Abiotic Stress Management for Resilient Agriculture

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Editors

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Springer

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ISBN 978-981-10-5743-4 ISBN 978-981-10-5744-1 (eBook)
DOI 10.1007/978-981-10-5744-1

Library of Congress Control Number: 2017953015

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Foreword

The global agriculture production has undergone drastic changes in recent years and is being seriously limited by various abiotic stresses. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) revealed that by 2020 there could be a decline of agricultural yields of up to 50% in some countries in Africa as a result of climate change and variability. Moreover, a number of edaphic stresses, including chemical (nutrient deficiencies, excess of soluble salts, salinity, alkalinity), physical (high susceptibility to erosion, steep slopes, shallow soils, surface crusting and sealing, low water-holding capacity, impeded drainage, low structural stability, root restricting layer, high swell/shrink potential) and biological (low or high organic contents), have also emerged as major challenges for the production of crops, livestock, fisheries and other commodities.

This book addresses the management of soil-related abiotic constraints, stresses in drylands, heavy metal toxicities, salinity, water logging, high temperature and drought tolerance and also presents mitigation strategies for immediate on-farm solutions with a special emphasis on approaches based on specific and potential plant bio-regulators for enhancing crop and water productivity in semi-arid regions. Special emphasis has been given to contextualizing the strategy for improving crop adaptations to climate change, biotechnological tools for improvement of tolerance and abiotic stress management in major food grains, commercial horticulture and vegetable crops and their production. This book also highlights livestock and their nutritional management during drought, mitigation options for GHG emissions from ruminants and mitigation of climatic change effects for sheep farming in arid environment. Overall, this volume covers a wide range of subjects that provide the readers a way forward in abiotic stress management to enable more productive agriculture.

I congratulate the editors for compiling this publication that will add to a greater deal to the global understanding of and implications for not only food security worldwide, but also for the socioeconomic conditions of communities affected by climate change and management of abiotic stress for resilient agriculture.

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T. Mohapatra

Preface

Several transformative changes, such as the growing population, changing lifestyles, expanding urbanization, accelerating land degradation, and climate change-induced abiotic stresses, are threatening the future food and nutrition security especially in low-income countries. The abiotic stress factors emerge mainly due to drought, extreme temperature (heat, cold chilling/frost), and floods in addition to edaphic settings, leading to chemical (ion/nutrient deficiencies/toxicities), physical (high erosion, hard pans/shallow soils, surface sealing/impeded drainage), and biological (low/high organic contents) constraints; these abiotic stress factors are also intrinsically linked to the production of crops, livestock, fisheries, and other commodities. Only 9% of the world's agricultural area is conducive for crop production, while 91% is afflicted by abiotic stresses which widely occur in combinations. While losses extending to more than 50% of agricultural production occur due to abiotic stresses, their intensity and adverse impact are likely to amplify manifold with climate change and overexploitation of natural resources. Fragile agroecosystems like the dryland areas are highly vulnerable to their disastrous impact.

Thus development of a strategic framework for inclusive, sustainable, and innovation-led agricultural growth is essential for these harsh agroecosystems afflicted by abiotic stresses. Multidisciplinary and holistic approaches to manage the stressed environments should aim at characterization of abiotically stressed environments; reoriented, novel, and scaled-up natural resource management (NRM) technologies for stress mitigation; improved adaptation to stressed environments; and task-oriented capacity building. Augmentation, integration, and promotion of the best available tools, approaches, and technologies should involve investments and incentives for breeding protocols, regional networks for exploring synergies, and dynamic policy support. Therefore, this book is an assemblage of 24 chapters by 68 experts in the area of abiotic stress tolerance/management, natural resource management, and strategic program of building resilience in crop, livestock, and policy implementation. Up-to-date of advances and prospects for understanding stress environments, adaptation and mitigation options in crops and animal husbandry, and policy support for abiotically stressed agroecosystems have been attempted. State-of-the art account of the information available has been synthesized in terms of challenges, scope and opportunities, coping strategies, and management of abiotic stresses using novel and new tools for resilient agriculture. Some of the chapters present management approaches for tackling specified stresses like

edaphic constraints, stresses in drylands, heavy metal toxicities, salinity, waterlogging, high temperature and drought tolerance, and mitigation strategies for immediate on-farm solutions with a special emphasis on bio-regulators.

It is anticipated that this book will provide a practical update on our knowledge for improving management of abiotic stresses for resilient agriculture and allied sectors under changing global climate change conditions. This book establishes a set of principles based on current understanding on abiotic stresses and will be useful for different stakeholders, including agricultural students, scientists, environmentalists, policy makers, and social scientists.

We are extremely thankful to all the contributors for their efforts in providing comprehensive and cogent reviews.

Baramati, Maharashtra, India

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About the Editors

Dr. Paramjit Singh Minhas has about four decades of diversified research experience on management of natural resources. His main contributions include soil-water-plant interactions in saline and other edaphically harsh environments and the development of management strategies for deficit irrigation, use of low-quality waters, salinity afflicted and shallow basaltic soils for raising the production potential of crops, orchard/forestry plantations. By holding key research management positions in the Indian Council of Agricultural Research (viz., project coordinator, All India Coordinated Project on Management of Salt-Affected Soils and Use of Saline Water in Agriculture; assistant director general, integrated water management; director of research, Punjab Agricultural University; assistant director general, Soil and Water Management; and director, ICAR-National Institute on Abiotic Stress Management), he has demonstrated leadership skills in formulating and implementing research programs and providing vision and direction. His research endeavors have been recognized with several awards like Rafi Ahmed Kidwai Award, Swami Pranavananda Sarswati Award in Environmental Science and Ecology, Jain-INCID *Krishi Sinchai Vikas Puraskar* in 2005, Hari Om Ashram Trust Award, the CSSRI Excellence Award on Soil Salinity and Water Management, Su Kumar Basu Award, and the 12th International Congress Commemoration Medal. He is a fellow of National Academy of Agricultural Sciences, Indian Society of Soil Science, and Punjab Academy of Sciences, associate editor of *Agricultural Water Management* (Journal by Elsevier, the Netherlands), and a member of the editorial board of Indian Journal of Agricultural Sciences.

Dr. Jagadish Rane Principal Scientist and Head of School of Drought Stress Management at ICAR-National Institute of Abiotic Stress Management (NIASM). He started his research carrier at ICAR-Indian Institute on Wheat and Barley Research in 1993. In 2007–2011, he led a plant phenotyping team for the evaluation of gene technology to improve drought tolerance in upland rice at International Center for Tropical Agriculture (CIAT). He has organized multi-location experiments across India to understand the plant traits and genes for resilience to abiotic stresses. He has established a plant phenomics platform and developed prototypes of low-cost phenotyping tools for field evaluation of germ plasm. He has standard-

ized protocols for various screening procedures (viz., transgenic events in biosafety, identification of water-efficient genotypes, etc.).

Dr. Ratna Kumar Pasala Senior Scientist dealing with plant abiotic stress physiology at ICAR-Indian Institute of Oilseeds Research, Hyderabad, and a member of the editorial board of plant science journals and reviewer of many international and national journals. He has research experience in plant stress functional biology at ICAR-National Institute of Abiotic Stress Management (NIASM) and International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). His major research expertise is in plant stress physiology and plant bio-regulators for the mitigation of abiotic stresses through redox-mediated mechanism. He is a recipient of R.D. Asana Gold Medal Award and Young Scientist Fellowship Award by FAO.

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Chapter No.: FM 0 0 0 3 1 5 9 7 7 1

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