**Crop improvement using the CRISPR/Cas9 system**

Major: Biology

Department of Microbiology and Molecular Genetics, Oklahoma State University, Stillwater, OK 74078, USA

**Key Words:**

crop, genome, CRISPR/Cas9, genetic engineering, improvement

**Abstract**

With the world’s population constantly growing, the demand for food grows higher and higher. By using many different genome editing technologies, such the CRISPR/Cas9 system, the quality of crops being produced can be improved to meet the rising demands of this world. Scientists can create crops with resistance to biotic or abiotic stresses, to counter deteriorating environmental conditions, and provide immediate improvement to existing crops. All of this will be done by using the above technology to change the plants performance and heredity. Due to the precision of this new technology, the CRISPR/Cas9 system is much more efficient than any conventional crop breeding methods or genetic engineering methods previously utilized. The technology not only improves the crops nutrition but helps the crops fight off pests and thrive in tough environmental factors such as drought. This study will discuss not only how these technologies work but how they can be improved in the future with further development.

**Introduction**

With the increasing population comes an increase in the need for food. However, the natural species of crops produced today are not able to meet this growing demand. By 2050 the world’s population with roughly reach 9 billion, requiring crop production to nearly double (Jaganathan et al. 2018). Selection breeding and crossing methods are some original methods of crop breeding but with mutations being so random, it made the isolation and purification processes that much more difficult. By incorporating the CRISPR/Cas9 system, targeting specific DNA and manipulating gene functions that much easier. Unlike the first methods of crop breeding, the CRISPR/Cas9 uses simple designing and cloning methods while targeting multiple genome sites. Due to this the CRISPR/Cas9 system has become one of the most specific and efficient methodologies of gene editing. These advances made in the genome editing approaches has opened the gate for the breeding and targeting of almost any desirable trait in a plant. With the first genetically modified crops commercialized in 1996, genetic engineering has only advanced more and more helping to speed up the development of improved crops (Waltz, 2018). Looking to the future, this could be a game changer in the fight against world hunger.

**Recent Progress**

Today the CRISPR/Cas9 technology is known as the most powerful gene editing technology worldwide. When compared to other forms of gene editing technology, such as transcription activator-like effector nuclease (TALEN) and Zinc finger nuclease (ZFN), the CRISPR/Cas system proves to be more cost efficient and higher in editing efficiency due to having a much simpler structure and is much easier to manipulate when editing multiple sites. It has currently been adopted by almost 20 crop species to help improve biotic and abiotic stress management (Ricroch et al., 2017). In 2005, 42% of potential yield loss and 15% of global declines in food production are due to biotic stress on crops imposed by pathogenic micro-organisms (Oerke, 2005). Thus, using the CRISPR/Cas9 genome editing system has helped substantially to increase crop disease resistance and to tolerate more abiotic factors such as drought. Rice, wheat, and maize are examples of staple crops used worldwide that benefit from the use of genome editing by using the CRISPR/Cas9 system. With Maize being the number one staple crop in over one-third of the world’s population, and rice and wheat following as the second and third, enhancing these crops would be a crucial step in fighting world hunger. Since these crops are already so easy to grow and harvest, increasing disease resistance and the nutritional value in them could benefit millions, especially those living in third world countries where much of the population suffers from starvation and malnutrition. However, there are still limitations of the CRISPR/Cas9 system, and several modifications have been developed to increase target specificity and reduce off target cleavage. Such modifications include increasing the protospacer adjacent motif length which would reduce off target cleavage. The use of new breeding technologies such as the CRISPR/Cas 9 system also do not fall under GMO regulatory regimes in several countries. By the United States Department of Agriculture allowing CRISPR/Cas9 crops to be cultivated and sold free of monitoring regulations, several millions of dollars can be saved and reduce the time it would usually take to release a GMO crop (Waltz, 2018).

**Discussion**

With the population growing as fast as it is, it is important that a new food source or solution presents itself quickly. The CRISPR/Cas9 genome editing system could be the answer to this problem, but will it prove to be as successful as scientists hope it to be? With the ability to choose desired traits and apply those directly into the breeding pool, the CRISPR/Cas9 based technology is proved to be a breakthrough technique. Though recent modifications have led to an increase of efficiency of the system, this is still a fairly new study and has plenty of room for improvement. The improvement of disease resistance, the increase of nutritional value of the crops, and increasing the important traits of this system can all be seen as future works in this area to improve the overall function. Since this study is still fairly new results are still in the works of seeing how effective this study will be. However, if this study continues to progress at the rate it is, it is very likely to gain popularity very soon and become essential to the world when trying to conquer world hunger and feed the growing human population.

**References**

Jaganathan D, Ramasamy K, Sellamuthu G, Jayabalan S, Venkataraman G (2018) CRISPR for crop improvement: an update review. Front Plant Sci 9:985

Oerke, E. C. (2005). Crop losses to pests. *J. Agric. Sci.* 144, 31–43. doi: 10.1017/s0021859605005708

Ricroch, A., Clairand, P., and Harwood, W. (2017). Use of CRISPR systems in plant genome editing: toward new opportunities in agriculture. *Emerg. Top. Life Sci.* 1, 169–182. doi: 10.1042/etls20170085

Waltz, E. (2018). With a free pass, CRISPR-edited plants reach market in record time. *Nat. Biotechnol.* 36, 6–7. doi: 10.1038/nbt0118-6b