Chapter 50
Molecular Markers

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ABSTRACT

Conventionally, establishment of relationship between the genotype and phenotype through genetic analysis was considered as key to success in plant breeding. The discovery of molecular markers has changed the entire scenario of genome analysis. Coinheritance of a gene of interest and a marker suggests that they are physically close on the chromosome. A marker must be polymorphic in nature for their identification and utilization. Such polymorphism can be detected at three levels: phenotype (morphological), difference in biomolecules (biochemical), or differences in the nucleotide sequence of DNA (molecular). These markers act as a versatile tool and find their importance in taxonomy, plant breeding, gene mapping, cultivar identification, and forensic science. They have several advantages over the conventional methods of plant breeding for developing new varieties with higher rate of success. This chapter covers the basic principles and applications of various types of markers with special emphasis on molecular markers.

INTRODUCTION

Genes and their alleles have been used as genetic markers on the basis of their phenotypic expressions. Information about their inheritance pattern, linkage and segregation during their movement from generation to generation, and their exact location on chromosomes is essential in order to carry out genetic studies. Conventionally, all this is done by evaluating the relationship between genotype and governed phenotype. Such types of markers are called morphological marker or phenotypic marker. Later, the discovery of biochemical and molecular markers has changed the entire scenario of genome analysis and has supplemented the existing knowledge of genetics. In the classical genetics, location of a gene in the chromosome and its inheritance pattern can be studied through linkage analysis. In molecular genetics, clues to the location of a gene can come from comparing the inheritance of a gene with the inheritance of a molecular marker. Coinheritance or genetic linkage of a gene of interest and a molecular marker suggests that they are physically close together on the chromosome. However, the molecular marker must be polymorphic in nature, meaning thereby that it must be found in variable forms so that

DOI: 10.4018/979-8-3693-3026-5.ch050

chromosome with the mutant gene can be distinguished from the chromosome with normal gene through marker which it carries. This polymorphic nature of marker can be analyzed at three levels: phenotype (morphological), differences in biomolecules (biochemical) or differences in the nucleotide sequence of DNA (molecular). These markers act as a versatile tool and find their own importance in various fields like taxonomy, plant breeding, gene mapping, genome and cultivar identification, forensic science etc. They have several advantages over conventional methods and assist to reduce the overall time span of developing new varieties with higher rate of success.

CLASSICAL MARKERS

During early history of plant breeding, only visible markers were used as selectable markers. They may be classified as morphological markers and cytological markers.

Morphological markers

The morphological features or phenotypes which are governed by genes are considered as morphological markers or phenotypic markers. They are generally qualitative traits like color of the flower, albinism, and altered leaf morphology that can be scored visually. Morphological markers are usually dominant or recessive. Most of the identified morphological markers are alleles of the wild type phenotypes which have accumulated in the population through mutations. Since the rate of spontaneous mutation is slow, number of such mutations found in natural population is also low. The problem is more acute in the case of forestry species and animal systems (Avise, 1994, Grover & Sharma, 2016).

Further, most of the quantitative characters are governed by polygenes, each contributing a small portion. Therefore, they are difficult to identify. Therefore, the genes controlling quantitative traits cannot be used as morphological markers. Availability of good number of genetic marker is the key to success for any plant or animal improvement program. Discovery of biochemical and molecular markers have been able to solve this problem to a large extent.

Cytological markers

Karyotypes and banding patterns of the chromosomes can be used as cytological markers. The physical structure of the chromosomes observed at the metaphase stage of mitosis has been used to construct the karyotypes of the organisms. The banding patters of the chromosomes derived through e.g. G-banding, Q-banding, R-banding etc. can also be used as markers. The color, width, order and position of the bands can be considered as important features of the markers. Different landmarks of the chromosomes are used for characterization and detection of chromosome mutation, linkage group identification and physical mapping. The physical maps developed through cytological and morphological markers are used for construction of linkage maps. However, in plant breeding cytological markers have limited use (Avise, 1994, Grover & Sharma, 2016).

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