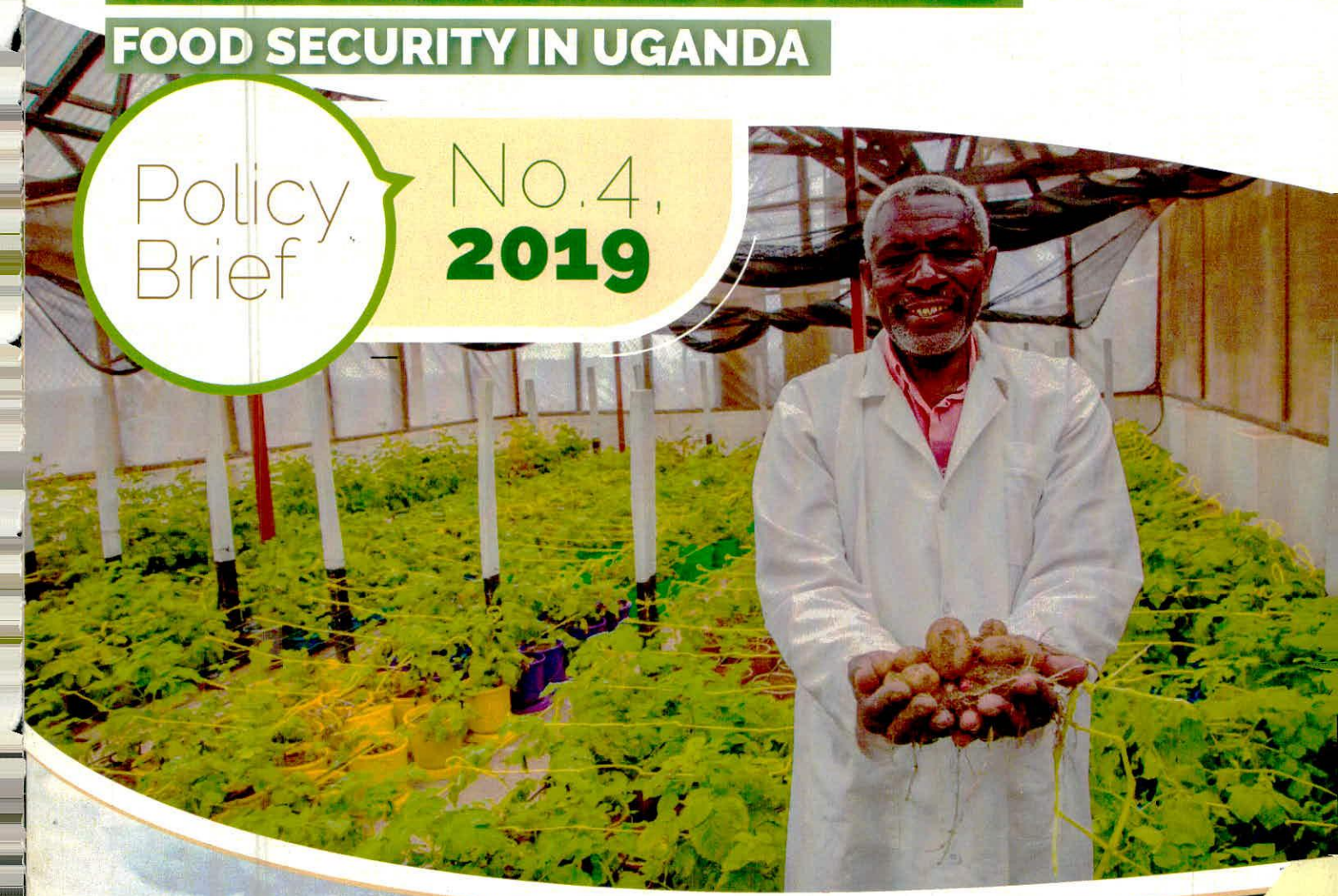
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BIOTECHNOLOGY FOR AGRICULTURAL TRANSFORMATION AND SUSTAINED FOOD SECURITY IN UGANDA

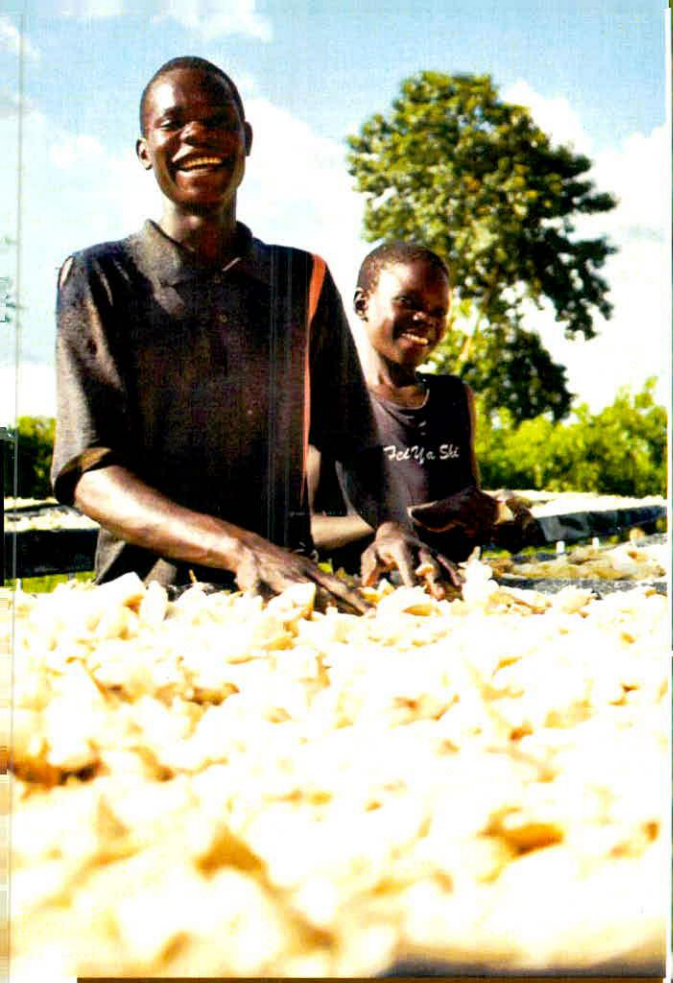
Policy Brief No.4, 2019



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Executive Summary

Biotechnology holds potential to transform Uganda's agriculture. However, the right set of conditions for the country to capitalize on that potential remain to be created. The Ministry of agriculture lists low productivity as one of the greatest challenges facing Uganda's agricultural sector. Key contributors to this state of affairs are a host of factors that consistently cripple farmers' efforts to reap meaningful gains from their labor. These include pests and diseases, depleting soil fertility, poor quality inputs and the vagaries of climate change such as drought and flooding. A host of pioneering research projects—using modern biotechnology approaches—are underway in the country to address such challenges. Yet the results of this research cannot be accessed by farmers. Policy intervention is needed to ensure that biotechnology responds to the priorities set for Uganda's agriculture. Decisions ought to be urgently taken to establish an enabling policy environment that will allow farmers to access the above referenced options from the country's research initiatives.

Background

Biotechnology is a set of tools that uses a whole or part of the organism, or substances from them to make or modify a product, improve plants, animal breeds or microbes, for specific uses. Modern biotechnology comprises genomics (molecular characterization of all species); transformation (introduction of single genes conferring potentially useful traits into plant, livestock, fish, and tree species; Molecular breeding (identification and evaluation of desirable traits in breeding programs with the use of marker assisted selection); and Vaccine technology (use of modern immunology to develop recombinant DNA vaccines for improving control of lethal diseases) (FAO, 2004) among other disciplines.

The second half of the 20th century brought with it several advances in agricultural biotechnology. These included new tools and techniques for the integration of important agronomic traits into crop or animal varieties beyond what has been possible in nature. Crops/animals developed using the new methods are called genetically modified (GM), genetically engineered or biotech crops/animals.

Genetic modification is a modern biotechnology tool that involves altering the genetic makeup of an organism using recombinant DNA technology to enable development of crops with specific desirable traits. It facilitates manipulation of individual genes, modifying crops by switching off or silencing particular genes carrying undesirable traits (Nap, Metz, Escaler, & Conner, 2003). Below, this policy brief discusses how this tool has been used to develop solutions to address key challenges faced by Uganda's agriculture sector. It also points out a few other ways this technology could be used to transform the country's agriculture.

Several crops of strategic national importance have been developed at the National Agricultural Research Organization (NARO). These include bananas for resistance to bacterial wilt and nematodes, and nutrient enhancement; maize for drought tolerance and insect pest resistance; cassava and sweet potato for virus disease resistance; potato for resistance to late blight; rice for nitrogen use efficiency, water use efficiency and salt tolerance. These crops will play an important role once adopted, in increasing agricultural productivity, as well as food and income security especially for small holder farmers.

As climate change increasingly threatens agricultural productivity worldwide, Uganda's agricultural sector will benefit from crops and animals with enhanced resilience such as those mentioned above. Crops and animals with improved resilience against drought, flooding, poor soil conditions will be critical in a country like Uganda where crop losses can mean health and economic devastation.

Weeds and crops compete for water, nutrients, and sunlight, hindering crops from receiving enough of these necessities. The result is stunted growth of crops and consequently low yields. Unfortunately, weeding itself is hectic, time consuming and crops can themselves be destroyed in the process of weeding. However, genetically modified for herbicide tolerant crops provide an opportunity to apply specific herbicides, killing the weeds but not the crops. Herbicide tolerant soybean, canola, maize, cotton etc. have been widely adopted in many countries. Herbicide tolerance allows farmers to save money and time from reduced herbicide sprays. Saved income can be used to purchase nutritious food to supplement the diet and attend to other basic needs.

Genetic engineering has allowed new options for improving the nutritional value of foods. Soybean and canola producing higher proportions of healthy oils have been developed. 'Golden rice' genetically engineered to produce more beta-carotene (which the body uses to make vitamin A) has received regulatory approval in a number of countries. Crops like sorghum, maize and in Uganda, banana, cassava and sweet potato have been improved (biofortified) to produce higher levels of beta-carotene. Other transgenic crops in development include soybeans with higher protein content, potatoes with more nutritionally available starch and an improved amino acid content, and beans with more essential amino acids. Such crops will be important in preventing crippling blindness and death from Vitamin A Deficiency (VAD) in people who have nutritionally inadequate diets. They will also be key for addressing malnutrition, improving food quality and ultimately boosting food security.

Aflatoxins are a serious food safety threat around the world. They are toxic chemicals that can cause death through cancer and liver diseases to both animals and man. Biotech crops such as insect resistant maize are also protected against mold which can otherwise grow in the perforations created by pest damage and produce toxins like aflatoxins that threaten and undermine food safety. Aflatoxins that contaminate food are also controlled by using *Arspergillus flavus* that does not produce aflatoxins but can out compete its aflatoxin-producing relatives. The most promising strategy currently being used to reduce preharvest contamination of crops with aflatoxin is to introduce non-aflatoxin (biocontrol) *A. flavus* into the crop environment (Ehrlich K. C., 2014). Microorganisms are also being used as preservatives to enhance the shelf-life of food stuffs.



Fresher produce genetic engineering can result in improved keeping properties to ease transportation of fresh produce, giving consumers access to nutritionally valuable whole foods and preventing decay, damage, and loss of nutrients. Transgenic fruits e.g. tomatoes with delayed softening can be vine-ripened and still be shipped without bruising.

Research is underway to develop foods that taste better and remain fresh for longer. Flavor can be altered by enhancing the activity of plant enzymes that transform aroma precursors into flavoring compounds. Also, by turning off the gene(s) responsible for browning, apples and potatoes that maintain their fresh color for longer have been developed. Such foods are more appealing to consumers and have benefits for farmers too since they can be stored for longer as they do not bruise easily. This eases longer term storage and transportation without compromising quality and reduces food waste while also enhancing food security.

Recommendations

Despite noteworthy progress in biotech research, the establishment of functional biosafety regulations in Uganda has been sluggish, and arriving at concrete commercialization decisions remains largely difficult. Modern biotechnology will be a useful and complementary (to conventional systems) tool in improving agricultural production food security and quality in Uganda. However, to effectively maximize the potential of modern biotechnology to transform agriculture, we recommend the following:

- Establishment of functional biosafety systems that are science-based, flexible and responsive to the needs of Ugandan farmers while ensuring safety of this technology. This calls for, among other things, the enactment of requisite enabling regulations such as the Genetic Engineering Regulatory Act (GERA), 2018.
- Prioritize and facilitate coherence and optimal interaction among different actors in the biosafety regulatory system. This will ensure that decisions are predictable resulting in flexible, efficient regulatory approaches and implementation, and ultimately judicious and regulated access to technology.
- Consistent investment in capacity development. Increased and sustained government funding for agricultural biotechnology is fundamental. Priority areas e.g. research and development, infrastructure etc. that will enhance competitiveness and achieve greater positive impact should prioritized for funding.

Acknowledgements:

The contribution of teachers and lecturers including

Prof. Sylvester Katuromunda[2]
Mr. Abbas Kisambira[4]
Mr. Andrew Zirintusa[5]

who guided the students during essay writing is highly appreciated. This Policy Brief was supported with funds provided under the NextGen Cassava Project. It is extracted from essays written by students in the biotech essay competition over the past six consecutive years since 2013. We are also grateful to the leadership and team members of our partner organizations.

Citation: Muhumuza JR, Kimbugwe A, Wanyama G, Babirye K, Serunkuma B (2019) Biotechnology for agricultural transformation and sustained food security in uganda. Uganda Biosciences Information Center (UBIC), NARO.

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