

REVIEW

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Plant responses to UV-B radiation: signaling, acclimation and stress tolerance

Zhiren Chen¹, Yuan Dong¹ and Xi Huang^{1*} 

Abstract

Ultraviolet-B (UV-B) light is an intrinsic part of sunlight that reaches the earth's surface, and affects plant survival and adaptation. How plants respond to UV-B light is regulated by the wavelength, intensity and duration of UV-B radiation, and is also regulated by photosynthetically active radiation perceived by phytochrome and cryptochrome photoreceptors. Non-damaging UV-B light promotes plant photomorphogenesis and UV-B acclimation which enhances plant tolerance against UV-B stress. However, high-level UV-B radiation induces DNA damage, generates reactive oxygen species (ROS) and impairs photosynthesis. Plants have evolved efficient mechanisms to utilize informational UV-B signal, and protect themselves from UV-B stress. UV RESISTANCE LOCUS8 (UVR8) is a conserved plant-specific UV-B photoreceptor. It interacts with CONSTITUTIVELY PHOTOMORPHOGENIC1 (COP1) to initiate UV-B-specific light signaling and regulate UV-B responsive gene expression. A set of transcription factors such as ELONGATED HYPOCOTYLS (HYS) function downstream of the UVR8-COP1 module to promote seedling de-etiolation for photomorphogenic development and biosynthesis of sunscreen flavonoids for UV-B stress tolerance. In addition to UVR8 signaling pathways, plants subjected to damaging UV-B radiation initiate stress protection and repair mechanisms through UVR8-independent pathways. In this review, we summarize the emerging mechanisms underlying UV-B stress acclimation and protection in plants, primarily revealed in the model plant *Arabidopsis thaliana*.

Keywords: UV-B stress, Photoreceptor, UVR8, Flavonoid, Transcription factor

Introduction

Light provides plants with the energy source needed for photosynthesis and acts as an important environmental cue to regulate plant survival and development. However, light can also function as an abiotic stress factor for plants [e.g., high light, ultraviolet-B (UV-B) radiation] (Demarsy et al. 2018; Kami et al. 2010; Shi and Liu 2021; Yadav et al. 2020). UV-B (280–315 nm) light is an intrinsic part of sunlight that reaches the earth's surface. Plants are inevitably exposed to UV-B light of varied levels throughout their life cycle. Their physiological responses to UV-B light are regulated by the wavelength, intensity and

duration of UV-B irradiation (Jenkins 2009), and are also affected by photosynthetically active radiation perceived by phytochrome and cryptochrome photoreceptors (Rai et al. 2020; Tissot and Ulm 2020). Plants perceive UV-B light through the plant-specific UV-B photoreceptor UV RESISTANCE LOCUS8 (UVR8) (Kliebenstein et al. 2002; Rizzini et al. 2011), which elicits specific light signaling for photomorphogenic and acclimatory responses, including seedling de-etiolation, leaf and root development, phototropisms, flowering and the biosynthesis of phenylpropanoid derivatives (Arongaus et al. 2018; Dotto et al. 2018; Favory et al. 2009; Kim et al. 1998; Kliebenstein et al. 2002; Wargent et al. 2009; Yadav et al. 2020; Yang et al. 2020). Accumulated in the UV-B acclimation, the phenylpropanoid derivatives flavonols serve as sunscreen to contribute to UV-B stress tolerance. However, high-level UV-B irradiation provokes UV-B stress which damages plant growth and impairs their development.

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Responses Of Plant To Uv B Radiation

**Jelte Rozema, W.W.C. Gieskes, S.C. van
de Geijn, C. Nolan, H. de Boois**



Responses Of Plant To Uv B Radiation:

Environmental Pollution and Plant Responses Shashi Bhushan Agrawal, Madhoolika Agrawal, 2023-01-30

Comprehensive and global in scope Environmental Pollution and Plant Responses provides an analysis of the research on the factors contributing to the deteriorating environmental quality and its effect on plant performance. The issues include environmental pollution and global climate change, response patterns of plants at different levels, mechanisms of interaction, tolerance strategies, and future research prospects. The author evaluates trends and gives management strategies for abating the problem. This volume highlights the complexities of environmental problems and the affect of pollution on every level of the ecosystem.

Responses of Tea Plants to Climate Change: From Molecules to Ecosystems Wenyan Han, Chaoling Wei, Colin Mark Orians, Selena Ahmed, Marco Landi, 2021-01-08

Stress Responses in Plants Bhumi Nath Tripathi, Maria Müller, 2015-05-27 This collection discusses the variety of specific molecular reactions by means of which plants respond to physiological and toxic stress conditions. It focuses on the characterization of the molecular mechanisms that underlie the induction of toxicity and the triggered responses and resistances. The nine chapters all written by prominent researchers examine heavy metal toxicity, aluminum toxicity, arsenic toxicity, salt toxicity, drought stress, light stress, temperature stress, flood stress, and UV B stress. In addition, information on the fundamentals of stress responses and resistance mechanisms is provided. The book addresses researchers and students working in the fields of plant physiology and biochemistry.

Ecological responses to environment stresses Jelte Rozema, J.A.C. Verkleij, 2012-12-06 September 1987 the Faculty Biology of the Vrije Universiteit Amsterdam commemorated the fact that Prof Dr Wilfried Hans Otto Ernst had been active as a scientist for 25 years. This period of 25 years of scientific research started at the Institut für Angewandte Botanik, Institute of Applied Botany of the University of Münster FRG. In 1965 he completed his Ph D thesis entitled Untersuchungen der Schwermetallpflanzengesellschaften Mitteleuropas unter Einschluss der Alpen. He was appointed full Professor at the Department of Ecology of the Vrije Universiteit Amsterdam in 1973. On the occasion of his 25th anniversary as a scientist a promise was made though in covert terms which we could not redeem at that time. The promise held to offer Prof Ernst a book in which his former and present staff members, Ph D students and colleagues should write a review about their specialism concerning a central theme. Now at the beginning of 1990 we consider the chapters of Ecological Responses to Environmental Stresses to be completed. The book reflects the wide range of research approaches that has been initiated and organized by Wilfried Ernst. The editors hope to have attained the primary aim of the production of the book of friends that is to gather relevant papers of staff members and colleagues of Wilfried Ernst. The title of the book Ecological Responses to Environmental Stresses covers the majority of the chapters included.

Plants' Responses to Novel Environmental Pressures Alessio Fini, Massimiliano Tattini, Raquel Esteban, 2018-02-01 Plants have been exposed to multiple environmental stressors on long term seasonal and short term daily basis since their appearance on land. However the frequency and the intensity of

stress events have increased much during the last three decades because of climate change. Plants have developed however a multiplicity of modular and highly integrated strategies to cope with challenges imposed by novel usually harsher environments. These strategies include migration, acclimation and adaptation. Twelve articles in this research topic exactly focus on the relative significance of these response mechanisms for the successful acclimation of plants to a wide range of novel environmental pressures. Four articles additionally explore how plants respond to severe stress conditions resulting from the concurrent action of multiple stressors. Ten articles mostly examine how morpho-anatomical, physiological and biochemical related traits integrate when plants suffer from novel threats such as solid, gaseous and electromagnetic pollutants. Suitable physiological indicators for developing conservation strategies are described in the last two works. This research topic highlights that bottom up as well as top down approaches will be necessary to develop in near future in the study of plants' responses to environmental pressures.

Nitric Oxide Action in Abiotic Stress Responses in Plants M. Nasir Khan, Mohammad Mobin, Firoz Mohammad, Francisco J. Corpas, 2015-04-20. This book offers an up to date review of the regulatory role of nitric oxide (NO) changes in the morphological, physio-biochemical as well as molecular characteristics of plants under abiotic stress. The first of two parts comprises four chapters and focuses on the properties, chemical reactions involving NO and reactive nitrogen species in plants. The second part, consisting of eleven chapters, describes the current understanding of the role of NO in the regulation of gene expression, NO signaling pathways and its role in the up-regulation of the endogenous defense system and programmed cell death. Furthermore, its interactions with other signaling molecules and plant hemoglobins under environmental and soil related abiotic stresses including post-harvest stress in fruits, vegetables and ornamentals and wounding are discussed in detail. Together with the companion book *Nitric Oxide in Plants: Metabolism and Role in Stress Physiology*, this volume provides a concise overview of the field and offers a valuable reference work for teachers and researchers in the fields of plant physiology, biochemistry and agronomy.

Photosynthesis and Respiratory Cycles during Environmental Stress Response in Plants Aryadeep Roychoudhury, 2022-12-29. This new volume aims to be the single source that discusses in a comprehensive and elaborate way the photosynthetic and respiratory mechanisms in plants under hostile situations and the proper mitigating strategies to continue uninterrupted photosynthesis and respiration under such situations. Photosynthesis and respiration are the two main physiological processes for sugar biosynthesis and mobilization for driving all other vital functions. This volume delivers a wealth of sound information on these processes for scientists, researchers and academicians. With chapters from renowned scientists, researchers and global leaders, this volume focuses on the effect of environmental stressors on photosynthetic pigments, photosystems, activities of photosynthetic enzymes and protein complexes, PSII photochemistry, carbon fixation pathways, photosynthetic efficiency, glycolytic and Krebs cycle pathways and ATP production and electron transport chain of plants. The recovery of photosynthesis and respiration through application of phytohormones, signaling molecules and other protective agents are also emphasized. Genetic

engineering to enhance photosynthetic efficiency is highlighted as well

Sustainable Agriculture Reviews Eric Lichtfouse, 2017-01-17 This book deals with a rapidly growing field aiming at producing food and energy in a sustainable way for humans and their children It is a discipline that addresses current issues such as climate change increasing food and fuel prices poor nation starvation rich nation obesity water pollution soil erosion fertility loss pest control and biodiversity depletion Novel environmentally friendly solutions are proposed based on integrated knowledge from sciences as diverse as agronomy soil science molecular biology chemistry toxicology ecology economy and social sciences Indeed sustainable agriculture decipher mechanisms of processes that occur from the molecular level to the farming system to the global level at time scales ranging from seconds to centuries For that scientists use the system approach that involves studying components and interactions of a whole system to classical narrow science Instead of solving problems using the classical painkiller approach that treats only negative impacts sustainable agriculture treats problem sources Because most actual society issues are now intertwined global and fast developing sustainable agriculture will bring solutions to build a safer world this book series gathers review articles that analyze current agricultural issues and knowledge then proposes alternative solutions It will therefore help all scientists decision makers professors farmers and politicians who wish to build a safe agriculture energy and food system for future generations

Reactive Oxygen, Nitrogen and Sulfur Species in Plants Mirza Hasanuzzaman, Vasileios Fotopoulos, Kamrun Nahar, Masayuki Fujita, 2019-07-02 Presents a multidisciplinary analysis of the integration among reactive oxygen species ROS reactive nitrogen species RNS and reactive sulfur species RSS Since plants are the main source of our food the improvement of their productivity is the most important task for plant biologists In this book leading experts accumulate the recent development in the research on oxidative stress and approaches to enhance antioxidant defense system in crop plants They discuss both the plant responses to oxidative stress and mechanisms of abiotic stress tolerance and cover all of the recent approaches towards understanding oxidative stress in plants providing comprehensive information about the topics It also discusses how reactive nitrogen species and reactive sulfur species regulate plant physiology and plant tolerance to environmental stresses **Reactive Oxygen Nitrogen and Sulfur Species in Plants Production Metabolism Signaling and Defense Mechanisms** covers everything readers need to know in four comprehensive sections It starts by looking at reactive oxygen species metabolism and antioxidant defense Next it covers reactive nitrogen species metabolism and signaling before going on to reactive sulfur species metabolism and signaling The book finishes with a section that looks at crosstalk among reactive oxygen nitrogen and sulfur species based on current research done by experts Presents the newest method for understanding oxidative stress in plants Covers both the plant responses to oxidative stress and mechanisms of abiotic stress tolerance Details the integration among reactive oxygen species ROS reactive nitrogen species RNS and reactive sulfur species RSS Written by 140 experts in the field of plant stress physiology crop improvement and genetic engineering Providing a comprehensive collection of up to date knowledge

spanning from biosynthesis and metabolism to signaling pathways implicated in the involvement of RONSS to plant defense mechanisms Reactive Oxygen Nitrogen and Sulfur Species in Plants Production Metabolism Signaling and Defense Mechanisms is an excellent book for plant breeders molecular biologists and plant physiologists as well as a guide for students in the field of Plant Science **Response of Field Crops to Abiotic Stress** Shuvasish Choudhury,Debojyoti Moulick,2022-12-15 Response of Field Crops to Abiotic Stress Current Status and Future Prospects is a collection of useful scientific resources for students researchers and academicians on diverse aspects of abiotic stress responses in field crops The book provides its readers with a vivid understanding of abiotic stress responses in field crops by covering diverse aspects It offers exhaustive explanations of the impact and responses of field crops to abiotic stresses This book offers comprehensive coverage of Climate change impact on field crops Arsenic and aluminium stress responses in field crops Drought high temperature and flooding stress responses in field crops Salinity and osmotic stress responses in field crops Heavy metal stress responses in field crops UV stress responses Elemental biofortification Reactive oxygen species ROS metabolism Nutraceutical and human health Computational modelling approaches for abiotic stresses in plants **Progress in Botany** 66 Karl Esser,Ulrich Lüttge,Wolfram Beyschlag,Jin Murata,2005-12-17 With one volume each year this series keeps scientists and advanced students informed of the latest developments and results in all areas of the plant sciences The present volume includes reviews on genetics cell biology physiology comparative morphology systematics ecology and vegetation science

UV-B Radiation and Crop Growth Sunita Kataria,Vijay Pratap Singh,2023-01-01 This book is an inclusive collection of topics on research on UVB for its impact on plants with a focus on its use as an emerging technology for crop growth and protection This book covers role of UV B on biological systems and its transformation from generic stressor to specific regulator It also explores the past research in UVB studies and the changing mind sets regarding UV B in recent time with respect to the plant growth It also explores the discovery of specific UV B photoreceptor UVR8 and UVR8 mediated plants responses This book is of interest to teachers researchers agriculture scientists and plant physiologists Also the book serves as additional reading material for undergraduate and graduate students of agriculture forestry ecology soil science and environmental sciences *Environmental Adaptations and Stress Tolerance of Plants in the Era of Climate Change* Parvaiz Ahmad,M.N.V. Prasad,2011-12-02 Climate change is a complex phenomenon with a wide range of impacts on the environment Biotic and abiotic stress are a result of climate change Abiotic stress is caused by primary and secondary stresses which are an impediment to plant productivity Prolonged exposure to these stresses results in altered metabolism and damage to biomolecules Plants evolve defense mechanisms to withstand these stresses e g synthesis of osmolytes osmoprotectants and antioxidants Stress responsive genes and gene products including expressed proteins are implicated in conferring tolerance to the plant This volume will provide the reader with a wide spectrum of information including vital references It also provides information as to how phytoconstituents hormones and plant associated microbes help the plants

to tolerate the stress This volume also highlights the use of plant resources for ameliorating soil contaminants such as heavy metals Dr Parvaiz is Assistant professor in Botany at A S College Srinagar Jammu and Kashmir India He has completed his post graduation in Botany in 2000 from Jamia Hamdard New Delhi India After his Ph D from the Indian Institute of Technology IIT Delhi India in 2007 he joined the International Centre for Genetic Engineering and Biotechnology New Delhi He has published more than 20 research papers in peer reviewed journals and 4 book chapters He has also edited a volume which is in press with Studium Press Pvt India Ltd New Delhi India Dr Parvaiz is actively engaged in studying the molecular and physio biochemical responses of different plants mulberry pea Indian mustard under environmental stress Prof M N V Prasad is a Professor in the Department of Plant Sciences at the University of Hyderabad India He received B Sc 1973 and M Sc 1975 degrees from Andhra University India and the Ph D degree 1979 in botany from the University of Lucknow India Prasad had published 216 articles in peer reviewed journals and 82 book chapters and conference proceedings in the broad area of environmental botany and heavy metal stress in plants He is the author co author editor or co editor for eight books He is the recipient of Pitamber Pant national Environment Fellowship of 2007 awarded by the Ministry of Environment and Forests Government of India

Responses of Plants to UV-B Radiation Jelte Rozema, Yiannis Manetas, Lars Olof

Björn, 2013-06-29 The research in this book covers papers on a great number of research projects on the responses of plants and crops of natural terrestrial ecosystems of agro ecosystems and of aquatic ecosystems to enhanced solar UV B as a result of stratospheric ozone depletion Some introductory chapters deal with general aspects of how plants respond to UV B radiation Photosynthetically Active Radiation PAR is a primary energy resource for terrestrial plants necessary for plant growth Inevitably terrestrial plants absorb UV B when exposed to solar radiation The spectral balance between PAR and UV B is discussed in several chapters The responses of plants and ecosystems from the Antarctic and Arctic to enhanced solar UV B radiation as a consequence of the hole in the ozone layer are considered in some detail In addition the papers in the book discuss the problem of how responses of plants to UV B radiation interact with other environmental factors The book is of great importance for those who are involved in global change topics biologists ecologists earth scientists agronomists environmental scientists and those who develop environmental policy

Photosynthesis and the Environment N.R.

Baker, 2006-07-06 Photosynthesis and the Environment examines how photosynthesis may be influenced by environmental changes Structural and functional aspects of the photosynthetic apparatus are examined in the context of responses to environmental stimuli particular attention being given to the processing of light energy by thylakoids metabolic regulation gas exchange and source sink relations The roles of developmental and genetic responses in determining photosynthetic performance are also considered The complexity of the responses to environmental change is demonstrated by detailed analyses of the effects of specific environmental variables light temperature water CO₂ ozone and UV B on photosynthetic performance Where appropriate attention is given to recent developments in the techniques used for studying photosynthetic

activities The book is intended for advanced undergraduate and graduate students and a wide range of scientists with research interests in environmental effects on photosynthesis and plant productivity Oxidative Stress and Redox Regulation in Plants, 2009-10-09 The field of redox is rapidly changing specifically in relation to plants where redox reactions are exacerbated compared to non photosynthetic organisms The development of proteomics has allowed the identification of hundreds of molecular targets of these systems and the recent discovery of glutaredoxin's ability to bind iron sulfur centers ISCs and to participate in ISC assembly in other apoproteins has provided many new insights This volume presents new research on oxidative stress in plants ranging from the production of reactive oxygen species or reactive nitrogen species to their accumulation their involvement in signal transduction and their degradation while also covering the links among oxidative stress and biotic and abiotic stresses Cutting edge reviews written from a broad range of scientific perspectives For over 40 years series has enjoyed a reputation for excellence Contributors internationally recognized authorities in their respective fields Arctic Climate Impact Assessment - Scientific Report Arctic Climate Impact Assessment, 2005-11-07 Arctic Climate Impact Assessment was prepared by an international team of over 300 scientists experts and knowledgeable members of indigenous communities and is the most comprehensive volume on Arctic climate change available Illustrated in full color throughout ROS Regulation during Plant Abiotic Stress Responses Zhulong Chan, Chun-Peng Song, Woe Yeon Kim, Ken Yokawa, 2017-02-08 Plants are continuously exposed to a wide range of environmental conditions including cold drought salt heat which have major impact on plant growth and development To survive plants have evolved complex physiological and biochemical adaptations to cope with a variety of adverse environmental stresses Among them reactive oxygen species ROS are key regulators and play pivotal roles during plant stress responses which are thought to function as early signals during plant abiotic stress responses ROS were long regarded as unwanted and toxic by products of physiological metabolism However ROS are now recognized as central players in the complex signaling network of cells Therefore a fine tuning control between ROS production and scavenging pathways is essential to maintain non toxic levels in plants under stressful conditions through enzymatic and non enzymatic antioxidant defense systems We focus on the roles of ROS during plant abiotic stress responses in this Research Topic Plant responses to multiple abiotic stresses and effects of hormones and chemicals on plant stress responses have been carefully studied Although functions of several stress responsive genes have been characterized and possible interactions between hormones and ROS are discussed future researches are needed to functionally characterize ROS regulatory and signaling transduction pathways UV-B and Biosphere Jelte Rozema, W.W.C. Gieskes, S.C. van de Geijn, C. Nolan, H. de Boois, 2012-12-06 Current phase out schedules of the production and emission of CFCs indicate that chlorine loading in the stratosphere is not yet at its maximum The recovery of stratospheric ozone is estimated to take time and elevated levels of UV B radiation are expected to occur throughout most of the next century Despite numerous physiological studies of UV B effects on plants often grown in climate

chambers knowledge of UV B effects on organisms and processes in natural aquatic or terrestrial ecosystems is poor. Currently it appears that UV B radiation is not just an environmental stress factor to plants. In various ways which are incompletely understood UV B affects a wide range of physiological and ecological processes. Remarkably recent field studies indicate that enhanced UV B does not markedly affect photosynthesis, growth and primary production but rather interferes with plant morphogenesis and plant and ecosystem functions relating to the secondary metabolism. This special issue and book UV B and Biosphere is an attempt to cover this range and to report the progress made in the research of ecological effects of enhanced solar UV B radiation. The papers in this book formed the basis of an international workshop entitled UV B and Biosphere, December 15-18, 1995 in Wageningen, The Netherlands. A first reaction of Hans de Boois on the number of papers and sessions scheduled from Friday to Sunday morning was far too many.

Plant MicroRNAs and Stress Response

Deepu Pandita, Anu Pandita, 2023-07-17

MicroRNAs (miRNAs) are small 20-24 nt single stranded regulatory RNA molecules or gene regulators of critical transcriptional or post transcriptional gene regulation in plants in sequence specific order that respond to numerous abiotic stresses and animals non coding highly evolutionarily conserved and widely distributed throughout the plant kingdom. MiRNAs are master regulators of plant growth and development, development attenuation under various environmental stresses by stress responsive miRNAs and plant stress responses and tolerance. Drought, salinity, heat, cold, UV radiation, heavy metal, pathogens, pests and other microbial infections affect survival, growth, development, quality, yield and production of plants. Stress induced miRNAs down regulate their target miRNAs. This down regulation leads to the accumulation and function of positive regulators highlighting their roles in stress responses and tolerance. Plant miRNA mediated modifications include overexpression or repression of stress responsive miRNAs and or their target complementary or partially complementary gene products, miRNA resistant target genes, target mimics and artificial miRNAs. Thus miRNAs may serve as genomic gold mines, novel potent and potential targets in plant genetic manipulations and miRNA based biotechnology will aid plant improvement and crop plant tolerance to different environmental stresses. This book reviews our recent understanding of plant microRNAs, biogenesis and functions, computational tools and bioinformatics, regulation of plant growth and development, expression studies and the role of plant miRNAs in various biotic and abiotic stress response regulation in plants.

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