# Broadening the Genetic Base of Crop Production

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Edited by

**H.D. Cooper**
*Food and Agriculture Organization of the United Nations, Rome, Italy, and Secretariat of the Convention on Biological Diversity, Montreal, Canada*

**C. Spillane**

*Institute for Plant Biology, Zurich University, Zurich, Switzerland*

**T. Hodgkin**

*International Plant Genetic Resources Institute, Rome, Italy*

CABI *Publishing*
*in association with*
Food and Agriculture Organization of the United Nations
*and*
International Plant Genetic Resources Institute

A catalogue record for this book is available from the British Library, London, UK.

**Library of Congress Cataloging-in-Publication Data**
Broadening the genetic base of crop production / edited by H.D. Cooper, C. Spillane, and T. Hodgkin.
p. cm.
Includes bibliographical references.
ISBN 0-85199-411-3 (alk. paper)
1. Food crops--Germplasm resources. 2. Plant genetics. 3. Genebanks, Plant. I. Cooper, H. D. (H. David) II. Spillane, Charlie. III. Hodgkin, T. IV. Food and Agriculture Organization of the United Nations. V. International Plant Genetic Resources Institute.

SB123.3.B76 2000
333.95'34--dc21 00–044455

Published jointly by:
CABI *Publishing*, a division of CAB *International*
CABI Publishing, CAB International, Wallingford, Oxon OX10 8DE, UK
Tel.: +44(0)1491 832111; Fax: +44 (0)1491 833508;
Email: cabi@cabi.org; Web site: www.cabi.org
CABI Publishing, 10 E 40th Street, Suite 3203, New York, NY 10016, USA
Tel: +1 212 481 7018; Fax: +1 212 686 7993; Email: cabi-nao@cabi.org

Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla, 00100 Rome, Italy
Tel.: +39 06 57051; Fax: +39 06 57053152;
Email: webmaster@fao.org; Web site: www.fao.org

International Plant Genetic Resources Institute (IPGRI)
Via delle Sette Chiese 142, 00145 Rome, Italy
Tel.: +39 06 51892; Fax: +39 06 5750309
Email: ipgri@cgiar.org; Web site: www.ipgri.cgiar.org

ISBN 0 85199 411 3 (CABI)
ISBN 92 5 104438 4 (FAO)
ISBN 92 9043 458 9 (IPGRI)



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Typeset in 10/12pt Garamond by Columns Design Ltd, Reading
Printed and bound in the UK by Biddles Ltd, Guildford and King's Lynn

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# Contributors


A. Amri, *International Center for Agricultural Research in the Dry Areas (ICARDA), PO Box 5466, Aleppo, Syria*

F.A. Asaad, *Field Crops Research Institute, Agricultural Research Center (ARC), PO Box 12619, 9 Gamaa Street, Giza, Egypt*

J. Ashby, *International Centre for Tropical Agriculture (CIAT), Cali, Colombia*

A. Baratin, *CAUSSADE Semences, Z.I. Avenue de Meaux, 82300 Caussade, France*

M. Baron, *LIMAGRAIN Génétique, BP 1, 63720 Chappes, France*

J.A. Barrett, *Department of Genetics, University of Cambridge, Downing Street, Cambridge CB2 3EH, UK*

A. Barrière, *INRA, Station d'Amélioration des Plantes Fourragères, 86600 Lusignan, France*

J.P. Baudoin, *Faculté Universitaire des Sciences Agronomiques de Gembloux, 2 Passage des Déportés, 5030 Gembloux, Belgium*

A. Benbelkacem, *Institut Technique des Grandes Cultures (ITGC), BP 16, El-Harrach, Algiers, Algeria*

J. Berthaud, *Institut de Recherche pour le Développement (IRD), 911 Avenue Agropolis, BP 5045, 34032 Montpellier cedex, France*

G. Berthe, *LIMAGRAIN Génétique, BP 1, 63720 Chappes, France*

M. Bonierbale, *International Potato Center (CIP), PO Box 1558, Lima, Peru*

P. Brabant, *INA-PG, 16 rue Claude Bernard, 75005 Paris, France*

J.E. Bradshaw, *Scottish Crop Research Institute (SCRI), Invergowrie, Dundee DD2 5DA, UK*

A. Boyat, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*

F. Camarena, *Universidad Nacional Agraria La Molina, Apdo 456, Lima, Peru*

M. Cambolive, *PIONEER Génétique, BP 5, 31840 Aussonne, France*

P. Carolo, *RUSTICA Prograin Génétique, Domaine de Sandreau, Mondonville, 31700 Blagnac, France*

F. Castillo González, *Colegio de Postgraduados, IREGEP, Texcoco, México 56230, México*
S. Ceccarelli, *International Center for Agricultural Research in Dry Areas (ICARDA), PO Box 5466, Aleppo, Syria*
S. Chandra, *Indian Institute for Pulses Research, Kanpur 208024, India*
A. Charcosset, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
M. Chaudhry, *Ayub Agricultural Research Institute, Faisalabad, Pakistan*
J.C. Clément, *IRD, 213 Rue Lafayette, 75480 Paris cedex 10, France*
L. Colon, *Centre for Plant Breeding and Reproduction (CPRO-DLO), PO Box 16, Wageningen 7600 AA, The Netherlands*
H.D. Cooper, *Food and Agriculture Organization of the United Nations. Present address: Secretariat of the Convention on Biological Diversity, World Trade Centre, Suite 300, 393 St Jacques, Montreal, Quebec, Canada H2Y 1N9*
J. David, *ENSAM INRA, UFR de Génétique et Amelioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
J. Dallard, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
M. Derieux, *INRA, Domaine de Brunehaut, 80200 Estrées-Mons, France*
B. Desprez, *Florimond Desprez Co., BP 41, 59242 Cappelle en Pévèle, France*
J.L. Desselle, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
F. Devaux, *MAISADOUR, Silo de Haut Mauco, Route de Saint Sever, 40000 Mont de Marsan, France*
P. Dubreuil, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
J. Durovray, *NOVARTIS, 12 route de Crossay, Senneville, 28700 Francourville, France*
H. Duval, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
R.A. El-Einen, *Field Crops Research Institute, Agricultural Research Center (ARC), PO Box 12619, 9 Gamaa Street, Giza, Egypt*
M. El-Felah, *Institut National de la Recherche Agronomique de Tunisie (INRAT), Rue Hedi Karray, 2880 Ariana, Tunis, Tunisia*
A.F. El-Sayed, *Field Crops Research Institute, Agricultural Research Center (ARC), PO Box 12619, 9 Gamaa Street, Giza, Egypt*
L. Emperaire, *IRD/ISA, SCLN 210, Bloco C, sala 112, 70862-530, Brasilia (DF), Brazil*
J. Enjalbert, *INRA, Laboratoire de Pathologie Végétale, Grignon, 78850 Thiverval-Grignon, France*
W. Erskine, *International Center for Agricultural Research in Dry Areas (ICARDA), PO Box 5466, Aleppo, Syria*
M. Ferranet, *MAISADOUR, Silo de Haut Mauco, Route de Saint Sever, 40000 Mont de Marsan, France*
G. Forbes, *International Potato Center (CIP), Experimental Station at Santa Catalina, PO Box 17-21-1977, Quito, Ecuador*
L. Frese, *Federal Centre for Breeding Research on Cultivated Plants (BAZ), Gene Bank, Braunschweig, Germany*
E.A. Frison, *International Network for the Improvement of Banana and Plantain, Parc Scientifique Agropolis II, 34397 Montpellier cedex 5, France*

A. Gallais, *Station de Génétique Végétale, INRA-PROMAIS programme, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
R. García Espinosa, *Colegio de Postgraduados, IFIT, Texcoco, México 56230, México*
P. Garnier, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-Sur-Yvette, France*
P. Gepts, *Department of Agronomy and Range Science, University of California, 1 Shields Avenue, Davis, CA 95616-8515, USA. Email: plgepts@ucdavis.edu*
I. Goldringer, *INRA-UPG-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
M.M. Goodman, *Department of Crop Science, North Carolina State University, Raleigh, NC 27695, USA*
B. Gouesnard, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
S. Grando, *International Center for Agricultural Research in Dry Areas (ICARDA), PO Box 5466, Aleppo, Syria*
M. Harrabi, *Institut National Agronomique de Tunisie (INAT), 43 Avenue Charles Nicole, 1082 Tunis-Belvédère, Tunisia*
T. Hodgkin, *International Plant Genetic Resources Institute, Via delle Sette Chiese 142, 00145 Rome, Italy*
J.-P. Horry, *CIRAD-FLHOR, Département des Productions Fruitières et Horticoles, BP 153, 97202, Fort de France cedex, Martinique*
M.A. Huarte, *Instituto Nacional de Tecnología Agropecuaria (INTA), Ruta 226, km 73.5, Balcarce, Buenos Aires 7620, Argentina*
K.M. Ibrahim, *School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, UK*
C. Iglesias, *1400 Woodland, West Lafayette, IN 47906, USA*
L.W. Kannenberg, *Plant Agriuclture Department, University of Guelph, Guelph, Ontario, Canada N1G 2W1*
A.J. Kennedy, *West Indies Central Sugar Cane Breeding Station, Groves, St George, Barbados*
A. Lacombe, *VAN der HAVE France, Domaine de la Revanche, 32700 Lectoure, France*
B.A. Lambert, *VERNEUIL Recherche, Avenue de la Croix Blanche, 49630 Corné, France*
J.A. Landeo, *International Potato Center (CIP), PO Box 1558, Lima, Peru*
V. Lavergne, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
M. Lefort, *Bureau des Ressources Génétiques (BRG), 16 rue Claude Bernard, 75231 Paris cedex 05, France*
M. Leipert, *SDME, Centre de Sélection, rue du Bois Musquet, 28300 Champhol, France*
M. Lobo, *Corporación Colombiano de Investigación Agropecuaria, C.I. La Selva, Apartado Aereo 100 ó 470, Rionegro, Colombia*
D. Louette, *Chemin de la Croix, 30260 Brouzet les Quissac, France*
N.P. Louwaars, *Plant Research International, PO Box 16, 6700 AA, Wageningen, The Netherlands*
M. Maatougui, *Institut Technique des Grandes Cultures (ITGC), BP 16, El-Harrach, Algiers, Algeria*

G.R. Mackay, *Scottish Crop Research Institute (SCRI), Invergowrie, Dundee DD2 5DA, UK*
A. Majesté, *COOP DE PAU Semences, Avenue Gaston Phoebus, 64230 Lescar, France*
S. McGuire, *Technology and Agrarian Development, Wageningen University, Nieuwe Kanaal 11, 6709 PA Wageningen, The Netherlands*
M.S. Mekni, *Institut National de la Recherche Agronomique de Tunisie (INRAT), Rue Hedi Karray, 2080 Ariana, Tunis, Tunisia*
G. Mergeai, *Faculté Universitaire des Sciences Agronomiques de Gembloux, 2 Passage des Déportés, 5030 Gembloux, Belgium*
P. Miclo, *INRA, Station d'Amélioration des Plantes, Domaine de Melgueil, 34130 Mauguio, France*
H. Mimoun, *Institut Technique des Grandes Cultures (ITGC), BP 16, E-Harrach, Algiers, Algeria*
D. Misevic, *PIONEER Génétique, BP 5, 31840 Aussonne, France*
J.P. Monod, *PROMAIS, 20 rue Bachaumont, 75002 Paris, France*
Y. Montalant, *INRA, Domaine de Brunehaut, 80200 Estrées-Mons, France*
O. Niangado, *Foundation Novartis, BPE 1449, Bamako, Mali*
E.A.J. Nissilä, *Boreal Plant Breeding Ltd, FIN-31600 Jokioinen, Finland*
P. Nourrissat, *NOVARTIS, 12 route de Crossay, Senneville, 28700 Francourville, France*
R. Ortiz, *International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, 502 324 Andhra Pradesh, India*
S. Paillard, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
A. Panouillé, *INRA, Unité Expérimentale du Maïs, 40390 Saint-Martin-de-Hinx, France*
J.L. Pham, *Genetic Resources Center, International Rice Research Institute, PO Box 933, 1099 Manila, Philippines*
F. Pinton, *Université Paris-10 Nanterre, Ladyss, Bat. K, 92001 Nanterre cedex, France*
M. Pollacsek, *INRA, Unité d'Amélioration des Plantes, Domaine de Crouelle, 63039 Clermont-Ferrand cedex, France*
L.M. Pollak, *USDA-ARS Corn Insects and Crop Genetics Research Unit, Department of Agronomy, Iowa State University, Ames, IA 50011, USA*
M. Raillard, *CARGILL Génétique Europe, Croix de Pardies, 40300 Peyrehorade, France*
P. Ramírez Vallejo, *Colegio de Postgraduados, IREGEP, Texcoco, México 56230, México*
C. Rebourg, *INRA-UPS-INA.PG, Station de Génétique Végétale, Ferme du Moulon, 91190 Gif-sur-Yvette, France*
P. Rimieri, *INRA, Station d'Amélioration des Plantes Fourragères, 86600 Lusignan, France*
R.A. Robinson, *Retired Crop Scientist, 445 Prevost Lane, Fergus, Ontario, Canada N1M 2N3*
F. Romero Rosales, *Colegio de Postgraduados, IFIT, Texcoco, México 56230, México*
T. Ronsin, *NICKERSON Semences, Route de Longué, 49160 Longué-Jumelles, France*
R. Salazar, *SEARICE, 83 Madasalin St., Sikatuna Village, Quezon City, Philippines*
W. Salhuana, *Pioneer Hi-Bred International, Inc., 6204 SW 16th Ct, Miami, FL 33183, USA*
J.P. Sampoux, *RUSTICA Prograin Génétique, Domaine de Sandreau, Mondonville, 31700 Blagnac, France*
J. Sanou, *INERA/CRRA de Farako Bâ, 01BP910, Bobo-Dioulasso 01, Burkina Faso*
A. Sarker, *Bangladesh Agricultural Research Institute, Joydebpur, Dhaka, Bangladesh*

G. Second, *Institut de Recherche pour le Développement (IRD, ex-ORSTOM), 911 Avenue Agropoplis, BP 5045, 34032 Montpellier cedex 1, France*
S. Second, *Institut de Recherche pour le Développement (IRD), 911 avenue Agropolis, BP 5045-34032 Montpellier cedex 1, France*
D. Segonds, *RAGT, Avenue St Pierre, BP 31, 12033 Rodez cedex 5, France*
B. Sharma, *Genetics Division, Indian Agricultural Research Institute, New Delhi 110012, India*
S.L. Sharrock, *International Network for the Improvement of Banana and Plantain, Parc Scientifique Agropolis II, 34397 Montpellier cedex 5, France*
A.S. Shreidi, *Agircultural Research Center (ARC), PO Box 2480, Tripoli, Libya*
N.W. Simmonds, *9 McLaren Road, Edinburgh EH9 2BN, UK*
M. Smith, *Department of Plant Breeding, Cornell University, Ithaca, New York, USA*
L. Sperling, *Systemwide Program for Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA), International Center for Tropical Agriculture (CIAT), c/o Frankenstraat 26, 2582SL The Hague, The Netherlands*
C. Spillane, *Institute for Plant Biology, Zurich University, Zollikerstrasse 107, CH-8008 Zürich, Switzerland*
W. Spoor, *Crop Science Department, Scottish Agricultural College (SAC), West Mains Road, Edinburgh EH9 3JG, UK*
C. Tabel, *RAGT, Avenue St Pierre, BP 31, 12033 Rodez cedex 5, France*
S.P. Tallury, *Department of Crop Science, North Carolina State University, Raleigh, NC 27695, USA*
B.R. Trognitz, *International Potato Center (CIP), PO Box 1558, Lima, Peru*
M. Tufail, *Ayub Agricultural Research Institute, Faisalabad, Pakistan*
M.C. Tyagi, *Genetics Division, Indian Agricultural Research Institute, New Delhi 110012, India*
M. Veteläinen, *Nordic Gene Bank, PO Box 41, S-230 53 Alnarp, Sweden*
P. Vincourt, *RUSTICA Prograin Génétique, Domaine de Sandreau, Mondonville, 31700 Blagnac, France*
R. von Bothmer, *Department of Plant Breeding Research, The Swedish University of Agricultural Sciences, SE-268 31 Svalöv, Sweden*
R. Waugh, *Scottish Crop Research Institute (SCRI), Invergowrie, Dundee DD2 5DA, UK*
E. Weltzien, *Genetic Resources and Enhancement Program, International Centre for Research in the Semi Arid Tropics (ICRISAT), Bamako, Mali*
J.R. Witcombe, *Centre for Arid Zone Studies, University of Wales, Bangor, Gwynedd LL57 2UW, UK*
A. Yahyaoui, *Ministère de l'Agriculture, Institution de la Recherche et de l'Enseignement Supérieure Agricole (IRESA), 30 rue Alain Savary, 1002 Tunis, Tunisia*
D. Ziegler, *Federal Centre for Breeding Research on Cultivated Plants (BAZ), Gene Bank, Braunschweig, Germany*

# Foreword

The world's political leaders, meeting in Rome at the 1996 World Food Summit, made a public commitment to halve the number of under-nourished people by 2015. The World Summit Plan of Action sets out a component of this task: 'to pursue, through participatory means, sustainable, intensified and diversified food production'. The better use of plant genetic diversity and resources will be a prerequisite to meeting this challenge. Greater use of plant genetic diversity will be required in order to produce varieties adapted to the extreme and highly variable environments of low-productivity or marginal areas. The need to combine sustainable productivity increases with mounting pressure to reduce the use of agrochemicals, and make more efficient use of water and nutrients, is likely to place even greater reliance on the utilization of a wider range of plant genetic resources in high-productivity areas.

The importance of improving conservation and use of the genetic diversity of useful plants has been recognized in a variety of ways over the last decade. The Convention on Biological Diversity reflected a strengthened global recognition of the importance of maintaining biodiversity for development. The Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture, which was adopted by 150 countries at the International Technical Conference on Plant Genetic Resources (held in Leipzig in June 1996), identified a series of specific ways in which conservation and use of plant genetic diversity could be improved. The Conference of Parties to the Convention on Biological Diversity in November, 1996, highlighted key elements of the Global Plan of Action. These are: broadening the genetic base of major crops; increasing the range of genetic diversity available to farmers; strengthening the capacity to develop new crops and varieties that are specifically adapted to local environments; exploring and promoting the use of under-utilized crops; and strategies that deploy genetic diversity to reduce crop vulnerability.

This emphasis on the wise use of genetic resources, and the contribution that this can make to socioeconomic development and food security, is reflected in the strategy and programmes of the Food and Agriculture Organization and the International Plant Genetic Resources Institute.

The very limited amounts of plant genetic variation that are present in modern varieties of some crops has been identified as an area of major concern by a number of international and national bodies and expert commentators. Substantial losses in production have resulted from the narrow genetic base present in some crops, the loss of many millions of tons of production of maize in the USA in the early 1970s being one of the most famous examples. Increasingly, production tends to depend on fewer varieties drawn from a narrower genetic base. Additionally, farmers' choice of varieties to plant is often limited by poor access to genetic resources, particularly in developing countries.

Concerned with the limited use of the available genetic diversity, the FAO Global Plan of Action identified broadening the genetic base of crops as a key element of the activities that should support improved use of plant genetic resources. The plan is concerned to see genetic vulnerability reduced and increased amounts of diversity made available to farmers. It recognizes that ways need to be found whereby increased amounts of useful genetic diversity can be brought into breeding programmes and into crop production systems. The ways in which this might be done are many and varied, and this book examines the rationale and need for activities to broaden the genetic base of crop production, and examines past experience and discusses new methodologies. We hope that it will stimulate more research and practical activities in this area.

*Mahmud Duwayri*
*Director, Plant Production and Protection Division*
*Food and Agriculture Organization of the United Nations*
*Rome*

*Geoffrey Hawtin*
*Director General, International Plant Genetic Resources Institute*
*Rome*

# Preface

> Plant breeding and the production of new cultivars is widely regarded as underpinning agriculture and the development of society. Yet crop failures and risks associated with genetic uniformity on large cultivated areas, yield stagnation (below potentially attainable levels), and persistent failures to achieve sustainable production increases in important local ecologies are widespread problems. What is frequently not recognized is that continuing success requires a long-term and sustainable commitment to the effective utilization of plant genetic resources by enhancing and expanding the genetic base from which future cultivars will be generated.
>
> This is not a question of more collecting, storage and evaluation – we have more than 6 million accessions in the world's genebanks. Nor is it enough to introduce selectively a few genes. Indeed, the future needs for an enhanced base cannot be predicted and the particular needs of farming systems should not be prejudged.
>
> Because of this, and of the short term interests of many involved in current national and international breeding programmes, there is a clear need for an international commitment by FAO and others to take a lead in championing base broadening of the world's food and fibre crops. This commitment should take many forms: initiating specific crop programmes; promoting awareness; and supporting and linking local, national and regional activities. It should be aimed at ensuring that farmers and breeders have increased access to useable diversity.
>
> The commitment should be an essential component of an ecologically sound approach to agricultural production based on the more effective use of genetic diversity, employing, as appropriate, decentralized plant breeding driven by the specific needs of farmers and consumers. Strengthening the participation of farmers' communities is vital to achieving these goals.

The above statement was prepared by a group of experts meeting in Rome, September 1997, to examine ways to further the objectives of Activity 10 of the FAO Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture: 'Increasing genetic enhancement and base-broadening efforts'. The full statement, with recommendations, and a list of participants, is provided on p. 437.

Following that meeting, it was decided to produce the present book, to bring together, in one volume, a number of papers on various approaches which contribute to broadening the genetic base of crops. By broadening the genetic base of crops we mean, in particular, increasing the amount of genetic diversity used to produce new crop varieties or used in agricultural production. This reflects a continuing concern with the fact that much crop production depends on very limited amounts of genetic variation and that, in many cases, the genetic diversity present in a crop is not easily available to the plant breeder or the producer interested in making use of it.

The book has a similar title to one published 20 years ago (A.M. van Harten and A.C. Zeven (1979), *Broadening the Genetic Base of Crops*. Proceedings of the conference, PUDOC, Wageningen, The Netherlands). The earlier book, and the conference on which it was based, emphasized collecting and evaluating germplasm, and methods for overcoming barriers to the use of wild relatives. The present book focuses more on the ways in which the amounts of genetic diversity in production can be increased and the ways in which breeding programmes can make use of greater amounts of genetic variation. A number of papers describe 'incorporation' work (*sensu* Simmonds, *Biological Reviews* 66, 189–241, 1991), that is, the large-scale development of locally adapted populations from unimproved or exotic sources, through long-term population-based approaches. It also reflects the many developments that have taken place over this period in participatory plant breeding and *in situ* conservation of genetic resources.

This book could not have been prepared without the help of the many individuals who generously contributed their time, energy and expertise to its writing and production. Above all, the authors of the various chapters are thanked for their contributions as well as for their patience and forbearance in adapting to changing deadlines. Special acknowledgement is due to Norman Simmonds, whose seminal paper on 'Introgression and incorporation: strategies for the use of genetic resources' (*Biological Reviews* (1993) 68, 539–562) stimulated the development of a specific activity on the issue in the Global Plan of Action. In the Food and Agriculture Organization (FAO), particular thanks go to Mahmud Duwayri, Niek van der Graaf, Helena Gomez, Erik Kueneman, Tony Putter, Marcio Porto and Peter Kenmore, for encouraging and guiding the initiative. Nina Dudnik worked tirelessly in keeping the editors more organized than they otherwise would have been. Finally, thanks go to Paul Stapleton of the International Plant Genetic Resources Institue, Shalini Dewan of FAO and Tim Hardwick of CABI *Publishing* for their cooperation in publishing this work.

# Acronyms and Abbreviations

| | |
|---|---|
| ACMV | African cassava mosaic virus |
| ADG | Andigena group |
| AFLP | amplified fragment length polymorphism |
| APIC | Association of Potato Intergenebank Collaborators |
| ARI | advanced research institute |
| ASTA | American Seed Trade Association |
| BAZ | Bundesanstalt für Züchtungsforschung an Kulturpflanzen (Federal Centre for Breeding Research on Cultivated Plants), Germany |
| BCMV | bean common mosaic virus |
| BRG | Bureau des Ressources Génétiques, France |
| BTI | Boyce Thompson Institute |
| BUCAP | Biodiversity Use and Conservation in Asia Programme |
| CBD | Convention on Biological Diversity |
| CENARGEN | Centro Nacionalde de Recursos Genéticos e Biotechnologia (of EMBRAPA), Brazil |
| CGIAR | Consultative Group on International Agricultural Research |
| CIAL | local committee for agricultural research |
| CIAT | Centro Internacional de Agricultura Tropical |
| CILSS | Comité Permanent Inter-Etats de Lutte contre la Sècheresse dans le Sahel |
| CIMMYT | Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico (International Wheat and Maize Improvement Centre) |
| CIP | Centro Internacional de la Papa, Peru (International Potato Center) |
| CIRAD | Centre de Coopération Internationale en Recherches Agronomiques pour le Développement, France |
| cms | cytoplasmic male sterility |
| CORAF | Conférence des responsables de recherche agronomique africains |
| CORPOICA | Corporación Colombiana para la Investigactión en Agricultura, Colombia |

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|---|---|
| CRBP | Centre des Recherches Régionales sur Bananiers et Plantains, Cameroon |
| CRSP | collaborative research support programmes |
| DGER | Direction Générale de l'Enseignement et de la Recherche, France |
| DM | dynamic management |
| DUS | distinctiveness, uniformity and stability |
| EBN | endosperm balance number |
| EMBRAPA | Empresa Brasiliera de Pesquisa Agropecuaria |
| ESD | equal seed descent |
| FAO | Food and Agriculture Organization of the United Nations |
| FFS | farmer field school |
| FHIA | Fundación Hondureña de Investigación Agrícola |
| GCA | general combining ability |
| g-cms | genic–cytoplasmic male sterility |
| GE | genotype × environment |
| GEM | Genetic Enhancement of Maize Project |
| GILB | Global Initiative on Late Blight |
| HOPE | hierarchical, open-ended population enrichment |
| HR | horizontal resistance |
| HYE | high-yielding environments |
| HYV | high-yielding variety |
| IAEA | International Atomic Energy Agency |
| IARC | International Agricultural Research Centre |
| IBPGR | International Board for Plant Genetic Resources |
| ICA | Instituto Colombiano Agropecuario |
| ICARDA | International Center for Agricultural Research in Dry Areas |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| ICTA | Imperial College of Tropical Agriculture |
| IDRC | International Development Research Centre |
| IIRB | International Institute of Sugarbeet Research, Belgium |
| IITA | International Institute for Tropical Agriculture |
| INIBAP | International Network for the Improvement of Banana and Plantain |
| INIFAP | Instituto Nacional de Investigaciones Forestales y Agropecuarias |
| INRA | Institut National de la Recherche Agronomique, France |
| INSAH | Institute for the Sahel |
| INTA | Instituto Nacional de Tecnología Agropecuaria, Argentina |
| IPGRI | International Plant Genetic Resources Institute |
| IPR | intellectual property rights |
| IRAT | Institut de Recherches Agronomiques Tropicales et de Cultures Vivrières, France |
| IRRI | International Rice Research Institute |
| ISNAR | International Service for National Agricultural Research |
| ISO | International Standards Organization |
| ISWYN | International Spring Yield Wheat Nursery |
| ITC | INIBAP Transit Centre |
| IWIS | International Wheat Information System |
| KUL | Katholieke Universiteit Leuven, Belgium |