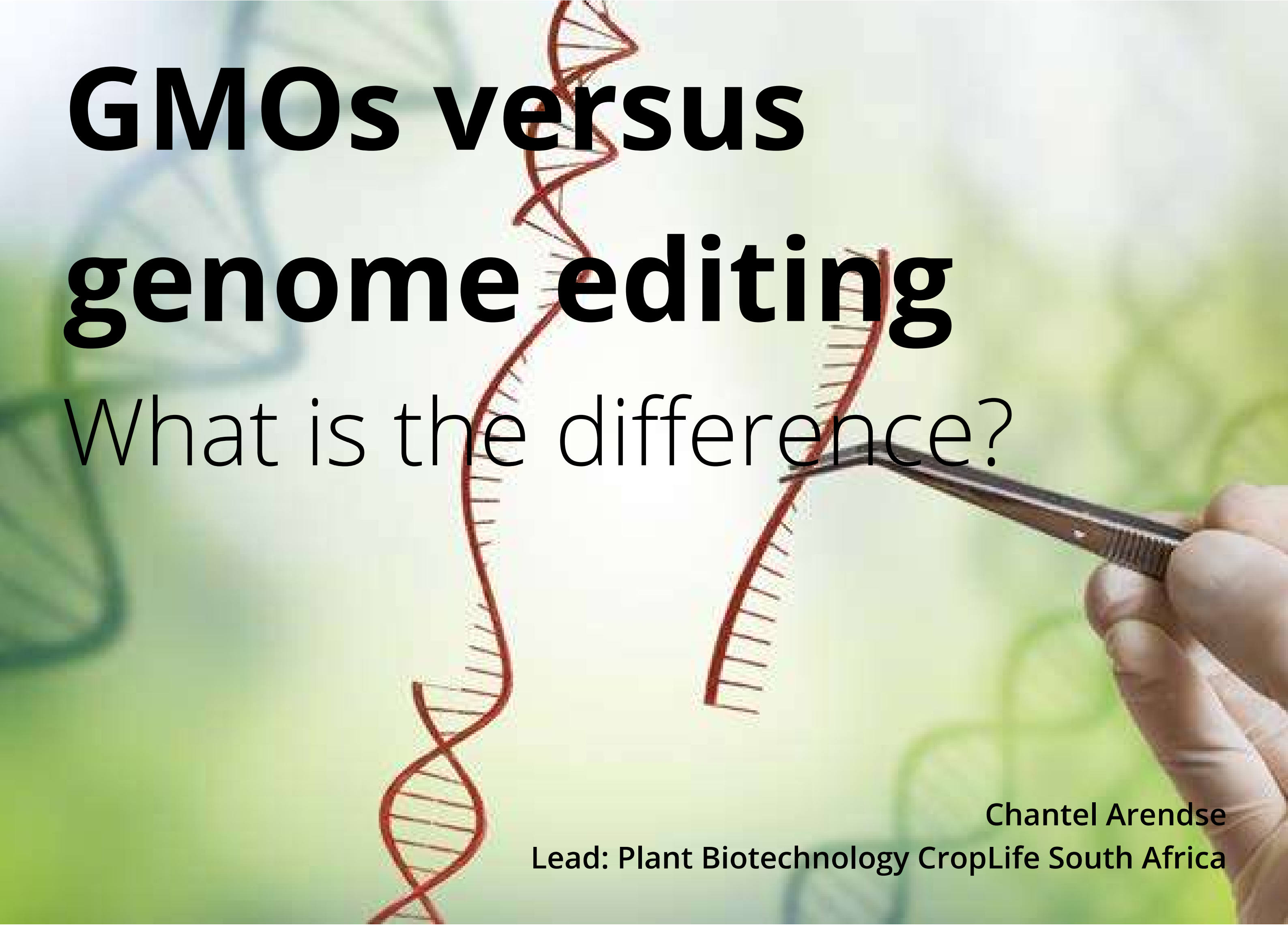

GMOs versus genome editing

What is the difference?

Chantel Arendse
Lead: Plant Biotechnology CropLife South Africa

Terminology such as genetic modification, transgenesis, genome editing and so forth can all be very confusing. Is there really a difference? Isn't GMOs the same as genome editing? The explanations below may help to eliminate some of the confusion around the different types of plant breeding tools that coexist today and are used in various complementary ways for crop improvement.

Conventional or traditional breeding tools

The earliest genetic improvements in plants and animals were achieved through selective and crossbreeding methods to produce desirable traits such as higher yield, improved taste, or better disease resistance in offspring. These traditional methods gave breeders limited control over all the other genes that were transferred between plants during this process and therefore it took many years and many breeding cycles to successfully get the desired combination of traits in plants. These breeding tools or methods were later complemented by mutagenesis techniques that involved the use of harsh chemicals and/or radiation to randomly change or mutate the DNA of crop plants. The use of mutagenesis for crop improvement introduced innumerable changes to the DNA of crops, none of which was characterised or subjected to regulatory safety assessments as is required with more modern plant breeding tools deployed today.

The domestication of our food crops over many thousands of years demonstrates that humans have always had a hand in the modification of our present-day food supply. Long before the advent of modern breeding tools (such as genetic modification and genome editing), crop improvements using traditional breeding tools introduced modifications in plants mediated at the genetic level in a cruder and less predictable manner, giving us modern day foods that are mostly unrecognisable from their earlier ancestors.

Crop improvements: Random transfer of innumerable number of genes to the plant genome
Regulatory status: Subject to registration as a new variety, but no safety testing required
Crop improvement timeline: 5-30 years
Genetic modification/Genetic engineering

Approximately 40 years ago, scientists began using genetic engineering technology to make more precise and predictable changes to the DNA of organisms. Some of the applications of this technology include its use in the production of vaccines, the production of insulin in bacterial cells and, of course, its use in modern agriculture, giving us insect resistant and herbicide tolerant crops. Within the plant breeding context, genetic modification or transgenesis involves identifying a desired gene with a known function and inserting it into the genome of the targeted plant, resulting in what we commonly known as GMOs (genetically modified organisms), GM foods or biotech crops. The most well-known example of transgenesis is the transfer of the gene expressing the insecticidal BT protein from the soil bacterium *Bacillus thuringiensis* (abbreviated "Bt") into crops such as maize and cotton, giving us Bt crops with built in protection against targeted insect pests.

Today, biotech crops are grown in 29 countries covering a total production area of 190.4 million hectares and includes major staple crops such as soybeans, maize, and canola, as well as cotton (ISAAA, 2019). Despite the ongoing public debate on GM technology, their addition to the plant breeding toolbox has contributed over 22% more food to the global food supply without the need for additional resources such as land, soil, and water, thereby reducing the environmental impact of agriculture.

Crop improvements: Targeted genes for specific traits inserted within the plant genome
Regulatory status: Highly regulated, safety testing required
Crop improvement timeline: 5-10 years

Genome Editing/ New breeding techniques
More recent discoveries in plant science have added yet another category of diverse plant breeding tools, collectively known as genome editing tools or new breeding techniques (NBTs). These techniques facilitate crop improvement by allowing small tweaks (edits) to be made directly to the native genome of an organism, without the need for inserting "foreign" DNA, as is the case with genetic modification. Genome editing tools work like a pair of molecular scissors, making cuts in a plant's DNA at targeted sites that allow deletions, edits, or additions to be made to the genome so that plant breeders can more rapidly and predictably achieve the desired plant characteristics in new varieties.

The main genome editing tools deployed in crop improvement include TALENS (transcription activator-like effector nucleases), ZFNs (zinc-finger nucleases) and the well-known, Nobel prize winning tool called CRISPR (Clustered Regularly Interspaced Short Palindromic Repeat). The major advantages of genome editing over previous breeding tools is that they are more precise, less expensive, offer greater flexibility and are easier to use. Depending on how genome editing tools are used, most applications generate genetic changes in plants that are comparable to and no different from those produced through traditional breeding methods or derived from mutations in plants that occur naturally over time.

The versality of genome editing tools has resulted in an upsurge in research focusing on unique ways to use the technology to make agriculture more sustainable, provide safer and more nutritious food, mitigate against climate and marginal growing conditions, protect against new and emerging pests and diseases, as well as better consumer value products. While regulatory oversight over genome editing tools is still evolving, the emerging trend amongst countries that have put regulatory frameworks in place, regards products derived from genome editing technologies the same as traditionally bred crops, not GMOs, and regulates them as such.

Crop improvements: Targeted deletions, edits, or additions of gene sequences at specific locations in the plant genome

Regulatory status: Mixed regulation, safety testing dependent on jurisdiction

Crop Improvement timeline: 2-3 years

In summary

Since people began farming, we have been selecting for genetic changes in plants for new and improved characteristics and traits. The only thing that has evolved are the various plant breeding tools available today, allowing for improvements to be made to our food crops in a faster, efficient, and more precise manner. Innovations in plant science have made all of this possible and will continue to offer unique solutions as we advance our understanding of plant genetics, specific traits, and their related gene function. As farmers face the daunting task of having to consistently increase yields in the face of uncertain and challenging growing conditions, we cannot afford to ignore the contributions that all plant breeding technologies bring to help us meet our global food security targets.