CONTENTS

ABOUT THE SERIES: FRONTIERS OF ECONOMICS AND GLOBALIZATION v

ABOUT THE EDITORS vii

LIST OF CONTRIBUTORS ix

INTRODUCTION xxi

CHAPTER 1 BIOTECHNOLOGY AND AGRICULTURE: CURRENT AND EMERGING APPLICATIONS 1

Robert W. Herdt and Rebecca Nelson

1 Introduction 2
2 Genetic basics 2
   2.1 Molecular markers 4
3 Current and near-term applications 5
   3.1 Diversity analysis 5
   3.2 Products of marker-assisted selection 6
   3.3 Transgenic products 7
   3.4 Cisgenic products 9
   3.5 Transgenic animals 9
4 Prospective commercial products 10
   4.1 Drought tolerance in crop plants 10
   4.2 Plant genetic modification for better human nutrition 12
   4.3 Pharmaceuticals from transgenic plants 14
   4.4 Biofuels 15
   4.5 Environmental bioremediation 16
5 Emerging DNA-based techniques 16
   5.1 Genomic selection 16
6 Reflections and conclusions 17
References 19
CHAPTER 2 GENETICALLY MODIFIED CROPS AND GLOBAL FOOD SECURITY
Matin Qaim

1 Introduction 30
2. GM crops and food security: potential pathways 31
   2.1 GM crops and food availability 32
   2.2 GM crops and economic access to food 34
   2.3 GM crops and nutritional value 35
3. Socioeconomic impacts of commercialized GM crops 36
   3.1 Impacts of herbicide-tolerant crops 36
   3.2 Impacts of insect-resistant crops 38
      3.2.1 Agronomic and economic effects 38
      3.2.2 Poverty and distribution effects 40
4. Potential impacts of future GM crops 42
   4.1 Crops with improved agronomic traits 42
   4.2 Crops with improved nutritional traits 44
5. Institutional and policy issues 47
6. Conclusion 49
References 50

CHAPTER 3 CURRENT AND POTENTIAL FARM-LEVEL IMPACTS OF GENETICALLY MODIFIED CROPS IN DEVELOPING COUNTRIES
Terri Raney and Ira Matuschke

1 Introduction 55
2 Farm-level impacts of GM crops in developing countries: experiences from Asia, Africa, and Latin America 57
   2.1 Asia 57
   2.2 Africa 63
   2.3 Latin America 66
3 The research pipeline 68
   3.1 What is in the research pipeline? 69
   3.2 Genetically modified drought-tolerant maize 70
   3.3 Genetically modified rice 74
   3.4 Genetically modified wheat 75
4 Conclusions 75
Acknowledgments 76
References 77
CHAPTER 4 THE IMPACT OF BT COTTON AND THE POTENTIAL IMPACT OF BIOTECHNOLOGY ON OTHER CROPS IN CHINA AND INDIA

Carl E. Pray, Latha Nagarajan, Jikun Huang, Ruifa Hu and Bharat Ramaswami

1 Introduction 84
2 Investments in agricultural biotechnology 85
  2.1 Public investments in Chinese agricultural biotech 85
  2.2 Agricultural biotech R&D investments in India 86
  2.3 Adoption of biotechnology 88
    2.3.1 Adoption of GM crops in China 88
  2.4 Adoption of GM cotton in India 89
    2.4.1 Illegal Bt introduction and spread 90
    2.4.2 Legal Bt technology and status 91
3 Empirical studies on the impact of adoption of Bt cotton 92
  3.1 Impact of Bt cotton adoption in China 92
    3.1.1 Agronomic and economic impacts 93
    3.1.2 Health effects 96
  3.2 Impact of adoption of Bt cotton in India 97
    3.2.1 Reduction in insecticide use, increase in aggregate yields 97
    3.2.2 Increased farm income and spillovers 99
    3.2.3 Impact of seed and royalty price controls and farmers’ benefits 101
4 Potential impact of biotechnology in other crops 104
  4.1 GM crops in the pipeline in China 104
    4.1.1 Impact of GM rice 104
  4.2 GM crops research in India 105
    4.2.1 Bt eggplant 105
5 Conclusions 108
Acknowledgments 109
References 110

CHAPTER 5 CONTRIBUTIONS OF PUBLIC AND PRIVATE R&D TO BIOTECHNOLOGY INNOVATION

Wallace E. Huffman

1 Introduction 116
2 Some background 117
### Contents

3 Important scientific discoveries providing the foundation for GM crops 118
4 New intellectual property rights that facilitated innovation in plants 120
5 Innovation in GM traits for major crops 122
6 Adoption of GM crop varieties 125
7 Pricing and benefit distribution from a GM trait 129
8 A major transformation of research and the seed industry 131
9 More evidence on private and public R&D investments in crop improvement and biotechnology 138
10 Conclusions 144

References 145

---

**CHAPTER 6 SPATIAL PRICING OF GENETICALLY MODIFIED HYBRID CORN SEEDS** 149
*Kyle W. Stiegert, Guanming Shi and Jean-Paul Chavas*

1 Introduction 149
2 Literature review 152
3 The model 153
4 Data 155
5 Estimation 157
6 Econometric results 162
7 Implications for spatial pricing 165
8 Concluding remarks 168
   Acknowledgments 170
   References 170

---

**CHAPTER 7 THE ENVIRONMENTAL BENEFITS AND COSTS OF GENETICALLY MODIFIED (GM) CROPS** 173
*Justus Wesseler, Sara Scatasta and El Hadji Fall*

1 Introduction 173
2 Theoretical framework for assessing the environmental benefits of GM crops 175
3 Environmental benefits and costs of GM crops 177
   3.1 Yield effects of GM crops 178
   3.2 Pesticide use effects of GM crops 180
   3.3 Fertilizer use and GM crops 182
   3.4 Environmental safety issues of GM crops 184
   3.5 Tillage and GHG emission effects 186

---
CHAPTER 8 COEXISTENCE OF GENETICALLY MODIFIED (GM) AND NON-MODIFIED (NON-GM) CROPS: ARE THE TWO MAIN PROPERTY RIGHTS REGIMES EQUIVALENT WITH RESPECT TO THE COEXISTENCE VALUE?
Volker Beckmann, Claudio Soregaroli and Justus Wesseler

1 Introduction 202
2 Coexistence regulations 202
3 A generic model assessing coexistence 206
4 Coexistence and regulations 208
   4.1 Liability rights and distribution of costs and benefits 209
      4.1.1 Prohibitive transaction costs 212
      4.1.2 Zero transaction costs 213
      4.1.3 Positive transaction costs 214
   4.2 Spatial implications 215
   4.3 Equivalence of the property rights systems 216
5 Conclusions 219
References 221

CHAPTER 9 BIOTECHNOLOGY AND BIOFUEL
Steven E. Sexton and David Zilberman

1 The economics of biofuel 226
2 The impacts of biotechnology on agricultural productivity 229
3 The impacts of biofuel on food, fuel, and GHG emissions 231
4 Beyond yield effects: The future of biofuel and biotechnology 239
References 240

CHAPTER 10 CONSUMER PREFERENCES FOR GENETICALLY MODIFIED FOOD
Jayson L. Lusk

1 Introduction 243
   1.1 Question #1: Most studies suggest consumers are willing to pay significant premiums to avoid GM foods, so why do foods advertised as “GM-free” have almost no market penetration in the United States? 244
1.2 Question #2: If consumers are concerned about GM food, why are they generally uninformed and unknowledgeable about the technology? 250
1.3 Question #3: If consumer WTP for GM food is affected by information, why do most economic models assume WTP for GM food is unaffected by policies and labels? 252
1.4 Question #4: Why there is so little consensus on the factors explaining the difference in U.S. and European preferences for GM food? 254
2 What does it all mean? 257
Acknowledgment 259
References 259

CHAPTER 11 THE EFFECT OF GM LABELING REGIME ON MARKET OUTCOMES 263
Elise Golan and Fred Kuchler

1 GM product differentiation and labeling regime: the evidence 264
2 GM labeling unlikely to have large effects on consumer choice 266
3 Labeling regime does not change the distribution of differentiation costs 268
4 Other factors tipped the balance to a non-GM strategy in labeling countries 270
4.1 Consumer confidence in government and the safety of the food supply 271
4.2 A non-GM strategy was usually affordable 272
4.3 Wholesome competition 274
4.4 Market momentum contributes to market bifurcation 275
5 Conclusion: labeling regime does not determine market outcome 277
References 278

CHAPTER 12 INTERNATIONAL TRADE AND WELFARE EFFECTS OF BIOTECHNOLOGY INNOVATIONS: GM FOOD CROPS IN BANGLADESH, INDIA, INDONESIA, AND THE PHILIPPINES 283
Guillaume P. Gruère, Antoine Bouët and Simon Mevel

1 Introduction 284
2 Lessons from past studies 286
3 The case of GM food crops in Bangladesh, India, Indonesia and the Philippines 290
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.3 Scope for precaution</td>
<td>346</td>
</tr>
<tr>
<td>3.2 A coherent PP framework</td>
<td>346</td>
</tr>
<tr>
<td>4 Looking more closely at remedies</td>
<td>347</td>
</tr>
<tr>
<td>4.1 Screening, pre-release testing, and post-release surveillance, STS</td>
<td>349</td>
</tr>
<tr>
<td>4.2 Innovation and the PP</td>
<td>350</td>
</tr>
<tr>
<td>5 Genetically modified crops as a case of innovation</td>
<td>352</td>
</tr>
<tr>
<td>5.1 A stylized release protocol for genetically modified crops</td>
<td>352</td>
</tr>
<tr>
<td>5.2 Where might PP prohibitions apply?</td>
<td>354</td>
</tr>
<tr>
<td>5.3 Current regulatory practice applied to GM crops</td>
<td>355</td>
</tr>
<tr>
<td>5.4 International agreements: the case of the Cartagena Protocol on Biosafety</td>
<td>358</td>
</tr>
<tr>
<td>5.5 Applying the STS-based protocol: two case examples</td>
<td>359</td>
</tr>
<tr>
<td>5.6 A digression: where does market risk fit in?</td>
<td>361</td>
</tr>
<tr>
<td>6 Lessons for precaution and innovation</td>
<td>362</td>
</tr>
<tr>
<td>6.1 Is routine pre-release testing too costly?</td>
<td>362</td>
</tr>
<tr>
<td>6.2 Could the mix of pre- and post-release remedies be improved?</td>
<td>363</td>
</tr>
<tr>
<td>7 Concluding comments</td>
<td>364</td>
</tr>
<tr>
<td>References</td>
<td>365</td>
</tr>
</tbody>
</table>

SUBJECT INDEX

369