

## Chapter 2

### **Genomic Designing for Climate-Smart Tomato**

#### 2.1 Introduction

#### **2.2 Challenges, Priorities, and Breeding Objectives**

##### 2.2.1 Productivity

##### 2.2.2 Fruit Quality

###### 2.2.2.1 Nutritional Quality

###### 2.2.2.2 Sensory Quality

###### 2.2.2.3 Mild Stress as a Tool to Manage Quality

##### 2.2.3 Biotic and Abiotic Stresses

###### 2.2.3.1 Biotic Stresses

(Pests and Pathogens of Tomatoes, Impact of Climate Change on Pest and Pathogen Resistance, New Emerging Tomato Diseases)

###### 2.2.3.2 Abiotic Stresses

(Water Deficit, Salinity Stress, Temperature Stress (High-temperature stress and Chilling and cold stress), Mineral Nutrition Deficiency (Nitrogen, Phosphorus, Potassium, Calcium))

###### 2.2.3.3 Stress Combination

#### **2.3 Genetic and Genomic Resources for Trait Breeding**

##### 2.3.1 Genetic Resources

###### 2.3.1.1 Origin of Tomato and Its Wild Relatives

###### 2.3.1.2 Genetic Resources as Sources for Adaptation

###### 2.3.1.3 Natural and Induced Mutants

##### 2.3.2 Molecular Markers and Gene/QTL Mapping

###### 2.3.2.1 Evolution of Molecular Markers

###### 2.3.2.2 Trait Mapping

###### 2.3.2.3 Specific Populations to Dissect Phenotypes

###### 2.3.2.4 Genes and QTLs (quantitative trait loci) Controlling Tomato Disease Resistance

(Resistance Gene and QTL Discovery, Resistance Gene and QTL Architecture, Molecular Basis of Resistance Genes and QTLs)

##### 2.3.3 Genomic Resources

###### 2.3.3.1 The Reference Genome Sequence

###### 2.3.3.2 Resequencing Tomato Accessions

##### 2.3.4 SNP (Single nucleotide polymorphisms) Markers

###### 2.3.4.1 SNP Discovery

###### 2.3.4.2 SNP Arrays

###### 2.3.4.3 Genotype Imputation

##### 2.3.5 Diversity Analyses

##### 2.3.6 Cloned Genes/QTLs

##### 2.3.7 New Resources for Gene/QTL Identification

##### 2.3.8 Genome-Wide Association Studies

###### 2.3.8.1 The Conditions for Applying Genome-Wide Association Studies

###### 2.3.8.2 Meta-Analysis

##### 2.3.9 Genetic Dissection of Abiotic Stress Tolerance

###### 2.3.9.1 Genetic Control of GxE Interaction

###### 2.3.9.2 Grafting as a Defense Against Stresses

##### 2.3.10 Omic Approaches

- 2.3.10.1 Metabolome Analyses
- 2.3.10.2 Transcriptome Analyses for EQTL Mapping
- 2.3.10.3 Multi-omic Approach
- 2.3.10.4 MiRNA and Epigenetic Modifications
- 2.3.11 Databases

## **2.4 Breeding for Smart Tomato**

- 2.4.1 Traditional Breeding
- 2.4.2 Marker-Assisted Selection
  - 2.4.2.1 Marker-Assisted Backcross for Monogenic Traits
  - 2.4.2.2 Marker-Assisted Selection for QTLs
  - 2.4.2.3 Advanced Backcross for the Simultaneous Discovery and Transfer of New Alleles
  - 2.4.2.4 Pyramidal Design
  - 2.4.2.5 Breeding for Resistance to Pests and Pathogens
- 2.4.3 Genomic Selection

## **2.5 Designing Ideotypes by Ecophysiological Modeling**

- 2.5.1 What Is an Ideotype?
- 2.5.2 Current Process-Based Models of Tomato for the Prediction of GxExM Interactions
- 2.5.3 Process-Based Models Design of Tomato Ideotypes
- 2.5.4 Prospects on the Use of Model-Based Plant Design

## **2.6 Biotechnology and Genetic Engineering**

- 2.6.1 A Brief History of Genetic Engineering in Tomato
- 2.6.2 Toolkit for Genetic Engineering Tomato
  - 2.6.2.1 Gene Silencing and Homologous/Heterologous Expression
  - 2.6.2.2 Genome Editing
  - 2.6.2.3 Comprehensive Genomic Engineering on Tomato
- 2.6.3 Genetic Engineering for Improving Pest and Pathogen Resistance
- 2.6.4 Regulatory Status of Gene Edited Plants

## **2.7 Conclusion and Prospects**

References