiate a particular action and whether there is sufficient funding to finance the solution to the problem. In addition, scientist in the India must develop consensus among all the interested parties before taking any action or risk their actions being challenged in court. Most policy-makers and agricultural scientist operate within a highly complex environment constrained by numerous external factors. A successful scientific solution will need to take into consideration each of these external factors.

In order for information to be accepted by a policy-maker and his constituents, it must be credible. Fortunately, good scientific information requires thorough research and documentation which is consistent with the need for credibility. They will want to know who developed the information, why was it developed, did the funder of the research have a particular outcome in mind, and does any contrary research information exist?

It is also important for scientists to think about how accurate and credible the information being produced is compared to how accurate the policy-maker needs it to be in order to be useful. In the context of the type of information produced, how much risk and uncertainty is acceptable to practitioners? Do policy-makers in this area agree on the levels of risk that are acceptable?

And finally, the information must be better than the information available from other sources. It is important for academic researchers to be aware that they are in competition for a decision-maker's attention. Advocates on either side of an issue will be vying for their attention and ultimately, support. Thus, the information must directly and concisely address the decision-maker's questions. It must also be available to the decision-maker when he or she wants it; this may require a researcher to be flexible with his/her time and availability.

Communication and collaboration are the keys to successful relationships

There are multiple facets to communication, some of which require common sense while others require concerted efforts to overcome barriers caused by different training and context.

Often the biggest barrier to interaction between scientists and policy-makers is the lack of awareness of one another's existence. For example, despite the fact that significant research programs devoted to University based biotechnology driven research; Researchers are rarely call upon by policy makers for advice. Legislation is introduced, committee hearings are scheduled and votes are taken, all with little or no input from the local scientific community. Why does this happen? Time and again only some name surface in media as panacea for all agrigarian problems.

Many user groups, including legislators and government agency heads, either have no contact with universities or may not encourage researchers and academics to participate in or observe the decision-making process. In the international context there is numerous protocol and political considerations that affect the willingness to cooperate. However, universities can be excellent locations for developing new ideas and applications like:

- a. Expanding the types of research conducted by scientists to address the needs of local and state governments should be considered. Including policy-makers and other practitioners early in the design phase of research assures that the research is relevant to their particular concerns.
- b. Partnerships between government agencies, agri-business companies, academia, and other stakeholders can be extremely fruitful. Through collaborative efforts by these groups, new relationships are established which can then become the standard approach to future problem solving.
- c. The Internet is playing an increasingly important role in the dissemination of information. Designing scientific websites in consultation with potential users of the information can improve its utilization. Focusing on the kinds of information a policy-maker is interested in and describing how the data were developed, how it was intended to be used, and the current state of the science also improves its chances of utilization.

Unfortunately, policy-makers, agri-business managers are not just looking for technical information; they are often looking for advice, which is inconsistent with the role of scientists. A scientist's desire to be precise about what they know and more importantly, what they do

not know, conflicts with the need for a policy-maker/ agri-business manager or scientists to make a decision.

Policy-makers are interested in developing the best solution under the circumstances. They need to reach conclusions even when inadequate information is available, or there is conflicting information. This may mean that the loudest voice or the person with the greatest access may influence the outcome even though it is not the technically correct choice.

It is incumbent upon the scientist to find ways to meet the needs of the policy-maker and agri-business manager, not the other way around. Longer-term forums provide opportunities for scientists and practitioners to interact can provide opportunities for the facts to be heard and fairly considered. In spite of the urgent need of multidisciplinary approach; still departmentalization & compartmentalization is unbreakable fact. Need of the hour is team-based research rather individual or discipline centered research.

Appreciating the time constraints on policy-makers will improve the utility of scientific research

The utility of information for policy-makers and agri-business managers is directly related to the relevancy of the information and its timeliness. A frequently cited problem concerning the use of scientific research is that the information is not available when needed. Failure to provide information when it is needed may result in the information losing virtually all of its value to the decision-maker.

Policy-makers often operate in a world of crisis management. The crisis of the day, that is, the problem that demands an immediate response, gets their attention. When this occurs, a policy-maker will reach out to persons that are both knowledgeable about the crisis and are immediately available. Rarely does a scientist meet both criteria. He or she has other demands on their time and cannot afford to be “waiting in the wings” for the next crisis that demands their skill set.

It may be more practical for a scientist to establish an on-going relationship with the committee staff or assistants of a decision-maker. There are a couple of reasons for this. First, the staff person will likely be made aware of the policy-maker's need for information to address a particular issue relevant to the scientist's expertise. Second, the staff person is more likely to have the time to meet with the scientist when the issue isn't acute but may become an issue in the future.

7.6 Conclusions

There are many opportunities to improve the utility of agriculture based scientific research through developing new kinds of relationships with decision-makers. The key is developing an appreciation of the constraints and opportunities associated with working in the context of the "real" world, and establishing three-way flows of information with true engagement of decision-makers at one end of the flow, the researchers at the other end and the need of agri-business in Indian environment. Expanded use of intermediaries and translators can enhance the flow of information where scientists and/or agencies do not engage directly with decision-makers. Additional suggestions for increased integration of science and decision making include:

- a. developing and documenting as check-list of the local needs of the stakeholders
- b. facilitating long-term relationships and trust between agri-business managers, scientists and decision-makers.
- c. having people representing different backgrounds and perspectives in the same room when developing short and long-term research agendas

These efforts are important and necessary, and require both financial and institutional support. Evaluation of ways to improve the utility and communication of scientific research is itself a legitimate research objective that will significantly enhance the societal benefits of investments in science. An expanded focus on applied and adaptive scientific research is likely to result in increased interaction with policy-makers and agri-business-managers.

There was general agreement that educational efforts must receive at least as much attention as the technical strategies if there is to be widespread acceptance of the new development as

part of everyone's daily diet. The same scientific rigor that enables GMOs to be created can and should be applied to testing their long-term effects on the environment and making the results quickly and widely known. Respondents also agreed that there were legitimate and valid arguments on both sides of the issues and additional communication was essential to find common ground that would allow technology to be developed and adopted where such actions were in the best interest of society. This way India may get into 'Gene-Revolution' from 'Green Revolution' showing the newer path to be emulated by others.

7.7 Discussions and Future Dimensions

India, as a member of the "WTO", has to take the responsibility and make decisions. And pertinent question exists, who shall be responsible for the decisions: Scientists, politicians, researchers, philosophers, civil society, state institutions, private companies - or all of them together. The decision should be based on scientific knowledge and moral issues. Human activities are subject to ethical and moral laws. Science gives answers to universal questions but is ethically and morally neutral. However, new science brings new technology and this technology can be used in a good or bad manner, creating new ethical problems. The ethical imperatives of responsible citizens are to be informed about the possibilities opened by science and technology and to participate in decision making in an informed way. The problems emerge from the knowledge gained by science, but this knowledge can be utilised by people who may apply the respective technologies carelessly or in wrong ways. The moral obligation of scientists is to inform the general public of the possible ways that scientific knowledge can be used and misused. The general public or its representatives have the moral obligation to understand more about science and technology, and based on this information, make decisions to avoid potential misuses.

The major responsibility of the plant genetic engineers is to assure the safety of the released products to the consumer and to the environment. In order to deal with these issues, it is necessary to assess systematically the types of the engineered plants according to the final product which should be achieved and formulate critical assessment programs for the individual groups. The classification of the engineered plants should be based on three major considerations:

- a. Who are the consumers and what is the purpose of the product? For example, are the engineered products edible or do they provide raw materials for industry?
- b. Do the plants contain detrimental selectable markers for the environment or for health?
- c. What is the capacity of the engineered plants to cross pollinate with wild relatives and become detrimental to the environment?

The parameters which should be carefully monitored for edible modified plants should deal with health-safety of the consumers (i.e. antibiotic resistances if antibiotic resistance markers have been used as selective markers), allergies which can be induced by the modified plant. The selectable markers which cause herbicide resistance should be used only in cases in which it is known that there is an extremely low probability of gene flow to wild-weed relatives. The new strategies for production of modified plants intend to minimise the use of herbicide resistance's as selectable markers.

The risk assessment of the environmental danger resulting from engineered plants is a major concern of people around the world. This issue is being studied and science literature and research do validate that the environmental impact of genetically modified crops brought new information on this topic.

Another issue which should be critically studied is the idea of invasive plant species into territories of non-invasive species. Plants are capable of increase (by propagation and expansion into “new” areas), when rare, and then, they may become invasive (under certain sets of biotic and abiotic conditions). The concept that a plant that is engineered will become invasive was analysed in recent studies and results from rape, maize, potato and beet, show that the likelihood that well regulated genetically engineered plants will unintentionally create problems in respect of invasion is extremely remote.¹⁸

¹⁸ Based on in-depth interviews of scientists, ISAAA Reports and Doctoral Theses from in science.

References:

1. Al-Hammadi, Arif Sayeed Aqulan, *Genetic and Phenotypic Characterization of cotyledon-Mutants of Tomato*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2000.
2. Arvind, P., *Evidence for zinc, amino and organic acids induced protection to cadmium exposed *Ceratophyllum demersum* L.: A free floating aquatic macrophyte*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2004.
3. Chrispeels, Maarten (2003), *Plants, Genes, and Crop Biotechnology* (Boston: Jones and Bartlett)
4. Datta, Sudipta, *Analysis of CaMV 35S Promoter and Testing Synthetic Promoters for Homology based Gene Silencing*, unpublished Ph.D. thesis, Department of Genetics, University of Delhi, Delhi, 2008.
5. Dennis, Elizabeth S. and Danny J. Llewellyn, eds. (1991), *Molecular Approaches to Crop Improvement* (New York: Springer-Verlag Wien).
6. David, Clark (2005), *Molecular Biology* (New York: Elsevier Academic Press), pp.599-633.
7. Dutta, Ajaswata, *Molecular and Abiotic Stress Signal Transduction Studies on TIA Biosynthetic Pathway Genes in Periwinkle*, unpublished Ph.D. thesis, Department of Botany, University of Delhi, Delhi, 2008.
8. Fox, Jeffrey L. (2003), “Resistance to Bt. Toxin Surprisingly Absent from Pests.” *Nature Biotechnology*, Vol. 21, pg: 958–959.
9. Fumento, Michael (2004), *BioEvolution: How Biotechnology Is Changing Our World* (New York: Encounter Books).
10. Gali, Krishna Kishor, *Selection, Characterization and application of fungicide- tolerant or chitinolytic bacteria for control of fungal diseases of groundnut with special reference to the late leaf spot*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2004.
11. Glare, Travis R. and Maureen O’Callaghan (2000), *Bacillus thuringiensis: Biology, Ecology and Safety* (West Sussex: John Wiley & Sons).
12. Hamilton, Kathryn A., Richard E. Goodman and Roy L. Fuchs (2002), *Safety Assessment of Insect-Protected Cotton*, In: “Biotechnology and Safety Assessment, 3rd ed., Thomas, John A. and Roy L. Fuchs, eds.” (San Diego: Academic Press,), pp. 436 - 461.

13. Halford, Nigel, ed. (2006), *Plant Biotechnology: Current and Future Applications of Genetically Modified Crops* (West Sussex: John Wiley & Sons).
14. Hess, David J. (2007), *Alternative Pathways in Science and Industry: Activism, Innovation, and the Environment in an Era of Globalization* (Cambridge: The MIT Press).
15. Irwin, Alan and Mike Michael (2003), *Science, Social Theory and Public Knowledge* (Maidenhead: Open University Press).
16. Jain, Shalu, *Molecular and Biochemical Studies in Stress Sensitive vs. Stress Tolerant Cell Lines of Arachis hypogaea (Peanut)*, unpublished Ph.D. thesis, Department of Botany, University of Delhi, Delhi, 2008.
17. Kranthi, K. R. (2005), *Insecticide Resistance – Monitoring, Mechanisms and Management Manual* (Nagpur: Central Institute for Cotton Research, India).
18. Kung, Shain-dow and Wu Ray, eds. (1993), *Transgenic Plants Volume 1: Engineering and Utilization* (San Diego Academic Press).
19. Kung, Shain-dow and Wu Ray, eds. (1993), *Transgenic Plants Volume 2: Present Status and Economic Impacts* (San Diego: Academic Press).
20. Kumar, Paladugu Kranthi, *Restriction Fragment Length Variation/DNA Methylation in Barley Interspecific Hybrids, Addition Lines and Segmented Aneuploid*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 1997.
21. Kumar, Sarvesh (2003). *A Study of Cotton Seed Marketing: Opportunities and Constraints for Genetically Modified Crops*. (An unpublished Report) School of Management Studies, University of Hyderabad, Hyderabad.
22. Kumari, M. Kavitha, *Molecular Mapping of the polycotyledon Gene in Tomato*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2003.
23. Laju, Paul K., *Molecular Analysis of Light and Hormone Signalling Mutants, *pho1* and *pho3*, of *Arabidopsis Thaliana**, unpublished Ph.D. thesis, Department of Plant Molecular Biology, University of Delhi, 2008.
24. Lal, Shalini, *Screening, EST Profiling and Generation of Transgenic Mulberry for Abiotic Stress Tolerance*, unpublished Ph.D. thesis, Department of Plant Molecular Biology, University of Delhi, Delhi, 2008.
25. Malhotra, Shweta, *Complete Nucleotide Sequence of a 30-Kilobase Plasmid pA387 from *Amycolatopsis benzoatilytica* DSM 43387 and molecular Characterization of the Vector*

- pKVERL2 Capable of Conjugative Transfer from Escherichia coli to Amycolatopsis*, unpublished Ph.D. thesis, Department of Zoology, University of Delhi, Delhi, 2008.
26. Manoj, Kumar, *Expression of Vibrio Cholerae Antigens in Tomato for Development of Plants-Based Oral Vaccine Against Cholera*, unpublished Ph.D. thesis, Department of Plant Molecular Biology, University of Delhi, Delhi, 2008.
 27. Meur, Gargi, *Regulatory gene NPR1 and its role in biotic response in plants*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2005.
 28. Metz, Matthew (2004), *Bacillus thuringiensis: A Cornerstone of Modern Agriculture*, (New York: Haworth Press, Binghamton).
 29. Mittal, Alka, *Characterization of resistance in the diamondback moth to Bacillus thuringiensis Cry toxins*, unpublished Ph.D. thesis, Department of Zoology, University of Delhi, Delhi, 2008.
 30. Pandey, Roopali, *Transgenic Tomatoes for Improved Fruit Characteristics Through Genetic Manipulation of Polyamine Biosynthesis*, unpublished Ph.D. thesis, Department of Genetics, University of Delhi, Delhi, 2008.
 31. Patil, Basavaprabhu L., *Study of Gene Functions in Indian Cassave Mosaic Virus*, unpublished Ph.D. thesis, Department of Plant Molecular Biology, University of Delhi, Delhi, 2008.
 32. Perpich, Joseph G. ed. (1986), *Biotechnology in Society: Private Initiatives and Public Oversight*, (New York: Pergamon Press).
 33. Pooja, Suman, *Pesticide Residue Analysis on Different Matrices: Estimation of Uncertainty and Variability*, unpublished Ph.D. thesis, Department of Zoology, University of Delhi, Delhi, 2008.
 34. Peter, Singer and Jim Mason (2006), *The Way We Eat: Why Our Foods Choices Matter*, (Emmaus, PA: Rodale Books).
 35. Proceeding of **AgriBiotech 2006** (9-11 March, 2006). First International Conference on Biotechnology for Sustainable Agriculture & Agro Industry. Hyderabad Razdan, Anupama *Biotechnological Approaches to Improve Phlox Drummondii Hook* unpublished Ph.D. thesis, Department of Botany, University of Delhi, 2008.

36. Ramchiary, Nirala, *Molecular Mapping of Yield Components and Seed Glucosinolate Traits in Brassica Juncea*, unpublished Ph.D. thesis, Department of Genetics, University of Delhi, Delhi, 2008.
37. Regal, P.J. (1994), "Scientific Principles for ecologically based risk assessment of transgenic organisms", *Molecular Ecology* 3, pp.5-13.
38. Rissler, Jane and Margaret Mellon (1996), *The Ecological Risks of Engineered Crops* (Cambridge: The MIT Press).
39. Ruse, Michael and David Castle, eds. (2002), *Genetically Modified Foods: Debating Biotechnology* (Amherst, NY: Prometheus Books).
40. Schell (1993), *Plant Biotechnology: State of the Art in Developed nations and relevant Safety consideration*, In: "African Regional Conference for International Conference on Safety in Biotechnology. Held during 11-14 October 1993 Harare, Zimbabwe" (Netherlands: MEBO Environmental Consultancy), pp.23-29.
41. Sehgal, Deepmala, *Assaying Polymorphism at DNA Sequence Level for New and Novel, Genetic Diversity diagnostics of Safflower (Carthamus Tinctorius L.), and Phylogenetic Reconstruction of the Genus Carthamus*, unpublished Ph.D. thesis, Department of Botany, University of Delhi, Delhi, 2008.
42. Sharma, Poonam, *Haloalkane Dehalogenase (LinB) is Responsible for β - and δ -Hexachlorocyclohexane Transformation in Sphingobium indicum B90A and IS 6100-Mediated Acquisition of lin Genes via Homologous Recombination*, unpublished Ph.D. thesis, Department of Zoology, University of Delhi, Delhi, 2008.
43. Shekhar, Bhoosani Chandra, *Towards improving protocols for in vitro plant regeneration and Agrobacterium-mediated transformation of indica rice genotype*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 2004. Sharma, Manju (2003). *First Foundation Day Lecture on Regulatory Measure for Utilizing Biotechnological Developments in Different Countries*, TASS, IARI, New Delhi, October 17.
44. Shotwell, Mark A. and Brian A. Larkins (1991), *Improvement of the Protein Quality of Seeds by Genetic engineering*, In: "Plant Gene Research: Molecular Approaches to Crop Improvement, Dennis, E. S. and D. J. Llewellyn, eds." (New York: Springer-Verlag Wien), pp.32-61.

45. Singla, Bhumica, *Molecular Analysis of Somatic Embryogenesis in Wheat (Triticum Aestivum)*, unpublished Ph.D. thesis, Department of Plant Molecular Biology, University of Delhi, 2008.
46. Sree, B. Karuna, *Studies on Water Stress- responsive Proteins and enzymes in Rice (Oryza sativa L.): Identification and Partial Characterization of Aldose Reductase*, unpublished Ph.D. thesis, University of Hyderabad, Hyderabad, 1998.
47. Stevenson, Trevor W. (1991), *Molecular Biology of Flavonoid Pigment Biosynthesis in Flowers*, In: “Molecular Approaches to Crop Improvement. Edited by: Dennis, Elizabeth S. and Danny J. Llewellyn”, (New York: Springer-Verlag Wien), pp.124.
48. Syvanen, Michael and Clarence I. Kado, eds. (2002), *Horizontal Gene Transfer*, (San Diego: Academic Press), pp.455.
49. Thomson, J. R., ed. (1984), *Advances in research and technology of seed: Part 9*. (Pudoc Wageningen: International Seed Testing Association).
50. Vidhyasekaran, P. (2004), *Concise Encyclopedia of Plant Pathology*.
51. Wakelyn, Phillip J., Noelle R. Bertoniere, Alfred Dexter French, Devron P Thibodeaux, Barbara A. Triplett, Marie-Alice Rousselle, Wilton R. Goynes (Jr.), J.Vincent Edwards, Lawrence Hunter, David D. McAlister, Gary R. Gamble (2007), *International Fiber Science and Technology: Cotton Fiber Chemistry and Technology* (Taylor & Francis Group: CRC Press).
52. Young, A.L. (1994), The Scientific Method, *Biotechnology*, 12, p.432.
53. Pollan, Michael (2002), *The Botany of Desire: A Plant's-Eye View of the World* (New York: Random House).

Chapter VIII: Findings and Conclusions

8.1 Findings

Historically the Indian agriculture has been characterized by a mix of both formal and informal seed supply management systems. The formal seed supply component consists of both the public and private sector companies, which have relatively divergent objectives and financial arrangements. Within the informal sector, one can differentiate between seed saved-on farm and that which is obtained from trading and exchange subsystems within the organized or unorganised, which is considered a distinct market.

The subject of biotechnology- especially the advent of genetic engineering – has contributed a substantial part of our knowledge about ‘new science’ and its involvement in new product development, i.e., Genetically Modified Crop (GMC). Ranging from research and development (R&D), new product market through the patent and policy implications, to the management of technological change; the impact of technology is of central concern to the stakeholders and those who seek to analyse the impact of technology. The thesis is an outcome of such an integrative approach towards the subject of ‘potential for new technology’ using a conceptual framework (research and development, new product development and its marketing dimensions, policy implications through patent regime?) to allow a thorough analysis of biotechnological and complementary issues surrounding the strategy and structure of the Indian Seed Industry.

The Seed Industry structure has two components, first Industry level structure and second organisational structure i.e. company or firm level structure. A group of many companies form an Industry. Any change in the industry’s structure does affect a company’s structure explicitly or implicitly, which means any change at macrocosm will affect microcosm. The same holds true for the reverse case as any change at the company level structure will affect the industry level structure. Similarly, technology plays a crucial role as a change agent based on the technological fit (genetic engineering concept) is being used. While ‘change’ is a very relative term, the measurement of the structural change and formulating strategy to accept the change, implement the change in the technological term is contextual. The ‘technology fit construct i.e. the alteration of genetic material of crop for desired trait or change’ and its

outcome in terms of new product development as GMC has redefined the Indian Seed Industry. The role of Monsanto's (Transnational Company) R&D activities/findings and the subsequent licensing to Indian Private Seed companies have led to a market churn leading to structural change of industry as strategic decision of sublicensing. For genetic engineering (Bt. gene) technology supply chain, findings of the thesis lead to inference that it is a monopoly market of Transnational company namely Monsanto. Where as, in product portfolio, i.e. Bt. cotton, the Indian seed market is an oligopoly market. GMC (Bt. cotton – new product) vendor is very evident, because only those companies are able to sell this new product that had paid the license fee to Monsanto. Hence, it is evident that GMC portfolio gives a competitive advantage to the companies having sub-licensing agreement with Mahyco Monsanto Biotech (MMB) over other seed companies.

Rapid changes are taking place in the structure of the Indian Seed Industry and the global seed market. The fundamental role of Indian Government is changing from that of an input provider to a market and policy regulator. Market liberalization and globalization are two powerful forces transforming the agriculture sector and in particular the seed industry in India. The presence of the transnational companies can be felt in Indian seed market in terms of their merger and acquisition, joint venture, licensee companies which are selling their product with their approval or transferring technology to a select few. Bt. cotton is the best example to substantiate this phenomenon.

The Policy initiatives play a very important role and have a direct implication on the Technological Environment in the form of legal construct like; IPR, Environmental Laws & Rules, change in process patent law to product patent law, commitment to international treaties, etc. The effects of scientific technological findings are immense and unstoppable but great care should be taken to avoid misuse in order to employ the efficient tools of science only for the benefit of our society and the country. The Plant Variety Protection (PVP) and Farmers' Right Act, effect on agriculture is:

- i. Investment pattern in plant breeding by private seed companies and public institutions,
- ii. International transfer of plant materials,

- iii. The access to public germplasm,
- iv. The diffusion of seed among farmers and,
- v. Preservation of biodiversity.

Therefore the policy research challenge is to identify and target high-priority biological research and development for arising at managerial solutions to solve critical problems facing the small and marginal farmers.

Experts opine about biotechnology in term of gene expression and the abundance of gene-transcripts which in turn used in new product development, but in reality, they are extrapolating this information from a variety of measurements that different technologies may provide. Indeed, there are many reasons that applying different technologies to gene-transcript abundance may give different results. This may result from an incomplete understanding of the gene in question or from shortcomings in the applications of the technologies. Hence, there are nine basic considerations for making a technology choice for gene expression that will impact the overall outcome viz. architecture, specificity, sensitivity, sample requirement, coverage, throughput, cost, reproducibility, and data management. These considerations will have to be taken into consideration in the context of available transgenic (genetic engineering) technologies which have direct implications on new product development.

The use of Biotechnology for seed improvement is in the evolutionary phase in the Indian seed industry. Genetically Modified Crop as a product portfolio is a gift of biotechnology and the ramification of this technology to different crops is possible. It may be reiterated at this juncture that Biotechnology in the form of GMC is not a panacea to all the problems of Agriculture. Biotechnology is rather a “knowledge resource” that needs to be managed and appropriately leveraged for increased productivity. Biotechnology related initiatives improve Research and Development (R&D) of any company which tries to use it for its competitive advantage. Further, this initiative leads to the enhancement of organizational efficiency in R&D capacity development, thus leading to a niche market for its GMC brand (new seed product brand). This also paves the way to enter in specialized seed portfolio segment produced with the help of biotechnology.

Various researchers have brought out the strategic need for innovation in terms of path breaking radical innovation culminating itself into New Product Development. Observing the current and future demands of market economy, innovation gives a competitive edge to a company over rivals. This competitive edge is in the area of product positioning in the market. The competitive advantage juxtaposes itself as 'profit' with respect to market competition. Though existing products continue in the market, new products and their features lure customers to exploit advantage by fitting according to the customer's need and want. Logically, innovation based new product's basic purpose is to maximize 'profit' for companies. This profit motivation drives companies to invest more in R&D based innovation leading to new technology generation which in turn helps in improvising products. The Biotechnology based GMCs are the classic example of it. In future, with the tools of biotechnology it is possible to manipulate the final output i.e. yields of any crop in qualitative and quantitative ways by altering the seed at genetic level. In future, the competitive strategy will be the number of patents through which genetic nature of product can be manipulated according to the wants of the customers.

The research ascertains that at the beginning when a new product is launched, small and marginalized farmers face the unfavourable terms of trade; pay more for genetically modified seed (new product) than receive from the sale of their output. An improved domestic regulatory framework would intensify competition amongst suppliers of inputs seed and fertilizer. Merely a regulatory structure is not going to improve the state of affairs of small and marginal farmers. At the implementation level, regulatory structure should be proactive in curbing down spurious seed supply; maintaining the price of seeds (because in cropping season at peak time artificial scarcity of seed has been reported by respondents from Nanded, Parbani, Adilabad and Nizamabad districts) at different level of supply chain. It is the small and marginal farmers (consumers) who suffer more because of artificial scarcity of seed created by the retailers and dealers. It was observed that the Bt. cotton seed of Rasi Seeds (one of the company which sells Bt. cotton seed) was available in Bodhan, Mahesa, Dharmabad and Parbani markets if farmers were willing to pay more than maximum retail price (MRP). At the same time zero-Bt. (brand name given by retailers to spurious Bt. seeds: which comprise of seeds of established brands like; Brahma, Rasi, Banni: collected at the time of

ginning. Zero Bt. is the local name of given by retailers to these spurious, uncertified and unbranded Bt. cotton seeds which was reported during the field survey for this research) was available at every retailers shop and it was priced half the price of branded Bt. cotton seed. Since the sowing time lasts only around 10-15 days, farmers have to compromise; at this stage small and marginal farmers are more affected.

As part of the advertising strategy, Private Seed companies promote seeds by donating seeds to select farmers for field demonstration plots; when the seed is typically new and the farmer always be a big farmer, but connoting opinion leaders who tend to be emulated.

In the cropping year 2007-2008 and 2008-2009, because of many new entrants to the Bt. cotton Seed Market with their own Bt. cotton seed brands and Government enforced MRTP Act brought down the peak price of per unit seed packet (of 450 gm/packet) from Rs.2200 to Rs.750. Presence of many companies ensured that the availability of Bt. cotton seed in the market; but still leading to 'Oligopoly Market'. Reduction in price and availability of Bt. cotton seed reduced the black marketing and spurious seed.

The Indian Seed Industry needs a parallel flow/channel/development of knowledge base structure, based on an in-depth understanding of the linkages between research and policy changes and thus can respond quickly to the changing market dynamics and marketing strategies. Taking into consideration the unexplored potential of Genetically Modified Crops, the Indian Seed Industry has tremendous opportunities for the development of improved Genetically Modified Crops. The marketing potential is not only available within the country but also at global level since 23 countries were growing different GMCs by the year 2007.

In addition to the issues mentioned above, the commercial benefits of GMCs should not be neglected. The process of producing a transgenic plant with the desired features and developing it into a final product goes through all the required biosafety tests - is a very long and expensive endeavour. Therefore one should very carefully evaluate the market of the expected "product" i.e. market potential. In addition, as patents, breeders rights, etc. are now covering genes, methods of genetic transformation, different varieties and other "tools" of

genetic transformation, it is imperative to analyse all these issues before starting the long voyage of producing transgenic plants for applied purposes. Some of the key findings of the study are:

- i. Bt. cotton has reduced the demand of pesticides.
- ii. Bt. cotton seed brands have wiped out the demand for hybrid cotton seed brands from the market.
- iii. The Indian Seed Industry is using existing marketing channels to sell biotechnology based new products i.e. Bt. cotton seed (an example of Genetically Modified Crop).
- iv. There is an increase in the R&D expenditure of private seed companies. They are now producing and improving their product lines and product portfolio giving more choices to the consumer (farmer).
- v. There is demand pull from customer side by showing preference to only Bt. cotton seed brands over hybrid cotton seed brands and landrace cotton seed brands. Which is evident by two logic; first customers are ready to pay the price for the new product which is inferred from willingness to pay above maximum retail price, second by purchase decision of customer by buying decision by customer in terms of sale of spurious Bt. cotton seed brands.
- vi. Word of mouth is the most important factor in this market for buying decision process.
- vii. It is being observed that prices of Bt. cotton seed have fallen down as the number of seed companies selling these seed had increased over the years. This also indicates to the oligopoly market.
- viii. All 'Bt. cotton' seed, brands launched in market were brand extension of the companies' best selling hybrid brands.
- ix. According to the Tenth Plan: 'agricultural development is central to economic development of the country' and Seed Policy (Seed is the most important determinant of agricultural production potential on which the efficiency of other agriculture inputs is dependent), the entire agricultural economy can see a transformation if special efforts are undertaken to provide 'GOOD SEED' to the farmers.
- x. The role of the State is also important in reducing the price the Bt. cotton seed [intervention of Govt. of AP through MRTP Act.]

- xi. The farmers are ready to pay for the quality seed. This finding goes contradictory to the previous research and findings which state that farmers want to save money on seed or they are not inclined to pay the price for improved seed.
- xii. In view of India becoming a member of WTO, it is a compulsion to revise the existing Intellectual Property Laws. The new developments in technological areas like Biotechnology expose the inadequacies in the patent system.
- xiii. The four of the most important factors that are currently driving the consolidation of the Indian Seed Industry are:
 - a. The development of new genetic traits of GM crops those are able to (i) increase the efficiency of farm production; and (ii) offer new product specifications for industrial or end users.
 - b. Synergies, whereby research capabilities and technology are shared across multiple product lines.
 - c. Closely linked to the above point, Economies of scale in research and development which is in the area of agri-genomics, marketing and a whole host of other functions. Such economies of scale are of strategic importance, considering the need to invest vast sum of money in regard to biotechnology to develop new GM traits.
 - d. Since, intellectual property rights create barriers to entry, transformation events introduced in plants via biotechnology are protected by patents.
- xiv. The yield/productivity is 'the only' foremost criteria for consumer buying decision.
- xv. First movers are the large farmers; they influence the market directly as small and marginal farmers just imitate them later.
- xvi. Bt. cotton is the classic case of success story as innovated product.
- xvii. Transnational companies in India are to selling their technology through sub-licencing.

8.2 Conclusions

- i. The performance of Bt. cotton seed by controlling pest problem (boll worm problem) and reduction in pesticide spray and increase in yield shows the prowess of

biotechnology. The demand for Bt. cotton seed brands have take away the market from the best performing hybrid seed brands of cotton crop. Bt. cotton case inferred that ‘Gene Revolution’ technology will bring down the demand of ‘Green Revolution’ technologies. Biotechnological innovation based ‘Gene Revolution’ is in the process of creative destruction of ‘Green Revolution’ Technologies.

- ii. It was observed that there have been moves, albeit fairly hesitant, away from government-run seed marketing organizations towards increased participation by the private sector. Bt. cotton seed in India is sold by only private companies. None of the Government organizations like National Seed Corporation or State Seed Corporations have technology to produce Bt. cotton seed. In addition not even government funded research institutes are able to come out with same technology or any substitute to it.
- iii. Earlier the State was playing a major role in ‘new product development’ in seed industry but now it is transnational companies; whose competitive advantage in R&D for the commercialization of knowledge is playing a crucial role. The contextual scenario had raised a new market dynamics comprising of a sequence of DNA, a genome database, a gene patent, a genetic test, a market, a new product, a new innovation, R&D, technology, a crop and the Potential for business. These linkages need to be understood as a single phenomenon.
- iv. An appropriate role of state, market, civil society and natural resource management policy and management is the need of the hour.
- v. The farmers purchase seeds based on the previous year’s performance. As consumers, they experiment with the different brands from different companies. Major players in current year may go in oblivion in the third year if even a small kind of abnormality is found in the final produce in terms productivity or quality along with natural adaptability of the product in local geophysical environment.
- vi. The consequences for farmers:
 - a. The marketing strategy developed by seed companies having possession of new technology had been focused on farmers, *the first customers*; interested in agronomic

traits of GM crops. They have shaped farmers' profitability expectations. In the case of 'Bt.cotton seed', the marketing strategy was based on the concept of 'technological package'. Only Monsanto; a transnational company is selling the GM technology and Indian seed companies are licensed to use the technology to develop their own 'Bt. Cotton seed brand' with the help of gene transfer technique. This allows for 'combined marketing', including adjusting prices of seeds and using the existing distribution channels and existing market.

- b. When selling this technology, Monsanto charges a 'technological fee'. It results from the private origin of the new technology and has to be considered together with property and patenting right. Generally, the technological fee is first paid by seed companies, and is later transferred to farmers. The technological fee imply increased seed cost - as such cost is to be paid each year - and a loss of autonomy for farmers because till now all the gene transfer has been done on the existing hybrid brands rather than variety seeds which can be used for next season as farmers of India are doing it with other crops and what is known as farm saved seed. Till the year 2009 no 'varietal Bt. Cotton seed' has been developed by ICAR led research institutions.

- vii. It was observed throughout the consumer survey that the marketplace had a problem, i.e. 'the saga of boll worm and money spent on pesticides has a purpose to control the chronic return on investment'. Bt. cotton is being sold as 'the technical solution to the identified market problem' that exists and can be solved with technology.

- viii. Supply Chain: From the laboratory to the end user, Genetically Modified Crops make a long journey involving (a) the selection of traits, (b) isolation of gene(s)involved, (c) engineering of gene for suitable expression in plants, (d)production of transgenic plants, (e) molecular, biochemical, and physiological analyses, (f) seed set and inheritance, (g) laboratory testing of traits, (h) greenhouse testing of traits, (i) analysis of toxicity and environmental impact, (j) limited field trial, (k) breeding and field tests, (l) multiplication and distribution system via a national seed system/industry, (m) production by farmer, (n) marketing and (o) the consumer.

- ix. **Applications and Commercialization:** The goal of technology transfer related to biotechnology based innovation has policy component in the form of the Intellectual property Right (IPR). Government funded research has benefited the public, and such benefit includes the development and transfer of technologies from public laboratories to private companies. This phenomenon had made Green Revolution a success story. Translating basic research discoveries into commercial applications and social benefits requires a set of interactions involving many types of people and institutions. Patenting, licensing, and regulatory issues are all areas that affect the rate and cost of technology transfer. In agricultural biotechnology, technology transfer has been hindered by central government in delay of implementing a mechanism to regulate environmental testing of the biotechnology products. Patent policy has been modified at the central level to overcome obstacles that had kept government-and university-sponsored research from being commercially exploited. But in the case of GMC, the entire dimension of collaboration or sub-licensing is, in between the transnational companies to the private seed companies of India.
- x. **Solution to the Customers Problem:** Bt. cotton seed as competitive advantage has mobilized the operation to excel at determining business and product opportunities by engaging the customer, and provided an embedded solution for pest problem (bollworm problem). Bt. gene introduced in the product (cotton plant) which solves customer's problem by producing toxin to kill the pests which thrive on plant for food need, embodied by technology to the plant. The new product is the outcome of Transnational Company's R&D led innovation. The Indian seed industry therefore needs to bring a formidable mix of internal and external to the entire structural format to bear on these opportunities. The better inclusive structures in terms of centralized R&D, the better the chances for growth with profit by solving customers (farmers) problems. This holds good for both public and private sector because the Bt. cotton has improved the yield and reduced the consumption of pesticide.
- xi. **Biotechnology is an interconnected:** Biotechnology is an interconnected race between companies to secure additional business. What one supplier loses in business, another secures. Therefore many companies are moving rapidly to arrive at the opportunity before their competitor and competing in the same market. Initially, there

was no competition in an uncontested area of GMC. Later it was observed that fourteen companies entered in Bt. cotton market with their own seed Bt. cotton seed brands.

- xii. **Coping with technological barrier to entry and using Research and Development as a Competitive Advantage in Market:** Those seed companies who invested in acquiring expertise in biotechnology and equipments that gives them market specific advantage, entered in specialized transgenic seed portfolio. For them, investment in the R&D will not only raise the barrier, but will also lower costs and improve repeatability and quality. These have a disproportionate effect in terms of competitive advantage and position. Investing in Research and Development financed from profits raises the barrier to entry and give a competitive edge in the market place.
- xiii. **Raising the Expectations of the Customer and their expectation from the marketplace, thereby enhancing the companies Position:** Any Company's initiatives should raise the customer's expectations in products and services. Setting the standard for performance in the marketplace makes the competitive advantage to the initiator of the idea. The continual resetting of the customer's expectation level will also raise the barrier to entry from features and services perspective, another difficult target to reach for others. This can also catch others off guard because they would not be able to understand the schedules that the partnership establishes for implementation. Beginning with one company (Mahyco Monsanto Biotech: MMB) in 2002, it has increase to 14 companies in 2007 and from 3-approved types of Bt. cotton seed brands to 62-approved types of Bt-cotton seed brands in the year 2007. Indian seed companies paid the sub-license fee for the use of technology.
- xiv. Small and marginal farmers are the worst affected. They are completely unprotected in the hand of market forces. They even do not have strength to avail whatever facility and security provided by the state. Role of State as 'implementer' of the rules, regulation and policy is more crucial now then ever. [Based on consumer survey, i.e. farmers' survey].
- xv. The role of so called 'progressive farmer' is important but at the same time it is questionable. They are actually the big and rich farmers. They have a major say in the local village economy. Their strength is their large land holding and their allied roles

at the same time. Their role as moneylender, middlemen, local agriculture input seller and buyer of the final produce metamorphosis in different time in the agricultural season.

- xvi. Success story of Bt. Cotton will pave the way for other Genetically Modified crops like, golden rice and other genetically engineered products.
- xvii. As an agricultural input seed is the only product which never get discount and money is paid at the time of purchase that too in cash. Further it was observed that dominant brands of market advance booking are done by consumer.
- xviii. Slowly, concentration of the seed business will be dominated by big companies.
- xix. Proprietary issues may lead to the introduction of terminator technology in the market to protect the market.
- xx. Harnessing the comparative advantages of the public and the private sector is a prerequisite for the efficient provision of highly beneficial biotechnology innovations for the Indian Seed Industry.
- xxi. Agricultural research can meet the increasing demands of farm production by using Biotechnology. To achieve this, there will have to be a paradigm shift from the technological methodologies held in the 1970s and 1980s. A radical change and transformation in the thought processes that plan the needs of the new century. Conservative and obsolete policies drawn from an older era will have to give way to realistic measures reflecting the urgency of the demand for technological breakthroughs. The success of the Green Revolution of the earlier decades will now have to be repeated through a Biotechnological revolution.

8.1.1 Hypotheses

The detailed quantitative and qualitative analyses performed on the responses of the different stakeholders like consumers, managers, scientists, NGOs, dealers, retailers etc. of the Indian Seed Industry based on primary and secondary data concludes following:

Hr1: GM crops provide higher yield, improve pest control, provide drought resistance, reduce dependence on chemical fertilizer, short growing season. Therefore it is better for overall economy; society.

Based on finding from chapter 4 and chapter 7 this hypothesis is **accepted**.

Hr2: Indian market has the potential for GM product.

Based on finding from chapter 4 and chapter 7 this hypothesis is **accepted**.

Hr3: Farmers get more choice.

Based on finding from chapter 4 and chapter 7 this hypothesis is **rejected**. In fact GMC has synchronized the option.

Hr4: Genetically Modified Crop has a positive impact on socio-economic status of farmer.

Based on finding from chapter 4 this hypothesis is **accepted**.

Hr5: Structure of Industry changes in response to market.

Based on finding from chapter 5 and chapter 6 this hypothesis is **accepted**.

Chapter IX: Recommendations

9.1 Suggestions and Recommendations:

- i. The Indian Seed Industry needs to take careful steps before going ahead considering the Biotechnological solutions; as Green revolution was the outcome of public research initiative and Gene revolution is a product of private research initiative. Harnessing the comparative advantages of the public and the private sector is a prerequisite for the efficient provision of highly beneficial biotechnological innovations for the Indian Seed Industry.
- ii. The issue of Biotechnology related risk-assessment should be handled by appropriate working groups as discussed and dealt with the ethical, legal, environmental and long-term implication of genetically engineered crops. Representatives of all parties and experts in the field should be members of national scientific committees. Plant genetic engineers, ecologists, physicians, environmentalist, legal experts, representatives of the public and administration should participate in the committees in country like India in order to deal critically with each problem, and should issue specific directives for future cases.
- iii. Research on Genetically Modified Crops must be focused and prioritized with problems considered in the Indian context. For example, in the case of pulses, conventional breeding has not succeeded in creating many new varieties. As regards the prioritization of research, budgets should not be spent on researching everything but selected crops should be studied by public institutions and research centers. The concept of genetic engineering research has to be strictly assessed in the paradigm of policy in the Indian context and scientific infrastructure with results, excellence and accountability.
- iv. Strategies for National Competitiveness: It is important to develop a national strategy for biotechnology in agriculture because biotechnology offers opportunities for increased sustainability, profitability, and international competitiveness in agriculture. Biotechnology research spans a continuum from basic science through practical application; its practitioners must be conversant with the general biology of an organism, with the biochemical and genetic details of its life cycle, and with the needs

of modern agriculture. The national strategy for biotechnology in agriculture must focus on solving important scientific and agricultural problems and institutional structures available to support research, training researchers in new scientific areas, and efficiently transferring technology. Along with it, there is an urgent need of a single window monitoring body which can act like a 'watchdog' on agriculture related issue.

- v. To strengthen the Indian Seed Industry, multi-directional communication is required among stakeholders like farmers, seed companies, policymakers, Universities, research stations, researchers and civil society, etc.; which will in turn anticipate the opportunity and risk related to Genetically Modified Crops.
- vi. The understanding of linkages between biotechnological research and policy change assumes a lot of importance so, to respond quickly to changing market dynamics and opportunities in new techno-based market. For Indian Seed Industry, it is time for restatement of long - term strategy, both to guide activities in the coming years and to stimulate dialogue among stakeholders. These developments include a changed political and economic context since implementation of the recent patent policy has brought new dynamics within the Indian Seed Industry because of technological innovation, affordability and accessibility of techno-based product by farmers as well as seed companies (end consumer and intermediary consumer).
- vii. University - Industry - Government relations need to be strengthened so that the Biotechnology based innovations which are the outcome of basic research and since it needs altogether different skills than other technological break through. Most of the works are confining to laboratory conditions. Universities have this kind of set-up but them short for funds and mostly dependent on governmental funding or research grants. Industry lacks such a kind of expertise but have money to share some financial burden of research. Government can play a mediator between Industry and University. This will reduce the cost of Research and Development substantially and the technology developed therefore can be low cost and affordable.

The other method can be making a consortium by bringing many companies together. This consortium can fund and direct the Universities towards some of the research

questions and needs which can bring the solutions for the common problem. This strategy also reduces the cost of research. Here too, role of government is important as a mediator and observer.

- viii. The interaction among agricultural universities, seed industry, and government may be the future key to innovation and growth in a biotechnological knowledge-based product like GMC, in the Indian seed market. Government needs to formulate and implement a strategic vision towards harnessing the potential benefit of new technology; proactive legal initiatives over academic resource such as university intellectual property emanating from research leading to institutional capacity to transfer technology through patenting, licensing, and incubation will help the industry in long run.
- ix. Stringent policies addressing parallel black marketing of uncertified seed, curbing down spurious seed and adherence of Maximum Retail Price need to be devised. Along with this a very efficient and effective law enforcing network need to be created.
- x. Policies and interventions need to be drawn for price regulation and establishment monitoring structure need to be strengthened.
- xi. The private players in Indian seed industry are small and mostly are tiny companies started by new generation of entrepreneurs during post 1980's. They mostly buy foundation seed from Agriculture research station and develop their own certified seed; adhering to law of the land they sell certified seed in market. Some of these companies could able to produce better quality of seed through their own R&D facility in due course of time. After that they become leader in certain crops hybrid seed in Geographical niche market. After the advent of Biotechnology and the kind of financial support needed for the development of GMC, which is beyond the financial strength of these companies, this will lead to perpetual dependence on MNC' technology transfer. Therefore, in such condition a consortia of Indian seed companies can be formed by a group of these Indian private companies to reduce the R&D expenditure and success in product development can be shared by the members of the consortia. A time may come that this type of consortia will be able to sell their own technology.

- xii. Government has to take a firm and bold initiatives to break silo effect and departmentalized mindset of scientists and take necessary steps so that they work as team, to solve Indian agriculture related problems.
- xiii. India has a huge agriculture research infrastructure in the form of ICAR run research institutions and agricultural universities. Leveraging on it and firm action on scientist politicizing the system for their name and fame should be restricted. Repetitive research should be discouraged. Young scientists should be given a degree of freedom so that they can freely use their mind for knowledge generation rather than mundane administrative work. Even after more than ten years of Bt. cotton story, none of the central government research institutions could able to come up with its own Bt. technology or any kind of substitute. This questions the capability of such a money guzzler public sector research infrastructure. Meanwhile China could able to produce it own Bt. technology and marketing it to other countries including India. Today China holds first position in cotton production in the world.
- xiv. It seems time has come when, rather than creating knowledge, government research institutions should focus on applied and commercial aspect of innovation and technology.
- xv. When the goal of public and private sector seed companies are same i.e. to provide good quality certified seed; Government can take initiative to create a structure which is inclusive of both and tuned to the goal.
- xvi. The cause of low farm productivity is the use of landrace seed varieties. Seed replacement in phased manner ensure better yield. Even though better qualities of seed developed in Agriculture research stations are available; farmers are not aware of them. Agriculture extension officers can play a vital role by designing a communication channel which touches every village and educate farmers by informing the benefits of seed replacement by better quality of seeds, produced through R&D efforts of Agricultural Universities and Government Research Institutions.
- xvii. The role of Agriculture officers is going to be crucial with respect to GMC seed. First they will be acting as law enforcer and second, as touch point for source of information.

- xviii. Government of India initiatives are required to develop GMC in the form of variety seed so that farmers can reuse the farm saved seed for next growing season.
- xix. Private companies and research institutions should make negotiable arrangements to share the GM technology.
- xx. The relationship between research institutes and Indian seed industry needs to be strengthened, to fully realize the commercial benefits through a clear economic analysis of the benefits of transgenic crops.
- xxi. The role of media must be balanced based on scientific data rather than on sensationalism. They should emphasize publishing technically correct information rather than selling more copies. The mainstream population must be involved and communicated to without hype or false hope.
- xxii. The modus operandi adopted by the Government of India for sustaining the Green Revolution is not applicable to biotechnology. When the seeds of the Green Revolution were first tested and their efficacy established the government was confronted with the problem of finding ways to produce and distribute them among farmers. The Government set up state seed corporations, and enacted seed laws in 1966. Directions for promoting state seed corporations by the Ministry of Agriculture and National Seeds Corporation were such that the seed production capacity in India was enhanced, and the Green Revolution became sustainable. Whereas in the case of biotechnology, the government has taken a number of bold steps. It has set up the Department of Biotechnology (DBT) where scientists are encouraged to carry out research in biotechnology. Institutes such as the Council for Scientific and Industrial Research (CSIR) and universities have responded in an impressive manner to the research initiatives of the DBT. Research in biotechnology is expensive and though many institutes are involved in carrying out research, considerable investment is still required. Therefore, the private sector can play an important role in accelerating research in biotechnology. It can emerge as a producer of seeds. Also because research by itself cannot reach the market unless suitable systems are evolved, the country's private sector can play a meaningful role in taking the products of biotechnology to the people.

- xxiii. There is also a need to foster research into the social, ethical, economic, and environmental impacts of emerging technologies in agriculture as this will not only help predict any negative ramifications of such interventions but also evolve strategies to deal with them.

9.2 Scope for Future Research

This study laid a foundation for multi-directional research for future enquiry. The methodology can be used for studying other GMCs and proliferation of biotechnology to other industry like pharma-sector. Some of the areas which could be:

- i. Product cost analyses for Genetically Modified seeds.
- ii. The study can be extended to other crop.
- iii. The relationship between consumer and scientific forms of knowledge and understanding.
- iv. The study, consumer understanding as central theme from policy perspective.
- v. From the link to science and technology to the direct relationship between industry and stakeholders, wherever biotechnological ramification is visible.
- vi. Debate on convention on Biological Diversity and argument like ‘who own traditional knowledge is the unanswered area for scientist. At the same time what type of changes will occur not only in Indian Seed Industry but also other industries where biotechnology is going to play a leading role? Biotechnology related industries need to be assessed based on ‘how sanitary and Phytosanitary Standards (SPS) and Technical Barriers (TBT) will be measured. How these two factors is going to churn Indian Seed Industry. Standards on these two factors are basically set by the scientific community because they are being considered as expert on science related knowledge.
- vii. Future research in biotechnology related managerial issues have to take consideration of the recent happenings like mad-cow disease, bird-flu and swine-flu because in term of knowledge capital we are trying to capitalize on the basic unit of life i.e. DNA.
- viii. Biotechnology is new technology and its diffusion will bring new dimension to the market which re-orient the concept of knowledge management, technology management, innovation and business research methodology. These areas of knowledge need further research from business management perspectives.

Glossary

Acre: the imperial unit of area, equal to 4840 square yards, and approximately 0.4 hectare.

Antibiotic: A compound produced by a microorganism that kills other microorganisms or retards their growth. Genes for antibiotic resistance are used as markers to indicate that successful gene transfer has occurred.

Anther: the part of a stamen that produces the pollen grains, which contain the male gametes.

Bacillus thuringiensis: A bacteria that produces a toxic poison to certain types of insects.

DNA: A double-helix shaped molecule inside cells that carries the genetic information.

Gene: a discrete unit of inheritance represented by a length of DNA located in a chromosome. The gene is a code for the production of a specific kind of protein or RNA molecule, and therefore for a specific inherited characteristic.

Genetically modified food: A food product that contains a genetically modified plant or animal as an ingredient.

Hectare: the metric unit of area, equal to 10 000 square metres, or 2.471 acres.

Herbicide: A chemical substance used to kill weeds or undesirable plants.

Hybrid: the progeny of two distinct parents, which may be different species belonging to the same genus or two varieties of the same species. In rare cases, hybrids are formed across a generic barrier.

Insecticide: A chemical that kills insects. Used in agriculture to kill insects that eat crops.

Mutagenesis: the natural low incidence of mutations can be magnified by exposing seeds or other plant parts to ultraviolet or gamma radiation, or to chemicals such as bisulfite and ethylmethanesulfonate.

Mutation: a change in a gene. The substitution of a single base in DNA can lead to a simple or 'point' mutation, changing the identity of a single amino acid in a particular position in a polypeptide. Deletion or insertion of one or more bases causes a 'reading frame' shift during translation, resulting in substantial changes to the amino acid sequence in a polypeptide. Even a point mutation can lead to the production of an inactive enzyme if it occurs in a critical position that contributes to the catalytic site. A good example is the abrupt conversion of coloured petals to white in many flowering plants, which indicates the loss of an active enzyme somewhere in the pathway leading to anthocyanin pigment production.

Organic farming: Farming that uses no artificial chemicals or genetically engineered plants or animals.

Pesticide: A chemical meant to kill plants or insects that hurt crops.

plant breeding: the crossing of distinct parents followed by selection from the progeny constitutes breeding; selection alone does not constitute a breeding program. To recognise that crossing has taken place via natural agencies (wind or insect pollination) is valuable, but varieties so obtained are merely discoveries. A plant breeder worthy of the title will replicate a suspected parentage by experimental crossing and selection.

Resistance: An immunity developed within a species (especially bacteria) via evolution to an antibiotic or other drug.

Seed: a fully developed ovule, containing a plant embryo, with or without distinct endosperm, and surrounded by a seedcoat or seedcoats. Sometimes fruit coats enclose the seed, as in the grains of cereals.

Species: a 'kind' of living organism. The individual members of a species are interfertile (at least in theory, because this is prevented by self-fertilization in some plants, such as peas). A plant species may or may not have an impediment to breeding freely with its closest relatives in the same genus.

Sterility: the inability to produce functional gametes, either egg cells, or sperm cells in pollen grains. Male sterility can be cytoplasmic or nuclear in origin; cytoplasmic male sterility involves a factor coded in the mitochondrial genome.

transgenic plant: a plant that has been transformed by incorporation of a construct that includes a gene or genes from another species of plant, or any other kind of living organism, or a virus.

Toxin: A poison that is produced by a living organism.

Transgenic: A genetically engineered animal or plant that contains genes from another species.

Transgenic plant: A plant that has successfully incorporated a transferred gene or constructed piece of DNA into its nuclear or plastid genomes.

Variety: a distinct type within a species, equivalent to cultivar for cultivated plants.

References and Bibliography

Books:

- Acharya, K. C. S. (1983), *Food Security System in India*, (New Delhi: Concept Publishing Co.).
- Adede, A. O. (2001), *The Political Economy of TRIPS Agreement: Origins and History of Negotiations*. ICTSD, ACTS & QUNO, July 2001.
- Alagh, Y.K., ed. (2003), *Globalisation and Agricultural Crisis in India*, (New Delhi: Deep & Deep Publications in association with Indian Economic Association).
- Alam, Ghayour (2004), *Technology Generation and IPR issues (State of Indian Farmer, A Millenium Study: Volume-5)*, (New Delhi: Ministry of Agriculture, Government of India).
- Alam, Ghayour (2001), *Indian Agricultural Research past performance and emerging Issue*, (New Delhi: Centre for Technology Studies, Ministry of Agriculture, Government of India).
- Atherton, K. T., ed. (2002), *Genetically Modified Crops: Assessing Safety*, (London: Taylor and Francis).
- Baligh, Helmy H. (2006), *Organization Structures: Theory and Design, Analysis and Prescription*, (New York: Springer Science and Business Media).
- Bernal, J.D. (1965), *Science in History (Vol-3: The Natural Sciences in our Time)*, 3rd ed., Penguin Books, (Published by all India People Science Network on arrangement with Trustees of Bernal Estate). pp.971-972.
- Bhale, N. L., (1999), "*Heterosis Breeding in Cotton*", In, *Handbook of Cotton in India*. Mumbai: Indian Society for Cotton Improvement).
- Bhalla, G.S. and Gurmail Singh (1996), *Impact of GATT on Punjab Agriculture* (Chandigarh: Institute for Development and Communication).
- Bhalla, G. S. and Gurmail Singh (2001), *Indian Agriculture: Four Decade of Development*, (New Delhi: Sage Publication (India)).
- Bossche, Peter Van den (2005), *The Law and Policy of the World Trade Organization: Text, Cases and Materials* (Cambridge: Cambridge University Press).

- Braun, Joachim von, M. S. Swaminathan, and Mark W. Rosegrant (2004), *Agriculture, Food Security, Nutrition and Millennium Development Goals* (Washington: IFPRI).
- Brooker, G. and P. Barfoot (2008), *GM Crops: Global Socio-economic and Environmental Impacts 1996-2006*, P.G. Economics.
- Bud, R. (1993), *The Uses of Life: A History of Biotechnology*, (Cambridge: Cambridge University Press).
- Busch, L., W. B. Lacy, J. Burkhardt and L. R. Lacy (1991). *Plants, Power, and Profit: Social, Economic, and Ethical Consequences of the New Biotechnologies* (Cambridge: Blackwell).
- Chandrasekhar, C.P. and Jayati Ghosh (2002), *The Market That Failed: A Decade of Neoliberal Economic Reforms in India* (New Delhi: LeftWord).
- Cherunilam, Francis (2001), *Global Economy and Business Environment* (Mumbai: Himalaya Publishing House).
- Chrispeels, Maarten (2003), *Plants, Genes, and Crop Biotechnology*. (Boston: Jones and Bartlett).
- Cliff, Stafford (2001), *50 Trade Secrets of Great Design Packaging* (Massachusetts: Rockport Publishers,
- Conway Gordon (1997), *The doubly green revolution: food for all in the 21st century*. (London: Penguin), p.334.
- Dennis, Elizabeth S. and Danny J. Llewellyn, ed. (1991), *Molecular Approaches to Crop Improvement* (New York: Springer-Verlag Wien).
- David, Clark (2005), *Molecular Biology* (New York: Elsevier Academic Press).
- Desai, D. K. and Hari Prakash (1973), *Indicators of Change in Indian Agriculture 1961-971*. In, *New Opportunities in Changing Agriculture*. (Ahmedabad: Centre for Management in Agriculture, Indian Institute of Management), pp.11-35
- Dreyfus, Hubert L. and Mark A. Wrathall (2006), *A Companion to Phenomenology and Existentialism*. (Oxford: Blackwell Publishing).
- Dubey, Muchkund (2005), *WTO and South Asian Countries: Developing Unison*, (New Delhi: South Asian Yearbook of Trade and Development, Centre for Trade and Development).

- Evens, Ronald P., ed. (2007), *Drug and Biological Development - From Molecule to Product and Beyond* (New York: Springer).
- Engels, Frederick (1976 reprint), *Dialectics of Nature*. (Moscow: Progress Publishers).
- Erbisch, F. H. and K. M. Maredia, ed. (1998), *Intellectual Property Rights in Agricultural Biotechnology*, (Oxford: CAB International).
- Evans, Phillip (1996), *Unpacking the GATT: A Step by Step Guide to the Uruguay Round*, (Calcutta: Consumer Unity & Trust Society (CUTS)).
- Fedoroff, Nina and Nancy Marie Brown (2004), *Mendel in the Kitchen: A Scientist's view of Genetically Modified Foods* (Washington: Joseph Henry Press).
- Fraley, R.T., S.G. Rogers, R.B. Horsch, G.M.Kishore, R. Beachy, N.Tumer, D.A. Fischhoff, X. Delannay, H.J. Klee and D.M. Shah (1988), "Genetic Engineering for Crop Improvement. In: Chromosome Structure and Function ed.: Gustafson, J.P and R. Appels", (New York: Plenum), pp. 283-298.
- Frank, Robert H. (1991), *Microeconomics and Behavior* (New York: McGraw-Hill).
- Frankel, R. Francine (2005). *India's Political Economy 1947-2004*, 2nd ed. (New Delhi Oxford University Press).
- Friedman, Thomas L. (2005), *The World is Flat: A Brief History of the Twenty-First Century*, (Farrar Straus and Giroux).
- Fumento, Michael (2004), *BioEvolution: How Biotechnology Is Changing Our World*, (New York: Encounter Books).
- Galbraith, John Kenneth (1962), *Economic Development in Perspective* (New York: Fawcett Publications Inc.).
- Ganguli, A.S. (1985), *Biotechnology- New Frontiers in Indian Agriculture* (Bombay: Forum of Free Enterprise).
- Ghosh, Ambica (1988), *Emerging Capitalism in Indian Agriculture: The Historical Roots of Its Uneven Development*, (New Delhi: People's Publishing House).
- Gittinger, J. Price (1982), *Economic Analysis of Agricultural Projects*. , 2nd ed., EDI Series in Economic Development, (Baltimore: The Johns Hopkins University Press).
- Glare, Travis R. and Maureen O'Callaghan (2000), *Bacillus thuringiensis: Biology, Ecology and Safety* (West Sussex: John Wiley & Sons).
- Haig, Matt (2003), *Brand Failure* (London: Kogan Page).

- Hall, G. (1995). *Genetically Modified Organism*, In ed.: G. T. Tzotzos, “A Guide to Biosafety (Oxon: CAB International).
- Hage, Jerald and Marius Meeus, eds. (2006), *Innovation, Science, and Institutional Change*, (Oxford: Oxford University Press).
- Halford, Nigel, ed. (2006), *Plant Biotechnology: Current and Future Applications of Genetically Modified Crops* (West Sussex: John Wiley & Sons).
- Hamilton, Kathryn A., Richard E. Goodman and Roy L. Fuchs (2002), *Safety Assessment of Insect-Protected Cotton*, In: “Biotechnology and Safety Assessment, 3rd ed., Thomas, John A. and Roy L Fuchs, eds.” (San Diego: Academic Press), pp. 436 – 461.
- Herring, Ronald J. (2004), *Political Ecology from Landscapes to Genomes: Science and Interest* (New York: Cornell University, Ithaca).
- Hazell, Peter B. R. and C. Ramasamy, ed. (1991), *The Green Revolution Reconsidered-The Impact of High-Yielding Rice Varieties in South India* (Published for the International Food Policy Research Institute by The Johns Hopkins University Press: Baltimore).
- Holmes, Frederic Lawrence (2001), *Meselson, Stahl and the Replication of DNA: A History of ‘The Most Beautiful Experiment in Biology’* (New Haven: Yale University Press).
- Howe, C.J. and J.S. Ward (1989), *Nucleic Acid Sequencing - A Practical Approach* (Oxford: Oxford University Press).
- Hunt, E. K. (1972), *Property and Prophets: the evolution of economic institutions and ideologies* (New York: Harper and Row).
- Hunt, Shelby D. (2003), *Foundations of Marketing Theory: Towards a General Theory of Marketing* (New Delhi: Prentice-Hall of India).
- Jha, Dayananth (2003), *Agricultural R&D in India: Growth, Equity and Institutional Challenges*, In “India's Agricultural Challenges: Reflection on Policy, Technology and Other issues”, pp.171-195.
- Johnson, Stanley (1974), *The “Green Revolution”* (London: Hamilton).
- Jones, D. D., and J. H. Maryanski (1990), *Safety considerations in the evaluation of transgenic plants for human food*. In: “Risk Assessment in Genetic Engineering, M. A. Levin and H. S. Strauss, eds.” (New York: McGraw-Hill), p. 70.

- Kaplan, Robert S. and David P. Norton (1996), *The Balance Scorecard: translating strategy into action* (Boston: Harvard Business School Press).
- Katiyar, R.P. (2000), *Intellectual Property Right and Agriculture*, In: Recent advance in seed science and technology, A. Gour, A. K. Vari, K. Kant and S.P. Yadav, eds. (New Delhi: IARI), pp.137-143.
- Ketchen Jr., David J. and Bergh D. Donald eds. (2005), *Research Methodology In Strategy and Management Volume 2* (Oxford: Elsevier Ltd.).
- Kitcher, Philip (2001), *Science, Truth, and Democracy* (New York: Oxford University Press).
- Kloppenburg, J. R., Jr. (1988), *First the Seed: The Political Economy of Plant Biotechnology, 1492-2000* (Cambridge: Cambridge University Press).
- Kranthi, K. R. (2005), *Insecticide Resistance – Monitoring, Mechanisms and Management Manual* (Nagpur: Central Institute for Cotton Research, India).
- Kung, Shain-dow and Wu Ray, eds. (1993), *Transgenic Plants Volume1: Engineering and Utilization* (San Diego: Academic Press).
- Kung, Shain-dow and Wu Ray, eds. (1993), *Transgenic Plants Volume 2: Present Status and Economic Impact* (San Diego: Academic Press).
- Lewin, Benjamin (2004), *Gene VIII* (New Jersey: Pearson Prentice Hall).
- Lin, Nan (2001), *Social Capital: A Theory of Social Structure and Action* (Cambridge: Cambridge University Press).
- Luis Destefano-Beltran, P. Nagpala, K. Jaeho and J. M. Dodds (1991), *Genetic Transformation of Potato to Enhance Nutritional Value and Confer Disease Resistance*. In “Molecular Approaches to Crop Improvement. Edited by: Dennis, Elizabeth S. and Danny J. Llewellyn” (New York: Springer-Verlag Wien).
- Martineau, B. (2001), *First Fruit: The Creation of the FlavrSavr Tomato and the Birth of Genetically Engineered Food* (New York: McGraw-Hill).
- McDonald, Miller B. and Francis Y. Kwong ed. (2005), *Flower Seeds: Biology and Technology* (Oxfordshire: CABI Publishing).
- Merton, Robert K. (1968), *Social Theory and Social Structure* (New York: The Free Press).
- Metz, Matthew (2004), *Bacillus thuringiensis: A Cornerstone of Modern Agriculture*. (Binghamton: Haworth Press, NY).

- Michman, Ronald D. and Edward M. Mazze (1998), *The Food Industry Wars: Marketing Triumphs and Blunders* (Westport: Quorum Books).
- Miles, Raymond E. and Charles C. Snow (2003), *Organizational Strategy, Structure, and Process*, reprint, (Stanford: Stanford University Press).
- Misra S.K. and V.K. Puri (2007), *Indian Economy - Its Development Experience* (Mumbai: Himalaya Publishing House).
- Murthy, N. Linga, K. Venkat Narayana, T. Papi Reddy, M. Ashok Kumar, “*Pattern of Development in India: A study of Andhra Pradesh*” (Warangal: Department of Economics (sponsored by Planning Commission, Government of India), Kakatiya University).
- Murray, David R. (2003), *Seeds of Concern: the genetic manipulation of plants*, (Australia: University of New South Wales Press and CABI Publishing).
- Murray, David R., ed. (1991), *Advanced Methods in Plant Breeding and Biotechnology*. (Oxford: CAB International).
- Murty, A. G. K. and D. K. Desai (1970), *A Study on multi-nutrient fertilizer market: A Pilot study in Guntur District, Andhra Pradesh*, (Ahmedabad: Faculty for Management in Agriculture and Co-operatives, Indian Institute of Management).
- Narayanan, V. K. (2001), *Managing Technology and Innovation for Competitive Advantage*, (New Delhi: Peason Education Asia).
- Nicotera, Anne Maydan, Marcia J. Clinkscapes and Felicia Walker (2003), *Understanding Organizations Through Culture and Structure: Relational and Other Lessons From the African-American Organization* (Mahwah: Lawrence Erlbaum Associates).
- Norelli, J.L. and H.S. Aldwinckle (2000), *Transgenic varieties and rootstocks resistant to fireblight*, In: “Joel L Vanneste, ed., *Fire Blight - the Disease and its Causal Agent, Erwinia amylovora*”, (Oxford: CAB International), pp. 275–92.
- Oden, Howard W. (1999). *Transforming the Organization: A Social-Technical Approach*. (Westport: Quorum Books).
- Paarlberg, R. L. (2001), *The Politics of Precaution: Genetically Modified Crops in Developing Countries*, (Baltimore and London: International Food Policy Research Institute).

- Pinstrup-Andersen, Per and Ebbe Schioler (2001), *Seeds of Contention: World Hunger and the Global Controversy over GM Crops* (New Delhi: Oxford University Press).
- Pollan, Michael (2002), *The Botany of Desire: A Plant's-Eye View of the World* (New York: Random House).
- Pray, C. and R. Basent (2000), *Issue in Private Agriculture Research* (USDA: AER, Economic Research Service), pp.32-55.
- Pray C. E., and B. Ramaswami (1991), *A Framework for Seed Policy Analysis in Developing Countries*, (Washington D.C.: International Food Policy Research Institute).
- Pride, William M. and O.C. Ferrell (2000), *Marketing: Concepts and Strategies*, 10th ed. (Chennai: All India Publishers & Distributors).
- Primrose, S. B. (1987), *Modern Biotechnology* (London: Blackwell Scientific Publications).
- Pua, E. C. and M. R. Davey, ed. (2007), *Biotechnology in Agriculture and Forestry: Transgenic Crops (V)* (Heidelberg: Springer-Verlag Berlin).
- Rabinow, P. (1996), *Making PCR: A Story of Biotechnology* (Chicago: University of Chicago Press).
- Rai, M. and B. M. Prasana (2000), *Transgenic in Agriculture* (New Delhi: Directorate of Information and Publication of Agriculture, Krishi Bhawan, ICAR publication, Pusa).
- Ramu, S. Shiva (1997), *International Joint Ventures* (New Delhi: Wheeler Publishing).
- Randhawa, M.S. (1974), *Green Revolution-A case study of Punjab* (New Delhi: Vikas).
- Randhawa, M.S. (1982), *A History of Agriculture in India [Volumes-I, II & III]* (New Delhi: Indian Council of Agricultural Research).
- Randhawa, M.S. (1982), *A History of Agriculture in India: Volume-IV* (New Delhi: Indian Council of Agricultural Research).
- Rao, C. H. Hanumantha (1975), *Technical Change and Distribution of Gains* (Macmillan India).
- Rao, Y. V. Krishna, ed. (1997), *The Impact of GATT and Economic Policy on Indian Agriculture* (New Delhi: People's Publishing House).
- Ravinder, Reddy Ch, V.A. Tanapi, P.G. Bezkorowajnyj, S.S. Navi and N. Seetharama (2007), *Seed System Innovations in the semi-arid Tropics of Andhra Pradesh*. (India: International Livestock Research Institute (ILRI), ICRISAT, Patancheru, Andhra Pradesh).

- Reddy, P.P. and A. Jyothy, ed. (1991), *Biotechnology: Human Welfare* (Hyderabad: Osmania University).
- Rissler, Jane and Margaret Mellon (1996), *The Ecological Risks of Engineered Crops*, (Cambridge: The MIT Press).
- Rond, Mark (2003), *Strategic Alliances as Social Facts: Business, Biotechnology, and Intellectual History*, (Cambridge: Cambridge University Press).
- Roussel, P., K. Saad and T. Erickson (1991), *Third Generation R&D* (Cambridge, MA: Harvard University Business School Press).
- Ruse, Michael and David Castle, eds. (2002), *Genetically Modified Foods: Debating Biotechnology* (Amherst, NY: Prometheus Books).
- Sahai, Suman (2004), *Is Agbiotechnology suited to Agricultural Production in India? India's Agricultural Challenges: Reflection on Policy, Technology and other issues*. pp.161-170.
- Santhanam, V. and Sundaram, V. (1999), *Historical Perspective of Cotton in India, Handbook of Cotton in India* (Mumbai: Indian Society for Cotton Improvement).
- Sharma, Manju (2003). *First Foundation Day Lecture on Regulatory Measure for Utilizing Biotechnological Developments in Different Countries* (New Delhi: TASS, IARI), October 17.
- Shiva, Vandana (2002), *Globalization of Agriculture, Food Security and Sustainability*. In: "Sustainable Agriculture and Food Security", (New Delhi: Sage Publication), pp.11-70.
- Shiva, Vandana (1999), *Appropriation of indigenous knowledge and culture*, In "Intellectual property, Drahos P., ed.", (Aldershot: Ashgate).
- Shiva, Vandana (1996), *Biodiversity-based Productivity* (New Delhi: RFSTE).
- Shiva, Vandana (1992), *Ecological, Economic and Political costs of the Green Revolution*. In, "Towards Hope: An Ecological Approach to the Future, Vandana Shiva, Jeremy Seabrook, Gunther Hilliges, Upendra Baxi, Edward Goldsmith and Paul Ekins, eds.", (INTACH), pp.1-18.
- Sherman, Andrew J. (1999). *Franchising & Licensing: Two Ways to Build Your Business*. AMACOM Books, New York.

- Shotwell, Mark A. and Larkins, Brian A. (1991). *Improvement of the Protein Quality of Seeds by Genetic engineering*. In, "Plant Gene Research: Molecular Approaches to Crop Improvement. editors: Dennis, E. S. and Llewellyn, D. J.". Springer-Verlag Wien, New York; pg. 32-61
- Singer, Peter and Jim Mason (2006), *The Way We Eat: Why Our Foods Choices Matter*, (Emmaus, PA: Rodale Books).
- Sircar, Kaushik (2004), *A new Approach to Rural Marketing* (Mumbai: Publishing Himalaya House).
- Shetty, Kalidas, Gopinadhan Paliyath, Anthony Pometto and E. Robert Levin, eds. (2006), *Food Biotechnology*, 2nd ed. (BocaRaton: CRC Press Taylor & Francis Group).
- Shewry, P. R., J.A. Napier and P. Davis, eds. (1998), *Engineering Crop Plants for Industrial End Uses* (London: Portland Press).
- Shimkets, Richard A., ed. (2004), *Methods in Molecular Biology Volume 258: Gene Expression Profiling-Methods and Protocols* (New Jersey: Humana Press).
- Spirkin, Alexander (1983), *Dialectical Materialism* (Mascow: Progress Publishers).
- Stanford, Naomi (2005), *Organization Design: The Collaborative Approach* (Oxford: Elsevier Butterworth-Heinemann).
- Stone, S., A. Matysek and A. Dolling, (2002), *Modelling Possible Impacts of GM Crops on Australian Trade*, (Melbourne: Productivity Commission Staff Research Paper).
- Stevenson, Trevor W. (1991), *Molecular Biology of Flavonoid Pigment Biosynthesis in Flowers*, In: "Molecular Approaches to Crop Improvement. Edited by: Dennis, Elizabeth S. and Danny J. Llewellyn, eds." (New York: Springer-Verlag Wien).
- Syvanen, Michael and Clarence I. Kado, eds. (2002), *Horizontal Gene Transfer* (San Diego: Academic Press).
- Sompal (2002), *WTO Agreement on Indian Agriculture*. In: "WTO Agreement & Indian Agriculture, Anwarul Hoda, ed."(Delhi: Social Science Press), pp.3-15.
- Taimini, K. Brij (2001), *Vision for 21st century: Food Security in 21st century Perspective and Vision* (Konark Publication), pp. 148-175.
- Tavantzis, Stylianos Michael, ed. (2002). *dsRNA Genetic Elements: Concepts and Applications in Agriculture, Forestry, and Medicine*, (New York: CRC Press LLC).

- Thacker, Eugene (2005), *The Global Genome: Biotechnology, Politics and Culture* (Cambridge: The MIT Press).
- Thomas, John A. and Roy L. Fuchs, eds. (2002), *Biotechnology and Safety Assessment*, 3rd ed. (San Diego: Academic Press).
- Thomson, J.R., ed. (1984) *Advances in research and technology of seed: Part 9* (Pudoc Wageningen: International Seed Testing Association).
- Tirole, Jean (1996), *The Theory of Industrial Organization* (New Delhi: Prentice-Hall of India Private Limited).
- Todo, Yasuyuki and Koji Miyamoto (2006), *Knowledge Spillovers from Foreign Direct Investment and the Role of Local R&D Activities: Evidences from Indonesia*, In: "Economic Development & Culture Change" (Chicago: The University of Chicago Press), pp. 173-200.
- Toffler, Alvin , *The Third Wave*. PAN Books, Macmillan India.
- Vidhyasekaran, P. (2004), *Concise Encyclopedia of Plant Pathology*. Food Products Press & (New York: The Haworth Press Inc.)
- Vinig, G. T. and R.C.W. Vander Voort, eds. (2005), *Research on Technological Innovation and Management Volume 9: The Emergence of Entrepreneurial Economics* (Amsterdam: Elsevier The Netherlands).
- Ulyanosvsky, Rostislav (1981), *Agrarian India between the World Wars: A study of Colonial-Feudal Capitalism* (Moscow: Progress Publishers).
- Wakelyn, Phillip J., Noelle R. Bertoniere, Alfred Dexter French, Devron P Thibodeaux, Barbara A. Triplett, Marie-Alice Rousselle, Wilton R. Goynes (Jr.), J. Vincent Edwards, Lawrence Hunter, David D. McAlister, Gary R. Gamble (2007), *International Fiber Science and Technology: Cotton Fiber Chemistry and Technology* (Taylor & Francis Group: CRC Press).
- Ward, Benjamin (1967), *Elementary Price Theory* (New York: The Free Press).
- Watson James D. (with Andrew Berry) (2003), *DNA-The Secret of Life*, (New York: Alfred A. Knopf).
- Watson, J. D. (1970), *The Double Helix* (London: Penguin Books).
- Williams, J.G. and R.K. Patient (1988), *Genetic Engineering* (Oxford: IRL Press).

Wüger, Daniel and Thomas Cottier (2008), *Genetic Engineering and the World Trade System: World Trade Forum* (Cambridge: Cambridge University Press).

Young, Jeffrey (1998), *Forbes Greatest Technology Stories: inspiring tales of the entrepreneurs and in inventors who revolutionized modern business* (New York: John Wiley & Sons Inc.).

Journals:

Abelson, Philip H. (1997), “Impacts on U.S. technology in a Changing world”, *Technology in Society*, 19 pp.595-607.

Adler, R.G. (1984), “Biotechnology as an intellectual property”, *Science*, Vol. 224, pp.357-363

Anderson, C., P. Baenziger, R. Barnes and R. Kleese (1994), “NIH drops bid for gene patents”, *Science*, 263, (February 18), p.909.

Alston, J.M., R.J. Sexton and M. Zhang (1997), “The Effect of Imperfect Competition on the Size and Distribution of Research Benefits”, *American Journal of Agricultural Economics*, 79 (November), pp 1252–1265.

Andersson, Per and Bengt Molleryd (2001), “Buying centre consequences of technological convergence” *European journal of Purchasing and supply chain*, 7, pp.121-132.

Ansoff, Igor H. and John M. Stewart (1967), “Strategies for a technology-based business”, *Harvard Business Review*, November/December, 45(6), pp.71-83.

Antonelli, Cristiano (2004), “Localized product innovation: the role of proximity in the Lancastrian product space”, *Information economics and policy*, 16, pp. 255-274.

Arunachalam, V. (2001), “The Science behind Tradition”, *Current Science* pp.1272-1275.

Azhakanandam, K., J.B. Power, K.C. Lowe, E. C. Cocking, T. Tongdang, K. Jumel, H.F.J. Bligh, S.E. Harding and M.R. Davey (2000), “Qualitative assessment of aromatic indica rice (*Oryza sativa* L.): Proteins, lipids and starch in grain from somatic embryo - and seed-derived plants”, *Journal of Plant Physiology*, 156, pp.783–89.

- Bambawale, O. M., A. Singh, O. P. Sharma, B. B. Bhosle, R. C. Lavekar, A. Dhandapani, V. Kanwar, R. K. Tanwar, K. S. Rathod, N. R. Patange and V. M. Pawar (2004), "Performance of Bt cotton (MECH-162) under Integrated Pest Management in farmers' participatory field trial in Nanded district, Central India", *Current Science*, 86 (12), pp.1628-1633
- Bantel, Karen A. (1997), "Performance in adolescent, technology- based firms: product strategy, implementation, and synergy", *Journal of High technology management research*, 8, pp.243-262.
- Barinaga, M. (1997), "Making Plants Aluminum Tolerant" *Science*, 276 (June 6), p.1497.
- Bauerschmidt, Alan (1996), "Speaking of Strategy", *Strategic Management Journal*, Vol. 17, No.8 (Oct.), pp. 665-667.
- Bayus, Barry L. (1995), "Optimal dynamic policies for product and process innovation", *Journal of Operations Management*, 12, pp.173-185.
- Becheikh, Nizar, Rejean Landry and Nabil Amara (2006), "Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993-2003", *Technovation*, 26, pp.644-664.
- Benfey, P. and N.H. Chua (1989), "Regulated Genes in Transgenic Plants", *Science*, 244, pp. 174–181.
- Berg Paul et al. (1974), "Potential biohazards of DNA molecules", *Science*, Vol.1974, p.303.
- Berg, P., D. Baltimore, H. W. Boyer, S. N. Cohen, R. W. Davis, D. S. Hogness, D. Nathans, R. Roblin, J.D. Watson, S. Weissman and N. D. Zinder (1974), "Potential biohazards of recombinant DNA molecules", *Science*, 185, p.303.
- Bergelson, J., C.B. Purrington and G. Wichmann (1998), "Promiscuity in Transgenic Plants", *Nature*, 395, p.25.
- Berkes, F., D. Feeny, B. J. McCay and J. M. Acheson (1989), "The Benefits of the Commons", *Nature*, 340, pp. 91–93.
- Betz, F. S., B. G. Hammond and R. L. Fuchs (2000), "Safety and advantages of *Bacillus thuringiensis*-protected plants to control insect pests", *Regulatory Toxicology and Pharmacology*, 32, pp.156-73.

- Beyer, P., S. Al-Babili, X. Ye, P. Lucca, P. Schaub, R. Welsch and I. Potrykus (2002), “Golden Rice: introducing the beta-carotene biosynthesis pathway into rice endosperm by genetic engineering to defeat vitamin A deficiency”, *Journal of Nutrition*, 132, pp.506S-10S.
- Bevan, M. (2000), “The Bugs from Brazil”, *Nature*, 406, pp.140–141.
- Bhat, S. F. and S. Srinivasan (2002), “Molecular and genetic analyses of transgenic plants: considerations and approaches”, *Plant Science*, 163, pp.673-81.
- Bhattacharyya, M. K., A. M. Smith, T. H. Ellis, C. Hedley and C. Martin (1990), The wrinkled-seed character of pea described by Mendel is caused by a transposon-like insertion in a gene encoding starch-branching enzyme”, *Cell*, 60, pp.115-22.
- Birthal, Pratap S., O. P. Sharma and Sant Kumar (2000), “Economics of Integrated Pest Management: Evidences and Issues”, *Indian Journal of Agricultural Economics*, 55 (4), pp. 643-659.
- Boddewyn, J. (1966), “A construct for Comparative Marketing Research”, *Journal of Marketing Research*, Vol.3, No.2, pp. 149-153.
- Bonaccorsi, Andrea and Paola Giuri (2001) “The long-term evolution of vertically-related industries”, *International journal of Industrial organization*, 19, pp.1053-1083.
- Bonanno, Giacomo and Barry Haworth (1998), “Intensity of competition and the choice between product and process innovation”, *International Journal of Industrial Organization*, 16, pp. 495-510.
- Bosworth, Derek L. (1980), “The transfer of U.S technology abroad”, *Research Policy*, 9, pp.378-388.
- Bradford, K. J. and M. A. Cohn (1998), “Seed Biology and Technology: At the crossroads and Beyond. Introduction to the symposium on Seed Biotechnology: Application and Advance and a Prospectus for the Future”, *Seed Science Research*, 8 pp.153-160.
- Brady, T, H Rush, M. Hobday, A. Davies, D. Probert and S. Banerjee (1997), “Tools for technology management: an academic perspective”, *Technovation*, 17(8), pp.417-426.
- Brahmi, Pratibha, Sanjeev Saxena and B. S. Dhillon (2004), “The Protection of Plant Varieties and Farmers’ Rights Act of India”, *Current Science*, Vol. 86, No. 3, pp.392-398.

- Brill, W. J. (1985), "Safety concerns and genetic engineering in Agriculture". *Science*, Vol. 227, pp. 381-384.
- Brosen, B. Wade, Jean-Paul Chavas, Warren R. Grant and L.D. Schnake (1985), "Marketing Margins and Price Uncertainty: The Case of U.S. Wheat Market", *American Journal of Agriculture Economics*, Vol.67, No.3, pp.521-528.
- Brown, J. R. (2003), "Ancient horizontal gene transfer", *Nature Reviews Genetics*, 4, pp.121-32.
- Brown, Steve and Felicia Fai (2006), "Strategic resonance between technological and organizational capabilities in the innovation process within firms", *Technovation*, 26, pp.60-75.
- Buchanan, B. (2001), "Genetic engineering and the allergy issue", *Plant Physiology*, 126, pp.5-7.
- Buck, K. (1989), "Brave new botany", *New Scientist*, 122 (No. 1667), pp.32-35.
- Carayannis, Elias G. (1999), "Knowledge transfer through technological hyperlearning in five industries", *Technovation*, 19, pp.141-161.
- Carlini, C. R. and M. F. Grossi-de-Sa (2002), "Plant toxic proteins with insecticidal properties: a review of their potentialities as bioinsecticides", *Toxicon*, 40, pp.1515-39.
- Casper, Steven (2007), "How do technology clusters emerge and become sustainable? Social network formation and inter-firm mobility within San Diego biotechnology cluster", *Research Policy*, 36, pp. 438-455.
- Caswell, J. and D. Padberg (1992), "Toward a More Comprehensive Theory of Food Labels", *American Journal of Agricultural Economics*, 74, pp. 460-468.
- Caswell, J., M.E. Bredahl and N.H. Hooker (1998), "How Quality Management Metasystems Are Affecting the Food Industry", *Review of Agricultural Economics*, 20, pp. 547-57.
- Cetindamar, D., S.N.Wasti, H. Ansal and B. Beyhan, (Article in Press), "Does technology management research diverge or converge in developing and developed countries?" *Technovation*, 14 pages.
- Chilton, M-D., M. H. Drummond, D. J. Merio, D. Sciaky, A. L. Montoya, M. P. Gordon and E. W. Nester (1977), "Stable incorporation of plasmid DNA into higher plant cells: the molecular basis of crown gall tumorigenesis", *Cell*, 11, pp.263-71.

- Christensen, Jens Froslev (2002), “Incongruities as a source of organizational renewal in corporate management of R&D”, *Research Policy*, 31, pp.1317- 1332.
- Coghlan, A (2000), “Land of opportunity”, *New Scientist*, 168(2263), pp. 31–33.
- Coghlan, A (2001), “Banana bonanza”, *New Scientist*, 171, (2300), p.7.
- Colyvas, Jeanette A. (2007), “From divergent meanings to common practices: The early institutionalization of technology transfer in the life sciences at Stanford University” *Research Policy*, 36, pp. 456-476.
- Conceicao, Pedro and Manuel V. Heitor (2007), “Diversity and integration of science and technology policies”, *Technological Forecasting & Social Change*, 74, pp. 1-17.
- Conway, G., and Toenniessen, G. (2003), “Science for African food security”, *Science* 299, pp.1187-88.
- Coombs, R., P. Narendren and A. Richards (1996), “ A literature- based innovation output indicator”, *Research Policy*, 25, pp. 403-413.
- Cormican, Kathryn and David O’Sullivan (2004), “Auditing best practice for effective product innovation management”, *Technovation*, 24, pp. 819-829.
- Day, Jonathan D., Paul Y. Mang, Ansgar Richter and John Roberts (2001), “The innovative organization: Why new ventures need more than a room of their own”, *The McKinsey Quarterly*, No.2(May).
- de Duve, C (1996), “The birth of complex cells”, *Scientific American*, 274(4), pp.38–45.
- Drekkers, R. (2003), “Strategic capacity management: meeting technological demands and performance criteria”, *Journal of Materials processing technology*, 139, pp. 385-393.
- De la Fuente, J.M, V. Ramirez-Rodriguez, J.L. Cabrera-Ponce and L. Herrera-Estrella, (1997), “Aluminium tolerance in transgenic plants by alteration of citrate synthesis”, *Science*, 276, pp.1566–68.
- Desai, Ashok V. (1980), “The origin and Direction of industrial R&D in India” *Research Policy*, 9, pp.74-96
- Diamond, J. (2002), “Evolution, consequences, and future of plant and animal domestication”, *Nature*, 418, pp.700-707.
- Doebley, J. (2001), “George Beadle’s other hypothesis: one-gene, one-trait”, *Genetics* 158, pp.487-93.

- Doebley, J. Stec, A. and L. Hubbard (1997), “The evolution of apical dominance in maize”, *Nature*, 386, pp.485-88.
- Dougherty, Deborah and Sarah M. Corse (1995), “When it comes to product innovation, what is so bad about bureaucracy?”, *Journal of High technology management research*, 6, pp.55-76.
- Drucker, Peter F. (1984), “ Our entrepreneurial economy”, *Harvard Business Review*, (January – February), pp.59-64.
- Duffy, P. A., M. K. Wohlgenant and J. W. Richardson (1990), “The Elasticity of Export Demand for US Cotton”, *American Journal of Agricultural Economics*, 72, pp. 468–474.
- Du, Jun, James H. Love and Stephen Roper (2007), “The innovation decision: An economic analysis”, *Technovation*, 27, pp.766-773.
- Dunphy, Steven M., Paul R. Herbig and Howes Mary E. (1996), “The Innovation Funnel”. *Technological Forecasting and Social Change*, 53, pp.279-292.
- During, K, P. Porsch, M. Fladung and H. Lorz (1993), “Transgenic potato plants resistant to the phytopathogenic bacterium *Erwinia carotovora*”, *Plant Journal*, 3, pp.587–98.
- Ebers, Mark and Walter W. Powell (2007), “Biotechnology: Its origins, organization, and outputs”, *Research Policy*, 36, pp.433-437.
- Edquist, Charles and Leif Hommen (1999), “Systems of innovation: theory and policy for the demand side”, *Technology in Society*, 21, pp.63-79.
- Eisenberg, R. (1992), “Genes, patents, and product development”, *Science*, 257 (August 14), p.903.
- Enayati E. (1995), “ Intellectual property under GATT”, *Biotechnology*, Vol.13, pp. 460-462.
- Ethridge, M. Dean, Fred C. White and D. Kannan (1975), Optimising Seed Acreage: Decision Making with Production and Utilization Uncertainties”, *American Journal of Agricultural Economics*, Vol.57, No.3(May), pp. 439-449.
- Evanson, R. E. and J. D. Putnam (1987), “Institutional Change in Intellectual Property Rights”, *American Journal of Agricultural Economics*, Vol. 69, No.2.(May) pp. 403-409.
- Ewen, S. W. and A. Pusztai (1999), “Effect of diets containing genetically modified potatoes expressing *Galanthus nivalis* lectin on rat small intestine”, *Lancet*, 354, pp.1353-54.

- Fagerberg, J. and B. Verspagen (2002), “Technology-gaps, innovation-diffusion and transformation: An Evolutionary Interpretation”, *Research Policy*, Vol. 31, pp.1291-1304.
- Falck-Zepeda, J.B., G. Traxler and R.G. Nelson (2000), “ Surplus Distribution from the Introduction of a Biotechnology Innovation”, *American Journal of Agricultural Economics*, 82(2), pp. 360–369.
- Fallah, M. Hosein and Thomas G. Lechler (2008), “Global Innovation performance: Strategic challenges for multinational corporations”, *Journal of Engineering and Technology Management*, 25, pp. 58-67.
- Fan, Shenggen, Peter Hazell and Sukhadeo Thorat (2000), “Government Spending, Growth and Poverty in Rural India”, *American Journal of Agricultural Economics*, Vol. 82, No.4, pp.1038-1051
- Feistritzer, W.P. (1975), “The role of seed technology for agriculture development”, *Seed Science Technology*, 3, pp.415-429
- Ferber, D. (1999), “Biotech Critics Watch The Watchdogs”, *Science*, 286, (November 26) p.5445.
- Finniston, Monty (Sir) (1982), “Technology: The Future Determinant of Society”, *Technology In Society*, Vol.4, p.8.
- Fox, Jeffrey L. (2003), “Resistance to Bt. Toxin Surprisingly Absent from Pests”, *Nature Biotechnology*, 21, pp.958–959.
- Fox, J. (1990), “ Everything but the animals”, *Biotechnology*, 8, p.822.
- Francis, Dave and John Bessant (2005), Targeting innovation and implications for capability development, *Technovation*, 25, pp.171-183.
- Frohman, Alan L. (1982), “Technology as a competitive weapon”, *Harvard Business Review*, Vol.-59, (Jan,-Feb.), pp.97-104,
- Fuente, J. M. de la, V. Ramirez-Rodriguez, J.L. Cabrera-Ponce and L. Herrera-Estrella (1997), “ Aluminum tolerance in transgenic plants by alteration of citrate synthesis”, *Science*, 276, pp.1566-68.
- Gadgil, Madav and Ghate Utkash (1999), “Intellectual Property Rights and Agricultural Technology: Linking the Micro and the Macro Scales”, *Indian Journal of Agricultural Economy*, Volume 54, No.3 (July-September).

- Gadwal, V. R., (2003), "The Indian Seed Industry: Its history, current status and future", *Current Science*, 84 (3), pp. 399-406.
- Ganapathy, R.S. (1973), "R&D, marketing, and social goal", *Economic and Political Weekly*, Vol.8, No.8, (Feb.24), p.M7-M12.
- Gaskell, G., M.W. Bauer, J. Durant and N. C. Allum (1999), "Worlds Apart? The Reception of Genetically Modified Foods in Europe and the US", *Science*, 285(5426), pp: 384–387.
- Gasser, C.S. and R.T. Fraley (1992), "Transgenic Crops", *Scientific American*, (June) pp.62–69.
- Geeta Rani, M. (2000), "Community gene banks sustain food security and farmers rights", *Biotechnology and Development Monitor*, Volume 41, pp.19-32.
- Ghosh, S. K. (2000), "Biodiversity and IPR: Ethics and Politics", *Journal of Intellectual Property Rights*, 5(4), pp.196-205
- Giovannoni, J. J., D. DellaPenna, A. B. Bennett and R. L. Fischer (1989), "Expression of a chimeric polygalacturonase gene in transgenic rin (ripening inhibitor) tomato fruit results in polyuronide degradation but not fruit softening", *Plant Cell*, 1, pp.53–63.
- Gopalkrishnan, S. and Damanpour (1997), "A Review of Innovation Research in Economics, Sociology and Technology Management", *Omega, International Journal of Management Science*, Vol. 25, No.1, pp.15-28.
- Greene, A.E., and R.F. Alison (1994), "Recombination between Viral RNA and Transgenic Plant Transcripts", *Science*, 263, pp.1423–1425.
- Greenstein, Shane and Garey Ramey (1998), "Market Structure, innovation and vertical product differentiation", *International Journal of Industrial Organization*, 16, pp. 285-311.
- Greis, Noel P. Diberner, D. Mark and Alden S. Bean (1995), "External Partnering as a response to innovation barriers and global competition in biotechnology", *Research Policy*, 24, pp.609-630.
- Gupta, A. K. (1999), "Making Indian Agriculture more knowledge Intensive and Competitive: The case of Intellectual Property Rights", *Indian Journal of Agriculture Economics*, 54(3), pp.342-369.

- Grover, Anil and Deepak Pental (2003), "In this Issue", *Current Science*, Vol.84.No.3 (February), p.10.
- Gura, T. (1999), "New Genes Boost Rice Nutrients", *Science*, 285, (August 13), pp. 994–995.
- Just, R. E. and D. L. Hueth (1993), "Multimarket Exploitation: The Case of Biotechnology and Chemicals", *American Journal of Agricultural Economics*, 75, p.936.
- Harabi, Najib (1995), "Appropriability of technical innovations - An empirical analysis", *Research Policy*, 24, pp.981-992
- Hardin, G. (1968), "The tragedy of the commons", *Science*, 162, pp.1243-48.
- Hardy, Cynthia and Deborah Dougherty (1997), "Powering product innovation", *European Management Journal*, 15, pp.16-27.
- Hasegawa, Harukiyo (2000), "Global acquisition and knowledge transfer – a case study of company D", *International Business Review*, 9, pp.587-598.
- Hauser, John R. and Kenneth J. Wisniewski (1982), "Dynamic Analysis of Consumer Response to Marketing Strategies", *Management Science*, Vol.28, No.5 (May), pp.455-486.
- Heisey, Paul W. and John P. Brennan (1991), "An analytical model of farmers' demand for replacement seed", *American journal of agricultural economics*, Vol. 73, No. 4:1044-1052.
- Hester, G. and C. S. Wright (1996), "The mannose-specific bulb lectin from *Galanthus nivalis* (snowdrop) binds mono- and dimannosides at distinct sites: structure analysis of refined complexes at 2.3 Å and 3.0 Å resolution", *Journal of Molecular Biology*, 262, pp.516-31.
- Hipkin, Ian (2004), "Determining technology strategy in developing countries", *Omega International Journal of Management* 32, pp.245-260.
- Hofte, H. and H.R. Whiteley (1989), "Insecticidal crystal proteins of *Bacillus thuringiensis*", *Microbiological Reviews*, 53, pp. 242–255.
- Homburg, Christian, Harley Krohmer and John P. Workman Jr. (1999), "Strategic Consensus and Performance: The Role of Strategy Type and Market-Related Dynamism", *Strategic Management Journal*, Vol.20, No.4, pp. 339-357.
- Horn, Henrik and Persson Lars (2001), "Endogenous mergers in concentrated markets", *International Journal of Industrial Organization*, 19, pp.1213-1244.

- Housman, Anjela and James R. Stock (2003), "Adoption and implementation of technological innovations within long-term relationships", *Journal of Business Research*, 56, pp. 681-686.
- Huang, F., L. L. Buschman, R. A. Higgins and W. H. McGaughey (1999), "Inheritance of resistance to *Bacillus thuringiensis* toxin (Dipel ES) in the European corn borer", *Science*, 284, pp.965-67.
- Hultink, Erik, Griffin Jan, Robben Abbie, S.J. Henry and Susan Hart (1998), "In search of generic launch strategies for new products", *International journal of Research in Marketing*, 15, pp. 269-285.
- Hyde, J., M. A. Martin, P. V. Preckel and C. R. Edwards (1999), "The Economics of Bt. Corn: Valuing the Protection from the European Corn Borer", *Review of Agricultural Economics*, 21(Fall/Winter).
- Iansiti, Macro and West, Jonathan (1997), "Technology Integration: Turning Great into Great Products", *Harvard Business Review*, (May).
- Iltis, H. (1983), "From teosinte to maize: the catastrophic sexual transmutation", *Science*, 222, pp.886-94.
- Iyer, Gopalkrishnan, R. LaPlaca, J. Peter and Arun Sharma (2006), "Innovation and new product introductions in emerging markets: Strategic recommendations for the Indian market", *Industrial Marketing Management*, 35, pp. 373-382.
- Jacob, F. (1977), "Evolution and tinkering", *Science*, 196, pp.1161-66.
- Jaenicke-Despres, V., E. S. Buckler, B. D. Smith, M. T. P. Gilbert, A. Cooper, J. Doebley, and S. Paabo, (2003), "Early allelic selection in maize as revealed by ancient DNA", *Science*, 302, pp.1206-08.
- Jennings, Daniel, F. Daniel and Samuel L. Seaman (1994, July), "High and Low Levels of Organizational Adaptation: An Empirical Analysis of Strategy", *Strategic Management Journal*, Vol. 15, No.6, pp.459-475.
- Joglekar, Prefulla and Morris Hamburg (1989), "Industry concentration and Allocation of Resources to Basic Research", *Management Science*, Vol.35, No.2, Feb., pp.208-225.
- Kafouros, Mario I. and Peter J. Buckley (2007) "Under what conditions do firms benefit from the research efforts of other organizations?", *Research Policy*, 37, pp. 225-239.

- Kalaitzondanakes, N. (2000), "Agrobiotechnology and Competitiveness", *American Journal of Agricultural Economics*, 82.
- Kamboj, V.P. (2000), "Herbal Medicine", *Current Science*, 78(1), pp.35-39.
- Kashyap, Pradeep (2003), "Revolution-in-waiting", *Praxis: Business line's Journal on Management*, Volume 4, Issue 2 (Managing Rural Markets), July, pp. 6-11.
- Kashkush, K., M. Feldman and A. A. Levy (2002), "Gene loss, silencing, and activation in a newly synthesized wheat allotetraploid", *Genetics*, 160, pp.1651-59.
- Kellogg, E. A. (2001), "Evolutionary history of the grasses", *Plant Physiology*, 125, pp.1198-1205.
- Kim, Namwoom and Rajendra K. Srivastava (1998), "Managing intraorganizational diffusion of technological innovations", *Industrial marketing management*, 27, pp. 229-246.
- Kim, Jerry W. and Monica C. Higgins (2007), "Where do alliances come from" the effects of upper echelons on alliance formation", *Research Policy*, 36, pp.499-514.
- Klerkx, Laurens and Cees Leeuwis (2008), "Balancing multiple interests: Embedding innovation intermediation in the agricultural knowledge infrastructure", *Technovation*, 28, pp.364-378.
- Kling, J. (1996), "Could Transgenic Supercrops One Day Breed Superweeds?", *Science*, 274, pp.180-181.
- Koellinger, Philipp (2008, article in press), "The relationship between technology, innovation, and firm performance- Empirical evidence from e-business in Europe", *Research Policy*, total 12 pages.
- Kohli A., S. Griffiths, N. Palacios, R. M. Twyman, P. Vain, D. A. Laurie and P. Christou (1999), "Molecular characterization of transforming plasmid rearrangements in transgenic rice reveals a recombination hotspot in the CaMV 35S promoter and confirms the predominance of microhomology mediated recombination", *Plant Journal*, 17, pp.591-601.
- Kranthi, K. R., and N. R. Kranthi (2004), "Modeling Adaptability of cotton bollworm, *Helicoverpa amigera* to Bt-cotton in India", *Current Science*, 87 (8), pp.1096-1107.
- Kunkel, T., Q.W. Niu, Y.S. Chan and N.H. Chua (1999), "Inducible Isopentenyl transferase as a High-efficiency Marker for Plant Transformation", *Nature Biotechnology* 17, pp.916-919.

- Lambertini, Luca and Raimondello Orsini (2000), "Process and product innovation in a vertically differentiated monopoly", *Economics letters* 68, pp.333-337.
- Langridge, W.H.R. (2000), "Edible vaccines", *Scientific American*, 283(3), pp. 66–71.
- Lauter, N.; and Doebley, J. (2002), "Genetic variation for phenotypically invariant traits detected in teosinte: implications for the evolution of novel forms", *Genetics*, 160, pp. 333-42.
- Lesser, William (1987), "The Impact of Seed Patents", *N.C.J.Agr. Eco.*, 9, pp.37-48.
- Liao, Shu-hsien (2005), "Technology management methodologies and applications A literature review from 1995 to 2003", *Technovation*, 25, pp.381-393.
- Liberatore, Matthew J. and Anthony C. Stylianou (1995), " Toward a framework for developing knowledge- based decision support systems for customer satisfaction assessment: An application in New product development", *Expert systems with applications*, 8, pp.213-228.
- Lichtenthaler, Eckhard (2004), "Technological change and the technology intelligence process: a case study", *Journal of Engineering and Technology Management*, 21, pp. 331-348.
- Lence, Sergio H. and Dermot J. Hayes (2005), "Genetically modified crops: their market and welfare impacts", *American journal of agriculture economics*, 87, pp.931-950.
- Lence, Sergio H., Dermot J. Hayes, Alan McCunn, Stephen Smith and William S. Niebur (2005), "Welfare impacts of Intellectual property protection in the seed industry", *American journal of agriculture economics*, 87(4), pp.951-968.
- Losey, J. E., L. S. Rayor and M. E. Carter (1999), "Transgenic pollen harms monarch larvae", *Nature*, 399, p.214.
- McAllan, A. B. (1982), "The Fate of Nucleic Acids in Ruminants", *Progress in Nutritional Science*, 41, pp. 309–317.
- Mann, C.C. (1999), "Crop Scientists Seek a New Revolution", *Science* 283, January 15, pp. 310–316.
- Mann, C. (1999), "Biotech goes wild", *Technology Review*, 102, pp.36-40.
- Maturin, L. and R. Curtiss (1977), "Degradation of DNA by Nucleases in Intestinal Tract of Rats", *Science*, 196, pp.216–18.

- Miller, H. (1994), "Risk assessment experiments and the new biotechnology", *Trends in Biotechnology*, 12, pp.292–295.
- Millstone, E., E. Brunner and S. Mayer (1999), "Beyond Substantial Equivalence", *Nature*, (October 7), p. 401.
- Mintzberg, Henry (1994), "The Fall and Rise of Strategic Planning", *Harvard Business Review*, (Jan.- Feb.), pp.107-114.
- Mourgues, F., M.N. Brisset and E. Chevreau (1998), "Strategies to improve plant resistance to bacterial diseases through genetic engineering", *Tibtech*, 16, pp.203–210.
- Leydesdorff, Loet (2000), "The triple helix: an evolutionary model of innovations", *Research Policy*, 29, pp.243–255.
- Linton, Jonathan D. (2002), "Implementation research: state of the art and future directions", *Technovation*, 22, pp.65-79.
- Liu, Yong-Biao, Bruce E. Tabashnik, Timothy J Dennehy, Amanda L. Patin and Alan C. Bartlett (1999), "Development time and resistance to Bt crops", *Nature*, 400, p.519.
- Losey, J.E., L.S. Rayor and M.E. Carter (1999), "Transgenic pollen harms monarch larvae", *Nature*, 399, p.214.
- Lovas, Bjorn and Sumantra Ghoshal (2000), "Strategy as guided evolution", *Strategic Management journal*, Vol. 21, No. 9, pp.875-896.
- Lowendahl, Bente and Oivind Revang (1998), "Challenges to Existing Strategy Theory in a Postindustrial Society", *Strategic Management Journal*, Vol. 19, No.8, (Aug.) pp.755-773.
- Malebra, Franco (2007), "Innovation and the dynamics and evolution of industries: Progress and Challenges", *International Journal of Industrial Organization*, 25, pp.675-699.
- Malik, Kauser Abdulla and Yusuf Jafar (2005), "Intellectual Property Rights in Plant Biotechnology: A contribution to Crop Biosecurity", *Asian Biotechnology Development Review*, Vol.8, No.1, pp.7-43.
- Martinez-Soriano, J.P.R. (2000), "Transgenic maize in Mexico: no need for concern", *Science* 287, p.1399.
- Mayeno, A. N. and G. J. Gleich (1994), "Eosinophilia-myalgia syndrome and tryptophan production: a cautionary tale", *Trends in Biotechnology*, 12, pp.346–352.

- McArthur, David N. and Ronald L. Schill (1995), “International Cooperative technology Arrangement: Improving Their Role in Competitive Strategy”, *Journal of Business Research*, 32, pp. 67-79.
- Mikkelsen, T. R., B. Andersen and J. R. Bagger(1996), “The Risk of Crop Transgene Spread” *Nature*, 380, p.31.
- Moschini, G. and Lapan, H. (1997), “Intellectual Property Rights and the Welfare Effects on Agricultural R&D”, *American Journal of Agricultural Economics*, 79 (November), pp. 1229–1242.
- Myers, N. (1998), “Lifting the Veil on Perverse Subsidies”, *Nature*, (March 26), p.392.
- Mowery, David and Nathan Rosenberg (1979), “ The influence of market demand upon innovation: a critical review of some recent empirical studies”, *Research Policy*, 8, pp.102-153.
- Naik, G., M., A. Qaim, Subramanian and D. Zilberman (2005), “ Bt Cotton Controversy: Some Paradoxes Explained”, *Economic and Political Weekly*, XL, 15, pp.1514-1517.
- Narula, Rajneesh and John Hagedoorn (1999), “Innovating through strategic alliances: moving towards international partnerships and contractual agreements, *Technovation*, 19, pp283-294.
- Nieto, Mariano (2003), “From R&D management to Knowledge Management An overview of Studies of Innovation Management”, *Technological Forecasting & Social Change*, 70, pp.135-161.
- Old, Bruce S. (1982), “Corporate directors should rethink technology”, *Harvard Business Review*, Vol.-59 (Jan,-Feb.), pp.6-14.
- Pal, S. and R. Tripp (2002), “India’s Seed Industry Reforms: Prospects and Issues”, *Indian Journal of Agricultural Economics*, 57 (3), pp.443-458.
- Pardey, Philip G. and Barbara Craig (1989), “Causal Relationships between Public Sector Agricultural Research Expenditures and Output”, *American Journal of Agricultural Economic*, (February.), pp. 9-19.
- Pinstrup-Andersen, P., N. Ruiz de Londou and E. Hoover (1976), “The impact of increasing food supply on human nutrition: implications for commodity priorities in agricultural research and policy”, *American Journal of Agricultural Economics*, 58, pp.131–142.
- Porter, Michael E. (1990), “Why Nations Triumph”, *Fortune* (Mar.12), pp. 94-108.

- Powledge, Fred (1995), *Bioscience*, Vol.45.No.7 (Jul-Aug.), pp 440- 444
- Pingali P. L. and G. Traxler (2002), “Changing locus of agricultural research: will the poor benefit from biotechnology and privatization trends?”, *Food Policy*, 27, pp.223-238.
- Pisano, Gary (2006), “Profiting from innovation and the intellectual property revolution”, *Research policy*, 35, pp.1122-1130.
- Porter, Michael E. (1979), “How competitive forces shape Strategy”, *Harvard Business Review*, (Mar.-Apr.), pp.137-145.
- Porter, Michael E. (1987), “ From competitive advantage to corporate strategy”, *Harvard Business Review* (May.-Jun.), pp.43-59.
- Porter, Michael E. (1990), “New Global Strategies for Competitive Advantage, *Planning Review*, (May.-Jun.), pp.4-18.
- Porter, Michael E. (1996), “What is Strategy?”, *Harvard Business Review*, (Nov.-Dec.), pp.61-78.
- Potrykus, I. (2001), “Golden Rice and beyond”, *Plant Physiology*, 125, pp.1157-61.
- Prahalad, C. K. and Gary Hamel (1994), “ Strategy as a Field of study: Why Search fir a New Paradigm?”, *Strategic Management Journal*, Vol. 15, special Issue: Search for New Paradigms, pp. 5-16.
- Pray, C. E., Bharat Ramaswami and T. Kelley (2001), “The Impact of Economic Reforms on R&D by the Indian Seed Industry”, *Food Policy*, Vol. 26, No. 6, pp. 587-598.
- Quist, D., and I. Chapela (2001), “Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico”, *Nature*, 414, pp.541-43.
- Raju, K. D. (2004), “WTO-TRIPS Obligations and Patent Amendments in India: A critical Stocktaking”, *Journal of Intellectual Property Rights*, Vol.9, pp.242-59.
- Rao, K. V., K. S. Rathore, T. K. Hodges, X. Fu, E. Stoger, D. Sudhakar, S. Williams, Christou P., M. Bharathi, D. P. Bown, K. S. Powell, J. Spence, A. M. Gatehouse, and J. A. Gatehouse (1998), “Expression of snowdrop lectin (GNA) in transgenic rice plants confers resistance to rice brow planthopper”, *Plant Journal*, 15, pp.469-77.
- Raphals, P. (1990), “Does medical mystery threaten biotech?”, *Science*, 249, p.619.
- Ranganathan, C.K. (2003), “Case Study: The making of Chik”, *Praxis: Business line’s Journal on Management*, Volume 4, Issue 2, July(Managing Rural Markets), pp.22-27.

- Reddy, S. A. and T. L. Thomas (1996), "Expression of a Cyanobacterial Delta 6-Desaturase Gene Results in Gamma-linolenic Acid Production in Transgenic Plants", *Nature Biotechnology*, 14, pp. 639–642.
- Regal, P.J. (1994), "Scientific Principles for ecologically based risk assessment of transgenic organisms", *Molecular Ecology*, 3, pp.5-13.
- Reid, T.R. (1998), "Feeding the planet", *National Geographic*, 194(4), pp.56–75.
- Rhyne, Lawrence C., Mary B. Teagarden and Willem Van den Panhuyzen (2002), "Technology-based competitive strategies The relationship of cultural dimensions to new product innovation", *The Journal of High Technology Management Research*, 13, pp.249-277.
- Rick, C. M. (1978), "The Tomato", *Scientific American*, 239, pp.77–87.
- Rieger, M. A., M. Lamond, C. Preston, S. B. Powles and R. T. Roush (2002), "Pollenmediated movement of herbicide resistance between commercial canola fields" *Science*, 296, pp.2386-88.
- Rip, Arie (1981), "A Cognitive Approach to Science Policy", *Research Policy*, 10, pp.294-311
- Roelofs, J. and P. J. Van Haastert (2001), "Genes lost during evolution", *Nature*, 411, pp.1013-14.
- Ronstadt, Robert and Robert J. Kramer (1982), "Getting the most out of innovation abroad", *Harvard Business Review*, Vol.-59, (Mar.-Apr.), pp.94-99.
- Rosenbloom, Richard S. and Alan M. Kantrow (1982), "The nurturing of corporate research", *Harvard Business Review*, Vol.-59 (Jan,-Feb.), pp.115-123.
- Rosenkranz, Stephanie (2003), "Simultaneous choice of process and product innovation when consumers have a preference for product variety", *Journal of Economic behaviour and organization*, 50, pp.183-201.
- Russo, E. (2003), "The birth of biotechnology", *Nature*, 421, pp.456-57.
- Rycroft, Robert W. (2006). "Time and technological innovation: Implications for public policy", *Technology in society*, 28, pp.281-301.
- Sable, Michael (2007), "The impact of the biotechnology industry on local economic development in the Boston and San Diego metropolitan areas", *Technological Forecasting and Social Change*, 74, pp.36-60.

- Saegusa, A. (1999), "Japan Tightens Rules on GM Crops to Protect the Environment, (June) *Nature*.
- Sahai, S. and S. Rehman (2004), "Bt-Cotton 2003-2004, Fields Swamped with Illegal Variants", *Economic and Political Weekly*, June 26, 39 (24), pp.2673-2674.
- Sahal, Devendra (1981), "Alternative conceptions of technology", *Research Policy*, 10, pp2-24.
- Sanchez, Ron (1996), "Strategic Product Creation: Managing New Interactions of Technology, Markets, and Organizations", *European Management Journal*, Vol.14, No.2, pp.121-138.
- Sasaki, A., M. Ashikari, M. Ueguchi-Tanaka, H. Itoh, A. Nishimura, D. Swapan, K. Ishiyama, T. Saito, M. Kobayashi, G. S. Khush, H. Kitano and M. Matsuoka (2002), "Green Revolution: a mutant gibberellin-synthesis gene in rice", *Nature*, 416, pp.701-02.
- Schnee, Jerome E. (1979), "R&D strategy in the U.S. Pharmaceutical Industry", *Research Policy*, 8, pp.364-382.
- Sehgal, Suri (1996), "IPR driven restriction of Industry", *Biotechnology and Development Monitor*, Vol.29, pp.19-21.
- Serageldin, I. (1999), "Biotechnology and Food Security in the 21st Century", *Science*, 285, July16, pp. 387-389.
- Shervani, Tasadduq and Philip C. Zerrillo (1997), "The Albatross of Product Innovation", *Business Horizons* (Jan.-Feb.), pp.57-62.
- Shiva V. and T. Crompton (1998), "Monopoly and Monoculture: Trends in Indian Seed Industry" *Economic and Political Weekly*, 33 (39), pp. A137-A151.
- Shiva V., A. Emani and H. A Jafri (1999), "Globalization and Threat to Seed Security: Case for Transgenic Cotton Trails in India", *Economic and Political Weekly*, March 6-13, pp.601-613.
- Shouse, B. (2001), "Spreading the word, scattering the seeds", *Science*, 294, pp.988-89.
- Singer, Alan E. (1994), "Strategy as Moral Philosophy", *Strategic Management Journal*, Vol. 15, No.3(Mar.), pp. 191-213.
- Siriram, R. and D. R. Snaddon (2005), "Verifying links in technology management, transaction processes and governance structures", *Technovation*, 25, pp.321-337.

- Slater, A., M. J. Maunders, K. Edwards, W. Schuch and D. Grierson (1985), "Isolation and characterization of cDNA clones for tomato polygalacturonase and other ripening related proteins", *Plant Molecular Biology*, 5, pp.137–147.
- Slater, Stanley F. and Eric M. Olson (2002), "A fresh look at industry and market analysis", *Business Horizons*, (Jan.-Feb.) pp. 15-22.
- Subbaram N. R. (2001), "Patenting in food technology area: a post WTO scenario", *Invention Intelligence*, Vol.36, No.4(July August), pp.165-167.
- Smith, C., C. Watson, J. Ray, C. Bird, P. Morris, W. Schuch and D. Grierson (1988), "Antisense RNA inhibition of polygalacturonase gene expression in transgenic tomatoes", *Nature*, 334, pp.724–726.
- Snow, A.A. and P.M. Palma (1997), "Commercialization of Transgenic Plants: Potential Ecological Risks", *Bioscience*, 47, pp: 86–96.
- Sobolevsky, Andrei, Gian Carlo Moschini and Harvey Lapan (2005), "Genetically modified crops and product differentiation: Trade and welfare effects in the Soybean complex", *American Journal of Agriculture Economics*, 87, pp.621-643.
- Song, Michael and R. Jeffrey Thieme (2006), "A cross-national investigation of the R&D-marketing interface in the product innovation process", *Industrial Marketing Management*, 35, pp.308-322.
- Southern, E. M. (1975), "Detection of specific sequences among DNA fragments separated by gel electrophoresis", *Journal of Molecular Biology*, 98, pp.503–517.
- Sree Vidya, C. S., M Manoharan, C.T. Ranjit Kumar, H.S. Savithri and S.G. Lakshmi (2000), "Agrobacterium-mediated transformation of tomato (*Lycopersicon esculentum* var. Pusa Ruby) with coat-protein gene of *Physalis mottle tymovirus*", *Journal of Plant Physiology*, 156, pp.106–10.
- Stone, R. (1995), "Sweeping patents put biotech companies on warpath", *Science*, 268 (May) 5, p.656.
- Strong, D. (1997), "Fear No Weevil", *Science*, 277 (August 22), pp: 1058–1059.
- Stuart, Toby E., Salih Zeki Ozdemir and Waverly W. Ding (2007), "Vertical alliance networks: The case of University-Biotechnology-Pharmaceutical alliance chain", *Research Policy* 36, pp.477-498.

- Suresh, A. and Puran Chand (2004), "Trade Related Aspects of Intellectual Property Rights: An Evaluation. *Kurukshetra*, (April), pp.21-26
- Taggart, James H. (1998), "Strategy Shifts in MNC Subsidiaries", *Strategic Management Journal*, Vol.19, No.7 (Jun.), pp. 663-681.
- Tabashnik, B. E. R. T. Roush, E. D. Earle and A. M. Shelton (2000), "Resistance to Bt. toxins", *Science*, 287, p.41.
- Tilman, D. (1998), "The greening of the Green Revolution", *Nature*, 396, pp.211-12.
- Timmons, A.M., Y.M. Charters, J.W. Crawford, et al. (1996), "Risks From Transgenic Crops", *Nature*, 380, p.487.
- Tripp R. and S. Pal (2000), "Information and Agricultural Input Markets: Pearl Millet Seed in Rajasthan", *Journal of International Development*, 12, pp.133-144.
- Tominen, Markku, Petteri Piippo, Takaya Ichimura and Yoshio Matsumoto (1999), "An analysis of innovation management systems' characteristics", *International Journal of Production economics*, 60-61, pp.135-143.
- Tuominen, Markku and Marko Torkkeli (2002), "Editorial: Innovation of technology management", *International journal of Production economics*, 80, pp.1-2.
- Tzokas, Nikolaos, Michael Saren and Douglas Browmlie (1997), "Generating Marketing Resources by Means of R&D Activities in High Technology Firms", *Industrial Marketing Management*, 26, pp.331-340.
- Vuola, Olli and Ari-Pekka Hameri (2006), "Mutually benefiting joint innovation process between industry and big-science", *Technovation*, 26, pp.3-12.
- VanWyk, Rias J. (1997), "Strategic Technology Scanning", *Technological Forecasting and Social Change*, 55, pp.21-38.
- Walbot, V (1991). "Maize mutants for the 21st century", *The Plant Cell*, 3, pp.851-56.
- Wang, R. L., A. Stec, J. Hey, L. Lukens and J. Doebley (1999). The limits of selection during maize domestication", *Nature*, 398, pp.236-39.
- Watson, J.D. and F.H.C. Crick (1953), "Molecular structure of nucleic acid. A structure for deoxyribose nucleic acid", *Nature*, 171, pp.737-38.
- Wijk Joren Van (1995), "PBR creates winner and losers", *Biotechnology and Development Monitor*, Vol.23, pp.15-19.

- Wilkinson, M., L. J. Elliott, J. Allainguillaume, M. W. Shaw, C. Norris, R. Welters, M. Alexander, J. Sweet and D. C. Mason (2003) 'Hybridization between *Brassica napus* and *B. rapa* on a national scale in the U.K.', *Science*, 302, pp.457-59.
- Wolf, Joachim and William G. Egelhoff (2002), "A Reexamination and Extension of International Strategy-Structure Theory", *Strategic Management Journal*, Vol.23, No.2, (Feb.), pp. 181-189
- Wood, D. W., J. C. Setubal, R. Kaul, D. E. Monks, J. P. Kitajima, V. K. Okura, Y. Zhou, L. Chen, G. E. Wood, N. F. Almeida Jr., L. Woo, Y. Chen, I. T. Paulsen, J. A. Eisen, P. D. Karp (2001), "The genome of the natural genetic engineer *Agrobacterium tumefaciens* C58", *Science*, 294, pp.2317-23.
- Ye, X., S. Al-Babili, A. Klott, J. Zhang, P. Lucca, P. Beyer and I. Potrykus, (2000), "Engineering the complete provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm", *Science*, 287, pp.303-05.
- Yeh, S., B. A. Moffatt, M. Griffith, F. Xiong, D. S. Yang, S. B. Wiseman, F. Sarhan, J. Danyluk, Y. Q. Xue, C. L. Hew, A. Doherty-Kirby and G. Lajoie (2000), "Chitinase genes responsive to cold encode antifreeze proteins in winter cereals", *Plant Physiology*, 124, pp.1251-64.
- Yin, Xiangkang and Ehud Zuscovitch (1998), "Is firm size conducive to R&D choice? A strategic analysis of product and process innovations.", *Journal of Economic Behaviour & Organization*, Vol.35, pp.243-262.
- Young, A.L. (1994), "The Scientific Method", *Biotechnology*, 12, p.432.
- Young, E. (1994), "Altered tomato faces ban from British shops", *New Scientist*, 143 (July 30), p.9.
- Zambryski, P., M. Holsters, K. Kruger, A. Depicker, J. Schell, M. Van Montagu and H. M. Goodman (1980), "Tumor DNA structure in plant cells transformed by *A.tumefaciens*", *Science*, 209, pp.1385-91.

Theses, Dissertations, Discussion papers and Reports:

- Anand, D., *State Response to Food Security: A Study of the Anantpur District of Andhra Pradesh*, unpublished PhD thesis, University of Hyderabad, Department of Political Science, School of Social science, Hyderabad, 2008.

- Asian Development Bank, *Biotechnology: Opportunities for Enhancing Agricultural Production*. (Agriculture Department Staff Paper No. 8), 1995.
- Datta, Sudipta, *Analysis of CaMV 35S Promoter and Testing Synthetic Promoters for Homology based Gene Silencing*, unpublished Ph.D. thesis, University of Delhi Department of Genetics, Delhi, 2008.
- Dhar, Biswajit (2002), *Sui Generis System for Plant Variety Protection option under TRIPS*. A Discussion Paper, Quaker UNO office, Geneva.
- Dutta, Ajaswata, *Molecular and Abiotic Stress Signal Transduction Studies on TIA Biosynthetic Pathway Genes in Periwinkle* unpublished Ph.D. thesis, University of Delhi. Department of Botany, 2008.
- FAO Legislative study Vol. 85, 2005.
- ISAAA (1996), *ISAAA Annual Report 1995: Shared Solution to Shared Problems*, ISAAA: Ithaca, New York.
- ISAAA (1997), *ISAAA Annual Report 1996: Advancing Altruism in Africa*, ISAAA: Ithaca, New York.
- James, Clive (2003), *Preview: Global Status of Commercialized Transgenic Crops: 2003*, ISAAA Briefs No. 30; ISAAA: Ithaca, New York.
- James, Clive (2006), *Global Status of Commercialized Biotech/Gm Crops: 2006*, ISAAA Brief No. 35; ISAAA: Ithaca, New York.
- James, Clive (2007), *Global Status of Commercialized Biotech/Gm Crops: 2007*, ISAAA Brief No. 37; ISAAA: Ithaca, New York.
- Jain, Shalu, *Molecular and Biochemical Studies in Stress Sensitive vs. Stress Tolerant Cell Lines of *Arachis hypogaea* (Peanut)*, unpublished Ph.D. thesis, University of Delhi Department of Botany, 2008.
- Krattiger, A.F. (2000). *An Overview of ISAAA from 1992 to 2000; ISAAA Briefs No. 19*. ISAAA: Ithaca, New York. 24pp.
- Kumar, Degala Ravi, *Changing Policies and Trends in Indian Agriculture and an Action Plan for Tobacco control: A Study of Bandapuram village, Devarapalli Mandal, West Godavari District, Andhra Pradesh*, unpublished M.Phil. Dissertation, University of Hyderabad, Centre for Regional Studies, Hyderabad, June 2003.
- Kumar, Sarvesh. *A Study of Cotton Seed Marketing: Opportunities and Constraints for*

- Genetically Modified Crops*, unpublished report, University of Hyderabad, School of Management Studies, Hyderabad, 2003.
- Laju, Paul K., *Molecular Analysis of Light and Hormone Signalling Mutants, pho1 and pho3, of Arabidopsis Thaliana*, unpublished Ph.D. thesis, University of Delhi, Department of Plant Molecular Biology, Delhi, 2008.
- Lal, Shalini, *Screening, EST Profiling and Generation of Transgenic Mulberry for Abiotic Stress Tolerance*, unpublished Ph.D. thesis, University of Delhi, Department of Plant Molecular Biology, 2008.
- Malhotra, Shweta, *Complete Nucleotide Sequence of a 30-Kilobase Plasmid pA387 from Amycolatopsis benzoatilytica DSM 43387 and molecular Characterization of the Vector pKVERL2 Capable of Conjugative Transfer from Escherichia coli to Amycolatopsis*, unpublished Ph.D. thesis, University of Delhi, Department of Zoology, Delhi, 2008.
- Manoj, Kumar, *Expression of Vibrio Cholerae Antigens in Tomato for Development of Plants-Based Oral Vaccine Against Cholera*, unpublished Ph.D. thesis, University of Delhi, Department of Plant Molecular Biology, 2008.
- Mittal, Alka, *Characterization of resistance in the diamondback moth to Bacillus thuringiensis Cry toxins*, unpublished Ph.D. thesis, University of Delhi, Department of Zoology, Delhi, 2008.
- NABARD, Annual Report: 2001-2002.
- NABARD, Annual Report: 2002-2003.
- NABARD, Warangal: Potential Linked Credit Plan: 2004-2005.
- Pandey, Roopali, *Transgenic Tomatoes for Improved Fruit Characteristics Through Genetic Manipulation of Polyamine Biosynthesis*, unpublished Ph.D. thesis, University of Delhi, Department of Genetics, Delhi, 2008.
- Pardey, P. and J. M. Alston (1996), *Revamping Agricultural R & D*. 2020 Brief No. 24. (Washington DC: IFPRI).
- Patil, Basavaprabhu L., *Study of Gene Functions in Indian Cassave Mosaic Virus*. unpublished Ph.D. thesis, University of Delhi, Department of Plant Molecular Biology, Delhi, 2008.
- Persley, G.J. and J.J.Doyle (1999), *Biotechnology for Developing-Country*

- Agriculture: Problems and Opportunities. Overview.* 2020 Vision. , October (Washington DC: International Food Policy Research Institute (IFPRI)).
- Pinstrup-Andersen, P., R. Pandya-Lorch and M.W. Rosegrant (1999). *World Food Prospects: Critical Issues for the Early Twenty-First Century*, 2020 Vision Food Policy Report (Washington DC: IFPRI).
- Pooja, Suman, *Pesticide Residue Analysis on Different Matrices: Estimation of Uncertainty and Variability*, University of Delhi, Department of Zoology, Delhi, 2008.
- Proceeding of AgriBiotech 2006, *First International Conference on Biotechnology for Sustainable Agriculture & Agro Industry*, Hyderabad (9-11 March, 2006).
- Qaim, M. (1998), *Transgenic Virus Resistant Potatoes in Mexico: Potential Socioeconomic Implications of North-South Biotechnology Transfer*. ISAAA Briefs No.7. ISAAA: Ithaca, New York. pp. 48.
- Qaim, M. (1999), *The Economic Effects of Genetically Modified Orphan Commodities: Projections for Sweetpotato in Kenya*, ISAAA Briefs No. 13. Ithaca, N.Y., and Bonn: ISAAA and Center for Development Research (ZEF).
- Qaim, M. (1999), *The Economic Effects of Genetically Modified Orphan Commodities: Projections for Sweetpotato in Kenya*, ISAAA Briefs No. 13. ISAAA: Ithaca, New York.
- Razdan, Anupama, *Biotechnological Approaches to Improve Phlox Drummondii Hook*, unpublished Ph.D. thesis, University of Delhi, Department of Botany, Delhi, 2008.
- Ramchiary, Nirala, *Molecular Mapping of Yield Components and Seed Glucosinolate Traits in Brassica Juncea*, unpublished Ph.D. thesis, University of Delhi, Department of Genetics, Delhi, 2008.
- Schell (1993), *Plant Biotechnology: State of the Art in Developed nations and relevant Safety consideration*. In African Regional Conference for International Conference on Safety in Biotechnology. Held during 11-14 October 1993 Harare, Zimbabwe. MEBO Environmental Consultancy, Netherlands, pp.23-29.
- Sehgal, Deepmala, *Assaying Polymorphism at DNA Sequence Level for New and Novel, Genetic Diversity diagnostics of Safflower (Carthamus Tinctorius L.), and Phylogenetic Reconstruction of the Genus Carthamus*, University of Delhi Department of Botany, Dehli, 2008.

Sharma Poonam, *Haloalkane Dehalogenase (LinB) is Responsible for β - and δ -Hexachlorocyclohexane Transformation in *Sphingobium indicum* B90A and IS 6100-Mediated Acquisition of lin Genes via Homologous Recombination* University of Delhi Department of Zoology, Delhi, 2008.

Singla, Bhumica, *Molecular Analysis of Somatic Embryogenesis in Wheat (Triticum Aestivum)*, University of Delhi, Department of Plant Molecular Biology, Delhi, 2008.

UNCTD-ICTSD project on IPRs and Sustainable Development. pp. 117-130.

World Bank (2008), *The World Development Report, Agriculture for Development*, World Bank, Washington DC, USA.

World Investment Report 1992, "Transnational Corporations as Engines of Growth", Transnational Corporations and Management Division, Department of Economic and Social Development, United Nations, New York, 1992.

Media Reports:

IRRI press release (October 29, 2004). *Asia New Rice Revolution*.

Becker, T., *TRIPS Agreement and Developing Nations*. Business India. Issue 562, 2000, pp.48-56.

Debroy, Bibek, *Protecting Intellectual Property*, Business Today, Vol.9, 2000, April 22-May 6, No.8, pp.62.

Business Standard- the strategist, *How companies approach Innovation*, Tuesday 18th December 2007, India.

Websites:

Bennett, R.M., Ismael, Y., Kambhampati, U., and Morse, S. (2004). *Economic impact of genetically modified cotton in India*. *AgBioForum*, 7(3), 96-100. Available on the World Wide Web: <http://www.agbioforum.org>. (access on 21st February, 2008).

Benbrook, Rachel C. (2000). *Rice research losing the patent bottle*. The Grain, Volume 1 March 31st 2000. [www.grain.org assessed on 18th June 2007].

Crouch, ML (1998) *How the Terminator terminates*. <http://www.biotechinfo.net/howto.html>>, accessed 2003.

Eaton, Charles, and Andrew W. Shepherd. "*Contract Farming: Partnerships for Growth*."

Food and Agricultural Organisation. Available at
 <<http://www.fao.org/DOCREP/004/Y0937E>>(access on 21st February, 2008).

Ho, M-W, Cummins, J & Bartlett, J (2000) *The killing fields - Terminator crops at large*.
 Institute of Science in Society (ISIS), <<http://www.isis.org/terminatorstory-pr.shtml>>,
 accessed 2003.

Juma, C. 2003. Biotechnology in the global communication ecology. Economic Perspectives.
 Online. Available at <http://usinfo.state.gov/journals/ites/0903/ijee/juma.htm>.

Kyoto Encyclopedia of Genes and Genomes. Bioinformatic Center, Institute for Chemical
 Research, Kyoto University, Japan, <<http://www.genome.ad.jp/KEGG>>, accessed 29
 May 2003.

Pinstrup-Andersen, P. and Cohen, M.J. (2000). '*Biotechnology and the CGIAR. Proceedings
 of the International Conference on Sustainable Agriculture in the Next Millennium –
 The Impact of Modern Biotechnology on Developing Countries*. Brussels: Friends of
 the Earth Europe. (Available at <www.ifpri.org>access on 21st February, 2008).

Warwick, H (2000) *Syngenta - switching off farmers' rights?* GeneWatch UK,
 <<http://www.genewatch.org>>, accessed 2004.

<http://www.agbios.com>
<http://www.agbioforum.org>. (access on 21st February, 2008).
<http://agricoop.nic.in> (access on 21st February, 2008).
www.anbg.gov.au/acra/acra-list-2000.html
www.biodiv.org
<http://www.biotech.co.in>
<http://www.choice.com.au>
<http://www.financialexpress.com/news/global-seed-industry-could-triple-soon-to-90bn-plus-study/41986/0> (access on 18th May 2009).
<http://india.gov.in/govt/acts.php#>
<http://www.oecd.org/biotrack/>
<http://www.oecd.org/env/biodiversity/>
http://www.rabobank.com/content/images/Rabobank_Indian_Agribiotechnology_intro_Jan2008_tcm43-55736.pdf (access on January, 2008).
<http://www.wto.org>

http://www.worldseed.org/en-us/international_seed/seed_imports.html (access on 21st February, 2008).

<http://www.navdanya.org>

<http://www.vshiva.net>

www.biotechnology.gov.au

www.btinternet.com/~nlpwessex

www.dsir.gov.in (access on 21st February, 2008).

www.foodstandards.gov.au

www.geneethics.org

www.genescan.com.au

www.genewatch.org

www.grain.org

www.i-sis.org

www.nasaa.com.au

www.newscientist.com

www.ogtr.gov.au

www.organicherbs.org

www.ofa.org.au

www.lexicon.net/zebra/temp/robjordan

www.affa.gov.au/pbrusers.ox.ac.uk/~wgtr

www.protein.com

www.ramshorn.bc.ca

www.etcgroup.org

www.seedsavers.net

www.ucsusa.org/agriculture

www.aphis.usda.gov/ppq/biotech

www.medwyns-prize-show-vegetables.com

www.nra.gov.au

www.sydney.foe.org.au/gene_ethics

www.vibhaseeds.com

APPENDIXES

APPENDIX -- I

I. a. History of Public Sector Breeding in Cotton

- 1968 MCU-5 (*G. Hirsutum*) with a spinning value of good 60's counts yarn
- 1969 Sujatha, the first commercial extra long *G. barbadense* cotton for Tamil Nadu.
- 1970 First commercial hybrid cotton H-4 (intra *hirsutum*)
- 1972 First interspecific hybrid cotton Varalakshmi (*Hirsutum x Barbadense*)
- 1974 Suvin (*GBarbadense*), superior to Sujatha for spinning 100-120's counts
- 1976 JKHy-1 Long staple hybrid cotton for Madhya Pradesh (intra *hirsutum*)
- 1978 Godavari: Long staple hybrid cotton for Maharashtra (intra *hirsutum*)
- 1980 H6: Long staple hybrid cotton for Gujarat (intra *hirsutum*)
- 1981: PKV Hy-2 Medium staple hybrid cotton for Vidharbha (intra *hirsutum*)
- 1981 DCH-32 an extra long staple hybrid cotton for South Zone* - *hirsutum x barbadense*
- 1982 Superior medium staple Variety LRA 5166 from Coimbatore research station (*hirsutum*) for southern cotton zone and Vidharbha region of Maharashtra
- 1983 NHH44 - High yielding medium-staple hybrid for Marathwada (intra-*hirsutum*)
- 1985 G.Cot DH7: Short staple desi cotton hybrid for Gujarat (*arboreum x herbaceum*)
- 1987: Savita: Extra long staple hybrid cotton for Tamil Nadu and Andhra Pradesh (intra *hirsutum*)
- 1988 G. Cot DH.9 Long staple desi cotton hybrid for Gujarat (*arboreum x herbaceum*)
- 1989: H8 Long staple hybrid cotton for Gujarat (*intra-hirsutum*)
- 1994 Hybrid cottons suitable for cotton-wheat cropping sequence released such as Tateh' for Punjab, 'Dhanalakshmi' for Haryana and "Maruvikas" for Rajasthan - all medium staple intra - *hirsutum*.
- 1995 DHB-105, a suitable replacement for DCH-32 - *hirsutum x barbadense*
- 1995 H10, Long staple intra-hirsutum hybrid cotton for Gujarat
- 1997 Om Shankar, medium staple early maturing hybrid cotton adaptable for the entire North- Zone** tract (intra *hirsutum*)

* South Zone: Tamil Nadu, Andhra Pradesh, Karnataka

**North Zone: Punjab, Haryana, Rajasthan

I. b. Chronology of Private Sector Hybrids

- 1979: MECH 11 from Mahyco- medium to long staple *intra-hirsutum* hybrid for Maharashtra and Andhra Pradesh.
- 1982: Mech 1 from Mahyco - *intra-hirsutum* long staple hybrid for Central* and South Zone.
- 1992: RCH.2 from Raasi Seeds - long staple *intra-hirsutum* hybrid for Tamil Nadu, Andhra Pradesh and Maharashtra
- 1993: Ankur 651 from Ankur Seeds - long staple *intra-hirsutum* hybrid for Maharashtra.
- 1995: Vikram 5 from Vikram Seeds - long staple *intra-hirsutum* hybrid for Gujarat
- 1996: Ajeet 11 for Maharashtra and Ajeet 33 for Central Zone from Ajeet Seeds: both medium to long staple *intra-hirsutum* hybrids.
- 1997: Paras Brahma from Hindustan Lever (taken over by Emergent Genetics) – long staple *intra-hirsutum* hybrid for Andhra Pradesh and Maharashtra.
- 1998: Maruti 9632 from Maruti Seeds - medium to long staple *intra-hirsutum* hybrid for central zone states.
- 1998: Bunny from Nuziveedu Seeds - long staple, medium duration *intra-hirsutum* hybrid with large boll size for central and south zone states
- 1999: Sri Tulasi (TCHH-4) from Tulasi Seeds, long staple *intra-hirsutum* hybrid for Andhra Pradesh, Maharashtra
- 2000: Dhanno from ProAgro, long staple *intra-hirsutum* hybrid.
- 2001: Navbharat 151 from Navbharat Seeds, for Gujarat.
- 2002: Bt hybrids, MECH 12, MECH162 and MECH 184 from Mahyco approved for all regions except North Zone.
- 2002: Durga from JK Seeds, extra long *intra-hirsutum* hybrid for Andhra Pradesh
- 2002: Kaveri 119, Kaveri 135, Kaveri 705 - long and extra long *intra-hirsutum* hybrids for Andhra Pradesh
- 2002: Sigma from Vibha Seeds - extra long *intra-hirsutum* hybrid for Maharashtra
- 2004: Bt hybrid RCH2 from Rasi Seeds approved for central and southern region

*Central Zone: Gujarat, Maharashtra, Chattisgarh and Madhya Pradesh

Timeline Summary for Regulatory Process Leading to Commercial Release of Bt.

Cotton in India

Year	Studies Undertaken	GOI Oversight
1995-1996	Application and permit for importation of Bt cottonseed containing the Cry1Ac gene.	DBT
1996-2000	Greenhouse breeding for integration of Cry1Ac gene into Indian germplasm, seed purification, and stock increase Limited field studies for potential of pollen escape, aggressiveness, and persistence	DBT RCMG
1998-2001	Biochemical and toxicological studies	RCMG (DBT) MEC
1998-2000	Multi-location field trials: agronomic and entomology performance of first generation Bt cotton hybrids, conducted by Mahyco and State agricultural universities.	RCMG (DBT) MEC
2000-2001	Soil rhizosphere evaluations and protein expression analyses from multi-location field trials	RCGM (DBT) GEAC
2001	Advanced stage multi-location field performance trials of first generation Bt cotton hybrids, conducted by ICAR	GEAC, ICAR DBT, MEC
2002	Submission of final bio-safety, environmental safety, gene efficacy and performance documentation to GEAC. Commercial release of first-generation Bt cotton hybrids by GEAC	GEAC
2002	Continued field performance trials of second generation Bt cotton hybrids for regulatory approval	RCGM (DBT) GEAC,
DBT - Department of Biotechnology GEAC - Genetic Engineering Approval Committee RCGM - Review Committee for Genetic Modification (Constituted by DBT) ICAR - Indian Council of Agricultural Research MEC - Monitoring & Evaluation Committees (Constituted by GEAC and RCGM)		

Source: Maharashtra Hybrid Seed Company Ltd. (MAHYCO)

Appendix: Legal and Policy Environment

International:

- i. Budapest Treaty (1977) Budapest Treaty of 28 April 1977 on the International Recognition of the Deposit of Micro-organisms for the Purpose of Patent Procedure.
- ii. European Council (1994) European Council Regulation No. 2100/94 on Community Plant Variety Rights, Brussels.
- iii. Food and Agriculture Organization of the United Countries (1983) International Undertaking on Plant Genetic Resources. Resolution 8/83 of the Twenty second Session of the FAO Conference, 5–23 November 1983.
- iv. Paris Convention, Paris Convention for the Protection of Industrial Property, of March 20, 1883, as revised at Brussels on December 14, 1900, at Washington on June 2, 1911, at The Hague on November 6, 1925, at London on June 2, 1934, at Lisbon on October 31, 1958, and at Stockholm on July 14, 1967, and amended on October 2, 1979.
- v. Phytosanitary Code; Agreement on the Application of Sanitary and Phytosanitary Measures, GATT Doc. MTN/FA 11-A1A-6 (Dec. 15, 1993).
- vi. The United Nations Convention on Biological Diversity, known informally as the Biodiversity Convention, is an international treaty that was adopted in Rio de Janeiro in June 1992. The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993.
- vii. The Cartagena Protocol on Biosafety of the Convention, also known as the Biosafety Protocol, was adopted in January 2000. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will for example let countries ban imports of a genetically modified organism if they feel there is not enough scientific evidence the product is safe and requires exporters to label shipments containing genetically altered commodities such as corn or cotton. The required number of 50 instruments of ratification/accession/approval/acceptance

by countries was reached in May 2003. In accordance with the provisions of its Article 37, the Protocol entered into force on 11 September 2003.

- viii. The Global Strategy for Plant Conservation (GSPC) is a program of the UN's Convention on Biological Diversity. The GSPC seeks to slow the pace of plant extinction around the world by 2010. The GSPC began as a grass-roots movement in 1999 with discussions at the 16th International Botanical Congress in St. Louis. A group of specialists subsequently met in Gran Canaria and issued the Gran Canaria Declaration Calling for a Global Plant Conservation Strategy. Following extensive consultations, the fleshed-out GPSC was adopted by the Parties to the Convention on Biological Diversity in April 2002.
- ix. TRIPS (Agreement on Trade-Related Aspects of Intellectual Property Rights, Including Trade in Counterfeit Goods), signed 15 December 1993, GATT Doc MTN/FA 11-A1C.
- x. United Countries Convention on Biological Diversity, negotiated at the United Countries Conference on Environment and Development in Rio de Janeiro in 1992, and entered into force on December 29, 1993.
- xi. UPOV (International Union for the Protection of New Varieties of Plant) (1991), International Convention for the Protection of New Varieties of Plants of 2 December, 1961, as revised at Geneva on 10 November, 1972, on 23 October, 1978, and on 19 March, 1991.
- xii. UPOV (1991) Diplomatic Conference Document DC/91/138. Revised 19 March 1991, UPOV publication no. 221 (CE), World Intellectual Property Organization, Geneva.
- xiii. UPOV (International Union for the Protection of New Varieties of Plant) (1978) International Convention for the Protection of New Varieties of Plants of 2 December, 1961, as revised at Geneva on 10 November, 1972 and on 23 October, 1978.
- xiv. UPOV (1961) International Convention for the Protection of New Plant Varieties. World Intellectual Property Organization, Geneva.

- xv. WIPO/UPOV (1990) Report of the Committee of Experts on the Interface between Patent Protection and Plant Breeders' Rights. Document WIPO/UPOV/CE/1/4. World Intellectual Property Organization, Geneva.
- xvi. WIPO (1988) Revised Suggested Solutions Concerning Industrial Property Protection of Biotechnological Inventions. Documents BioT/CE/IV/3 and BioT/CE/IV/4. World Intellectual Property Organization, Geneva.
- xvii. World Trade Organisation; Understanding on Rules and Procedures Governing the Settlement of Disputes, signed 15 December 1993, GATT Doc MTN/FA 11-A2
- xviii. World Trade Organisation's Phytosanitary Code, 1993.

Indian Laws:

- i. The Patents Act, 1970. Act title: ACT NO. 39 OF 1970. Enactment date: 19th September, 1970.
- ii. The Patents (Amendment) Act, 2002. Act title: ACT NO. 38 OF 2002. Enactment date: 25th June, 2002.
- iii. The Patents (Amendment) Act, 2005. Act title: NO. 15 OF 2005. Enactment date: 4th April, 2005.
- iv. The Geographical Indications of Goods (Registration and Protection) Act, 1999. Act title: ACT NO. 48 OF 1999. Enactment date: 30th December, 1999.
- v. The Trade Marks Act, 1999. Act title: ACT NO. 47 OF 1999. Enactment date: 30th December, 1999.
- vi. The seeds Act, 1966. Act title: ACT NO. 54 OF 1966. Enactment date: 29th December, 1966.
- vii. The Seeds Rules, 1968
- viii. The Insecticides Act, 1968. Act title: ACT NO. 46 OF 1968. Enactment date: 2nd September, 1968.
- ix. The Seeds (Control) Order, 1983.
- x. National Seeds Policy, 2002

Field Trial of GM Crops only after GEAC Approval, Rules Apex Court.**The Financial Express - May 2, 2006:** The Supreme Court has ruled that any field trial of genetically modified (GM) crops should be conducted only with the approval of the Genetic Engineering Approval Committee (GEAC). The Bench consisting of Chief Justice YK Sabarwal and Justice CK Thakkar on Monday passed this interim verdict on a petition filed by Aruna Rodrigues and others calling for a moratorium on field trials of GM crops and import of GM products. Speaking to FE, the advocate for the petitioner, Prashant Bhushan said : “The Supreme Court realised the gravity of the issue and said that the GEAC alone should give approval for any field trials of GM crops in the country.” Usually the GEAC, being the apex regulator under the environment ministry, gives approval to multi-locational, large scale field trials of GM crops. But the Review Committee on Genetic Manipulation (RCGM), a body under the promoter agency, Department of Biotechnology (DBT) approves multilocational contained field trials of GM crops. The monitoring and evaluation (MEC) is also constituted under DBT. The GEAC gives its approval for large-scale field trials on basis of the reports of RCGM and MEC. Even when the GEAC gives its final approval for commercial cultivation of GM crops after large scale field trials, the data presented by RCGM and MEC are considered.

Regulator tells Monsanto to cut GM Seeds Prices
http://agbios.com/sabp_main.php?action=ShowNewsItem&id=7517AFP - May 12, 2006:

US biotech giant Monsanto has been told on Friday to cut the cost of its genetically-modified seeds to farmers after monopoly investigators ruled it was manipulating prices, according to a report. The Monopolies and Restrictive Trade Practices Commission said the Indian joint venture, Mahyco Monsanto, imposed “unjustified” costs on farmers and demanded prices come down in a month, the media said. Activists and farmers’ groups claim failed crops, falling prices and surging production costs have contributed to an Indian farming crisis that saw 4,100 farmers commit suicide in the western state of Maharashtra alone in 2004. “We find that prima facie it has been established that the respondent is indulged in trade practices, which... have the effect of preventing, distorting and restricting competition,” said Justice B K Rathi, of the commission in the ruling on Thursday. Mahyco Monsanto immediately announced it would appeal against the decision in the Supreme Court, the country’s highest court, saying the ruling was “beyond the commission’s jurisdiction and inconsistent with the laws of India.” The company cut its royalty fee by 30 per cent to 900 rupees (\$20) per 450 grams bag of GM cotton seeds in March amid growing controversy over its tight grip on the Indian cotton GM seed market. It said the cut was in order “to best meet current market conditions.”

Research Instrument A: Questionnaire to the Farmers

This is part of the Doctoral study being conducted at School of Management Studies, University of Hyderabad to understand the Buyer's Behavior [Farmers], Product performance and factors which influence their decision making process at customer level influencing industry as a whole. Kindly answer the question in the space provided to the corresponding question. The personal details will be confidential and all the information provided shall be used for Academic purpose only. Your suggestions are very valuable for understanding Indian seed industry through the buyer's behavior, product performance and purchasing decision making mechanism of farmers. Your cooperation would be most appreciated.

Sarvesh Kumar
Research Scholar

Interviewer:

Date/ Time:

Village:

Mandal/Taluk:

Dist:

State:

Signature/Thumb impression of Farmer:

A. GENERAL PROFILE:

1 Personal Information

1.1 Farmer's Name:.....[Age:...Yrs, Sex:.....Education.....]

1.2 Address:

1.3 Name of the household(Head):

1.4 Type of Family: Nuclear/ Extended/ Joint/ Other

1.5 Religion/ Caste/ Sub-caste:

1.6 Indicate your occupation (mark $\sqrt{\quad}$)

a) owner cultivator [] b) tenant cultivator []

c) agricultural laborer [] d)other [] specify.....

1.7 Main source of income:

1.8 Secondary source of income:.....

C. General Questions about Seed:

1. What do you expect from seed that you sow in your farm?

(General question towards perception mapping that what does farmer thinks about the characteristics of good seed)

2. Do you purchase seed or use a portion of harvest for next season.....

If purchase; from where do you purchase.....

- a. Govt. institution
- b. Retailer of private seed company

3. Do you buy seed on credit or cash? if, on credit; from whom you get credit: **retailer who sell seed or of agri. input/ money lender/ other source** what use to be the condition.....or **% of interest**

3.1 Retailer gives you the desired brand or he gives the seed he want to sell

.....

3.2 Whether retailer offer seed in package (while selling it as credit):....[]

- a. Seed (any brand)
- b. Seed (for particular brand only)
- c. Seed + pesticide
- d. Seed +fertilizer
- e. Seed + loan(for other input)
- f. Seed+ pesticide + fertilizer
- g. Seed + crop insurance
- h. Guarantee about yield
- i. Other [Details].....

3.3 Any other condition retailer put for selling seed as credit.....

3.4. What should be govt. role to provide you seed of your choice and what modus operandi govt. can select to reach you.....

4. If your purchased seed fail to germinate what step do you take.....

5 If purchased seed don't give yield as proclaimed by seed company; what step do you take.....

Section D:

1. Experience in Cotton Cultivation.....
2. Area under cotton cultivation.....
3. From where do you purchase/get/ procure cotton seed:
 - a. Part of Produce stored since last cropping season
 - b. Seed given by friend/ relative
 - c. Retailer of private seed company
 - d. Govt. institution
4. Type of cotton seed used and brand of cotton seed:
 - a. Land Race
 - b. Hybrid Seed
 - c. Bt. Cotton*

5. Type and Choice of cotton seed /brand vs. Yield (Qt/Ac) per annum:

Choice of cotton seed/Brand vs. yield/annum	2004-2005	2005-2006	2006-2007	2007-2008

5.1 If farmer is using the same brand over past few year then ***Reason for it:***

5.1 If the farmer has changed the brand and company of seed then what is ***the reason for it:***

6. Cost of cultivation:

S.No	Description	Land Race	Hybrid	Bt. Cotton	Refugia
1	Soil Type				
2	Date/Month of Sowing				
3	Seed Cost				
4	Ploughing cost				
5	Fertilizer cost				
6	Pesticide cost				
7	Final Date/Month of Harvest				
8	Source of Irrigation				

7. Performance of Bt.cotton:

7.1 Was there any reduction of pest problem: Yes/No/can't say

7.1a Did Bt cotton reduced the number of spray of pesticide: Yes/No/Can't say

7.1b Did you reduce the quantity of pesticide in field: Yes/No/Can't say

7.1c Did Bt cotton Saved money on pesticide: Yes/No [if Yes; More/ Moderate/

Less/ Very less] **Ans. 7.1d**

7.1d. How much money you saved on Bt. Cotton.....

7.2 Was their yield benefit by using Bt. Cotton

7.3 other issue according to farmer.....

8 Would you like to grow Bt-cotton again [*Reason*].....

9. Other Questions Related to Bt. Cotton:

9.1 Did you follow Refugia.....

9.2 From whom you came to know about Bt cotton.....

9.3 How you sell Bt and Non Bt cotton.....

9.4 What do you do with left over cotton seed.....

9.5 What do you do with plant after harvesting.....

9.6 Do you go through the literature which comes with seed packet: *Yes/No/Sometimes?*

Please share the reason for this answer.....

9.6.a What do you understand from seed packet and its literature.....

9.6.b What is labeling?

E. Awareness towards Govt. Policy/Law:

1. Are you aware of:

- a) Genetically Modified Crop
- b) Farmer's Right Act/Seed Act
- c) The Biological Diversity Act-2002/The Biological Diversity Rule
- d) Biosafety issues /Patent Laws
- e) Consumer protection Act
- f) Crop insurance

If Yes, what do you know..... (Detail)

F. Other information [which farmer wants to give]:

G. Interviewer's comment:

Research Instrument B: Questionnaire for the Scientists

SECTION-I

Dear Sir/Madam,

This survey questionnaire is a part of the doctoral research being pursued by Sarvesh Kumar at School of Management Studies, University of Hyderabad, India. This research tries to understand the phenomenon by bringing together scientists from academia, government, industry, and the public sector. It seeks a balanced approach to understand problems of common concern for the well-being of the general public and Seed Industry with respect to scientific issues relating to nutrition, food safety, toxicology, risk assessment, health, and the environment caused by Genetically Modified Crop. Since Scientists are '*Creator, Controller and Master*' of this technology, so it is important to know the views of scientific community working in industry, government, and foundations. Therefore my humble request to you to kindly fill in your responses on the questionnaire at your convenience.

The personal details will be confidential and all the information provided shall be used for purely Academic purpose. Your cooperation will be most appreciated.

Sarvesh Kumar (Research Scholar)
Registration Number: 03MBPH03
School of Management Studies
University of Hyderabad
Hyderabad, India

A. Profile of the Scientist

1. Name of the scientist:
2. Name and address of the Organization:
3. Area of Research:
4. Past experience in Research:years
5. Please share your research experience:

B. About innovation of Genetically Modified Crop (GMC) and its Technology:

1. Sir/Madam, how much time (tentative) does it take to come out with GMC.....
 - 1.1. After success in laboratory condition; how much time is spent (tentative) on field trial for a GMC
.....
 - 1.2. After field trial; how much time is spent on commercialization of the GMC.....
2. Does your research involve working with Genetically Modified Crop:
3. Please share the information on the nature of technology and tools used to develop GMC:
4. How this technology is expressed with relevance to the plant:
5. In what way do you think that this technology can help in crop improvement:
.....
6. Are you aware of antibiotic markers? *Yes/No; if yes, what is their role in development of GMC:*
7. Do you know how transgenic plant is being developed? *Yes/No; if yes, please narrate your association.....*
8. Do you know how GMC can be used to make New Seed? ? *Yes/No; if yes, please narrate your experience*
9. Does your research cover transgenic plant like ***Bt. Cotton*** etc. Could you please share your research experience and its technical *modus operandi.....*
10. Why Refugia in Bt. Cotton field is suggested to farmer.....

10.1 Is it must to follow refugia.....

10.2 What will happen if Refugia is not being adhered with

11. Based on your experience and exposure what is your futuristic prediction for next five year for GMCs:

C. Opportunities and constrain of the Technology:

1. Please suggest some potential areas where genetic engineering can help in improvement of Crops:

.....
.....

2. If it is possible to get desired genetical change by use of Biotechnology; then

2.1 How much time do you think it take to develop GMCs:

2.2 What are the efforts associated to develop such desired seed/ plant?

2.3 What are the bottlenecks and risk do you find with this technology?

3. Antibiotic Resistance Markers in Genetically Modified (GM) Crops:

3.1 Are you aware of *Antibiotic Resistance Markers (ARM)*? *Yes/No*; if 'yes' why are they used?

a. Are you aware of any alternatives to *ARM*: *Yes/No*; if 'yes' what are they:
.....

b. How do you assess risk with respect to antibiotic resistance genes in GM crops.....

- c. If there is availability of alternatives to **ARM**; which way it will affect the current cost of technology:

.....

- 4. What potential opportunities and dangers (biosafety and environmental issue) do you anticipate for this technology:

.....

D. Opinion Survey [Controversies/Apprehensions] - Please share your views:

- 1. Please express your views that *Scientist own opinion in terms of advantages and disadvantages of this genetic engineering:*

- 2. Scientific Aspects of the GMC Controversy:

- 2.1 What are the *Popular Viewpoints*?

- 2.2 Have you come across of any of these popular viewpoint:

- 2.3 Does your research involve any of above mentioned viewpoint? What is your scientific observation towards these viewpoint:

- 3. Are you aware of Terminator technology? Yes/ No/can't say/Don't know/other.....specify

- 3.1 How it works?

- 3.2 Does your research involve this area:

- 3.3 What are its potential benefit and dangers of this technology?

4. GMC CONTAMINATION:

4.1 Please share your concern towards biological gene contamination?

4.2 Does your research cover this area? Yes/No; if yes please share your experience:
.....

4.3 Is there chance of causing biological gene contamination by GMCs?

4.4 Why refusal is being suggested to farmers to sow around their field in the case of Bt.cotton:.....

4.5 In which way life forms can be affect by biological gene contamination:

5. According to you what are the constraints associated from development to the final field success of GMCs? [Please explain]

6. Share your opinion on Biotechnology. [With respect to Consequences/ concerns/Apprehension]

E. Suggestions and Recommendation from Scientist (individual viewpoint):

1. Please suggest certain measure/ steps that how Labeling, Standards and Certification of GMC can be done effectively:

2. Please suggest certain steps for the safety assessment of GM crops.....

3. According to you what can be amicable solution towards Biosafety concern:

4. Suggest some policy choice for governing the GM Crop Revolution for country like India.....

5. Suggest some Design of Regulatory Systems for GMC Development and Use; in your view

6. Do you support GM crop: Y/N. Reasons.....

7. Please give some suggestion towards capacity building of Seed Industry for GMCs:
.....

F. Other information:

Research Instrument B: Questionnaire to the Scientists
SECTION-II (Interview/Discussion format)

Dear Sir/Madam,

My interaction cum discussion with you is a part of the doctoral research survey. I (Sarvesh Kumar) am pursuing my Doctoral Research at School of Management Studies, University of Hyderabad, India. My research tries to understand the phenomenon by bringing together scientists from academia, government, industry, and the public sector. It seeks a balanced approach to understand problems of common concern for the well-being of the general public and Seed Industry with respect to scientific issues relating to nutrition, food safety, toxicology, risk assessment, health, and the environment caused by Genetically Modified Crop. Since Scientists are '*Creator, Controller and Master*' of this technology, so it is important to know the views of scientific community working in industry, government, and foundations. Because of large number of stakeholder, the nature of research is *exploratory*. Your personal opinions and views based on your research opinion is very important to understand the phenomenon. Please feel free to share your views and data which you think is relevant towards this issue and not covered in discussion. I humbly request you for co-operation. I will be life long oblige to you for your precious time spent on the discussion.

[The personal details will be confidential and all the information provided shall be used for purely Academic purpose.]

With Regards,

Yours sincerely,
Sarvesh Kumar (Research Scholar)
Registration Number: 03MBPH03
School of Management Studies
University of Hyderabad
Hyderabad, India

Broad Issues (Issue for Open Discussion/Views/Opinion):

- 1) Genetically Modified Crop (*GMC*)
- 2) New Seeds (GM potential)
- 3) Transgenic plant like *Bt. Cotton*.
- 4) Refugia/ Biosafety issues.
- 5) Opportunities and constrain of the Biotechnology in terms of its use in Agriculture.
- 6) Use of genetic engineering in improvement of Crops.
- 7) Antibiotic Resistance Markers (*ARM*)
- 8) Biosafety and environmental issue.
- 9) Gene contamination
- 10) Suggestions and Recommendation.
- 11) Opinion/ View

**Research Instrument C: Questionnaire for Industry (Seed companies: Frame for Broad
Discussion/Interview with Managers)**

SECTION:I

This is part of the Doctoral study being conducted at School of Management Studies, University of Hyderabad to analyse the industry structure and strategy of Indian seed Industry, their product portfolio and transformation brought by New Technology-Biotechnology on them. Information provided shall be confidential and used for Academic purpose only. Your suggestions are very valuable to understanding the changes occurring during this volatile environment brought by this new technology. The aim of this research is to bring out some understanding for Seed Industry as a whole Your co-operation would be most appreciated.

Sarvesh Kumar
Registration No.: 03MBPH03
Research Scholar

A. BACKGROUND

- a. Trends in Industry and the Marketplace
- b. Driving Forces for biotechnology based Genetically Modified Product/ Technology associated with it.
- c. Product Opportunity/ Bt. cotton
- d. Research and Development.
- e. The Niche/Advantage/Uniqueness Of Position for 'New Seed'
- f. Brand Label, Joint Ventures, Acquisitions

B. MARKET DATA

- a. Product Mix offered to market.
- b. *Product-Services Mix*
- c. Customer Base

C. ROUTE TO MARKET

D. MARKETING REQUIREMENTS SPECIFICATION

- a. Market Opportunity
- b. Tie to Strategic Plan
- c. Scope of Product Line
- d. 'Gene' Parts and Product Configuration
- e. Timing to Introduction

E. CUSTOMER FIELD VISITS

F. COMPETITION

- a. Pricing Analysis
- b. Route to Market
- c. Technology
- d. Strategy Against Each Competitor

G. FIELD FEEDBACK

- a. Problems
- b. Complaints
- c. Suggestions
- d. Next Generation or Product Iteration

H. PROMOTION: Promotional Literature

I. PRODUCT EVOLUTION FLOWCHART: Life Cycle Management (GMC)/Biosafety

**Section II: Industry Questionnaire (Interview Frame for Other Stake Holders:
NGOs/Agriculture Officers/others)**

A. General Information:

B. Questions related to development/ use of Biotechnology in Seed Industry:

1. Biotechnology: How it can help Agricultural Improvement in India?
2. GMOs.
- 3 How GMOS can be used to make New Seed?
4. Bt. Cotton.
5. Terminator genes
6. Product Related Questions:
 - a. Use of Biotechnology.
 - b. How much time it takes to dev. Such plant?
 - c. The efforts associated to develop seed/ plant (GMC).
 - d. Biosafety/ Refugia
 - e. The constraints associated from development to the final field success.
 - f. Other.....
8. Final opinion on Biotechnology based GMC. [Consequences/ concerns/ Apprehension]

C. Opinion/ Views/Suggestions.