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Production of hybrid crops via CRISPR-Cas9-based gene editing

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In the past 50-60 years, the cultivation methods in agriculture have evolved immensely. Many researchers have tactfully invented new methods of growing crops optimally, such as the formation of hybrid crops to obtain the most favourable traits. However, even these methods seemed redundant because of the inability to maintain male-sterile lines and the low efficiency of cross-pollination amongst crops. This has given rise to another evolutionary competitive technology known as gene editing, whose principles lie in the alteration of the programmed genome to bring out the most beneficial characters of a crop. One of the most popular gene-editing techniques is through the production of haploids, which is based on the principle of simplified gene-editing on a haploid via CRISPR/Cas9 vector. This is useful in generating gene-specific mutations to bring out the most optimal traits. To create the haploids, a pollen-specific phospholipase encoding gene called the metallothionein (MTL) gene, present in most of the cereal crops like maize, rice, and wheat can be knocked off, thus triggering the haploid nature. This technology of gene-editing is logical because once a haploid is formed, a simplified platform for gene-editing is created for the CRISPR/Cas9 vector to cause genetic changes. Another breakthrough technology invented was the propagation of rice hybrids through apomixis (asexual reproduction process where clonal seeds are formed without fertilisation). The technology incorporated the use of CRISPR/Cas9 to create triple-knockout rice lines of the cereal-specific meiotic genes REC8 meiotic recombination protein (REC8), homologous pairing aberration in rice meiosis 1 (PAiR1) and omission of second division (OSD1) to produce non-recombinant diploid male and female gametes with the optimal phenotype. This artificial apomixis technology could also be used in other cereal crops since the homologues of these genes are always present in cereal crops. Although this technology sounds impressive, it has a few limitations including the reduction in genetic diversity from parent to offspring and the inability to control the accumulation of genetic mutations that are detrimental to the plant system. There is a wide scope to understand the molecular mechanisms by examining the underlying gene networks. Future research can also be performed on the introduction of an orderly genotype-independent delivery method for major crop species as well as the development of delivery tools for regional crops. If these major issues are addressed, this technology will be a huge success on the path of future 'superfoods'.

Keywords: Sterile, Cross-pollination, Haploid, CRISPR/Cas9, Mutation, Homologues

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