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Overview of CRISPR-Cas9 Technologies and its Application in Crop Improvement

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Genome editing offers a range of solutions for more efficient development of crops that are productive, adapted to stresses, climate-resilient, and less dependent on agro-inputs. Clustered regularly interspaced short palindromic repeats (CRISPR)–CRISPR-associated protein (Cas9) technology is the current dominant tool used for genome editing. Originally, a Cas9 nuclease was employed to induce a double-strand break in its target site, causing the deletion of a few base pairs, inversion and gene integration to deliver desired changes in organisms. Aside from the primary nuclease activity (knock-in/out), a Base editor system, Gene priming and Cargo chauffeuring activities have been reported to deliver functionalities to specific regions in the DNA such as regulating transcription and fluorescence DNA for visualizing and understanding biological systems. Limitations of the scope of Cas9 activity were also eliminated by the recent development of more Cas9 orthologues (Cpf1-RR and Cpf1-RVR). Cas9 together with the advent of novel base editing tools that enable precise genome modifications and DNA-free genome editing via ribonucleoproteins demonstrate significant promise in the development of future crop improvement strategies. However, large-scale adoption of CRISPR/CAS will require optimizing strategies while accounting for costs, ease of implementation, and potential impacts on production gains. This review focuses on CRISPR application in plants, advances in CRISPR technology, regulations that may disadvantage scientists, resources for the smooth application of CRISPR and the preparedness of Africa to benefit from CRISPR technology.

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caused by the nuclease are generally repaired by non-homologous end joining (NHEJ) eventually causing deletion and/or insertion of nucleotide(s) or, when a DNA repair template with homology regions with the target site is provided, homology-directed repair (HDR). In the NHEJ approach, the cell repair mechanism attempts to rejoin the cut ends but loses or induces a few bases in the process: a situation that can result in gene alterations due to frameshi mutations. In the HDR situation, donor repair templates are supplied and the DSB repair may results in the integration of the donor sequence to allow targeted

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regulated grain weight including Grain Width 2 (GW2), Grain Width 5 (GW5) and ousand-Grain Weight 6 (TGW6). All three genes generated mutants (gw5tgw6 and gw2gw5tgw6) which showed notably larger grain sizes than that of the wild-type. In hexaploid bread wheat, CRISPR-Cas9 has been used to modify multiple alleles to confer heritable resistance to powdery mildew **[10]**.

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An important feature of the agricultural application of CRISPRcombinations needed to survive in changing tness optimum in changing environments. Genetic recombination facilitates natural selection in addressing bottlenecks for evolution in an ecological context. Meiotic recombination is needed for homologous pairing during meiosis. It also ensures that o springs di er in their tness and decrease the risk factor for the population. Several genes including RECQ4, FANCM and FIGL1 are anti-cross-over genes, the mutation are made and presents a lot of possibilities hitherto not possible with conventional breeding for correcting abnormalities and improving the performance of current varieties. The future and the role of genome editing in plant research and sustainable crop production are eminent. Africa is at the inception -stages of using genome editing technology to improve crop production and utilization challenges. The predominant view in the literature is that CRISPR technology is simple and easy to apply mainly because the engineering advances have laid the groundwork for the creation, refinement and implementation of genome-modifying tools in advanced countries. However, a broad application of genome editing will rely on enhanced knowledge of genome organization and function, germplasm characterization, gene function characterization and identification of favorable variation in crops and their wild relatives. This should be complemented with phenotyping, omics and systems biology studies pursued across large-scale germplasm collections of important staples. There is also a need to commence the development of enabling technologies such as plant transformation protocols and tissue culture regeneration for important crops in order to take advantage of the opportunities in genome editing technologies. Comprehensive integration of these technologies is lacking in most African countries. However, there are regional centers, various CGIAR Centers, and universities that have equipped laboratories and institutions that support capacity-building in modern technological applications in Africa **[11]**. For instance, the Biosciences eastern and central Africa - International Livestock Research Institute (BecA - ILRI) Hub in Nairobi, Kenya, is a shared agricultural research platform that exists to increase access to affordable, world-class research facilities. The Facility houses Genomics, Bioinformatics and Breeding platforms and offers research-related and capacity-building