PHYSIOLOGY OF PLANTS UNDER ABIOTIC STRESS AND CLIMATE CHANGE

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PHYSIOLOGY OF PLANTS UNDER ABIOTIC STRESS AND CLIMATE CHANGE

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Preface

The plant physiology and plant molecular biology research group has evidently endorsed the new directions taken by the treatise to attract the pre-eminent scientists in plant biology/plant sciences. This book ***Physiology of Plants under Abiotic Stress and Climate Change*** has been done entirely due to commendable contributions from Scientists of Eminence in unequivocal fields. Unquestionably, our objective is to publish innovative science of value across the broad disciplinary range of the treatise. I restate that this plan has been undertaken with a view to strengthen the indistinguishable efforts to recognize the outcome of meticulous research in some of the very sensible and stirring areas of ***Plant Physiology-Plant Molecular Physiology/ Biology-Plant Biochemistry*** for holistic development of the science of agriculture and crop production under changing climate**.** I am ardent to keep on the exceptionality and the prologue of excellent new ideas ensuring that the treatise calls to the best science done across the full extent of modern plant biology, in general, and plant physiology, in particular. In *Volume 13,* with inventive applied research, attempts have been made to bring together much needed **eighteen review articles** by forty-eight contributors especially from premier institutions of India for this volume. All the eighteen review articles have been grouped in five broad sections, which on the whole highlight the necessity to find out evidence from the fields of plant nutriophysiology (physiology of plant mineral nutrients) and abiotic stresses under changing climate along with their control.

In the last 75 years, meaningful research on plant mineral nutrition showed facts regarding deficiency symptoms of essential nutrient elements and their implications on the physiology and biochemistry of plants and agricultural crops. Agricultural productivity heavily depends upon meeting the nutritional requirement of the crops in form of sixteen essential elements which are critical for their sustaining plant growth and development. Nutrient stress may be created as a consequence of deficiency as well as toxicity of the essential elements (N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, Mo and B) which plants require for their normal growth and development. Some of these nutrients play a protective role against oxidative damage in plants. However, in the situation of changing environment being happened naturally and through anthropogenic contributions, it is explicitly desirable to re-evaluate disorders caused by deficiencies and toxicities of essential mineral elements and/or heavy metals along with their symptoms on various crop plant parts in different time duration under range of temperature, humidity, moisture, soil structure and pH on the one hand and to re-examine plant processes under nutrient stresses through physiological and molecular approaches with a view to improve crop tolerance on the other hand. This is also important because of the resemblances of many of the deficiency or toxicity symptoms of essential mineral nutrient elements and/or heavy metals. A crop-wise evaluation including crop varieties under different agro-climatic zones by nutrio-physiologists of the world is extremely needed. A holistic benchmark analysis of various components leading to remunerative soil and plant nutrition management is imperative to sustain the pressure of increasing nutrient demand accruing from intensive cultivation featuring high density planting with low volume fertigation to extensive cultivation. The gathered information would be of value to the conventional breeders, plant biotechnologists and molecular biologists in tailoring plants to combat various abiotic stresses with special reference to nutrient stresses. In this volume, there are five major applicable sections judiciously distributed with select chapters.

Auspiciously, out of five relevant chapters of the ***Section I: Nutriophysiology and Mineral Nutrient Stresses,*** the very ***First Chapter*** has been dedicated as above for generating a precise review on the physiological and molecular approaches to improve crop tolerance to mineral nutrient deficiency and heavy metal toxicity, the subject of paramount significance in agriculture, brought together by a knowledgeable and eminent team of plant mineral nutritionists of NRL and related disciplines from Indian Agricultural Research Institute, New Delhi.

Accordingly, involvement of different mineral nutrients in various aspects of fruit physiology, ripening and storability indicated the significance of endogenous levels of mineral nutrients for the fruits. The ***Chapter 2*** has been devoted to review ripening and postharvest physiology of fruits, regulatory control on ripening and storability of fruits, factors affecting the status and role of mineral nutrients in fruits. The IARI plant physiologists have brilliantly compiled the precious pieces of information. Besides fruits, vegetable like potatoes contain good amount of carbohydrates for energy, high-quality protein, valuable minerals and essential vitamins. Many of the compounds present in potato are important because of their beneficial effects on human health, so, highly desirable in the human diet. Therefore, nutritional deficiencies are little known in the countries whose populations depend on potatoes as their basic food. Providentially, the ***Chapter 3*** of this volume consists of an exhaustive review revealing significance of phytonutrients in potato nicely written by a renowned scientist from Central Potato Research Institute, Shimla.

The role of nutrients in alleviating the detrimental effects of abiotic stress factors to maintain a high yield needs attention. Decrease in activity of the antioxidant enzymes due to limited availability of the metal co-factors weakens the antioxidant defense mechanism and exposes plants to greater damage from the ROS. At the same time toxicity of essential heavy metals like Fe, Mn and Cu stimulate generation of ROS (OH·) that modify the antioxidant defense and elicit oxidative stress. The production and detoxification of ROS and their modulation in response to nutrient stress have been discussed in ***Chapter 4*** by an original worker in this field.

In South Asia, poverty of rice consumers is extensive and with rise in population growth, the demand for rice is expected to become very high in future. According to a FAO estimate global rice yield, which is nearly 645 million tonnes in 2010 must reach 800 million tonnes in the year 2025 (FAOSTAT, 2010) for food security of rice consumers. However, the prospects of achieving this target are miserable; a disconcerted climate can make the fragile rice ecosystem more fragile and destabilize rice production. Further, in flood-prone environment, submerged soil causes high absorption of iron by the plant reaching physiologically toxic level and under moisture stress, iron deficiency reduces grain yield and low grain iron aggravates iron deficiency induced anemia of rice consumers in Southeast Asia. The strategies needed are well discussed in the light of the present scenario by thoughtful scientists in ***Chapter 5.***

Promisingly, six meaningful reviews have been selected for the ***Section II: Environmental Stresses: Molecular and Physiological Aspects*** with a view to changing environment and resulting abiotic stresses. Initially the plant genetic engineering was limited to model plant species, but now it can be extended to some other important cereal and vegetable crops for better management of multiple stresses for sustainable quality and quantity at the global level. A bioinformatics approach to study the phylogenetic relationship between the different ZFP group members would provide an insight into the evolutionary significance of this gene in stress tolerance and with these facts environmental stresses and transgenics: role of ZFP (ZAT) gene in multiple stress tolerance in plants has been reviewed in ***Chapter 6.*** Subsequently, ***Chapter 7*** overviews on QTLs linked to physio-morphological traits under water-limited conditions in rice (*Oryza sativa* L.) as drought is a major limitation for rice production in rain-fed ecosystems. An eminent scientist from Kerala Agricultural University emphasizes the need for the development and production of drought–resistant rice varieties, to stabilize and improve the production levels in the low-middle-yielding fields in this chapter.

The molecular events involved in SA and JA signaling are not yet well known. The ***Chapter 8*** covers favourably recent reports on SA/JA signal transduction genes involved and their role in regulation of abiotic stresses in higher plants. In addition, heat is a physical parameter that influences molecular (protein, DNA) or supramolecular (membranes, chromosomes) structures through simple thermodynamic effects. However, for a molecule or structure to be considered a sensor, any alteration induced should be upstream of a signalling cascade leading to a response. The review of ***Chapter 9*** accentuates briefly on plant responses to heat stress at the whole plant elucidating, in general, the sensing of temperature by plants providing physiological and molecular grounds as well as focusing upon the response of wheat crop towards high temperature followed by tolerance mechanisms and strategies for genetic improvement through crop biotechnology in global climate change. The review further suggests that crop scientists and breeders must select the most appropriate traits for crop improvement and should, therefore, make emphasis on the development of wheat varieties, which are resistant to high temperature around flowering. Next to this, in ***Chapter 10,*** authors have tried to illustrate physicochemical and biotechnological approaches with reference to plant responses for salinity stress typically defining a number of related terminologies besides coverage of numerous aspects of this expanding worldwide problem. Another important review in ***Chapter 11*** aims to define the role of ROS in seed physiology, mainly with regard to their duality as toxic and signaling species. This toxicity is largely due to the intermediates of oxygen reduction, such as the superoxide radical ($O_2^{\bullet -}$), hydrogen peroxide (H_2O_2) and the hydroxyl radical ($HO^{\bullet}$). A better understanding of ROS homeostasis, their site of production and gradient establishment is required to determine the precise roles of these species in seed metabolism and changes related to known aspects of seed physiology.

Positively, ***Section III: Heavy Metal Stresses,*** which is the extension of ***Section II,*** carries three evocative review articles of crucial value. Heavy metals are one of the most potent toxic and hazardous, still unavoidable pollutants that very often challenge plant's growth and development in a serious manner. The Brazilian scientist in ***Chapter 12*** has sumptuously enriched this volume by detailing some general aspects related to the chemical characteristics and properties of the metal ions usually found in biological systems and to other biochemical detoxification agents. This review is devoted to one of the most important chelating agents developed by plants, the phytochelatins. Afterwards in ***Chapter 13***, carrying vital information on the overall effects of metal toxicity, production of reactive oxygen species and their consequences in plants, well reviewed by an excellent team of scientists, as the metal induced damages in plants are seen as replacement of metals present at the active sites of the enzymes, damage to energy production pathways and the consequences on increased generation of ROS. Metals tend to accumulate in living organisms over time via food, water, and air pathways through biomagnification. Next to this in ***Chapter 14***, a concise and decisive account for heavy metal interference for ROS activities are discussed for understanding the various facets of ROS in plant growth and metabolism. Ecological and physiological significance of hyper accumulation is yet to be deciphered; however, intensive study in depth is warranted for proper selection of hyper accumulating plant species for phytoremediation purposes. *In-situ* trial could, at best, be beneficial for preliminary screening of plant types within a limited environment.

Three essential review articles have been assembled for ***Section IV: Stress Control Measures and Phytoremediation*** for this volume under the changing situation, which provide adequate insight for overcoming practical problems by anthropogenic contributions to the environment and plant scientists need to mitigate the same by evolving pragmatic measures. The soil water storage system of our pristine aquifers has come under increasing threat in the past hundred years or so. This is because countries throughout the world have contrived to introduce intensive agriculture, industrialization and urbanization on these hitherto steady state domains of nature. The ***Chapter 15*** describes the role of trees in areas where groundwater tables have declined to abnormally low depths. Authors are of the opinion that a holistic solution lies in re-obtaining a steady-state balance between precipitation, irrigation input of water *vis-a-vis* water requirement of the agro ecosystem and groundwater hydrology. In this system, the biodrainage potential of tree flora shall be a cardinal component. In ***Chapter 16***, the impact of abiotic stresses caused by different environmental factors on postharvest quality of fruit and vegetable crops is discussed. The set of strategies is of paramount importance to help growers all over the world to withstand the challenges that climate changes will impose throughout the next decades. Nevertheless, phytoremediation's basic processes are still largely not clear and hence require further fundamental or basic and applied research to optimize its field performance. A capable team of researchers has scientifically reviewed phytoremediation emphasizing tool for *in situ* risk reduction in ***Chapter 17***, which is doubtless imperative in the present perspectives.

Finally, the ***Chapter 18*** of the ***Section V: Plant Growth Regulators*** provides the journey of long-chain aliphatic alcohols to focus upon the bioregulating properties. Research suggests that it has been developed to be a new generation of agricultural chemicals and also in medicines to treat cancers and lowers cholesterols without any interference with the environment. However, still their commercial application is being evaluated under natural field conditions. Triacontanol (**TRIA**), a 30-carbon long chain aliphatic alcohol act as a photosynthesis enhancer. Hopefully, these regulators could be of immense help to agriculture in the years to come to fighting with recurrently expanding global human population, in general, and changing climate, in particular.

In this dedicated endeavour, I am delighted to state my authentic appreciation to the Members of the Advisory Committee as well as to all distinguished and talented contributors from well known institutions for bringing up this unrivalled, realistic, thoughtful and far-reaching treatise up to the international standard. In addition, I am extremely grateful to the ***Fellow Members of the Indian Society for Plant Physiology, New Delhi*** for their trustworthy moral support and valued suggestions from time to time. My esteem is very much due to the Hon'ble Vice-Chancellor Dr. Lalji Singh, Banaras Hindu University, the Director, Institute of

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* This volume is dedicated to esteemed distinguihsed Indian Contributors for their outstanding efforts in maintaining international standards and to make this volume meaningful, valuable and unique in the present scenario — **Editor**

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