
Preface

World population is increasing at an alarming rate, generating a concern for progressive and sustainable food production. The task becomes more challenging as plant growth and development is dependent on edaphic and environmental factors. Categorically these are abiotic stresses *viz.*, drought, flooding, salinity, extremes of temperature, mineral deficiency and adverse pH that limit crop production worldwide. Biotic stresses also cause crop yield losses. To cope with the increasing food requirements, understanding the effects of different types of stresses is a rapidly emerging domain to develop better and stress tolerant plants. It is of paramount significance to understand plant responses to stresses that disturb the homeostatic equilibrium at cellular and molecular levels and to identify a common mechanism to multiple stress tolerance.

Salinity, water stress (both drought and flooding), heat and cold are among the major abiotic stresses that adversely affect plant growth and development and cause more than 50 per cent yield losses. All these stresses are often inter-related that lead to oxidative stress and cellular damage. Plant stress tolerance involves changes at cellular, physiological and molecular levels. The recent advances in plant biology and rapid development of physiological, biochemical and molecular techniques have resulted in understanding the mechanisms of plant adaptation to stress at physiological and biochemical levels. The identification of genes/gene determinants involved in plant stress resistance/tolerance using techniques of molecular genetics, transcriptomics, proteomics and metabolomics has further opened the door for new approaches in understanding the mechanisms by which plant adapts to abiotic stresses and ultimately leads to improved and stress tolerant crops. This book provides recent information on all our knowledge of all aspects of plant perception, signaling and transgenic approaches for tolerance and adaptation to various environmental stresses.

Generation of reactive oxygen species (ROS) is responsible for the development of oxidative stress. Higher concentration of ROS has the potential to cause oxidative damage by reacting with biomolecules, whereas, in relatively low levels act as a signal molecule involved in acclimatory signalling, triggering tolerance to different stresses. The chapter 1 delves into oxidative stress and resulting antioxidative defense system in plants.

Being a substantive macronutrient, calcium participates in various structural and physiological phenomena like cell division (formation of microtubules supporting chromosomal movement), cell wall/membrane structure (as calcium pectate), pollen tube formation, nutrient metabolism and cell differentiation. It not only participates in regulation of various developmental processes but also supports plants to sense and respond to abiotic and biotic stimuli. The chapter 2 is focused on calcium signatures, Ca^{2+} sensors and their effect on pathogen defense responses.

Transcription factors (TFs) play vital regulatory roles in abiotic stress responses in plants by interacting with *cis*-elements present in the promoter region of various abiotic stress responsive genes. Now it has been possible to engineer stress tolerance in transgenic plants by manipulating the expression of TFs. This opens an excellent opportunity to develop stress tolerant crops in future. The chapter 3 provides an overview of the role of various transcription factors in crop improvement through transgenic technology.

In plants, hundreds of protein kinases (PKs) are known which are involved in cellular signal transduction services. PKs modify proteins by catalyzing addition of monophosphate groups to the side chains of the most commonly, specific serine, threonine and/or tyrosine residues in the protein backbone. Out of these kinase classes, the most conserved and best characterized protein kinase signaling pathways is mitogen-activated protein kinase (MAPK) cascade. A MAPK cascade consists of a three-tier system where each tier is phosphorylated by upper tier. It is represented as a MAP3K-MAP2K-MAPK module that serves as a link between upstream receptors and downstream targets. The chapter 4 summarizes the role of MAPK cascade in different stress responses in plants. The chapter 5 presents a discussion on recent advances made in understanding the role of plant hormones in modulating plant defense responses against various biotic as well as abiotic stresses.

The adaptation to various stresses has led to the development of common stress transduction pathways and increased synthesis of secondary metabolites, Ca^{2+} fluxes, an oxidative burst and an overlapping set of stress response genes. The main components of stress-induced signalling molecules are the cross-talk between the different signalling pathways allows plants to adjust their responses depending on the combination of stimuli. The chapter 6 focuses on the process of stress regulation in abiotic and biotic stress conditions.

Salinity affects about 20 per cent of the world's cultivated area and nearly half of the world's irrigated lands. As soluble salt levels increases, it becomes more difficult for plants to extract water from soil. The chapter 7 discusses about soil salinity, its effects on plants and tolerance mechanisms which permit the plants to withstand stress, with particular emphasis on ion homeostasis, Na^+ exclusion and

tissue tolerance. *Populus euphratica* is the only tree species naturally distributed at the edge of barren deserts or semi-barren deserts worldwide, and is well known for its high tolerance to salinity and atmospheric drought. It is not belongs in xerophyte but it have some characteristics of xerophyte. It can secrete salt from its body by discharging salty water through portals in its trunks and leaves. Due these all characters, *P. euphratica* considered model tree plant for salt tolerant. The chapter 8 focuses on the adaptability of *P. euphratica* in saline condition and their importance for arid lands.

Low temperature has a huge impact on the survival and geographical distribution of plants. It often affects plant growth and crop productivity, which causes significant crop losses. The changes in expression of hundreds of genes in response to cold temperatures are followed by increases in the levels of hundreds of metabolites, some of which are known to have protective effects against the damaging effects of cold stress. The chapter 9 provides an overview of the physiological and molecular mechanisms of chilling stress tolerance in plants.

High temperatures and drought affect plant growth at all developmental stages; especially, anthesis and grains filling are more susceptible. During these stresses, crops generally coordinate photosynthesis and transpiration, although significant genetic variation in transpiration efficiency has been identified both between and within species. To cope up and survive under such stresses, plants employ various mechanisms both at cellular and molecular level which includes modulation of primary and secondary metabolism, molecules and transcription factors related to cell signaling. Chapter 10 reviews the physiological, biochemical and molecular aspects of heat stress responses and tolerance mechanisms in plants. The chapter 11 highlights the recent development in drought tolerance in Crop plants.

Heavy metal pollution is increasing globally due to mining, industry, road traffic and other natural sources. In the earth crust, Al is the third most abundant element after oxygen and silicon whose naturally occurring forms are stables and does not pose a toxicity hazard in plants. However, under low pH (upon soil acidification) conditions, Al dissolves in various ionic forms [$\text{Al}(\text{H}_2\text{O})^{3+}$, $\text{Al}(\text{OH})^{2+}$ and $\text{Al}(\text{OH})_2^+$] of which Al^{3+} is potentially phytotoxic to plants. The chapter 12 provides a glance into the potential of mutagenesis and transgenic approach for Al-toxicity improvement in different plants. Among heavy metals, chromium (Cr) is a common contaminant of surface waters and ground waters because of its occurrence in nature, as well as anthropic sources. Cr (VI) is more toxic at lower concentrations than Cr (III), which tend to form stable complexes in soils. Chapter 13 discusses the deleterious effects of chromium on plant health, control measures and ameliorative methods to protect plant from these negative effects of Cr (VI).

Waterlogging is the condition, in which, soil pores are fully saturated with water. Under waterlogged condition, root system of plant is under anaerobic conditions and the shoot system is under normal atmospheric condition. The chapter 14 summarizes the adaptative traits of plants ensuring survival under waterlogging (aerenchyma formation and development of adventitious roots, availability of soluble sugars, antioxidant system, anaerobic metabolism), regulatory mechanisms

and signaling events responsible for triggering responses to waterlogging condition in plants.

Anthropogenic stress is the stress resulting from the influence of human beings on nature. Nowadays plant organisms are exposed to a large scale of new stressors related to human activity viz. toxic pollutants such as pesticides, noxious gasses (SO_2 , NO , NO_2 , NO_x , O_3 and photochemical smog); photooxidants; soil acidification and mineral deficit due to acid rains; overdoses of fertilizers; heavy metals; intensified UV-B irradiation etc. All these stresses decrease the biosynthetic capacity of plant organisms, alter their normal functions and cause damages which may lead to plant death. The chapter 15 discusses in detail about anthropogenic stress and its impact on plants growth and metabolism.

Now-a-days, agriculture has new huge challenges due to population growth, the pressure on agriculture liability on the environmental conservation, and climate change. To cope with these new challenges, many plant breeding programs have reoriented their breeding scope to stress tolerance in the last years. The chapter 16 and 17 emphasizes on sources of stress tolerance, genetics of stress tolerance, conventional breeding methods and modern molecular biological approaches to develop improved cultivars tolerant to most sorts of abiotic and biotic stresses, respectively.

Transgenic approach is one of the important tools available for modern plant improvement programmes. Transgenic plants are majorly developed by particle bombardment and *Agrobacterium* mediated transformation methods. The chapter 18 highlights the most significant achievements of the transgenic approach to improve tolerance to drought, salinity, chilling and heat stress and the limitations that hinder the commercialization of abiotic stress tolerant transgenic crops. The chapter 19 outlines the major yield-limiting biotic stresses and the plant stress resistance mechanisms and transgenic approaches to overcome biotic stresses.

Submergence has been identified as the third most important constraint for higher rice productivity in eastern India, because it sometimes resulted in near total yield loss. Improvement of germplasm is likely the best option to withstand submergence and stabilize productivity in these environments. The trait for submergence tolerance can be improved if the genetic bases of submergence are well understood. This chapter 20 focuses on physiological understanding of tolerance to submergence in crops and to explore the potential recent technologies like genetic engineering and molecular breeding to enhance the tolerance for submergence in water logged crops.

In order to adapt to stress conditions plants exhibit stress resistance, this involves differential expression of proteins. Recent advancements in the field of proteomics enable the researchers to understand the stress mechanism and deciphering the mechanism of plant protection against the biotic and abiotic stresses. The chapter 21 was intended to describe the various proteomic techniques available and provides information on differentially expressed proteins expressed in plants during biotic and abiotic stresses. This chapter also provides the brief details of different databases and bioinformatics tools available in the field of proteomics.

Molecular marker technology is a modern tool for crop improvement. A substantial progress has been achieved in mapping of genes/QTLs associated with stress tolerance in crops. Marker-assisted selection (MAS) of target genes/QTLs enables plant breeders to select for stress tolerance in breeding populations more precisely and rapidly. The chapter 22 provides an overview on the developments in DNA marker technology and their contributions towards genetics and breeding of stress tolerance in crops.

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