Africa could become a world agricultural leader in CRISPR and other new breeding techniques (NBTs)

It is 8:30 East African Standard Time. I disembark from a van filled with science journalists from Kampala, Uganda and accompanied by stakeholders from Uganda National Farmers Federation at the National Agriculture Crops Resources Research Institute in Namulonge.

We are on a fact-finding trip about research and the application of modern biotechnology in crop development. Upon arrival the team is welcomed into the Biosciences Laboratory by Dr. Titus Alicia, director of the root crops program.

I take keen interest in observing what is going on at the cassava tissue culture lab, where Dr. Teddy Amuge is picking tiny cells from a transparent glass plate and analyzing them under a microscope.

Amuge explains that there are two basic steps in plant genome editing, and the same applies to the application of synthetic biology and nanotechnology.

“The emerging field of synthetic biology, nanotechnology and gene editing has been making waves in the global scientific community recently and this includes scientists working in different laboratories in Africa,” she tells me.

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Dr. Teddy Amuge explains the cassava breeding process for resistance against CMV and CBSV at the tissue culture Lab in NaCRRI. Photo by Lominda Afedraru.

Emerging technologies in African labs

Agricultural scientists in Africa are already engaged in research in gene editing and synthetic biology. In Amuge’s eyes, synthetic biology is broadly understood as the deliberate design of novel biological systems and organisms that are drawn on principles explained by biologists, chemists and physicists in redesigning life:

> This is because the fusion of most metabolic pathways such as the one for plant cell wall circuits is so large. Scientists engaged in such research work use the routine engineering techniques called decoupling and abstraction to break the whole circuit into smaller pieces. Each piece has to be tested prior to assembling them.

There have been controversies surrounding the applications of genetically modified crops, she said. But now more than 90 percent of certain crops in the US are genetically modified.

With organizations opposing GM products, she sees a need for the public in Africa to understand that there is yet a new paradigm shift by scientists as they look to apply emerging technologies (often referred to as NBTs) in plant breeding.

How the breeding process is done

Amuge explained her research in synthetic biology:

> Plant synthetic biology has been recently effectively applied in embedding of completely artificial genetic code tracks into naturally existing plants. The solid foundation of synthetic biology is rooted from a technology that characterizes the molecules and the way that the networks of molecules behave. While genetic engineering deals with transfer of single genes or combination of single genes into a crop genome.

Amuge is developing disease-free cassava at the laboratory in Namulonge. This includes identifying a gene within a plant that is retarding its growth and is eliminated in order for the plant to continue growing normally. This is accomplished by silencing the infected gene and boosting existing ones whose functions enable the plant to grow well.

This technology also can be used to eliminate a gene that makes a plant vulnerable to a disease or to modify a gene to boost a plant's nutrients. This new field of plant breeding has emerged in recent years and is expected to support rapid, precise and robust improvements in plant breeding process:

> *Every single behavior of a plant is controlled by a gene. When a scientist identifies a stunted plant, he or she can silence this gene in the laboratory to enable the plant grow tall, or you simply delete the gene and eliminate it in the life cycle of the plant. There are genes which control disease resistance in the plant. It is the duty of scientists to ensure these genes are expressed for the plant to resist certain diseases for it to grow normally. We are now moving away from sourcing genes in other organisms to be inserted in plants that are challenged for resistance.*

Synthetic biology is not new. It's been used over the years by scientists in the health sector and those in agriculture are now trying to catch up.

Gene editing

As for the use of gene editing in the health sector, she said scientists usually identify a plant that contains properties of a drug because all plants have a composition of biological chemical. For instance, the Neem

tree has anti malaria properties. Pharmacists reproduce chemicals with properties exactly like that to develop anti malaria drugs.

Gene editing is being done by a few scientists in Uganda for research purpose. As for Amuge, she is researching the gene components that cause tolerance in cassava against Cassava Brown Streak Virus (CBSV).

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Rotten cassava tubers on the same farm as a result of CBSV infection. Photo by Lominda Afedraru.

“I have studied the plant characteristics to understand the behavior of the gene component. I have discovered those genes that tolerate the virus and in the next stage I can now carry out gene editing to cause resistance to the virus and develop plants which are totally free from CBSV,” she said.

She believes the arguments and controversies arising from the use of gene editing and synthetic biology in plant breeding will continue to boil. But that won’t discourage agricultural scientists globally, as they strive to improve plant breeding.

Dr. Titus explains that scientists in Uganda, East Africa and Africa are already applying technology of gene editing, nanotechnology and synthetic biology in their research work in the various agriculture laboratories across the continent. In many NBTs, there is no introduction of so-called “foreign genes,” which was often the focus of criticism from anti-biotechnology groups who claimed genetic modification altered the “natural” biological state and introduced novel risks. Titus said:

> These technologies do not require adding a new gene from a plant for resistance. For the case of nano technology in cassava breeding we simply obtain a tiny small gene which we mimic to diagnose the Cassava Mosaic Virus and Cassava Brown Streak Virus. For example we can insert 1 mm diameter of the mimicked gene to get about 2,000 of them. This helps us in identify the organism causing these diseases. At the end of it we get recombinant genes in the breeding process to resist both diseases.

Research scientists follow scientific regulations that govern biotech research globally but since the products have not yet been released for trials in Uganda and other African countries, it is not yet known if there is a national regulatory framework, he said.

Legal framework and comparisons

Dr. Jan Hennie Groenewald, executive manager for Biosafety South Africa, offered an overview of NBTs. He said it is important for scientists in Africa to develop agricultural products using emerging technologies because they may not be subjected to the strangulating regulations that have all but prevented the introduction of GMOs in most of the continent.
He argues that scientists in the health sector have been developing generic drugs using synthetic biology and these drugs have helped in curing patients suffering from sicknesses caused by different diseases. And research is proceeding on developing genetically-altered mosquitoes that could sharply reduce the incidence of malaria. Groenewald said:

> Scientists breeding mosquitos for malaria prevention are already using synthetic biology in the breeding process. This is because there are over 300 species of mosquitoes in the world and those causing malaria are probably two or three. Scientists have silenced the gene that causes reproduction during mating to cause disappearance of female mosquitos in the environment because they are spreading and causing malaria infection in human population. Scientists in Uganda at the Virus Research Institute with their partners in Senegal are already carrying out research in the same.

If the public is opposed to GMO products then scientists in Africa should breed plants using emerging technologies, which are easier to apply and cheap. To him, regulators should not impose heavy restrictions on the use of emerging technologies because any changes in the plant as a result of using CRISPR or most other NBTs could occur naturally although it would take a longer period of time.

For example, scientists in the US have bred mushrooms that remain fresh and do not immediately brown even if they are kept for a longer period after harvesting. This, he said, can and should be done by scientists in Africa.

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