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Commentary

# Enhancing Crop Yield and Quality through Molecular Breeding

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## DESCRIPTION

Molecular breeding of crops is a technique that uses molecular biology tools to improve the traits of interest in plants, such as yield and quality. Molecular breeding can be defined as the application of genetic manipulation performed at the level of DNA (Deoxyribonucleic Acid) to alter and enhance plant characteristics.

### Steps involved in molecular breeding

**Genotyping and creating molecular maps:** This step involves identifying and analyzing the genetic variation among different plant genotypes using molecular markers, such as Simple Sequence Repeats (SSRs), Single Nucleotide Polymorphisms (SNPs), or Genotyping by Sequencing (GBS). Molecular markers are DNA sequences that are associated with specific genes or traits. Molecular maps are graphical representations of the relative positions and distances of molecular markers on the chromosomes.

**Phenotyping and phenomics:** This step involves measuring and recording the trait values of different plant genotypes under various environmental conditions. Phenotyping is the process of observing and quantifying the physical and biochemical characteristics of plants, such as height, yield, quality, or stress tolerance. Phonemics is the comprehensive analysis of phenotypes using high-throughput technologies, such as imaging, spectroscopy, or sensors.

**QTL mapping or association mapping:** This step involves identifying and locating the genes or Quantitative Trait Loci (QTLs) that control the traits of interest in plants. QTLs are regions of DNA that influence the expression of quantitative traits, such as yield or quality, which are affected by multiple genes and environmental factors. QTL mapping or association mapping is the statistical analysis of the correlation between molecular markers and phenotypic traits in a population of plants.

**Marker-assisted selection or genomic selection:** This step involves using molecular markers or QTLs to select the best plant genotypes for breeding purposes. Marker Assisted selection (MAS) is the process of selecting plants based on their marker genotypes that are linked to desirable traits. Genomic Selection (GS) is the process of selecting plants based on their Genomic Estimated Breeding Values (GEBVs) that are predicted from their whole-genome marker data.

### Advantages of molecular breeding of crops for improved yield and quality

**Target specificity:** Molecular breeding can target specific genes or QTLs that affect yield and quality without altering other traits or genetic background.

**Efficiency and accuracy:** Molecular breeding can reduce the time and cost of conventional breeding by eliminating undesirable genotypes at early stages and increasing the selection intensity and accuracy.

**Novelty and diversity:** Molecular breeding can introduce novel genes or QTLs from different sources, such as wild relatives, landraces, or transgenes, to create new varieties with improved yield and quality.

**Sustainability and adaptability:** Molecular breeding can enhance the yield and quality of crops under changing environmental conditions, such as drought, salinity, heat, or pests.

### Examples of molecular breeding of crops for improved yield and quality

**Rice:** Molecular breeding has been used to develop rice varieties with higher yield potential, grain quality, disease resistance, drought tolerance, and salt tolerance. For instance, MAS was used to introgression QTLs for submergence tolerance from a flood-tolerant landrace into a high-yielding variety. GS was used to predict GEBVs for grain yield and quality traits in rice breeding populations.

**Wheat:** Molecular breeding has been used to improve wheat varieties for higher yield potential, grain quality, disease

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resistance, drought tolerance, and heat tolerance. For example, MAS was used to transfer QTLs for grain protein content from durum wheat into bread wheat. GS was used to estimate GEBVs for grain yield and quality traits in wheat breeding populations.

**Maize:** Molecular breeding has been used to enhance maize varieties for higher yield potential, grain quality, disease resistance, drought tolerance, and nitrogen use efficiency. For instance, MAS was used to incorporate QTLs for resistance to maize streak virus from a wild relative into a commercial hybrid. GS was used to predict GEBVs for grain yield and quality traits in maize breeding populations.

In conclusion, molecular breeding of crops is a powerful technique that can improve the yield and quality of crops by using molecular biology tools to manipulate the genes or QTLs that control these traits. However, there are still some challenges and limitations that need to be overcome, The traits related to yield and quality is often complex and variable, depending on multiple genes and environmental factors. Therefore, it is difficult to identify and validate the causal genes or QTLs for these traits. The genes or QTLs introduced by molecular breeding may interact negatively with other genes or QTLs in the recipient genome, resulting in undesirable effects or loss of function. Therefore, it is important to evaluate and optimize the compatibility and stability of the molecular breeding products.