



From Gene Discovery to Cultivar Development: Harnessing Genomic Tools and Advanced Breeding Approaches for Crop Enhancement

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Introduction

- Modern crop improvement is shifting from single-marker selection to integrated, data-driven breeding. This poster summarizes how genomics plus multi-omics accelerate discovery of genes and pathways that control key agronomic traits.

Approach

This work synthesizes evidence across next-generation sequencing (NGS), high-throughput genotyping, and omics-enabled trait biology, and maps these tools to advanced breeding strategies used in crops and their wild relatives.

Recommendations

- Build crop-specific pangenomes and trait-focused gene catalogs.
- Combine genomic selection with phenomics to improve prediction accuracy.
- Expand pre-breeding to safely introgress climate and pest resilience alleles from wild germplasm.

KEY GENOMIC TOOLS

- NGS and pangenomes: reveal structural variants and novel alleles.
- High-throughput genotyping: enables dense marker coverage for mapping.
- Transcriptomics, proteomics, metabolomics: link genotype to phenotype through regulatory and biochemical networks.
- Functional markers: support rapid, reproducible selection.

Conclusion

- Integrating NGS, multi-omics, and quantitative genetics builds a practical bridge from trait biology to breeding decisions.
- Precision molecular breeding and genomic selection shorten breeding cycles while improving resilience, yield, and quality.

Research Objectives

- Connect genomic discovery with practical breeding pipelines to develop resilient, high-performing cultivars under climate and pest pressures.
- Improve the combination of genomic selection and precision breeding methods to boost the development of climate-adaptive traits and pest-resistant varieties that will increase crop yield and sustainability under a variety of environmental conditions.

Advanced Breeding Strategies

- QTL mapping and GWAS: identify loci for yield, quality, and stress tolerance.
- AB-QTL and introgression lines (ILs): capture beneficial diversity from landraces and wild relatives.
- MAGIC populations: increase recombination to improve mapping resolution.
- MABC and MARS: pyramid favorable alleles with fewer breeding cycles.
- Genomic selection (GS): predicts performance early, accelerating selection in complex traits.

IMPACT FOR CROP ENHANCEMENT

- When genomic discovery is paired with precision breeding, the path from candidate genes to improved cultivars becomes faster and more reliable. Key outcomes include:
 - improved resistance to biotic stresses (pathogens and pests)
 - stronger tolerance to abiotic stresses (heat, drought, salinity)
 - higher yield stability and better nutritional or processing quality
 - broader genetic base through targeted use of diverse germplasm

Accelerating Climate-Resilient Crop Development



References

- Kumar, R., Das, S.P., Choudhury, B.U., Kumar, A., Prakash, N.R., Verma, R., Chakraborti, M., Devi, A.G., Bhattacharjee, B., Das, R. and Das, B., 2024. Advances in genomic tools for plant breeding: harnessing DNA molecular markers, genomic selection, and genome editing. *Biological Research*, 57(1), p.80.
- Spencer, & Warner. (2021). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Liceria Publications