# Molecular Breeding

## for Rice Abiotic Stress Tolerance and Nutritional Quality

Edited by
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Khandakar Md. Iftekharuddaula
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## Editor Biographies

**Dr. Mohammad Anwar Hossain** is a Professor in the Department of Genetics and Plant Breeding, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh. He received his BSc in Agriculture and MS in Genetics and Plant Breeding from BAU, Bangladesh. He also received an MSc in Agriculture from Kagawa University, Japan, in 2008 and a PhD in Abiotic Stress Physiology and Molecular Biology from Ehime University, Japan, in 2011 through a Monbukagakusho scholarship. As a JSPS post-doctoral researcher he has worked on isolating low phosphorus stress tolerant genes from rice at the University of Tokyo, Japan, during the period of 2015–2017. His current research program focuses on understanding physiological, biochemical, and molecular mechanisms underlying abiotic stresses in plants and the generation of stress-tolerant and nutrient-efficient plants through breeding and biotechnology. He has over 60 peer-reviewed publications and has edited 10 books, including this one, published by CRC press, Springer, Elsevier, and Wiley.

**Dr. Lutful Hassan** is a Professor in the Department of Genetics and Plant Breeding, BAU, Mymensingh, Bangladesh. Currently he is the Vice-Chancellor of BAU, Bangladesh. He obtained his BSc Agriculture and MSc in Genetics and Plant Breeding from BAU and his PhD in Plant Breeding from the University of Wales, UK. He has conducted post-doctoral research in different countries across the world through Japan Society for the Promotion of Science, Alexander von Humboldt, Norman E. Borlaug, and Royal Society Fellowship. He has also worked at the International Rice Research Institute (IRRI) as a consultant in "Stress to tolerant rice for Africa and South Asia (STRASA)" and "Sustainable Rice Seed Production and Delivery System (SRSPDS)" projects. His current research includes the development of high-yielding stress-tolerant rice and mustard varieties through conventional and molecular breeding approaches. He is a recipient of the John Dillon Memorial Fellow Award for agricultural research management, agricultural policy and/or extension technologies. He has over 150 peer-reviewed publications, and has edited 3 books including this one. He has given over 50 invited presentations nationally and internationally.

**Dr. Khandakar Md. Iftekharuddaula** is a Chief Scientific Officer and Head in the Division of Plant Breeding, Bangladesh Rice Research Institute, Gazipur, Bangladesh. He received his BSc in Agriculture and MS in Genetics and Plant Breeding from Bangladesh Agricultural University, Bangladesh. He has completed PhD research from the International Rice Research Institute and obtained his degree in Genetics and Plant Breeding from Bangladesh Agricultural University, Bangladesh. He has acted as Collaborative Research Fellow in the Transforming Rice Breeding Project implemented at the Bangladesh Rice Research Institute funded by the Bill and Melinda Gates Foundation for the duration of four years. He has special research experience in the development of submergence and stagnant flooding tolerant, deep-water tolerant, water-saving, irrigated, and premium quality rice varieties utilizing breeding and biotechnological tools. He has published 60 full-length scientific papers, five books/book chapters and six bulletins/proceeding papers.

**Dr. Arvind Kumar** is the Director of the International Rice Research Institute, South Asia Regional Centre, Varanasi, India. Dr. Kumar has twenty-six years of experience in rice research in South Asia and Southeast Asia. From breeding lines developed by him, 65 rice varieties have been released in 10 different countries. He successfully introgressed drought grain yield QTLs in popular high-yielding varieties following marker-assisted breeding (MAB) and has developed drought-tolerant improved versions of several popular varieties as well as varieties tolerant to multiple abiotic and biotic stresses. Dr. Kumar has identified 14 QTLs for grain yield under drought. Identified QTLs are being used on a large scale in marker-assisted breeding programs all over the world to develop rice varieties with improved yield under drought. Dr. Kumar also has identified seven genes for resistance against rice gall midge, which are used in breeding programs across the world, as well as QTLs for traits enhancing rice adaptability to dry direct-seeded situations. He has implemented 28 research projects, supervised more than 30 scholars, and published more than 30 chapters and 143 research manuscripts. For his varietal development work, he was awarded with the highest award for contribution to Indian agriculture, the Rafi Ahmed Kiwi Award by the Indian Council of Agricultural Research (ICAR), Government of India in 2014. The Nepal Council of Agricultural Research (NARC), Government of Nepal recognized him with honor in 2016 for his contribution to agriculture in Nepal for development of drought-tolerant varieties.

**Professor Robert Henry** conducts research on the development of new products from plants. His research targets improved understanding of the molecular basis of the quality of products produced from plants and genome analysis to capture novel genetic resources for diversification of food and energy crops. He is the Professor of Innovation in Agriculture and Foundation Director of the Queensland Alliance for Agriculture and Food Innovation, an Institute of the University of Queensland in partnership with the Queensland Government. He was previously director of the Centre for Plant Conservation Genetics at Southern Cross University and Research Program Leader in the Queensland Agricultural Biotechnology Centre. He has been involved in establishing several Cooperative Research Centres in Australia and has contributed to the management of research funding by Rural Research and Development Corporations in Australia. He is a graduate of the University of Queensland (BSc (Hons)), Macquarie University (MSc (Hons)) and La Trobe University (PhD). He was awarded a higher doctorate (DSc) by the University of Queensland for his work on variation in plants, is a Fellow of the Royal Australian Chemical Institute, recipient of the Guthrie Medal for his contributions to cereal chemistry and a Fellow of the Australian Academy of Technological Sciences and Engineering.

# Preface

Global population is projected to increase over 9 billion by 2050, and food and feed production will need to increase by 70%. Additionally, to alleviate the world's greatest health and poverty issues (micronutrient malnutrition) the development of nutrient-dense crops is urgently needed. Rice is one of the most important cereal food crops, and it provides food to more than half of the world's population, particularly in many developing countries in Asia, Africa, and Latin America. Globally, rice is grown on approximately 163 million hectares of land of which an estimated 60% or more is affected by various abiotic stresses (salinity, heat, drought, cold, submergence, radiation, heavy metals, etc.) causing significant yield losses. The situation becomes even worse due to climate change, which may multiply the frequency and severity of such abiotic stresses. Importantly, production of rice must continue to increase at the rate of 1 percent a year to maintain food security. Sustainable rice production delivering yields to meet ever-increasing demands and the development of biofortified rice is a major challenge for the scientific community, and will require the combined expertise of agronomists, farmers, breeders, and molecular biologists. Recently, molecular rice breeding in response to global climate change, the increasing fragility of our natural resources and threats to food grain security across the globe, have attracted considerable interest by the scientific community. Since then countless studies in various scientific disciplines dealing with different rice species, in different environments have focused on abiotic stress tolerance, grain and quality improvements, and rice biofortification. Although significant progress has been made over the last few years, there is still a need to bridge the large gap between yields in the most favorable environments and those under stress conditions. Strategies involving bridging the yield gap and increasing yield stability and adaptability to variable environmental conditions are of importance in assuring food security and sustainability in the future. Hence, there is an urgent need to improve our understanding of complex mechanisms regulating abiotic stress tolerance for developing modern rice varieties that are more resilient to abiotic stresses as well as to increase the bioavailable concentrations of essential micronutrients. The discovery of novel genes/QTLs, the analysis of their expression patterns in response to abiotic stress, and the determination of their potential functions in stress adaptation will provide the basis of effective engineering strategies to enhance rice yield under stress and non-stress conditions, to develop biofortified rice as well as sustainable utilization of natural resources.

Over the last decade, tremendous progress has been made in rice genome analysis. The progress has provided powerful tools—DNA markers—for plant genetics and breeding.

Now DNA-based markers have been widely used in the genetic analysis of agronomically important traits regulating abiotic stress tolerance, yield, and quality of rice. Tightly linked DNA markers and causal genes are used in marker-assisted selection in rice-breeding programs and are able to shorten the time of variety development. Another use of DNA-based markers is overcoming the barrier of "linkage drag" which refers to the presence of undesirable genes in the chromosomal region of the target gene, thereby making it difficult to avoid such traits when using conventional breeding. Also, economic analysis has shown the potential impacts of utilizing marker-assisted breeding by overcoming drawbacks of conventional breeding in rice that ultimately reduce the cost of production and promote economic growth.

In this book, *Molecular Breeding for Rice Abiotic Stress Tolerance and Nutritional Quality*, we present a collection of 21 chapters written by leading experts engaged with rice molecular breeding. The chapters of this book aim to contribute the latest understandings of molecular and genetic bases of abiotic stress tolerance, yield, and quality improvement of rice to develop strategies for abiotic stress tolerance and biofortification, which leads to enhanced rice productivity under abiotic stress conditions as well better utilization of natural resources to ensure food security through modern breeding as well as to curb the scourge of micronutrient malnutrition. Finally, this book will be a valuable resource for future environmental stress-related research, and can be considered as a textbook for graduate students and as a reference book for front-line rice researchers around the globe.

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