Food and Agriculture Organization
of the United Nations

Proceedings of the FAO International Symposium on the Role of Agricultural Biotechnologies in Sustainable Food Systems and Nutrition

Cover photos (from left to right, beginning with the top row):
©FAO/Ishara Kodikara
©FAO/Hkun Lat
©FAO/Aris Mihich
©Zaijie Dong
©FAO/Simon Maina
©FAO/Alessandra Benedetti
©FAO/Franco Mattioli
©FAO/M. Namundjebo
©FAO/Jon Spaull

Book design: Alessandro Mannocchi

Proceedings of the FAO International Symposium on the Role of Agricultural Biotechnologies in Sustainable Food Systems and Nutrition

Edited by John Ruane, James D. Dargie and Catríona Daly

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2016

ISBN 978-92-5-109330-6

Contents

Foreword ix

Preface xi

Acknowledgements xiii

Abbreviations and Acronyms xv

Chapter 1. Opening plenary session

1.1 Welcome address, by José Graziano da Silva 3

1.2 The state of knowledge in biotechnology, by Louise Fresco 7

1.3 Biotechnologies in action in Brazil, by Maurício Antônio Lopes and Pedro Luiz Oliveira de Almeida Machado 14

1.4 Breakthroughs in resource productivity, by Gunter Pauli 19

Chapter 2. High-level ministerial session

2.1 Statement by Néstor Roulet, Argentina 31

2.2 Statement by Frédéric Seppey, Canada 33

2.3 Statement by Katalin Tóth, Hungary 37

2.4 Statement by Papa Abdoulaye Seck, Senegal 39

2.5 Statement by Begum Matia Chowdhury, Bangladesh 41

2.6 Statement by Henri Eyebe Ayissi, Cameroon 46

2.7 Statement by Gerda Verburg, the Netherlands 49

2.8 Statement by Michael Scuse, the United States of America 51

2.9 Questions & Answers with the moderator 54

Chapter 3. Parallel sessions: Climate change

3.1 Report of outcomes from the three parallel sessions dedicated to the theme of climate change
Olivier Le Gall 63

Parallel session: Facing the challenges of climate change: Adaptation in the crop and forestry sectors

3.2.1 Report of the parallel session 66

3.2.2 Developing rice varieties with enhanced adaptation to lowland farming systems: Case studies from South Asia
Abdelbagi M. Ismail, Uma S. Singh, John D. Platten, Endang Septiningsih, Rakesh K. Singh, Arvind Kumar and David J. Mackill 69

3.2.3 Harnessing agricultural biotechnology for resilience to climate change: A lesson from water efficient maize for Africa (WEMA) project
Yoseph Beyene, Kiru Pillay, Kassa Semagn, Stephen Mugo, Sylvester Oikeh, Amsal Tarekegne, Kingstone Mashingaidze, Murenga Mwimali, Godfrey Asea, Alois Kullaya, Pedro Fato, Barbara Meisel, Francis Nangayo and Boddupalli M. Prasanna 71

3.2.4 Molecular breeding in legumes for resource-poor farmers: Chickpea for Ethiopia and India
Douglas R. Cook 74

3.2.5 Genomic approaches for dissecting fitness traits in forest tree landscapes
Ciro De Pace 77

3.2.6 Using genomics to understand and manage adaptation to climate change in forest trees
Sally N. Aitken 81

Parallel session: Facing the challenges of climate change: Adaptation in the livestock and fishery sectors

3.3.1 Report of the parallel session 84

3.3.2 Selective breeding in aquaculture for future environments under climate change
Panya Sae-Lim, Antti Kause, Han A. Mulder and Ingrid Olesen 87

3.3.3 Development of diagnostic tools and vaccines for aquatic animals
Alexandra Adams 90

3.3.4 Biotechnologies for animal breeding and coping with climate change
Paul Boettcher and Grégoire Leroy 92

3.3.5 Use of biotechnologies to improve feed quantity and quality: Adaptation to the changing climate from the animal nutrition perspective
Ulrich Meyer and Gerhard Flachowsky 95

3.3.6 Development of livestock vaccines and market access
Jean de Foucauld 97

3.3.7 The potential of landscape genomics approaches in characterizing genetic adaptation of indigenous goat genetic resources: A South African perspective
Farai Catherine Muchadeyi, Khanyisile Mdladla and Edgar Farai Dzomba 100

Parallel session: How can biotechnologies contribute to adaptation with mitigation co-benefits?

3.4.1 Report of the parallel session 102

3.4.2 Economics of agricultural biotechnology, food and nutritional security, and climate change adaptation and mitigation
Daniel A. Sumner 105

3.4.3 Biodiversity: Key to helping farmers adapt to climate change
Carlo Fadda, Gloria Otieno and Stephan Weise 107

3.4.4 Biological nitrification inhibition (BNI) in plants: Implications for improving nitrogen use efficiency and reducing nitrous oxide emissions from agricultural systems
Guntur Venkata Subbarao, Yasuo Ando, Idupulapati Madhusudhana Rao, Manabu Ishitanii, Jacobo M Arango, Tadashi Yoshihashi, Kazuhiko Nakahara, Takayuki Ishikawa, Masahiro Kishii, Pradhan Pradipta Pradhan, Santosh Deshpande, Charles Thomas Hash, Stefania Grando, Hans-Joachim Braun, Victor Kommerell and Lini Wollenberg 110

3.4.5 Mitigation of enteric methane emissions from ruminants: The role of biotechnology
Henning Steinfeld and Carolyn I. Opio 113

3.4.6 Use of biodiversity as a biotechnological tool for carbon sequestration in the tropics
Paulo Kageyama 116

3.4.7 Carbon sequestration in agricultural soils: The "4 per mil" programme
Hervé Saint-Macary, David Pot, Jean-Francois Soussana and Jean-Luc Chotte 119

Chapter 4. Parallel sessions: Sustainable food systems and nutrition

4.1 Report of outcomes from the three parallel sessions dedicated to the theme of sustainable food systems and nutrition
Margaret Gill 123

Parallel session: Improving productivity through enhanced resource use efficiency

4.2.1 Report of the parallel session 127

4.2.2 "Green Super Rice" to be resource saving and environment friendly
Sibin Yu and Qifa Zhang 130

4.2.3 Resource use efficiency in vegetables: Application of molecular breeding to bambara groundnut, an underutilized crop for low-input agriculture
Sean Mayes, Presidor Kendabie, Wai Kuan Ho, Hui Hui Chai, Razlin Azman, Aryo Feldman, Asha Karunaratne, Lim Miang Hoong, Lim Yin Sze, Patrick O'Reilly, Festo Massawe and Sayed Azam-Ali 132

4.2.4 Resource use efficiency: Applications of biotechnology in genetic improvement in tropical aquaculture
David J. Penman 135

4.2.5 Resource use efficiency in livestock: Bridging the biotechnology–livestock productivity gap in East Africa
Denis Fidalis Mujibi 138

4.2.6 Resource use efficiency in forestry: Utilization of tree genetic resources
Judy Loo and Ramni Jamnadass 141

Parallel session: Post-production value addition and food safety

4.3.1 Report of the parallel session 144

Sub-session 1: Enhancing value in the post-production phase

4.3.2 Use of feed additives generated through fermentation technologies for livestock feed
Cadaba Srinivas Prasad and Ashis Kumar Samanta 148

4.3.3 Use of biotechnologies to increase the storability and shelf-life of fruit
Eric van de Weg, Ernst Woltering and René Smulders 151

4.3.4 The promise of biotechnology tools to help control mycotoxins, especially aflatoxins
Howard-Yana Shapiro 153

Sub-session 2: Using biotechnologies to ensure the safety of food

4.3.5 Traditional milk fermentation as a potential tool for sustainable improvement of food safety
Kohei Makita, Fanta Disissa, Akafete Teklu, Girma Zewde and Delia Grace 156

4.3.6 Aflasafe: A case study for aflatoxin reduction in crops
Ranajit Bandyopadhyay, Peter J. Cotty, Adebowale Akande, Juliet Akello, Joseph Atehnkeng, Joao Augusto, Abuelgasim Elzein, Lawrence Kaptoge, George Mahuku, Charity Mutegi and Lamine Senghor 158

4.3.7 Diagnostic tools to detect pathogens causing tuberculosis in cattle and prevent their transmission through dairy products to humans
Flábio R. de Araújo, Nalvo F. Almeida and Martin J. Zumárraga 160

Parallel session: Nutrition and food quality

4.4.1 Report of the parallel session 163

4.4.2 Our foods, our diet, our health: Where do we go from here?
Anna Lartey 165

4.4.3 Application of biotechnologies to improve the quality of rice and wheat
Melissa Fitzgerald and Venea Dara Daygon 167

4.4.4 Biofortification of staple food crops: Justification, progress and future activities
Howarth E. Bouis 169

4.4.5 Fish matters: Role of biotechnology in improving nutrition
Albert G.J. Tacon 171

Chapter 5. Parallel sessions: People, policies, institutions and communities

5.1 Report of outcomes from the three parallel sessions dedicated to the theme of people, policies, institutions and communities
Sachin Chaturvedi 175

Parallel session: Social and economic impacts of agricultural biotechnologies for smallholders: Taking stock of the evidence and prioritizing future assessments

5.2.1 Report of the parallel session 179

5.2.2 Evidence-based policy-making: The role of impact assessment studies and their implications for agricultural biotechnologies
David J. Spielman 182

5.2.3 Lessons learned from case studies of applying biotechnologies for smallholders
Andrea Sonnino, James D. Dargie and John Ruane 185

5.2.4 Impacts of agricultural biotechnology and policies: China's experience
Jikun Huang 188

5.2.5 Socio-economic impact of agricultural biotechnologies for smallholders in India
Narayan G. Hegde 190

Parallel session: Public policies, strategies and regulations on agricultural biotechnologies

5.3.1 Report of the parallel session 192

5.3.2 The role of intellectual property rights in enabling or impeding the application of agricultural biotechnologies in a developing country context
Rodrigo Sara 195

5.3.3 Biotech policy: The need for historical perspective and context
Adrianne Massey 197

5.3.4 FAO must support peasants' selection and condemn the seizure of cropped biodiversity by patented genes
Guy Kastler 200

5.3.5 The challenges of developing national policies and regulations for agricultural biotechnologies: Reflections from cumulative experience
Eduardo J. Trigo 202

5.3.6 Ensuring that policies, strategies and regulations on agricultural biotechnologies benefit smallholders
Dominic Glover 204

Parallel session: Investing in biotechnology solutions through capacity development and partnerships

5.4.1 Report of the parallel session 207

5.4.2 Biosciences capacity building in Africa: Lessons learned from the Biosciences eastern and central Africa – International Livestock Research Institute (BecA–ILRI) Hub
Helen Altshul 210

5.4.3 Case studies of public–private partnerships in agricultural biotechnologies: Lessons learned
Denis J. Murphy 214

5.4.4 Building partnerships, empowering champions: The case of the Cornell Alliance for Science
Sarah Evanega 217

5.4.5 North–South/West–East cooperation in agricultural biotechnologies: Some lessons from Italy and China in buffalo
Riccardo Aleandri 220

5.4.6 South–South collaborations in agricultural biotechnology: Lessons learned
Sachin Chaturvedi and Krishna Ravi Srinivas 223

Chapter 6. Student interactive session: Bringing fresh perspectives

6.1 Report of outcomes from the student session
Kakoli Ghosh 227

6.2 Inputs from American University of Beirut, Lebanon 229

6.3 Inputs from Bogor Agricultural University, Indonesia 231

6.4 Inputs from Cornell University, the United States of America 233

6.5 Inputs from Universidad Nacional de Colombia, Colombia 235

6.6 Inputs from Universidade Federal do Rio Grande do Sul, Brazil 237

6.7 Inputs from Università degli Studi di Roma «La Sapienza», Italy 239

6.8 Inputs from University of Ghana, Ghana 241

6.9 Inputs from Wageningen University, the Netherlands 243

Chapter 7. Side events: Reports

7.1 Delivering nutrition, productivity and climate resilience –
The African Biofortified Sorghum project 247

7.2 Helping farmers grow: Climate change, food security and the technology nexus 248

7.3 The voice of farmers: Biotechnology in the field 249

7.4 New breeding technologies for smallholders' challenges 251

7.5 Practical approaches to regulation and oversight of agricultural biotechnology:
Experiences from developed and developing countries 252

Chapter 8. Final plenary session

8.1 Some highlights of the symposium from a non-FAO perspective,
by Louise Fresco 257

8.2 Closing statement, by José Graziano da Silva 260

Foreword

We face enormous challenges as we work to eradicate hunger, improve nutrition and make food systems more sustainable. Climate change in particular is undermining the livelihoods and food security of the world's poor, 80 percent of whom live in rural areas and depend on agriculture, including forestry and fisheries.

In addressing these challenges, we need to consider all possible approaches. I believe that the application of science and technology can play a substantial role. We must work to ensure that relevant knowledge and a broad portfolio of tools and practices are available to family farmers.

It was in this context that FAO convened the international symposium on *The Role of Agricultural Biotechnologies in Sustainable Food Systems and Nutrition* on 15-17 February 2016 at FAO headquarters, Rome. The symposium brought together over 400 people, including 230 delegates from 75 member countries and the European Union, as well as representatives of intergovernmental organizations, private sector entities, civil society organizations, academia/research organizations and producer organizations/cooperatives.

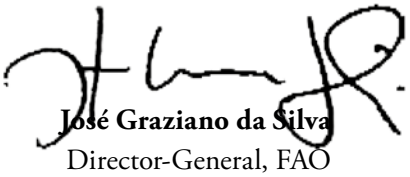
The symposium highlighted the important contribution that agricultural biotechnologies can make to achieving the Sustainable Development Goals. It also provided numerous examples where both low- and high-tech biotechnologies are being applied to meet the needs of family farmers.

The symposium successfully broadened the discussions beyond the narrow and polarized debate on genetically modified organisms. It reinforced FAO's role as a neutral forum that can bring together stakeholders from different backgrounds for a frank, open and constructive dialogue and exchange of knowledge on a controversial topic.

To meet the unprecedented challenges of the twenty-first century, a combination of responses from agroecology, agricultural biotechnologies and other approaches will be needed. The symposium indicated that agricultural biotechnologies and agroecology can be used as complementary options.

These proceedings bring together the keynote addresses, perspectives from high-level government representatives, summaries of the symposium's presentations and discussions, and more.

I hope they will contribute to more informed discussions at national, regional and global levels on the role of agricultural biotechnologies in meeting the myriad challenges faced in achieving sustainable agriculture and food security.



José Graziano da Silva
Director-General, FAO

Preface

Estimates indicate that almost 800 million people, about one out of every nine, do not have enough food to eat, while an even greater number are malnourished. At the same time, we are in a phase of exceptional population growth with the global population expected to pass 9 billion by the year 2050. One result is that the demand for food will increase, driven also by changes in dietary patterns towards more livestock products. The agriculture sectors, including forestry and fisheries, are also expected to produce more non-food products, for energy and feed.

This increased demand for food must be achieved while the natural resources upon which agriculture depends, such as land, water and soil, are increasingly threatened by environmental degradation and climate change. Because of climate change, key variables – such as temperature, rain patterns, water availability, frequency and intensity of 'extreme events', sea levels and salinization – will all change and have profound impacts on the crop, livestock, forestry and fishery sectors.

It is imperative to move towards food systems that are more sustainable yet produce more food that is of adequate nutritional value and that preserve and enhance ecosystem services and biodiversity.

Science and technology can play a substantial role in providing solutions to these challenges. The suite of practices and technologies available to producers should be as broad as possible, including all of the conventional technologies, such as those used to improve water management in irrigated and rainfed production systems, as well as the wide range of agricultural biotechnologies.

This symposium focused on the role of agricultural biotechnologies and took a multisectoral approach, encompassing the crop, livestock, forestry and fishery sectors, as well as the use of micro-organisms within these sectors. In organizing the symposium, FAO used a broad definition for biotechnology which covered low-tech approaches, such as those involving artificial insemination, microbial fermentation and biofertilizers, as well as high-tech approaches, such as those involving advanced DNA-based methodologies and genetically modified organisms (GMOs).

The symposium ran for two and a half days, beginning with an opening plenary session where keynote addresses were delivered by José Graziano da Silva, the FAO Director-General, and a distinguished group of speakers. The main technical discussions were organized around three main themes (climate change; sustainable food systems and nutrition; and people, policies, institutions and communities) and delivered through nine parallel sessions. A high-level ministerial session involved representatives from eight countries. There were five side events organized by external stakeholders as well as an innovative interactive session involving students from different universities around the world. The final plenary session included closing remarks by Louise Fresco (co-chair of the Advisory Panel) and José Graziano da Silva.

These proceedings, organized around eight chapters, provide a record of the main highlights of the symposium[1].

Chapter 1: Opening plenary session, contains the welcome address by the FAO Director-General and three keynote addresses.

Chapter 2: High-level ministerial session, contains the statements by the high-level representatives of eight member countries plus a summary of the subsequent question and answer session.

Chapter 3: Climate change, contains the summary report for the three parallel sessions presented at the final plenary session by a theme leader; the session reports prepared by the FAO rapporteurs; and summaries of the 17 presentations[2] given by the invited speakers.

Chapter 4: Sustainable food systems and nutrition, contains the summary report for the three parallel sessions presented at the final plenary session by a theme leader; the session reports prepared by the FAO rapporteurs; and summaries of the 15 presentations given by the invited speakers.

Chapter 5: People, policies, institutions and communities, contains the summary report for the three parallel sessions given at the final plenary session by a theme leader; the session reports prepared by the FAO rapporteurs; and summaries of the 14 presentations given by the invited speakers.

Chapter 6: Student session, contains the report presented at the final plenary session by the moderator plus 'inputs for policy-makers' from students of eight universities worldwide (Brazil, Colombia, Ghana, Indonesia, Italy, Lebanon, the Netherlands and the United States of America).

Chapter 7: Side events, contains the reports of the five side events arranged by external stakeholders. These side events were chosen based on pre-defined selection criteria following an international call for proposals. Reports were written by the side event organizers.

Chapter 8: Final plenary session, contains the statements by Louise Fresco (co-chair of the Advisory Panel) and the FAO Director-General.

---

[1] Video recordings of all plenary and parallel sessions, including the high-level ministerial session, student session and five side events, are also available at www.fao.org/about/meetings/agribiotechs-symposium/webcasting/en/

[2] PowerPoint presentations of these and all other talks given in the nine parallel sessions are available at www.fao.org/3/a-bc787e.pdf

Acknowledgements

Organization of this symposium[3] would not have been possible without the dedicated support and commitment of many people.

First and foremost among these were the members of the external **Advisory Panel**, established in April 2015 to provide FAO with guidance and advice on the thematic areas and overall structure of the symposium. We would like to give special thanks to the Panel's co-chairs: Louise Fresco (Wageningen University and Research Centre, the Netherlands) and Shadrack Moephuli (Agricultural Research Council, South Africa).

We would also like to gratefully acknowledge the extensive contributions of the other members of the Advisory Panel: Sachin Chaturvedi (Research and Information System for Developing Countries, India); Appolinaire Djikeng (Biosciences eastern and central Africa Hub, Kenya); Gebisa Ejeta (Purdue University, the United States of America); Sergio Feingold (National Institute of Agricultural Technology, Argentina); Olivier Le Gall (Institut National de la Recherche Agronomique, France); Margaret Gill (CGIAR Independent Science and Partnership Council, Italy); Dominic Glover (Institute of Development Studies, United Kingdom); Paulo Kageyama (University of São Paulo, Brazil); Adrianne Massey (Biotechnology Industry Organization, the United States of America); Eric Meunier (Inf'OGM, France); Thuy Nguyen (Department of Economic Development, Jobs, Transport & Resources, Australia); David Spielman (International Food Policy Research Institute, the United States of America); and Kongming Wu (Chinese Academy of Agricultural Sciences, China).

Theme leaders, working in cooperation with the Advisory Panel, played a key role in the development of proposals for the three parallel sessions held under each of the symposium's main themes:

- Climate change: Olivier Le Gall and Chittaranjan Kole (Jacob School of Biotechnology and Bioengineering, India)
- Sustainable food systems and nutrition: Sergio Feingold and Margaret Gill
- People, policies, institutions and communities: Sachin Chaturvedi and David Spielman

An **FAO interdepartmental Task Force** was responsible for the development and delivery of the symposium. The Task Force was chaired by Ren Wang (Assistant Director General, Agriculture and Consumer Protection Department) under the direct guidance of Maria Helena Semedo (Deputy Director-General, Coordinator for Natural Resources). Their clear leadership and strong support throughout the whole process was fundamental for the success of the symposium.

[3] The detailed symposium programme is available at www.fao.org/3/a-bc547e.pdf

The commitment and dedication shown by the Task Force members is gratefully acknowledged, particularly Devin Bartley, Julie Belanger, Paul Boettcher, Clayton Campanhola, Rodrigo Castaneda, Frederic Castell, Saulo Ceolin, Catriona Daly, Larissa Domínguez Fuentes, Kakoli Ghosh, Robert Guei, Jorge Hendrichs, Ljupcho Jankuloski, Aikaterini Kavallari, Jarkko Koskela, Harinder Makkar, Chikelu Mba, Alexandre Meybeck, Kae Mihara, William Murray, Karin Nichterlein, Arshiya Noorani, Erwin Northoff, Halka Otto, Melba Reantaso, John Ruane, Masami Takeuchi, Alberto Trillo Barca, Gerrit Viljoen and Daniele Volpe.

Most of the parallel and plenary sessions were chaired and/or moderated by Advisory Panel members. Apart from FAO staff, the remainder were kindly facilitated by Delia Grace (International Livestock Research Institute, Kenya); Courtney Paisley (Young Professionals for Agricultural Development [YPARD], Italy); Vimlendra Sharan (Embassy of India, Italy); and Eduardo Trigo (Ministry of Science, Technology and Productive Innovation, Argentina). YPARD (Marina Cherbonnier and Courtney Paisley) is also thanked for organizing the student session together with FAO.

FAO provided the majority of funding required to host the symposium. The remainder came from voluntary contributions provided by Agriculture and Agri-Food Canada (AAFC), Canada; the Ministry of Economic Affairs of the Kingdom of the Netherlands; and the United States Department of Agriculture, Foreign Agricultural Service, which are all gratefully acknowledged.

Finally, the FAO Plant Production and Protection Division (AGP) provided the core technical and organizational secretariat for the symposium, and special thanks are given here to Chikelu Mba, William Murray and John Ruane. AGP was also responsible for the administrative and operational aspects of the symposium, and the contributions of Sandra Castrucci, Catriona Daly, Diana Gutierrez Mendez, Desiree Kedjour, Alessia Laurenza, Elena Rotondo, Petra Staberg, Juliet Upton, Deborah Welcomme and Tania White are all gratefully acknowledged.

Abbreviations and Acronyms

ABCF	Africa Biosciences Challenge Fund
AI	Artificial insemination
AOCC	African Orphan Crops Consortium
ASF	African swine fever
AU	African Union
BecA–ILRI Hub	Biosciences eastern and central Africa – International Livestock Research Institute Hub
BNI	Biological nitrification inhibition
Bt	*Bacillus thuringiensis*
bTB	Bovine tuberculosis
CFT	Confined field trial
CGIAR	Consultative Group on International Agricultural Research
CH_4	Methane
CIMMYT	International Maize and Wheat Improvement Center
CITT	Comparative intradermal tuberculin test
CO_2	Carbon dioxide
COP21	21st Conference of the Parties of the United Nations Framework Convention on Climate Change
CRISPR	Clustered, regularly interspaced, short palindromic repeats
CRISPR-Cas9	Clustered, regularly interspaced, short palindromic repeats-CRISPR associated protein 9
ELISA	Enzyme-linked immunosorbent assay
Embrapa	Brazilian Agricultural Research Corporation
FAO	Food and Agriculture Organization of the United Nations
GEA	Genotype-environment association
GHG	Greenhouse gas
GM	Genetically modified
GMO	Genetically modified organism
GSR	Green Super Rice
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INTA	National Institute of Agricultural Technology (Argentina)

IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual property rights
IRRI	International Rice Research Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
MAS	Marker-assisted selection
N_2O	Nitrous oxide
NARS	National agricultural research systems
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organization
NUE	Nitrogen use efficiency
PCR	Polymerase chain reaction
PPD	Purified protein derivative
PPP	Public–private partnership
QTL	Quantitative trait locus
QTLs	Quantitative trait loci
R&D	Research and development
RNAi	RNA interference
SNP	Single nucleotide polymorphism
SSA	sub-Saharan Africa
SSC	South–South cooperation
TALEN	Transcription activator-like effector nucleases
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USDA-ARS	USDA Agricultural Research Service
WEMA	Water efficient maize for Africa
YPARD	Young Professionals for Agricultural Development
ZFNs	Zinc finger nucleases