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Nonhomologous end joining as key to CRISPR/Cas-mediated plant chromosome engineering

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摘要	Although clustered regularly interspaced short palindromic repeats (CRISPR)/CRISPR-associated protein (Cas)-mediated gene editing has revolutionized biology and plant breeding, large-scale, heritable restructuring of plant chromosomes is still in its infancy. Duplications and inversions within a chromosome, and also translocations between chromosomes, can now be achieved. Subsequently, genetic linkages can be broken or can be newly created. Also, the order of genes on a chromosome can be changed. While natural chromosomal recombination occurs by homologous recombination during meiosis, CRISPR/Cas-mediated chromosomal rearrangements can be obtained best by harnessing nonhomologous end joining (NHEJ) pathways in somatic cells. NHEJ can be subdivided into the classical (cNHEJ) and alternative NHEJ (aNHEJ) pathways, which partially operate antagonistically. The cNHEJ pathway not only protects broken DNA ends from degradation but also suppresses the joining of previously unlinked broken ends. Hence, in the absence of cNHEJ, more inversions or translocations can be obtained which can be ascribed to the unrestricted use of the aNHEJ pathway for double-strand break (DSB) repair. In contrast to inversions or translocations, short tandem duplications can be produced by paired single-strand breaks via a Cas9 nickase. Interestingly, the cNHEJ pathway is essential for these kinds of duplications, whereas aNHEJ is required for patch insertions that can also be formed during DSB repair. As chromosome engineering has not only been accomplished in the model plant Arabidopsis (Arabidopsis thaliana) but also in the crop maize (Zea mays), we expect that this technology will soon transform the breeding process.
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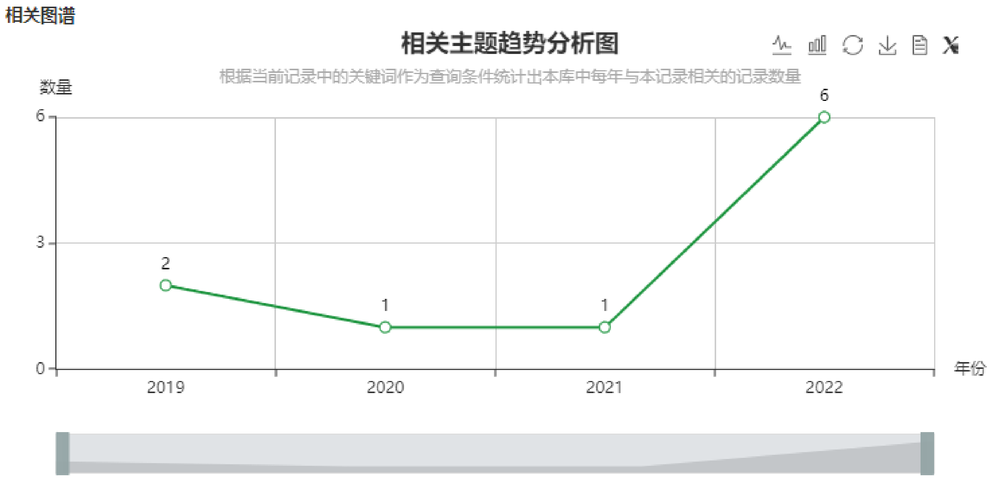

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