

Contents

Contributors	XVI
Abbreviations	XXI
1 Rice	
P.K. Subudhi, T. Sasaki, G.S. Khush	1
1.1 Introduction	1
1.1.1 Taxonomy and Origin of Cultivated Rice	1
1.1.2 Dispersal of Cultivated Rice	2
1.1.3 Varietal Diversity of Rice	3
1.1.4 Rice Varietal Improvement	4
1.1.5 Rice-Breeding Challenges in the 21st Century	5
1.2 Construction of Molecular Linkage Maps in Rice	6
1.3 Molecular Mapping of Simple and Complex Traits in Rice	16
1.3.1 Disease Resistance	17
1.3.2 Insect Resistance	20
1.3.3 Traits Relevant for Hybrid Rice Breeding	22
1.3.4 Grain Quality	26
1.3.5 Abiotic Stress Tolerance	27
1.3.6 Important Agronomic Traits	37
1.3.7 QTL × Environment Interaction	44
1.3.8 Utilization of Wild Species for Mapping and Introgression of Agronomic Traits	45
1.4 Molecular Characterization of Rice Germplasm	45
1.5 Progress in Marker-Assisted Breeding	46
1.5.1 MAS for Disease Resistance	47
1.5.2 MAS for Insect Resistance	47
1.5.3 MAS for Grain Quality	50
1.5.4 MAS in Hybrid Rice Breeding	50
1.5.5 Gene Pyramiding	51
1.5.6 MAS for Other Traits and QTL	51
1.5.7 MAS for Introgression of Alien Genes	52
1.6 Map-Based Cloning of Rice Genes and QTL	52
1.7 Advanced Works	55
1.7.1 Rice Physical Maps	55
1.7.2 Tools for Rice Functional Genomics	56
1.7.3 DNA Microarray	56
1.7.4 Insertional Mutagenesis	57
1.8 Future Scope of Work	58
References	60
2 Wheat	
R.K. Varshney, H.S. Balyan, P. Langridge	79
2.1 Introduction	79
2.2 Molecular Markers – Types and Availability	80

2.3	Construction of Molecular Maps	80
2.3.1	Genetic Maps	81
2.3.2	Transcript Genetic Maps or Functional Maps	84
2.3.3	Physical Maps	84
2.4	Application of Molecular Markers in Wheat Genetics and Breeding	87
2.4.1	Gene Tagging and QTL Analysis for MAS	87
2.4.2	Map-Based Cloning (MBC) of Genes in Wheat	97
2.4.3	Allelic Diversity	99
2.4.4	Comparative Mapping and Synteny	108
2.5	Impact of Genomics Research on Wheat Genetics and Breeding	109
2.5.1	Transcriptomics and Functional Genomics	110
2.5.2	Comparative Genomics and Bioinformatics	111
2.5.3	Novel Approaches	112
2.6	Concluding Remarks	114
	References	114

3 Maize

H. Cai	135	
3.1	Introduction	135
3.1.1	Brief History of the Crop	135
3.1.2	Botanical Description	135
3.1.3	Economic Importance	135
3.1.4	Breeding Objectives	136
3.1.5	Classical Mapping Efforts	137
3.1.6	Classical Breeding Achievements	137
3.1.7	Limitations of Classical Endeavors and Utility of Molecular Mapping	137
3.2	Construction of Genetic Maps	137
3.2.1	Brief History of Mapping Efforts	137
3.2.2	First-Generation Maps	138
3.2.3	Second-Generation Maps	139
3.3	Gene Mapping	140
3.4	Quantitative Trait Loci (QTL) Analysis	142
3.5	Marker-Assisted Breeding	144
3.6	Map-Based Cloning	144
3.7	Future Scope of Works	145
3.7.1	Maize Genome Sequencing	145
3.7.2	Next-Generation Marker Development: SNP	145
3.7.3	Map-Based Cloning Using Information of Sorghum and Rice Genome Sequences	146
	References	146

4 Barley

G. Backes, J. Orabi, G. Fischbeck, A. Jahoor	155	
4.1	Introduction	155
4.1.1	Genus <i>Hordeum</i>	155
4.1.2	Taxonomic Position of Barley	155
4.1.3	Gene Pools of Barley	155
4.1.4	The Wild Progenitor of Barley	156

4.1.5	Domestication of Barley	157
4.1.6	Important Traits for Domestication.....	159
4.1.7	Migration and History of Barley Cultivation	161
4.2	Construction of Genetic Maps	162
4.3	Gene Mapping	167
4.3.1	Resistance Genes.....	170
4.3.2	Genes Related to Abiotic Stresses.....	177
4.3.3	Traits Important for Domestication.....	177
4.4	Analysis of Quantitative Trait Loci.....	178
4.5	Marker-Assisted Breeding	195
4.6	Map-Based Cloning of Resistance Genes in Barley	196
4.6.1	<i>mlo</i> and <i>Ror</i> Genes	196
4.6.2	<i>Mla</i> and <i>Rar</i> Genes	197
4.6.3	<i>Rpg</i> Genes	198
4.7	Future Scope of Works	198
	References	199

5 Oat

H.W. Rines, S.J. Molnar, N.A. Tinker, R.L. Phillips	211	
5.1	Introduction	211
5.1.1	Brief History and Biology of Oat	211
5.1.2	Oat Grain Composition, Other Grain Quality Factors, and Agronomic Traits and Their Relation to Breeding Objectives.....	212
5.1.3	Limitations of Conventional Genetics and Breeding Approaches and the Utility of Molecular Mapping	214
5.2	Development of Molecular Linkage Maps in Oat.....	215
5.2.1	Mapping in Diploid Oats	215
5.2.2	Hexaploid Mapping: Kanota × Ogle	217
5.2.3	Other Hexaploid Oat Maps	218
5.2.4	Comparative and Integrative Mapping	219
5.2.5	Integration of Genetic and Chromosomal Maps	219
5.3	Gene Mapping	220
5.3.1	Gene mapping in Segregating Populations.....	220
5.3.2	Gene Tagging	226
5.3.3	DNA Sequence-Based Mapping	226
5.4	QTLs in Oat	228
5.4.1	Detection of QTLs.....	228
5.4.2	Integrative and Comparative QTL Investigations	228
5.5	Marker-Assisted Breeding	229
5.5.1	PCR-Based Markers	232
5.5.2	<i>Pc68</i> and <i>Pc94</i> Case Studies	232
5.5.3	Advances Toward MAS for Other Traits	234
5.6	Future Scope and Related Oat Genomic Research	235
	References	237

6 Secale

T. Chikmawati, X.-F. Ma, K. Ross, Miftahudin, J.P. Gustafson	243	
6.1	Introduction	243
6.1.1	Morphology	243
6.1.2	Cytology	243

6.1.3	Origin of Cultivated Rye	243
6.1.4	Distribution of the Genus <i>Secale</i>	244
6.1.5	Classification of the Genus <i>Secale</i>	245
6.2	Phylogenetic Relationships Among <i>Secale</i> Species Utilizing AFLP Analysis	247
6.3	Molecular Taxonomy of <i>Secale</i>	248
6.3.1	Distinction Among Annual Species	248
6.3.2	Distinction Among Perennial Species	248
6.4	Genetic Diversity Among Cultivated Rye Genotypes	249
6.5	Utilization of Molecular Markers in Rye Systematics	249
6.6	A Review of Linkage Mapping in Rye.....	250
6.6.1	Mapping Population and Linkage Maps	250
6.6.2	Markers.....	252
6.6.3	Mapping Programs	253
6.6.4	Segregation Distortion.....	253
	References	253

7 Sorghum

H.P. Singh, H.C. Lohithaswa	257	
7.1	Introduction.....	257
7.1.1	Center of Origin	257
7.1.2	Domestication	257
7.1.3	Taxonomic Position	258
7.1.4	Brief Morphology	259
7.1.5	Cytogenetic Structure	260
7.1.6	Economic Importance	260
7.1.7	Breeding Objectives	264
7.1.8	Classical Breeding Achievements	265
7.1.9	Limitations of Classical Endeavors and Utility of Molecular Mapping	265
7.2	Construction of Genetic Maps	267
7.2.1	First-Generation Genetic Maps	267
7.2.2	Integrated Genetic Maps	267
7.2.3	Comparative Mapping	269
7.3	Gene Mapping	280
7.4	Detection of Quantitative Trait Loci (QTL).....	281
7.5	Marker-Assisted Breeding	284
7.5.1	Marker Conversions	284
7.5.2	Marker-Assisted Selection	284
7.6	Physical Mapping in Sorghum	285
7.7	Structural Genomics.....	287
7.8	Functional Genomics	288
7.8.1	Development of ESTs	288
7.8.2	Gene Function Analysis	288
7.9	Future Prospects	290
	References	291

8 Pearl Millet

K.M. Devos, W.W. Hanna, P. Ozias-Akins	297	
8.1	Introduction	297

8.1.1	Brief History	297
8.1.2	Botanical Description.....	297
8.1.3	Economic Importance	298
8.1.4	Breeding Objectives and Achievements	298
8.1.5	Classical Mapping Efforts	299
8.1.6	Classical vs. Molecular Maps in Pearl Millet	300
8.2	Construction of Genetic Maps	300
8.2.1	Brief History of Mapping Efforts	300
8.2.2	First-Generation Genetic Maps	301
8.2.3	Comparative Genetic Mapping in Pearl Millet.....	309
8.3	Quantitative Trait Loci (QTL) Analyses.....	309
8.3.1	Domestication Syndrome	309
8.3.2	Drought Tolerance	310
8.3.3	Downy Mildew Resistance.....	311
8.3.4	Mendelization of QTLs.....	311
8.4	Marker-Assisted Breeding	311
8.5	Map-Based Cloning	312
8.6	Future Scope of Work	313
	References	313

9 Foxtail Millet

O. Panaud	319
9.1 Introduction.....	319
9.2 <i>Setaria</i> Complex	319
9.3 Molecular Maps of Foxtail Millet	321
9.4 Mapping Genetic Factors Underlying Plant Architecture	321
9.5 Conclusion and Perspectives	324
References	326

10 Finger Millet

M.M. Dida, K.M. Devos	327
10.1 Introduction.....	327
10.1.1 Brief History of the Crop	327
10.1.2 Botanical Descriptions.....	327
10.1.3 Economic Importance	329
10.1.4 Breeding Objectives	329
10.1.5 Classical Breeding Achievements	330
10.2 Genetic Mapping in Finger Millet	331
10.2.1 Brief History of Mapping Efforts	331
10.2.2 First-Generation Genetic Maps	331
10.2.3 Comparative Genetic Maps	332
10.3 Future Scope of Work	333
References	336

Subject Index

339