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### BRIDGE FUNDAMENTAL STUDIES AND THEIR APPLICATION FOR BREEDING BY DESIGN (BBD): USE OF VISUALIZATION TOOLS FOR QTL SEARCH AND HAPLOTYPE INFERENCE

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#### Abstract

Research in fruit genetics and molecular breeding has made significant advances over the past decades. Efforts have focused on numerous traits of interest through methods that include Quantitative Trait Loci (QTL) mapping, Genome-Wide Association Studies (GWAS), and candidate gene identification and validation. These approaches have successfully identified key QTLs and underlying causal or candidate genes, providing a theoretical foundation to develop cultivars with specific, desirable traits. Nonetheless, reviewing and synthesizing the vast body of available basic research for a specific trait of interest, and translating it into practical breeding applications, remains a complex and time-consuming task. To address this challenge, Breeding by Design (BBD) offers a strategic approach that integrates genetic insights (combining genetic mapping, thorough phenotyping, and chromosome haplotyping) with advanced analysis and visualization tools to bridge fundamental studies with breeding applications to create novel varieties.

In this work, we present an initiative to streamline this process for apple (*Malus domestica* Borkh.) breeding by integrating reliable literature with advanced tools to compile and display genetic data. This initiative includes (1) the development of a comprehensive and curated QTL inventory for key quality and disease resistance traits and (2) the creation of an analysis and visualization tool that provides an easy and user-friendly search and display of the complex QTL data by genomic regions. This tool additionally performs haplotype inference of traits using genotypic data, either from an existing but yet-to-be published genotypic database with thousands of apple cultivars, or from genotypic data directly uploaded by the user. By combining the curated QTL inventory with the visualization tool, our initiative is tailored to support targeted breeding decisions using the BBD approach. This integration bridges scientific results with practical breeding solutions, to enhance the efficiency of apple breeding programs and academic research.

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