Dinesh Chandra Uprety · V.R Reddy

Crop Responses to Global Warming

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Foreword

Global warming is the change in atmospheric temperature of the earth due to exponential rise of CO_2 and other greenhouse gases caused by anthropogenic and other activities. Rising temperatures are influencing various systems on the earth, including agriculture. In fact, global warming has a direct bearing on crops, food chains and production cycles in terms of marked changes on growth and yield processes of crops, insect and pest incidences, epidemics and increasing demands for irrigation resources. The impact assessment analysis of global warming has attracted the attention of the international scientific community. Recently India has set ambitious targets under its Intended National Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) by extending its significant role in building additional carbon sinks. As evident in the context of India where an agro-based economy prevails, the direct impact of climate change jeopardizes the national food security. Global warming is taking a toll on our rich and diverse food systems. Reports indicate that the steep rise in temperature since 1980 has led to reduction in yields of staple crops offsetting gains even from improved farm practices, which has several implications for agriculture, crop yields and patterns in the long run. Therefore, futuristic research studies in these directions are needed. A comprehensive predictive model is yet to be established – a model that can improve and strengthen a plant's resilience to the stresses caused by increase in temperature.

The authors of the book Drs. Uprety and Reddy have given a comprehensive account of the historical rise of earth's temperature, its sources and sinks and more importantly the impacts on the production of various crop plants. They have also given illustrative descriptions of the impact of rise in temperature on the growth and various physiological processes to explain the response of crop plants to the change in temperature. The most interesting section of the book is the compilation of case studies on different crops such as wheat, rice, maize, soybean, cotton and brassica. The authors have made their best efforts to explain the impact of temperature changes on growth, yield and biochemical, physiological, morphological and agronomic systems of each species. In addition, mitigation technologies and future thrust sections for each crop have added value to this book at high stack. The book is timely and will help readers understand the complex issues of climate change implications for crops and, subsequently, food security. I wish them great success in every sphere of life and appreciate for taking us on this enlightening journey.

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Dr. P.P. Dhyani

Preface

The monograph entitled "Crop Responses to Global Warming" describes the normal historical shifts in the earth's atmospheric temperature and weighs the evidence concerning anthropogenic induced changes in the level of temperature. There is not much study to explain the shift in temperature since the ice age, whereas the subsequent unprecedented increase in the earth's temperature after the preindustrial period has been possibly related to the anthropogenic activities. This rise in temperature has become a great threat to the productivity of crop plants. The increase in temperature has affected the crop calendar of tropical and temperate regions of the world by reducing the length of the effective growing season of crops. This monograph has given an overview of the global as well as Indian crop productivity in relation to the rise in the earth's surface temperature. The variability of past temperature changes and that of after the Industrial Revolution has been discussed in relation to the crop productivity and food security of the region. A chapter of this monograph is on the technologies to study the responses of crop plants to the elevated temperature. The innovative approaches have been described for the long-term experiments to investigate the lifetime responses of crop plants to the rise in temperature. Phytotrones, temperature gradient chambers, temperature gradient greenhouses (TGG), soil-plant-atmosphere research (SPAR) system, temperature-free air CO_2 enrichment technology (T-FACE), infrared warming technology (IRWT), free air temperature enrichment technologies (FATE), and soil warming systems (SWS) to simulate anthropogenic climate warming are described in this chapter.

The impact assessment analysis of rising temperature on crops such as wheat, rice, maize, soybean, cotton, and brassica are described, reviewed, and discussed in separate chapters as case studies. The responses of physiological processes and biochemical reactions to the elevated temperature in crop plants are described crop-wise. The effect of elevated temperature on the growth and development of crop plants has been discussed in relation to their phenological stages. The monograph also includes the impact of elevating temperature on crop/weed interaction, pest and diseases, and soil dynamics for each crop species independently. The mitigation technologies to counter the adverse effect of high-temperature stress are described for each crop according to their cultivation and climatic conditions. The future research strategies for each crop to meet the threat of elevating temperature on crop productivity and food security are described and discussed.

The monograph will assist in obtaining the detailed account on the historical analysis of the exponential rise in the temperature of the earth to the writers of climate change. The agricultural and environmental scientists will get the explanations of the phenological changes caused by rising atmospheric temperature and the physiological and biochemical characterization of these changes. The description of temperature enrichment technologies will help researchers and scientists to study the responses of biological materials to rising temperature. The monograph has first-hand knowledge on the mitigation technologies for ameliorating the global warming effects in crop plants. The detail description and suggestions on future strategies for each crop will be useful to the policy makers to change the farming policies to meet the challenges of global warming on crop plants. The monograph also describes the modification of crops and management systems to cope with changed temperatures which demonstrated the possibility of adoptions to high-temperature stress. The monograph will be the main text for teaching climate change, global warming, and environmental botany as no such book is currently available relating to the rising atmospheric temperature on crop plants. Therefore, the monograph will be highly useful for students of global climate change, environmental botany, and agricultural sciences, scientists, researchers, farmers, and policy makers.

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Acronyms

APX	Ascorbate peroxidase
AQY	Apparent quantum yield
ATP	Adenosine triphosphate
BT	Basal temperature
CAT	Catalase
CGR	Crop growth rate
CER	CO_2 exchange rate
CIM	Composite interval mapping
DACT	Degrees above canopy threshold
DON	Deoxynivalenol
DT	Day temperature
DTI	Drought tolerance index
EIL	Economic injury levels
FACE	Free Air CO_2 Enrichment Technology
FATE	Free Air Temperature Enrichment Technology
Fv/Fm	Photochemical efficiency of PS ll
GB	Glycine betaine
GCM	General circulation model
GDD	Growing degree days
GLAI	Green leaf area index
GMT	Global mean temperature
GR	Glutathione reductase
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute, Philippines
IRTR	Infrared thermal radiometer
KGDD	Killing growing degree days
LEA	Late embryogenesis abundant protein
LTD	Leaf temperature difference
MDA	Malondialdehyde
MT	Million tonnes
NOAA	US National Oceanic and Atmospheric Administration
NT	Night temperature
NGDD	Normal growing degree days
OTC	Open-top chamber

PEP	Phosphoenolpyruvate
PID	Proportional integrative differential
PETM	Paleocene-Eocene Thermal Maximum
Pn	Net photosynthetic rate
PSl	Photosystem l
PSll	Photosystem ll
Q10	Temperature coefficient
QP	Photochemical quenching
QPSll	Quantum yield of PS ll electron transport
QTL	Quantitative trait loci
ROS	Reactive oxygen species
RLSU	Rubisco larger subunit
RSSU	Rubisco smaller subunit
RWC	Relative water content
SA	Salicylic acid
SFW	Shoot fresh weight
SDW	Shoot dry weight
SPAR	Soil-plant-atmosphere research system
SACC	Screen-aided CO_2 control system
SPS	Sucrose phosphate synthase
SUTl	Suc transporter gene
TFACE	Temperature free-air controlled enhancement
TGC	Temperature gradient chamber
TGG	Temperature gradient greenhouses
TBARS	Thiobarbituric acid reactive substances
TKW	Thermal kinetic window
T.min	Minimum temperature
T.opt	Optimum temperature
T.max	Maximum temperature
T.T.	Thermal time