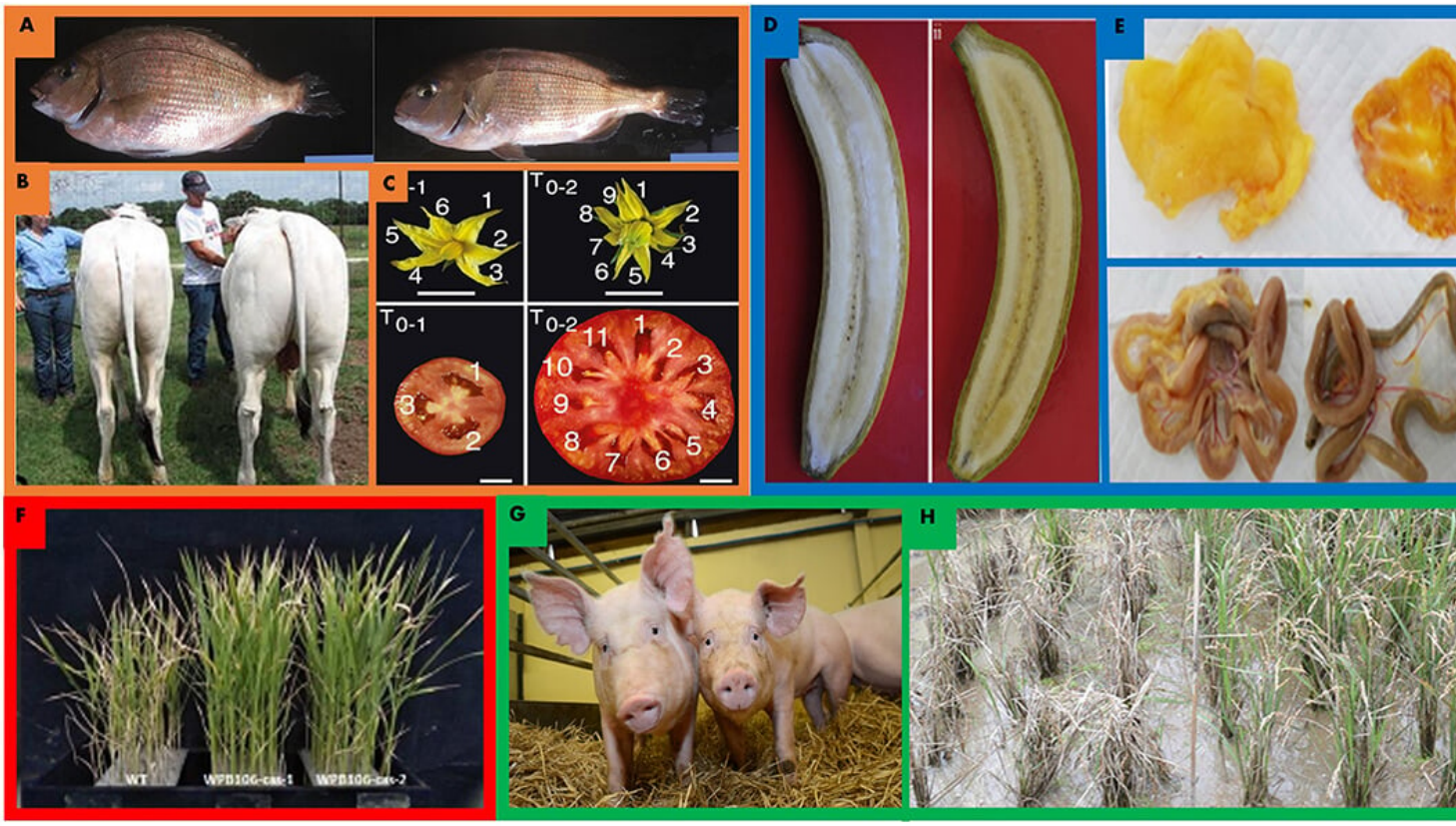
Gene editing: Powerful tool for managing climate change

Growing up, my family spent summer weekends on the beaches of New York State. Riding in a car packed with kids and stuff, someone would note how swelteringly hot it had been getting lately. Never missing my cue, I would scream with little restraint, “GLOBAL WARMING, GLOBAL WARMING, GLOBAL WARMING,” until one of my siblings took their turn in the rotation to “deal” with me. I learned about climate change in third grade and couldn’t help but sound the siren call for what I deemed an important, but too often forgotten, cause. Since then, climate change has become a household term as its devastating impacts become increasingly visible and advocates (screaming eight-year-olds included) expand awareness.

My fascination for the topic has continued into adulthood. As a plant biologist, I have continually been inspired by the work of peer researchers developing innovative solutions to the severe impacts of climate change on natural and agricultural environments. I have been especially galvanized by the disruption that the new editing tool CRISPR/Cas has brought in fields ranging from human medicine to farming.



This graphic depicts just a few of the gene editing applications in agriculture. Credit: Application of Gene Editing for Climate Change in Agriculture

Recently, I joined a dispersed team of researchers — Sarah Evanega, Modesta Abugu and Wilson Horner — in seeking to understand just how impactful gene editing can be in addressing climate change in agriculture. Looking broadly and deeply into the literature of gene editing applications in crops and

livestock we uncovered a beautiful array of successful gene edits. Our review of the literature in this field, published in Frontiers in Sustainable Food Systems, revealed four key points:

1) Many of the improvements in agriculture using gene editing have converged on four major traits: increased abiotic stress tolerance, improved disease tolerance, enhanced nutritional quality and greater yields. All of these traits are paramount as climate change worsens. The fewest interventions have been developed for abiotic stress, the non-living factors that negatively affect crop and livestock performance. High temperatures, salinity and drought are examples of such stresses. Abiotic stresses are predicted to be among the most deleterious for agricultural productivity in the face of climate change.

2) Gene editing has been applied to a vast array of crops and livestock organisms, with far fewer applications focused on livestock. The introduction of CRISPR/Cas systems has facilitated the recent surge in the number of gene editing innovations that have been produced. Limitations in delivering editing tools into cells and subsequently regenerating organisms from those edited cells continue to be a debilitating limitation to the use of this technology for climate change in agriculture.

3) The African continent is uniquely poised to benefit from advances in gene editing technology. Largely overlooked by the Green Revolution that delivered higher-yielding grain crop varieties to Asia and Central/South America, this technology can provide improved varieties of many crops and traits relevant to the needs of the diverse populations and geographies of the African continent.

4) Targeting creative sets of genes using a suite of approaches, researchers were able to generate a vast array of incredibly improved crop and livestock varieties.

While all innovations described in our review are powerful examples of this transformative technology, I would like to highlight one of my personal favorites of over 120 representative examples.

Agustin Zsögön and colleagues were able to identify and edit six genes associated with key domestication traits, domesticating a wild tomato relative and increasing fruit size three-fold and fruit number 10-fold while also improving nutrition, abiotic stress tolerance and disease tolerance. Not only did this research affect numerous climate change related traits, it also created a basis for future engineering of crop wild relatives. Crop wild relatives are often more disease resistant, resilient to unfavorable climates and nutritious, but suffer from low yields.

The exciting opportunities that exist for the future of agriculture using gene editing are undeniable. In the face of bleak climate change outcomes, gene editing is an important path forward for crop and livestock adaptation. Of course, the benefits of gene editing applications will only be realized when growers and producers finally gain access to these transformative technologies. Technological limitations aside, socio-political barriers to access must be surmounted prior to wide-scale adoption of gene edited products.

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