



The Role of Molecular Markers in Improvement of Fruit Crops

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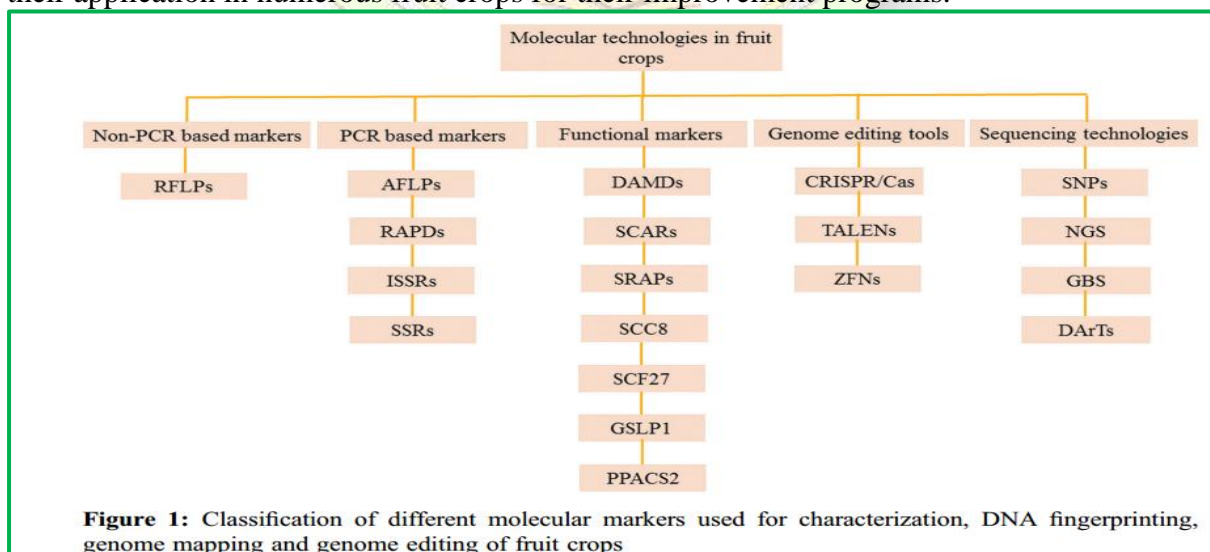
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The markers have been used over the years for the classification of plants. Markers are any trait of an organism that can be identified with confidence and relative ease, and can be followed in a mapping population with other words, they can be defined as heritable entities associated with the economically important trait under the control of polygenes (Beckman and Soller, 1986). Morphological markers can be detected with naked eye (naked eye polymorphism) or as difference in physical or chemical properties of the macromolecules. Therefore, there are two types of genetic markers, respectively: morphological markers or naked eye polymorphism and non-morphological markers or molecular markers. Molecular markers should have the following ideal properties, i.e., must be simple, inexpensive, polymorphic, with co-dominant inheritance, provide adequate resolution of genetic variations, easy to access, frequent occurrence in genome, require little amounts of DNA sample, have relationship with diverse phenotypes and easy exchange of data among laboratories Unfortunately, molecular markers technique may differ in every situation and their application depends on work purpose. Molecular markers vary from each other due to following features, i.e., genomic richness, detection level of polymorphism, specificity of locus, reproducibility and costs assay It is not easy to find a molecular technique which can fulfill all above requirements. However, techniques can be modified according to purpose of study which is undertaken. In this study, importance of molecular markers has been reviewed for genetic improvement programs in fruit crops. Present study is divided into two parts, first part is about brief description of available molecular markers, while second part includes their application in numerous fruit crops for their improvement programs.



Morphological markers: Morphological markers are those traits that are scored visually, or morphological markers are those genetic markers whose inheritance can be followed with the naked eye. The traits included in this group are plant height, disease response, photoperiod, sensitivity, shape or color of flowers, fruits or seeds etc. Although they are generally scored quickly, simply and without laboratory equipments, such markers are not put too much use. because of the following reasons: genotypes can be ascertained generally at whole plant or plant organ level and frequently the mature plant is used. Such markers frequently cause major alternations in the phenotype which is undesirable in breeding programs. Dominant, recessive interactions frequently prevent distinguishing all genotypes associated with morphological traits. Morphological markers mask the effect of linked minor gene, making it nearly impossible to identify desirable linkages for select and are limited in number, influenced by environment and also specific stage of the analysis.

Non-morphological markers or molecular markers: Until recently virtually all progress in both breeding and modern genetics have relied on the phenotypic or morphological assay. But with the advent of molecular markers a new generation of markers was introduced over the last two decades that have become an important tool in the genetic improvement of crop species and has changed the entire scenario of biological sciences. Molecular markers are any kind of molecule indicating the existence of a chemical or a physical process. Molecular markers include biochemical constituents (e.g. secondary metabolites in plants) and macromolecules (e.g. proteins and deoxyribonucleic acid) (Joshi et al., 1999).

Biochemical molecular markers: The first biochemical molecular markers used were the protein based markers. Proteins are attractive for direct genetic study because they are the primary products of structural genes. Changes in coding base sequence will under many circumstances, resulting in corresponding changes in the primary structure of proteins. Even single amino acid substitutions, deletions or additions can have marked effects on the migration of proteins under an electric field during electrophoresis. One of the earliest protein based markers to be used was Isozyme. Market and Moller (1959) coined the term to describe the multiple molecular forms of the same enzyme with the same substrate specificity. Isozymes are different forms of an enzyme exhibiting the same catalytic activity but differing in charge and electrophoretic mobility. In Isozyme analysis, crude plant extracts are subjected to electrophoresis using starch or polyacrylamide gels. Following electrophoresis, the enzymes of interest are detected by treating the gels with specific activity stains.

Properties desirable for ideal DNA Markers: Highly polymorphic in nature; codominant expression; selectively neutral behaviour; easy access and assay; easy exchange of data between laboratories; follow Mendelian inheritance; genetically linked to trait in question.; not affected by pleiotropism and epistatic interactions The different molecular marker technologies that are available today can be classified into two broad categories: based on molecular hybridisation and based on Polymerase Chain Reaction (DNA amplification).

Applications of Molecular Markers in Fruit Crops: Molecular markers play an important role in breeding programs, i.e., finding diverse parents, increasing selection of elite alleles at loci governing important characters, germplasm characterization, and intellectual property defences. The major objective of breeding program is improvements in development of new commercial and high yielding cultivars; marker-locus-trait combinations may possibly be used as selection criteria for diverse parent selection and selection in segregating populations during commercialization. These combinations are not only biologically and technically important but also more helpful for excellent cultivar performance in important target markets to fetch higher prices. Marker assisted breeding is more helpful in horticultural crops by utilization of model plants in related crop species through adoption of numerous breeding methods such as backcrossing as well as genomic selection known as novel techniques. When important breeding programs attain proper attention, then their efficiency can be improved

and costs can also be reduced by implementing of marker-assisted breeding. Advent of different markers played a vital role in MAS for efficient as well as rapid studies of germplasm including trait mapping. Molecular markers may increase our understanding regarding phenotypic characterization as well as their genetic relationship that can be utilized in further breeding strategies. MAS is more efficient and useful for breeders to attain early selection of a trait. When the trait is under complex genetic control, or when phenotypic traits are unreliable, MAS has significant use to resolve such issues.

Sub-tropical and Tropical fruits:

By using Quantitative trait loci (QTL) analysis: The genetic relationships between microsatellite markers and domesticated avocado cultivars (*Persea americana* Mill.). Genetic relationships amongst various avocado cultivars, providing vital information for breeding initiatives and genetic resource preservation. The history of avocado cultivars, which supports deliberate breeding efforts to preserve genetic diversity [4]. Citrus reticulata Blanco, Citrus sinensis L., and Citrus sinensis Osbeck as a collective were subjected to quantitative trait loci (QTL) analysis to test for citrus leprosis resistance. This interspecific hybrid citrus family has been shown to contain genetic regions associated with resistance to leprosis. The genetic mechanisms responsible for disease resistance in citrus breeding. Microsatellite markers and morphology in a polymorphic evaluation of mango (*Mangifera indica* L.) genetic diversity. The morphological and microsatellite marker-based methods assess the degree of genetic diversity and relationships amongst mango cultivars. A thorough comprehension of the diversity of mango germplasm was generated through the amalgamation of morphological characteristics and molecular markers. The Citrus tristeza virus (CTV) displayed unique patterns of gene expression using in silico hybridization and EST research. The study used EST analysis and silico hybridization to investigate changes in gene expression, which provided insight into the molecular responses of citrus plants to viral infections, particularly CTV.

Using (RAPD) Randomly Amplified Polymorphic DNA marker: Mandarin hybrids have RAPD fragments connected to an anti-*Alternaria* gene. Disease-resistant Mandarin hybrids were found to have RAPD fragments associated with a gene linked to *Alternaria* resistance. This contributes to the development of resistant cultivars by providing citrus cultivars with the genetic foundation for disease resistance. Lemon used RAPD markers mutations were found both in vivo and in-vitro. Lemon mutants were created both in controlled and open condition using (RAPD) markers. Molecular marker usefulness in identifying genetic changes and mutation among different lemon cultivar. RAPD marker aid in the recognition of *Mangifera indica* L. cultivar and the verification of genetic connections. The usefulness of molecular markers in this situation is demonstrated by their capacity to distinguish between various mango varieties and verify their genetic relationships.

Analysis of fruit crops for genetical diversity by using RFLP marker: Agricultural species exhibit both restriction fragment length polymorphism (RFLP) and genetic development. The idea of utilizing RFLP analysis for genetic enhancement in agricultural species was first presented by this work. The role of RFLP marker in selection support, genetic diversity, and plant breeding. Genetic markers' function in improving fruit crops. Molecular markers: their usefulness in improving fruit crops. It illustrated how diverse molecular markers, breeding techniques by enabling effective gene mapping and diversity analysis, such as RAPD and SSR markers, and selection. Utilizing molecular marker technology for plant genome analysis. The role of molecular markers in plant. It includes a number of marker strategies and how they can be used to map genes, identify genes, and comprehend genetic diversity in plant genomes. The prospects and obstacles for molecular breeding and analysis of the challenges and possibilities of molecular breeding. Tools' potential to boost crop yields and support sustainable agriculture in resource-poor areas.

Analysis of fruit crops for Genetical diversity by using (RAPD) and (ISSR) marker: Both molecular genetics and biochemical markers are used in forest tree biosystematics research. Understanding the evolutionary divergence and adaptation of distinct tree species can be aided by these genetic markers. Using RAPD and ISSR markers, assessment of genetic diversity of cashew germplasm is done. Analysis of genetic diversity of cashew germplasm by the use of RAPD and ISSR markers for better interpretation of the genetic variability found in cashew cultivars. Repetitive DNA sequences found in grapevines can be used to distinguish between cultivars and classes. Cultivar differentiation is made possible by the repetitive DNA of grapevines. By analyzing these sequences, the study improves the accuracy of grapevine cultivar identification, thereby advancing grape breeding and research.

Nuts

Utilizing AFLP and RAPID markers for analysis: Randomly-amplified polymorphic DNA (RAPD) was used to analyze California almond cultivars along with breeding lines in order to determine genetic and relatedness traits. Using RAPD profiling, California almond cultivars and lineages for breeding have genetically characterized. The usefulness of RAPD markers for assessing genetic relatedness and diversity in almond genetic material, which supports almond breeding techniques. The 408.040 at OSU AFLP markers from hazelnuts are linked to protection against the eastern filbert blight. In this work, marker linked to hazelnut resistance to the blight in the east were identified using AFLP markers. The identification of resistant genotypes, which has implications for the breeding of hazelnuts. Microsatellite marker analysis of *Pistacia vera* L. nuts. To use micro-satellite markers to identify pistachio nuts. Pistachio cultivar authentication through genetic markers is essential for business and quality control.

Temperate fruit crops

Examination using RAPD marker and AFLP marker: Using the method of AFLP and micro-satellite markers, genic variation analysis was conducted on the critically endangered Belgian wild apple (*Malus sylvestris* L. Mill.). AFLP and microsatellite markers are used to study genetic diversity in the critically endangered wild apple species. The diversity of genes and population dynamics of wild apples aided conservation efforts. RAPD markers are used for apple cultivar identification and analysis. RAPD markers were used in this work to identify apple varieties. The molecular markers can be used practically to differentiate between apple types, supporting varietal authentication and quality management. Rootstock cultivars of peaches are identified using the RAPD-DNA marker. The peach rootstock varieties and used RAPD-DNA marker to identify the subjects. The utilization of molecular markers to differentiate and describe several peach rootstock variants.

Conclusion

Recent improvements have decreased the cost of different sequencing techniques while increasing their throughput analyses. The goals set in this area have not been fully met yet and the discovery of highly appropriate and more efficient markers system is still needed. The current study encompasses the applications of numerous markers' systems used to assess genetic diversity on DNA basis in fruit crops. Molecular markers are able to enhance the effectiveness of breeding new and adapted cultivars in terms of time and cost. Generally, all molecular markers reveal useful information on DNA polymorphism and are used to describe in depth the plants' genetic make-up. Fruit breeding requires more time compared to other crops due to long juvenile phase, high level of heterozygosity and self-incompatibility between cultivars. Conclusively, MAS plays a significant role in the construction of high-density molecular marker maps of fruit crops using RFLPs, RAPDs, SSRs, ISSRs, SNPs, SCARs, In-Del, RAMPs, SSCPs and DArT resulting from sequencing technologies.

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