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CRISPR-Mediated Genome Editing for Yield Enhancement in Tomato

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Abstract : Tomato (Solanum lycopersicum L.) is one of the most significant vegetable crops in terms of its economic benefits. Both fresh and processed tomatoes are consumed. Tomatoes have a limited genetic base, which makes breeding extremely challenging. Plant breeding has become much simpler and more effective with genome editing tools of CRISPR and CRISPR-associated 9 protein (CRISPR/Cas9), which address the problems with traditional breeding, chemical/physical mutagenesis, and transgenics. With the use of CRISPR/Cas9, a number of tomato traits have been functionally distinguished and edited. These traits include plant architecture as well as flower characters (leaf, flower, male sterility, and parthenocarpy), fruit ripening, quality and nutrition (lycopene, carotenoid, GABA, TSS, and shelf-life), disease resistance (late blight, TYLCV, and powdery mildew), tolerance to abiotic stress (heat, drought, and salinity) and resistance to herbicides. This study explores the potential of CRISPR/Cas9 genome editing for enhancing yield in tomato plants. The study utilized the CRISPR/Cas9 genome editing technology to functionally edit various traits in tomatoes. The de novo domestication of elite features from wild cousins to cultivated tomatoes and vice versa has been demonstrated by the introgression of CRISPR/Cas9. The CycB (Lycopene beta someri) gene-mediated Cas9 editing increased the lycopene content in tomato. Also, Cas9-mediated editing of the AGL6 (Agamous-like 6) gene resulted in parthenocarpic fruit development under heat-stress conditions. The advent of CRISPR/Cas has rendered it possible to use digital resources for single guide RNA design and multiplexing, cloning (such as Golden Gate cloning, GoldenBraid, etc.), creating robust CRISPR/Cas constructs, and implementing effective transformation protocols like the Agrobacterium and DNA free protoplast method for Cas9-gRNAs ribonucleoproteins (RNPs) complex. Additionally, homologous recombination (HR)-based gene knock-in (HKI) via geminivirus replicon and base/prime editing (Target-AID technology) remains possible. Hence, CRISPR/Cas facilitates fast and efficient breeding in the improvement of tomatoes.

Keywords : CRISPR-Cas, biotic and abiotic stress, flower and fruit traits, genome editing, polygenic trait, tomato and trait introgression

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