
Plant Tolerance to Individual and Concurrent Stresses

Muthappa Senthil-Kumar
Editor

Plant Tolerance to Individual and Concurrent Stresses

 Springer

Editor
Muthappa Senthil-Kumar
National Institute of Plant Genome Research
New Delhi, India

ISBN 978-81-322-3704-4 ISBN 978-81-322-3706-8 (eBook)
DOI 10.1007/978-81-322-3706-8

Library of Congress Control Number: 2017930398

© Springer (India) Pvt. Ltd. 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer (India) Pvt. Ltd.
The registered company address is: 7th Floor, Vijaya Building, 17 Barakhamba Road, New Delhi
110 001, India

Preface

In nature, plants are exposed to one or more biotic and abiotic stresses either individually or in combination, which ultimately results in yield loss. During the life cycle, the same plant can face individually occurring one or more stresses. A large number of studies were undertaken to dissect the mechanisms imparting plant tolerance to multiple individual stresses. However, the concurrent stress tolerance has not been adequately studied owing to several complexities involved, including appropriate combined stress imposition method. In the recent past, several research groups around the world have started exploring the concurrent stress tolerance mechanisms under both biotic and abiotic stress combinations. This book compiles the information generated by these research groups along with their research progress and prospects, which would serve as a compendium of knowledge for researchers working on plant stress biology.

This book covers three major aspects under the proposed title. First, it introduces the existence of unique and shared responses in plants exposed to combined stress. Emphasis is given for understanding shared responses in comparison with multiple individual stresses. Second, the influence of abiotic stress on plant-pathogen interaction is elaborately covered. Third, comprehensive information about screening methods to identify genetic variation and the use of various tools to extrapolate information from individual stress studies to understand concurrent stress tolerance is elaborated. The chapterwise coverage of above said information is as follows.

Chapters 1 and 2 cover the overview of physiological and molecular mechanism involved in imparting both individual and combined stress tolerance. Importance is also given to the soil management and agronomic practices that will facilitate cultural management of crops under combined stress. Chapters 3 and 4 enumerates the impact of biotic stresses, namely, weed and pathogen on sequential and simultaneously occurring abiotic stresses including drought and temperature stress. Chapter 5 explains the approaches and avenues available for utilizing the understandings covered in the previous four chapters in terms of genomics-assisted breeding. Chapters 6 and 7 comprehend all previously described stress responses and set tone for specific stress tolerance mechanisms described in subsequent chapters. Chapter 8 focuses on the plant interaction with light and temperature, both as stimuli and stress. This chapter specifically covers the signaling responses and emphasizes the growth changes during combined stress. Hormonal cross talks under

combined stress and the coordinated regulation of stress tolerance mechanisms are discussed in Chap. 9. Impact of several individual stresses on plants and strategies for crop improvement are covered in Chap. 10. The Chap. 11 covers the plant-water relations during various pathogen infections. It also enumerates the complexity of these responses in the presence of drought stress. Overall, these 11 chapters delivers scintillating information that not only provide comprehension of up-to-date research outcome in understanding stress interaction and combined stress tolerance, but also enumerate future direction of research. Overall they acts as suitable study material for both students and researchers working this area. This book also delivers prospects for driving future research for developing strategies for crop improvement under multiple stresses.

Eminent researchers from this newly emerging field have contributed to this book as outlined above. This book will be not only served as a one-stop reference point for researchers working in plant responses to both biotic and abiotic stresses but also will be an authority of recent information in this area. It is noteworthy to emphasize the fact that despite the plants grown under field condition exposed to combination of multiple stresses, a comprehensive collection of recent information in this area is lacking. This book will sufficiently address this deficit and act as a reference material for the research community.

I acknowledge all the reviewers who made scientific and technical comments on each chapter included in this book for their valuable time and input.

New Delhi, India

Muthappa Senthil-Kumar

Contents

1	Concurrent Stresses Are Perceived as New State of Stress by the Plants: Overview of Impact of Abiotic and Biotic Stress Combinations	1
	Aarti Gupta and Muthappa Senthil-Kumar	
2	Closing the Biotic and Abiotic Stress-Mediated Yield Gap in Cotton by Improving Soil Management and Agronomic Practices	17
	Gunasekhar Nachimuthu and Ashley A. Webb	
3	Impact of Concurrent Weed or Herbicide Stress with Other Biotic and Abiotic Stressors on Crop Production	33
	Muthukumar Bagavathiannan, Vijay Singh, Prabhu Govindasamy, Seth Bernard Abugho, and Rui Liu	
4	Heat and Soil Moisture Stress Differentially Impact Chickpea Plant Infection with Fungal Pathogens	47
	Mamta Sharma and Raju Ghosh	
5	Genomics-Assisted Breeding for Improving Stress Tolerance of Gramineous Crops to Biotic and Abiotic Stresses: Progress and Prospects	59
	Roshan Kumar Singh, Pranav Pankaj Sahu, Mehanathan Muthamilarasan, Annvi Dhaka, and Manoj Prasad	
6	Plant Tolerance to Combined Stress: An Overview	83
	Wusirika Ramakrishna and Anuradha Kumari	
7	Drought and Heat Tolerance in Chickpea: Transcriptome and Morphophysiological Changes Under Individual and Combined Stress	91
	Renu Yadav, Sumandeep Juneja, Priyanka Singh, and Sanjeev Kumar	

8	Interaction of Light and Temperature Signaling at the Plant Interphase: From Cue to Stress	111
	Juhi Bhattacharya, Upendra Kumar Singh, and Aashish Ranjan	
9	Plant Responses to Combined Drought and Pathogen Infection: Current Understanding on the Role of Phytohormones ...	133
	Prachi Pandey and Muthappa Senthil-Kumar	
10	Simultaneous Expression of Abiotic Stress-Responsive Genes: An Approach to Improve Multiple Stress Tolerance in Crops	151
	M.S. Parvathi and Karaba N. Nataraja	
11	Tissue Water Status and Bacterial Pathogen Infection: How They Are Correlated?	165
	Urooj Fatima and Muthappa Senthil-Kumar	

Contributors

Seth Bernard Abugho Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA

Muthukumar Bagavathiannan Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA

Juhi Bhattacharya National Institute of Plant Genome Research, New Delhi, India

Annvi Dhaka National Institute of Plant Genome Research, New Delhi, India

Urooj Fatima National Institute of Plant Genome Research, New Delhi, India

Raju Ghosh International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, Telangana, India

Prabhu Govindasamy Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA

Aarti Gupta National Institute of Plant Genome Research, New Delhi, India

Sumandeep Juneja Centre for Plant Sciences, School of Basic and Applied Sciences, Central University of Punjab, Bathinda, Punjab, India

Sanjeev Kumar Centre for Plant Sciences, School of Basic and Applied Sciences, Central University of Punjab, Bathinda, Punjab, India

Anuradha Kumari Centre for Biochemistry and Microbial Sciences, Central University of Punjab, Bathinda, Punjab, India

Rui Liu Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA

Mehanathan Muthamilarasan National Institute of Plant Genome Research, New Delhi, India

Gunasekhar Nachimuthu New South Wales Department of Primary Industries, Australian Cotton Research Institute, Narrabri, NSW, Australia

Karaba N. Nataraja Plant Molecular Biology Laboratory, Department of Crop Physiology, University of Agricultural Sciences, Bengaluru, India

Prachi Pandey National Institute of Plant Genome Research, New Delhi, India

M. S. Parvathi Plant Molecular Biology Laboratory, Department of Crop Physiology, University of Agricultural Sciences, Bengaluru, India

Manoj Prasad National Institute of Plant Genome Research, New Delhi, India

Wusirika Ramakrishna Centre for Biochemistry and Microbial Sciences, Central University of Punjab, Bathinda, Punjab, India

Aashish Ranjan National Institute of Plant Genome Research, New Delhi, India

Pranav Pankaj Sahu National Institute of Plant Genome Research, New Delhi, India

Muthappa Senthil-Kumar National Institute of Plant Genome Research, New Delhi, India

Mamta Sharma International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, Telangana, India

Priyanka Singh Centre for Plant Sciences, School of Basic and Applied Sciences, Central University of Punjab, Bathinda, Punjab, India

Roshan Kumar Singh National Institute of Plant Genome Research, New Delhi, India

Upendra Kumar Singh National Institute of Plant Genome Research, New Delhi, India

Vijay Singh Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA

Ashley A. Webb New South Wales Department of Primary Industries, Tamworth Agricultural Institute, Calala, NSW, Australia

Renu Yadav Centre for Plant Sciences, School of Basic and Applied Sciences, Central University of Punjab, Bathinda, Punjab, India

About the Editor



Muthappa Senthil-Kumar is a scientist at the National Institute of Plant Genome Research, New Delhi, India. He received his B.Sc. in agriculture from Tamil Nadu Agricultural University, Coimbatore and M. Sc. and Ph.D. in crop physiology from the University of Agricultural Sciences, Bangalore, India. He was post-doctoral fellow at The Samuel Roberts Noble Foundation, Ardmore, Oklahoma, USA. He has published over 40 research articles and several review articles on understanding plant interaction with drought stress and pathogens. Currently, his research team is working to understand the interaction of drought and pathogen stress and their combined impact on plants.