# Advanced Concepts in Plant Genetics and Breeding Science

# Advanced Concepts in Plant Genetics and Breeding Science

**Dr. Prabha Banjarey**
Guest Teacher, Genetics and Plant Breeding
Indira Gandhi Krishi Vishwa Vidyalaya, Raipur, C.G.

**Dr. Ajit Kumar Mannade**
Assistant Professor, Plant Molecular Biology and Biotechnology
Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G.

**Dr. Ishu Kumar Khute**
Subject Matter Specialist, Genetics & Plant Breeding
Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G.

**Dr. Rohit**
Guest Teacher, Genetics and Plant Breeding
College of Horticulture and Research Station, Hathani
Bilaspur, MGUVV, Durg

VITAL BIOTECH PUBLICATION

Kota, Rajasthan, India
http://www.vitalbiotech.org/bookpublication/

An International Publishers

VITAL BIOTECH get Accredited by following International organization

https://www.portico.org/publishers/vital/
101 Greenwich Street, 18th Floor
New York, NY 10006

**Copyright © 2026 VITAL BIOTECH PUBLICATION**

Published by Vital Biotech Publication
First Edition: 2026

---

**All Rights Reserved**

No part of this book may be reproduced in any form, by photostat, microfilm, xerography, or any other means, or incorporated into any information retrieval system, electronic or mechanical, without the written permission of the publisher.

**Product Form:**

Digital download, online and hard bound

**Edition:**

**ISBN:** 978-93-48793-65-2

**Head, Production (Higher Education and Professional) & Publishing Director**

Dr. Jitendra Mehta

**Product Manager**

Aman Saxena

**General Manager**

Jaya Mehta

**Graphic Designer**

Kritika Lohomi

Information contained in this work has been obtained by Vital Biotech Publication (India), from sources believed to be reliable. However, neither Vital Biotech Publication (India) nor its authors guarantee the accuracy or completeness of any information published herein, and neither Vital Biotech Publication (India) nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that Vital Biotech Publication (India) and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be required.

Office Address:

**VITAL BIOTECH PUBLICATION**

772, Basant Vihar, Kota,
Rajasthan-324009 India
Visit us at: http://www.vitalbiotech.org
Contact No. +91-9784677044
Printed at: Vital Biotech Publication, Kota

# Preface

Plant genetics and breeding have played a central role in the development of agriculture and the improvement of crop productivity throughout human history. In the twenty-first century, rapid advances in molecular biology, genomics, bioinformatics, and biotechnology have transformed traditional breeding approaches into highly precise and efficient scientific disciplines. The integration of classical genetics with modern breeding technologies has opened new avenues for developing crop varieties with improved yield, quality, nutritional value, and resilience to biotic and abiotic stresses.

*Advanced Concepts in Plant Genetics and Breeding Science* is designed to provide a comprehensive understanding of the principles, methodologies, and emerging technologies that underpin contemporary crop improvement programs. The subject encompasses a wide range of topics, including Mendelian and quantitative genetics, molecular markers, genetic mapping, genomic selection, heterosis, hybrid breeding, mutation breeding, plant tissue culture, transgenic technologies, and genome editing tools such as CRISPR/Cas systems.

The growing challenges of global food security, climate change, shrinking agricultural resources, and evolving pest and disease pressures demand innovative and sustainable breeding strategies. Modern genetic and genomic tools enable breeders to identify, characterize, and manipulate genes associated with economically important traits with unprecedented accuracy and speed.

This book is intended for undergraduate and postgraduate students, researchers, plant breeders, and professionals in agricultural sciences. It is hoped that this text will serve as a valuable resource for enhancing knowledge, fostering innovation, and supporting future advances in plant genetics and breeding science.

**Dr. Prabha Banjarey**
**Dr. Ajit Kumar Mannade**
**Dr. Ishu Kumar Khute**
**Dr. Rohit**

**Dated – 25 Feb., 2026**

# CONTENTS


| S. NO. | | PAGE NO. |
|---|---|---|
| 1. | **Fundamentals of Plant Genetics and Breeding Science**<br>*Prabha Banjarey* | **1-14** |
| 2. | **Plant Genome Organization and Gene Expression**<br>*Ajit Kumar Mannade* | **15-26** |
| 3. | **Classical and Molecular Approaches to Plant Breeding**<br>*Ishu Kumar Khute* | **27-38** |
| 4. | **Cytogenetics and Chromosome Engineering in Crop Improvement**<br>*Rohit* | **39-50** |
| 5. | **Quantitative Genetics and Biometrical Techniques in Plant Breeding**<br>*Prabha Banjarey, Ajit Kumar Mannade, Ishu Kumar Khute, Rohit* | **51-62** |
| 6. | **Molecular Markers and Marker-Assisted Plant Breeding**<br>*Rahul Prajapati, J H Kahodariya, Aditi Singh, Naval Kishore Meena* | **63-74** |
| 7. | **Genomic Selection and Precision Breeding Strategies**<br>*S MD Basid Ali, Farzana Ahmad, Naval Kishore Meena* | **75-88** |
| 8. | **Genetic Engineering and Genome Editing in Crop Plants**<br>*Rahul Prajapati, Seema Mahlawat, Naval Kishore Meena* | **89-100** |
| 9. | **Epigenetics and Functional Genomics in Plant Improvement**<br>*J H Kahodariya, V. Madan Mohan Rao, V. Kavitha, P. Navya, T. Apurupa* | **101-112** |

| | | |
|---|---|---|
| **10.** | **Hybrid Breeding and Heterosis Exploitation in Crops**<br>*Deepak Panwar, Aditi Singh, Naval Kishore Meena* | **113-124** |
| **11.** | **Breeding for Biotic and Abiotic Stress Resistance**<br>*Prabha Banjarey* | **125-138** |
| **12.** | **Seed Science, Variety Development and Intellectual Property Rights**<br>*Ajit Kumar Mannade* | **139-150** |
| **13.** | **Bioinformatics and Artificial Intelligence in Modern Plant Breeding**<br>*Ishu Kumar Khute* | **151-160** |
| **14.** | **Climate-Resilient Crop Breeding for Sustainable Agriculture**<br>*Rohit* | **161-172** |
| **15.** | **CRISPR-Based Crop Improvement: Opportunities Challenges and Future Prospects**<br>*Muthe Santosh Tukaram, Priyansh Rahangdale, Jadala Supraja Jaya Sharma, Rajesh Pawar* | **173-186** |
| **16.** | **Climate Next-Generation Plant Breeding and Biotechnology: Genome Editing Genomics and AI for Climate-Resilient Crops**<br>*Eshwar, Muthe Santosh Tukaram, Sujaya Dewanjee Nilima Karmakar, Arijit Mukherjee* | **187-200** |
| **17.** | **Heterosis Breeding: Principles Advances and Future Prospects**<br>*Eshwar, Muthe Santosh Tukaram, Anushka Kuntal Priyanshi Joshi* | **201-212** |
| **18.** | **Molecular Characterization of Garden Cress Genotypes Based on Agronomic and Seed-Quality Traits**<br>*Raviraj Naresh Udasi, Bharath S S, Varshitha C, Pratiksha Raj Biju Sidharthan* | **213-224** |
| **19.** | **QTG-seq: A Paradigm Shift in Quantitative Trait Gene Discovery and QTL Fine Mapping**<br>*Vijeth G M, B Surender, Swapnil Dwivedi, Pankaj Kumar Bibhuti Bhusan Barik* | **225-238** |

**20. Precision Plant Breeding: Integrating Genome Editing with Artificial Intelligence** 239-250
*Ruth Elizabeth Ekka, Bibhuti Bhusan Barik, Basamma Komal Sahu, Rukhsar*

**21. Multi-Omics Approaches in Plant Breeding: Integrating Genomics, Transcriptomics and Metabolomics** 251-264
*Anushka Kuntal, Bibhuti Bhusan Barik Janaki Venkata Yashwanth, Varshitha C, Vikas Taya*