International Wheat Yield Partnership
Research to Deliver Wheat for the Future

IWYP SCIENCE BRIEF

NUMBER 17 JULY 2021

Supported by USDA

Developing a System for CRISPR-Based Precision Breeding in Wheat

Gene editing (GE) technologies can create targeted novel variation in the genomic regions of crop plants affecting major agronomic traits. A NIFA-IWYP Project "**Genome Editing for Improving Wheat Yield and Yield-Related Traits**", led by Eduard Akhunov at Kansas State University with other colleagues in the USA and UK is exploring the capabilities of GE to unlock the yield potential of the complex wheat genome and to integrate this technology into wheat pre-breeding pipelines. A project team established a gene editing pipeline based on the *Cas9* and *Cas12a* nucleases and used it to modify an initial set of 11 genes known from the literature to control the size, weight and number of grain in wheat.

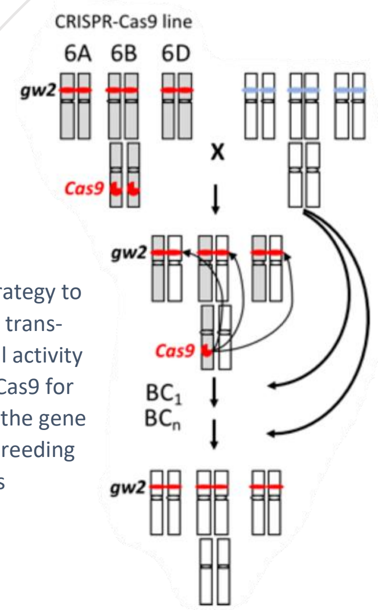

Figure 1. Strategy to utilize the trans-generational activity of CRISPR-Cas9 for transferring the gene edits into breeding lines

What Solutions have been Identified?

- Effective technical strategies for wheat genome editing capable of targeting single and multiple gene targets to achieve CRISPR-driven editing of multiple genes that have the potential to positively affect important yield component traits.
- The CRISPR-induced variants of five genes showing positive effect on grain size, grain weight or grain number.
- An effective approach for inducing novel gene editing events in the recipient germplasm to accelerate the creation of gene edited wheat lines that are less amenable to genetic transformation, i.e., overcomes genotype dependency.

What has been the impact of this research?

- The CRISPR technology has been used to introduce mutations into five genes controlling grain size, weight and number in several varieties from the CIMMYT (5 high biomass spring wheat lines) and the Kansas wheat breeding programs (5 winter wheat lines). The positive phenotypic effect of CRISPR editing was confirmed in greenhouse and field conditions, and while there are currently no plans to release any commercial varieties using this technology, the results show that CRISPR-based tools could play a positive role in improving genetic yield potential in wheat and can be rapidly deployed once conditions permit.

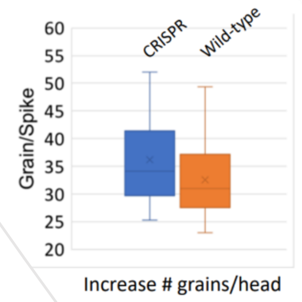

Figure 2. The effect of CRISPR editing in the *TaCKX2-1* gene on grain number

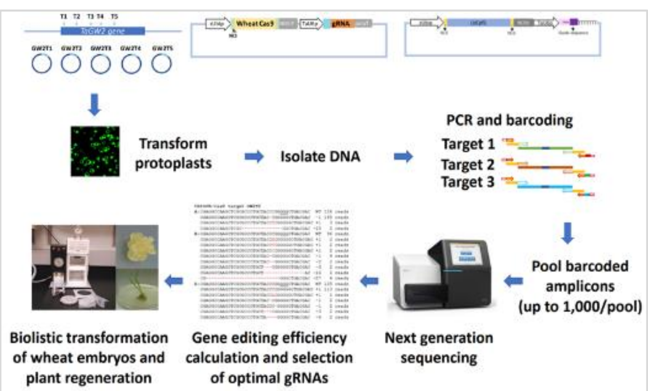

Figure 3. CRISPR-based gene editing pipeline

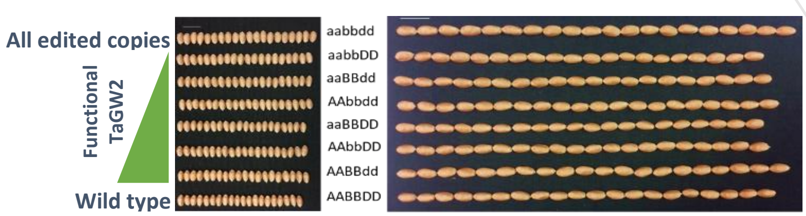

Figure 4. Effects of single, double and triple knockout mutations in the *TaGW2* gene homeologues on grain size. Triple knockout mutations (aabbdd) lead to larger grains (width and length). Wang et al. (2018). doi: 10.1007%2Fs00122-018-3166-7

N-IWYP711: E. Akhunov, Kansas State University (lead); H. Trick & A. Akhunova, Kansas State University; L. Yan, Oklahoma State University; S. Evanega, Cornell University; J. Dubcovsky, University of California Davis; C. Uauy, John Innes Centre. Supported by USDA NIFA. Grant Number: 2017-67007-25932.