PLANT TISSUE CULTURE ENGINEERING

FOCUS ON BIOTECHNOLOGY

Volume 6

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FOREWORD

It is my privilege to contribute the foreword for this unique volume entitled: “Plant Tissue Culture Engineering,” edited by S. Dutta Gupta and Y. Ibaraki. While there have been a number of volumes published regarding the basic methods and applications of plant tissue and cell culture technologies, and even considerable attention provided to bioreactor design, relatively little attention has been afforded to the engineering principles that have emerged as critical contributions to the commercial applications of plant biotechnologies. This volume, “Plant Tissue Culture Engineering,” signals a turning point: the recognition that this specialized field of plant science must be integrated with engineering principles in order to develop efficient, cost effective, and large scale applications of these technologies.

I am most impressed with the organization of this volume, and the extensive list of chapters contributed by expert authors from around the world who are leading the emergence of this interdisciplinary enterprise. The editors are to be commended for their skilful crafting of this important volume. The first two parts provide the basic information that is relevant to the field as a whole, the following two parts elaborate on these principles, and the last part elaborates on specific technologies or applications.

Part 1 deals with machine vision, which comprises the fundamental engineering tools needed for automation and feedback controls. This section includes four chapters focusing on different applications of computerized image analysis used to monitor photosynthetic capacity of micropropagated plants, reporter gene expression, quality of micropropagated or regenerated plants and their sorting into classes, and quality of cell culture proliferation. Some readers might be surprised by the use of this topic area to lead off the volume, because many plant scientists may think of the image analysis tools as merely incidental components for the operation of the bioreactors. The editors properly focus this introductory section on the software that makes the real differences in hardware performance and which permits automation and efficiency.

As expected the larger section of the volume, Part 2 covers Bioreactor Technology-the hardware that supports the technology. This section includes eight chapters addressing various applications of bioreactors for micropropagation, bioproduction of proteins, and hairy root culture for production of medicinal compounds. Various engineering designs are discussed, along with their benefits for different applications, including airlift, thin-film, nutrient mist, temporary immersion, and wave bioreactors. These chapters include discussion of key bioprocess control points and how they are handled in various bioreactor designs, including issues of aeration, oxygen transport, nutrient transfer, shear stress, mass/energy balances, medium flow, light, etc.

Part 3 covers more specific issues related to Mechanized Micropropagation. The two chapters in this section address the economic considerations of automated micropropagation systems as related to different types of tissue proliferation, and the use of robotics to facilitate separation of propagules and reduce labour costs. Part 4, Engineering Cultural Environment, has six chapters elaborating on engineering issues related to closed systems, aeration, culture medium gel hardness, dissolved oxygen,

photoautotrophic micropropagation and temperature distribution inside the culture vessel.

The last part (Part 5) includes four chapters that discuss specific applications in Electrophysiology, Ultrasonics, and Cryogenics. Benefits have been found in the use of both electrostimulation and ultrasonics for manipulation of plant regeneration. Electrostimulation may be a useful tool for directing signal transduction within and between cells in culture. Ultrasound has also applications in monitoring tissue quality, such as state of hyperhydricity. Finally the application of engineering principles has improved techniques and hardware used for long-term cryopreservation of plant stock materials.

Readers of this volume will find a unique collection of chapters that will focus our attention on the interface of plant biotechnologies and engineering technologies. I look forward to the stimulation this volume will bring to our colleagues and to this emerging field of research and development!

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PREFACE

Plant tissue culture has now emerged as one of the major components of plant biotechnology. This field of experimental botany begins its journey with the concept of 'cellular totipotency' for demonstration of plant morphogenesis. Decades of research in plant tissue culture has passed through many challenges, created new dreams and resulted in landmark achievements. Considerable progress has been made with regard to the improvement of media formulations and techniques of cell, tissue, organ, and protoplast culture. Such advancement in cultural methodology led many recalcitrant plants amenable to *in vitro* regeneration and to the development of haploids, somatic hybrids and pathogen free plants. Tissue culture methods have also been employed to study the basic aspects of plant growth, metabolism, differentiation and morphogenesis and provide ideal opportunity to manipulate these processes.

Recent development of *in vitro* techniques has demonstrated its application in rapid clonal propagation, regeneration and multiplication of genetically manipulated superior clones, production of secondary metabolites and *ex-situ* conservation of valuable germplasms. This has been possible not only due to the refinements of cultural practices and applications of cutting-edge areas of molecular biology but also due to the judicious inclusion of engineering principles and methods to the system. In the present scenario, inclusion of engineering principles and methods has transformed the fundamental *in vitro* techniques into commercially viable technologies. Apart from the commercialization of plant tissue culture, engineering aspects have also made it possible to improve the regeneration of plants and techniques of cryopreservation. Strategies evolved utilize the disciplines of chemical, mechanical, electrical, cryogenics, and computer science and engineering.

In the years to come, the application of plant tissue culture for various biotechnological purposes will increasingly depend on the adoption of engineering principles and better understanding of their interacting factors with biological system. The present volume provides a cohesive presentation of the engineering principles and methods which have formed the keystones in practical applications of plant tissue culture, describes how application of engineering methods have led to major advances in commercial tissue culture as well as in understanding fundamentals of morphogenesis and cryopreservation, and focuses directions of future research, as we envisage them. We hope the volume will bridge the gap between conventional plant tissue culturists and engineers of various disciplines.

A diverse team of researchers, technologists and engineers describe in lucid manner how various engineering disciplines contribute to the improvement of plant tissue culture techniques and transform it to a technology. The volume includes twenty four chapters presenting the current status, state of the art, strength and weaknesses of the strategy applicable to the *in vitro* system covering the aspects of machine vision, bioreactor technology, mechanized micropropagation, engineering cultural environment and physical aspects of plant tissue engineering. The contributory chapters are written by international experts who are pioneers, and have made significant contributions to

this emerging interdisciplinary enterprise. We are indebted to the chapter contributors for their kind support and co-operation. Our deepest appreciation goes to Professor G.C. Phillips for sparing his valuable time for writing the Foreword. We are grateful to Professor Marcel Hofman, the series editor, 'Focus on Biotechnology' for his critical review and suggestions during the preparation of this volume.

Our thanks are also due to Dr. Rina Dutta Gupta for her efforts in checking the drafts and suggesting invaluable clarifications. We are also thankful to Mr. V.S.S. Prasad for his help during the preparation of camera ready version. Finally, many thanks to Springer for their keen interest in bringing out this volume in time with quality work.

S. Dutta Gupta
Y. Ibaraki
Kharagpur/Yamaguchi, January 2005

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