Molecular Plant Breeding

B.D. Singh & N.S. Shekhawat

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To

The Prehistoric Humans,

who domesticated diverse wild species

to generate all our present-day crops,

and thereby initiated the highly successful

discipline of plant breeding

Foreword

It is a great pleasure to write the Foreword for this new book titled *"Molecular Plant Breeding*" by Professors B D Singh and N S Shekhawat who earlier taught in the universities at Varanasi and Jodhpur, respectively.

At the outset, I must confess that I am not a plant breeder. But I have been a plant biologist with deep interest in molecular biology and molecular genetics. Many years ago, in 1960, at California Institute of Technology (Caltech) in Pasadena. Just after the demonstration of RNA synthesis in vitro using the animals and bacterial systems, I happened to achieve the first success in the plant world in demonstrating RNA polymerase activity in nuclear extracts of pea embryos and young seedlings. I should however, add that I immediately shifted my attention to RNA polymerase activity in chloroplasts and all later work on nuclei was carried forward by another colleague, Ruchih Huang, and my wife, late Nirmala Maheshwari, in the Bonner laboratories (Huang, R.C., N. Maheshwari, and J. Bonner, 1960. Enzymatic synthesis of RNA. Biochem. Biophys. Res. Commun. 3, 689-694 (1960); James Bonner, Ru-Chih C. Huang, and Nirmala Maheshwari, 1961. The Physical State of Newly Synthesized RNA. Proc. N.A.S.47 (10) 1548-1554/ PNAS 1961 47 (10) 1548-1554). However, my general interest has continued in molecular biology, and thus the present book is of great interest to me.

Upon my return to India, later in mid-sixties, another discovery, the development of haploid plants by culture of microspores in vitro, was made in our laboratory at Delhi University which attracted the attention of geneticists and plant breeders all over the world. Currently, haploidy has become a very valuable technique for obtaining homozygous lines and purelines. Since the exploitation of hybrid vigour, too, is dependent on crosses of homozygous parental lines, haploids have assumed great importance even for the development and commercial use of elite hybrids.

I have looked into the book with the perspective of a student and a general plant biologist. And I am very happy to state that I find this book extremely useful. I think the authors have done an excellent job in bringing together a vast amount of information in a very concise and readable form. Plant Breeding in recent years – in common with many other disciplines – is taking a molecular approach. The gene revolution has ushered in a new era of use of molecular

markers. The authors have adopted a very pragmatic plan of writing. The book has four parts. Very appropriately, the first part starts with an introduction to basics concepts of classical genetics. It is then that the reader is taken to Part B dealing with the subject of "*Transgenic Technology"* and later to the theme of "*Molecular Markers*" in Part C. Part B begins with an introduction to genetic engineering techniques and goes on to give a very up-to-date information on various achievements thus far made in developing new crop varieties. Likewise, in Part C, the authors have adopted a very useful comprehensive approach. There is first an overview of the essential procedures and techniques – RFLP, AFLP and like -- that should make it easy for a student to understand the current scene of marker-assisted plant breeding.

Finally, Part D introduces, among other things, the subject of Intellectual Property Rights. In my time, no one bothered about patents. But the scientific scene has already undergone a vast change and, although I am personally quite ignorant of the issues involved, I realize that students now must have some general understanding of this important topic. I think that the authors have managed to summarize these in a simple way.

I wish to congratulate both the authors for their efforts. A very useful feature of the book is the numerous tables, which enable a quick grasp of the subject and the progress made. I have no doubt that the book will be very useful to students all over. I recommend this volume to all libraries.

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Preface

The prehistoric humans domesticated a diverse group of wild plant species, which ultimately gave rise to our present-day crops. Domestication permitted the development of agriculture, which prompted the humans to shift from nomadic to settled life style, and allowed the evolution and refinement of culture and civilization. An inevitable consequence of these developments was the incessant increase in human population, which is over 7.2 billion at present and is expected to cross 9.0 billion by the year 2042. It has long been realized that the crop yields are considerably improved by selecting lines with desirable features for cultivation. In view of this, extensive systematic research activities were devoted to the development of improved crop varieties leading to the formulation of the various schemes and methods of plant breeding. The success of breeding programmes depends mainly on the genetic variation(s) available to the breeder, and the effectiveness of the selection procedures for the character being improved. The bulk of plant breeding research has been focussed on the development of methods to satisfactorily resolve the above two issues.

Plant breeding has been highly successful in evolving improved crop varieties to provide for the growing needs of the ever expanding human population. But the climatic changes associated with the global warming, and the unfavourable effects of the modern-day agricultural practices on the biotic and abiotic components of the agricultural environment are inevitably adversely affecting crop yields. Therefore, the plant breeders have the dual challenge of developing climate smart crop varieties endowed with higher yielding ability, and resistance to the emerging pathogens and insect pests within progressively shorter time spans than ever before. Thus, plant breeders need to be able to access the desired genes and use them in their breeding programmes, and to devise such breeding strategies that enable them to develop new varieties in as short a period as possible.

Plant breeders are always in search of useful genes that could be deployed in the crop varieties to create in them the desired phenotypes. This search has enabled them to utilize related wild species as donors of valuable traits to many

of our crops. But many useful genes remain inaccessible to the breeders due to sexual incompatibilities. The development of recombinant DNA technology provided an opportunity to transfer and express in plants genes from any source and, thereby, create plants with novel traits. The transgenic technology has been considerably refined and used to develop many crop varieties with useful novel traits; a large number of these varieties have been approved for commercialization and are in cultivation since 1996. The transgenic varieties possess such useful traits as disease and insect pest resistance, resistance to drought, improved produce quality, and even higher yields. It is projected that the transgenic technology will enable the development climate smart crop varieties by bringing together the necessary genes from various sources.

In spite of the reported all-round positive impact, including beneficial effects on the environment, the consumer acceptance if transgenic varieties has been, if anything, lukewarm. The researches directed at the use of DNA for unequivocal identification of human individuals had the pleasant and highly useful side-effect of the development of DNA-based molecular markers. DNA markers have found a variety of applications in the various disciplines of biology, of which perhaps the most notable is that in the field of plant breeding leading to the emergence of marker-assisted plant breeding. Markers have enabled reliable and efficient indirect selection for traits, mapping and selection for quantitative trait loci, and more particularly, selection for various traits at the seedling stage and in off-season crops/greenhouses. Thus, markers allow rapid advance of generations and, thereby, drastically reduce the time required for the development of new crop varieties. Most commercial and many national breeding programmes are using the marker technology to achieve a variety of objectives.

Plant breeding has freely and gainfully utilized the developments in the other disciplines of biology to enrich its arsenal to enhance its capability the development of crop varieties designed to meet the changing requirements of agricultural production systems. The transgenic and marker technologies have emerged as extremely powerful tools for modification of crop genotypes. As a result, these technologies are progressively being integrated into breeding programmes. As a result, a modern plant breeder needs to be adequately familiar with the transgenic and marker technologies.

The book *Molecular Plant Breeding* is designed to provide a combined overview of plant breeding tools and techniques along with those of transgenic and marker technologies, each presented in a separate section of the book. This book is intended for graduate students offering an introductory course in plant breeding, and for those pursuing M.Sc. programmes in botany. It would also be useful for the students appearing in various competitive examinations. We have given special attention to keep the text simple and easy-to-understand and enjoyable, but at the same time comprehensive and detailed. Therefore, we made enormous efforts to make the content of this book as pleasant as possible for broad range of readers.

The authors are appreciative of the sincere efforts by Mr. Tanay Sharma and his production team, including the reviewers, editors and the graphics designers, of Scientific Publishers, Jodhpur. The authors like to extend their thanks to all the team for their commendable efforts, as a result of which the book has been brought out speedily in an excellent published form.

With this edition, we aim to serve a wide range of readers' groups with the intention of contributing towards technological advancement in molecular plant breeding. In the end, we would like to express our heartfelt appreciation for our family members, whose affectionate support gave us the courage to undertake this project and the energy to successfully complete the same.

B.D. Singh
N.S. Shekhawat

May 15, 2017
Varanasi, Jodhpur

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