DNA Markers

Definition of DNA Markers:

Those characters which can be easily identified are called marker characters. Any genetic element (locus, allele, DNA sequence or chromosome feature) which can be readily detected by phenotype, cytological or molecular techniques, and used to follow a chromosome or chromosomal segment during genetic analysis is referred to as marker.

Markers related to variations in DNA fragments generated by restriction endonuclease enzymes are called DNA markers or genetic markers.

Some other definitions of DNA markers are given below:

i. Any unique DNA sequence which can be used in DNA hybridization, PCR or restriction mapping experiments to identify that sequence is called DNA marker.

ii. A gene or DNA sequence having a known location on a chromosome and associated with a particular gene or trait refers to DNA marker.

Markers are of four types, viz:

(i) Morphological,

(ii) Biochemical,

(iii) Cytological, and

(iv) DNA markers.

These are briefly discussed as follows:

i. Morphological:

In plant breeding, markers that are related to variation in shape, size, colour and surface of various plant parts are called morphological markers. Such markers refer to available gene loci that have obvious impact on morphology of plant. Genes that affect form, coloration, male sterility or resistance among others have been analyzed in many plant species.

In rice, examples of this type of marker may include the presence or absence of awn, leaf sheath coloration, height, grain color, aroma etc. In well-characterized crops like maize, tomato, pea, barley or wheat, tens or even hundreds of such genes have been assigned to different chromosomes.

There are several demerits of morphological markers as given below:

a. They generally express late into the development of an organism. Hence their detection is dependent on the development stage of the organism.

b. They usually exhibit dominance.

c. Sometimes they exhibit deleterious effects.

d. They exhibit pleiotropy.

e. They exhibit epistasis.

f. They exhibit less polymorphism.

g. They are highly influenced by the environmental factors.

ii. Biochemical:

Markers that are related to variation in proteins and amino acid banding pattern are known as biochemical markers. A gene encodes a protein that can be extracted and observed; for example, isozymes and storage proteins.

iii. Cytological:

Markers that are related to variation in chromosome number, shape, size and banding pattern are referred to as cytological markers. In other words, it refers to the chromosomal banding produced by different stains; for example, G banding.

iv. DNA Markers:

A gene or other fragment of DNA whose location in the genome is known is called DNA marker. It is a unique (DNA sequence), occurring in proximity to the gene or locus of interest. It refers to any unique DNA sequence which can be used in DNA hybridization, PCR or restriction mapping experiments to identify that sequence.

It can be identified by a range of molecular techniques such as RFLPs, RAPDs, AFLP, SNPs, SCARs, microsatellites etc.

DNA markers are also known as molecular markers or genetic markers. To overcome problems associated with morphological markers, the DNA-based markers have been developed. Advantages of DNA markers are presented below.

a. They are highly polymorphic.

b. They have simple inheritance (often co-dominant).

c. They abundantly occur throughout the genome.

d. They are easy and fast to detect.

e. They exhibit minimum pleiotropic effect.

Their detection is not dependent on the developmental stage of the organism.

TABLE 18.1. Comparison of Morphological Markers and DNA Markers

S.No.	*Particulars*	*Morphological Markers*	*DNA Markers*
1.	Nature	Dominant	Co-dominant
2.	Polymorphism	Low	High
3.	Occurrence	Low	Abundant
4.	Detection	Easy	Easy
5.	Pleiotropic effect	High	Minimum
6.	Epistasis	Present	Absent
7.	Environmental effect	High	No effect

Properties of DNA Marker:

An ideal DNA marker should have some properties or characteristics.

Important properties of an ideal DNA marker are presented below:

i. Polymorphism:

Markers should exhibit high level of polymorphism. In other words, there should be variability in the markers. It should demonstrate measurable differences in expression between trait types and/or gene of interest.

ii. Co-Dominant:

Marker should be co-dominant. It means, there should be absence of intra-locus interaction. It helps in identification of heterozygotes from homozygotes.

iii. Multi-Allelic:

The marker should be multi-allelic. It useful in getting more variability/ polymorphism for a character.

iv. No Epistasis:

There should be absence of epistasis. It makes Identification of all phenotypes (homo- and heterozygotes) easy.

v. Neutral:

The marker should be neutral. The substitution of alleles at the marker locus should not alter the phenotype of an individual. This property is found in almost all the DNA markers.

vi. No Effect of Environment:

Markers should be insensitive to environment. This property is also found in almost all the DNA markers.

Applications of DNA Marker in Crop Improvement:

DNA markers have several useful applications in crop improvement.

The important applications are listed as follows:

i. DNA markers are useful in the assessment of genetic diversity in germplasm, cultivars and advanced breeding material.

ii. DNA markers can be used for constructing genetic linkage maps.

iii. DNA markers are useful in identification of new useful alleles in the germplasm and wild species of crop plants.

iv. DNA markers are used in the marker assisted or marker aided selection. MAS has several advantages over straight selection.

v. DNA markers are useful in the study of crop evolution.