

Preface

Light plays a pivotal role in regulating plant growth and development. Both quality and intensity of light as well as the photoperiod are very critical for plant morphogenesis. The significance of plant photoreceptors as key regulatory proteins that govern metabolic events and developmental changes within plants has been well documented. Complex, multiple photoreceptor systems respond to light and thereby regulate plant morphogenetic changes, functioning of the photosynthetic apparatus, and the trend of metabolic reactions. Moreover, photooxidative changes evoked by lighting condition may lead to the altered action of antioxidant defense system. Thus in combination with other agro-technical means, light, creating the mild photo-stress, might be an effective tool for phytochemical rich plant cultivation.

Crop failure due to unpredictable climate change is a matter of global concern. Threats such as pest attacks and diseases further aggravate the uncertainty of crop yields. Geo-climatic limitations of traditional agriculture and its dependence on environmentally hazardous fertilizers and pesticides have impelled the advancements in controlled environment farming techniques. The concept of controlled environment agriculture in greenhouses and closed plant production system has emerged as a reliable and sustainable alternative means of crop production. These “plant factories” for vertical farming are now becoming an indispensable part of the global food security system. However, the feasibility and sustainability of such systems are largely dependent on the power requirements. The large power requirements mainly from the electric lamps that provide the actinic light which drives the light reactions of photosynthesis, accounting for 40% of the recurring cost of plant factories, are the major bottlenecks to make controlled environment agriculture profitable.

The light source generally used for controlled environment agriculture is fluorescent light, metal-halide, high-pressure sodium, and incandescent lamps. Among them, fluorescent lamp has been the most popular. However, these lighting systems have a wide range of wavelengths from 350 to 750 nm and are of low quality for promoting plant growth and development. They also emit light with low photosynthetic photon flux and had limited lifetime of operation which restricts

their utilization in plant lighting systems when the goal is to sustain high crop productivity.

The steady development of the light-emitting diode (LED) technology with the emergence of new types of semiconductor materials has made it possible to apply it in an increasing number of new areas including plant growth and development. As an alternative to conventional lighting system, LED has been demonstrated to be an artificial smart lighting source for controlled environment agriculture and in vitro studies of plant morphogenesis. Various morphological, anatomical, and physiological attributes of plants grown both in vivo and in vitro have found to be regulated by spectral properties of LED. Apart from its regulatory role in plant growth and development, LED affects the amplification of functional components which contribute toward the selective control of antioxidative attributes. Since the LED emits over specific spectral regions, they can be used to regulate the levels of photosynthetically active and photomorphogenic radiation necessary for plant growth and development. This feature allows implementation of LED with specific spectral ranges that are involved in plant responses and also ensures the independent control of each spectral range and precise manipulation of spectral quality and light intensity. The flexibility of matching wavelengths of LED to plant photoreceptors may provide optimal production influencing plant morphology and metabolism. These solid-state light sources are therefore ideal for use in plant lighting designs for controlled environment agriculture as well as for studies on photomorphogenesis.

The present book aims to present a comprehensive treatise on the advancements made in the use of LEDs for sustainable crop production and to describe research achievements on photomorphogenesis. This book introduces readers to the fundamentals and design features of LEDs applicable for plant growth and development and illustrates their various advantages over the traditional lighting systems with cost analysis. It contains 14 chapters, and organizes the information in order to present a wide spectrum of applications of LEDs covering a diverse domain of plant sciences relevant to controlled environment agriculture and in vitro plant morphogenesis. The scope of this book has been expanded by including chapters that deal with the role of LEDs in regulating cellular redox balance, nutritional quality, and gene expression. The chapters are written by a team of international experts who are pioneers, and have made significant achievements in this emerging interdisciplinary enterprise. I am indebted to the chapter contributors for sharing their research outcomes and kind support. I am grateful to Dr. P. Morgan Pattison for sparing his valuable time to write the "Foreword." Thanks are also due to Mr. Arjun Karmakar and Ms. Nirlipta Saha for their help in checking the cited references.

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Light Emitting Diodes for Agriculture

Smart Lighting

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