Grace Finnerty
Cotter High School
Winona, Minnesota
Uganda, Food Insecurity

# Bananas on the Brink: Struggles and a Solution to Save Uganda's Staple Food

While Uganda is an ethnically diverse country, many Ugandans share a dependence on bananas as a staple crop. ("Uganda" 2022). The annual per capita consumption of bananas in Uganda is 600 pounds. This figure is particularly remarkable when compared to other countries. In the United States, the annual per capita consumption of bananas is 27 pounds (Cerier 2021). Even as bananas remain a central part of Ugandan life, the crop is threatened by banana wilt, a bacterial disease that destroys banana trees, and rural families are at risk for Vitamin A Deficiency (VAD) due to the lack of Vitamin A nutrients in staple crops. Ugandan scientists have developed genetically modified (GM) bananas that aim to combat these issues. One GM banana is resistant to banana wilt and the other is fortified with Vitamin A to reduce Vitamin A deficiency in rural Uganda. Distribution of these varieties will require the passage of the Biosafety Bill and support from governmental, educational, and NGO institutions for the distribution of the banana.

Surrounded by mountains, with the Kenyan Highlands to the East and the Rwenzori Mountains to the West, Uganda is a tropical plateau in East Africa. Uganda is intersected by rivers, including the Nile River, and is dotted with lakes. ("Uganda Geography, Maps, Climate, Environment and Terrain from Uganda | - CountryReports" n.d.) Uganda shares Lake Victoria, the second largest freshwater lake in the world, with Kenya and Tanzania. The plentiful water resources in Uganda create a rainy climate and fertile land ("Uganda" 2022).

The governing body that oversees this fertile land has the same basic structure seen in many democratic countries, with executive, legislative, and judicial branches. The president is the head of state and there is a prime minister to support the president. Despite its democratic structures, however, Uganda has an economic freedom score of 54.2, placing it in the mostly unfree category ("Uganda Economy: Population, GDP, Inflation, Business, Trade, FDI, Corruption" n.d.). This is primarily because of corrupt and dysfunctional institutions. The Heritage Foundation reports that the presidential elections "were tainted by government intimidation and the arrest of the principal opposition leader" ("Uganda Economy: Population, GDP, Inflation, Business, Trade, FDI, Corruption" n.d.). Uganda's constitution has been modified several times to keep President Museveni in power since 1986. Despite these problems and Uganda's economic freedom score placing below the world average, Uganda still scores above the regional average. President Museveni "is widely credited with restoring relative stability and economic growth to Uganda" ("Uganda Economy: Population, GDP, Inflation, Business, Trade, FDI, Corruption" n.d.). Uganda's regional appeal has resulted in a large refugee population, mostly coming from conflict regions near Uganda. Agricultural advancements present a tremendous opportunity for both native Ugandan farmers and refugees.

Of the 44.3 million people who live in Uganda, the majority, 73%, live in rural areas ("The Uganda National Household Survey 2019/2020."). Since the majority of people live in rural areas, agriculture is a key part of the Ugandan economy. Agricultural land makes up 71.2% of the country ("Uganda" 2022) and "80 percent of Ugandans grow at least some of their own food, and depend on their own harvests for their livelihood." (Doucleff 2013) Many farmers practice subsistence agriculture, growing food for their families and perhaps selling some of their produce locally. Ugandan farmers grow staple crops such as matooke bananas, cassava, and maize ("Uganda Geography, Maps, Climate, Environment and Terrain from Uganda | - CountryReports" n.d.). This subsistence lifestyle and dependence on a small number of staple crops requires farmers to be dependent on environmental factors outside of their control. Poor and unpredictable growing conditions can be devastating to farmers, especially since many farmers lack support, such as crop insurance, in times of need. (Segawa 2022).

Insecure and difficult conditions result in 41% of the population living in poverty (“Learn Facts about Uganda, Poverty, and Development” n.d.).”

In addition to environmental stresses, a large dependent population is also putting stress on farmers' ability to provide for their families. Uganda’s fertility rate is “among the world’s highest at close to 5.5 children per woman” (“Uganda” 2022). This results in a population where 48.21% are aged 0-14 years. (“United States - Age Dependency Ratio (% Of Working-Age Population) - 2022 Data 2023 Forecast 1960-2020 Historical” n.d.). Despite limited resources, communities are working to provide young people a better education in hopes of improving futures. UNICEF reports progress in educational outcomes in recent years, but there is still a long way to go. “The secondary level enrolment of the richest 20 percent of the population (43.1 percent) is five times that of the poorest 20 percent (8.2 percent).”(“Education”) Poverty and a lack of education, especially in rural communities, illustrate the need for alleviating agricultural issues in order to support families.

Within rural farming families, bananas are a staple crop. Making up the largest cultivated area among staple food crops (Cerier 2021), "bananas are the main source of starch in Uganda ... [and] almost every home has banana trees,” writes Calestrous Juma, who studies science and technology policy at Harvard University (Doucleff 2013). Bananas are eaten in a variety of ways: raw, prepared by cooking or drying, or fermented for beverages (Cerier 2021). Bananas are a central part of Ugandan culture and diet. Bananas provide “30 to 60 percent of daily caloric intake throughout the whole East African region (Conrow and Lynas 2017)” and an estimated 75% of Ugandan farmers grow bananas (Mbabazi et al. 2019) Due to such significant dependence on the banana crop, Ugandan farmers are vulnerable to banana wilt, a bacterial disease, and Vitamin A Deficiency (VAD), since bananas are not rich in this nutrient.

Banana wilt, also called Banana Xanthomonas Wilt Disease (BXW disease), “has been cutting banana yields by 30 to 50 percent in some regions of Uganda” (Doucleff 2013). Economic losses for Uganda due to banana wilt have been estimated to be between “US$ 200 and 295 million a year” (Ocimati et al. 2019). The current cultivation practices used to control the disease include cutting off the male buds on the banana tree to prevent the spread of the disease by insects, removing infected trees, and sterilizing farming tools (Shimwela et al. 2016a,b). However, these practices only help control the disease, they do not eliminate the problem of disease, so farmers are still suffering crop losses. Further, “the adoption of these practices is inconsistent as these techniques are labor intensive and may enhance disease spread if cutting of plants occurs during the rainy season” (Shimwela et al. 2016a,b). Even if farmers were able to consistently use disease control techniques, *Xanthomonas campestris*, the bacteria responsible for banana wilt, remains in the soil for 615 days, which makes it impossible for a farmer to use infected land for nearly two years (“Survival of Xanthomonas Campestris in Soil.”1974) Vitamin A deficiency is also a significant issue in Uganda. Priver Namanya Bwesigye, a plant biotechnologist at the National Agricultural Research Organisation in Uganda (NARO) writes that in Uganda “30% of people do not get enough of [Vitamin A], [and] the World Health Organization classifies the situation as grave if 15% of the population is deficient” (Mwesigwa 2017).

Some suggest that the issues of banana wilt and Vitamin A should be addressed through sanitation practices and diversified cropping systems. Anti-GMO organizations encourage farmers to transition to crops such as millet, amaranth, and carrots to reduce the risk of both wilt and Vitamin A deficiency (“The GMO Bill Puts the Future of Uganda under Threat: Slow Food Offers a Different Way Forward” 2017). While it is wise to diversify cropping systems, it is unrealistic to expect farmers to transition away from bananas, a staple fruit that is embedded in the food and culture of rural communities. Additionally, banana wilt is a much more powerful disease than some may assume. According to NARO, “Bacterial wilt could destroy up to 90 percent of all bananas in Uganda if it’s not controlled (Bendana 2019).” Given the difficulty in controlling this disease, avoiding bioengineered resistant bananas would mean accepting a loss in production. Given the fact that only

40% of children aged 6-23 months were meeting the minimum meal frequency in Uganda and the high level of poverty in the country, Ugandan farmers cannot afford to lose any fruit production (Kozicka et al. 2021). A Vitamin A fortified GM banana was identified as the best way to combat Vitamin A deficiency. The alternative, asking mothers to purchase Vitamin A supplements, is impractical since many lack the resources to do this (Afedraru 2018).

However, some additional concerns do remain: Does the arrival of GM bananas mean a loss in traditional banana varieties? Will GM bananas result in harmful agricultural practices? And are GM bananas safe? Firstly, the GM banana does not inherently mean the loss of traditional varieties and will likely not decrease the already existing diversity in banana varieties. The GM bananas were developed using popular varieties of bananas (Tripathi et al. 2017; Mbabazi et al. 2019) and the new GM bananas would likely be used by farmers already familiar with these varieties. Additionally, most Ugandan farmers already grow a small number of preferred varieties, meaning that the introduction of a GM banana is unlikely to result in a decrease in genetic diversity. Furthermore, GM bananas do not pose a threat to neighboring varieties. “Male and female sterility of most edible cultivars, lack of cross fertile wild relatives, and clonal propagation of banana all contribute to no risk of gene flow from transgenic banana plants to either wild or cultivated plants” (Tripathi et al. 2017).

Secondly, the use of GM bananas does not mean the abandonment of good and healthy farm practices. While herbicide-resistant GM crops in the United States have resulted in changed spraying practices (Jenkins 2017), there is no reason that Ugandan farmers should change healthy farming practices with the arrival of the GM banana. The only practices that will change are those aimed at controlling banana wilt. Farmers will no longer need to cut down infected trees, bury them, and disinfect their tools. Further, there should be no fear of corporate interference in Uganda due to GM bananas. Bananas grow from clippings, “so there's little risk of private corporations controlling the seed supplies for GM cassava or banana, like they do for corn and soybeans in the U.S. (Doucleff 2013)” The Ugandan scientists developing the GM banana also want to give the GM banana to Ugandan farmers for free because the project was always meant to be by Ugandans and for Ugandans (Doucleff 2013).

Thirdly, there is abundant evidence that genetic engineering is not inherently unsafe and the GM banana is no exception to this. The National Academy of Sciences states that “To date, no adverse health effects attributed to genetic engineering have been documented in the human population (Hamilton Kennedy 2016).” “The American Academy for the Advancement of Science agrees: “Contrary to popular misconceptions, GM crops are the most extensively tested crops ever added to our food supply” (Jenkins 2017). So, when a GM crop is made available, that was developed expressly for improvements in the lives of small-scale farmers, it is important that farmers have access to that crop. Motlantsi Musi, a South African farmer, warned “Americans beware…whenever you say no to GM technology, you are suppressing Africa (Hamilton Kennedy 2016).”

In order to make a banana resistant to banana wilt, scientists needed to use genetic engineering because “the sterile nature of the crop and the lack of resistance in *Musa* germplasm make improvement by traditional breeding techniques either impossible or extremely slow” (Tripathi et al. 2017). The Hypersensitive Response Assisting Protein (Hrap) and Plant Ferredoxin Like Protein (Pflp) genes were taken from sweet pepper and used in the banana since they had been found to be successful at providing defense against bacterial disease in plants such as tomatoes, orchids, and rice. “Sixty five transgenic events were evaluated for disease resistance. Complete resistance to Xanthomonas wilt disease was demonstrated for 11 transgenic events for both mother and progeny crops. Control nontransgenic plants developed disease symptoms and wilted completely” (Tripathi et al. 2014a). Ultimately, two of the successful varieties, Sukali Ndiizi and Nakinyika, were selected. The amino acid sequences of the two proteins used were compared to known allergens and toxins. When no similarity was found between the proteins used and the toxins and allergens in the databases, the proteins were confirmed to be

safe for human consumption.

The Vitamin A fortified GM banana was developed using genes with “beta–carotene from non-edible banana varieties from Southeast Asia” (Afedraru 2018) (Mbabazi et al. 2019). “There were initially 800 [banana] lines at NARL confined field trials. The team selected two lines with traits similar to those of the conventional variety but also with enhanced vitamin A properties” (Afedraru 2018). The two varieties selected were M9 and Nakitembe. The M9 variety was identified as being particularly advantageous at low altitudes, while the Nakitembe would be better at high altitudes. The likeability of the bananas was assessed through a blind sensory test comparing the new GM bananas with Non-GM bananas. “80% of the panelists rated fruit from one of the “M9" PVA-biofortified lines as the most preferred (Mbabazi et al. 2019).”

Both of these GM banana varieties hold tremendous promise for Ugandan farmers. One variety was found to be resistant to the deadly banana wilt disease and the other enhanced the banana’s ability to provide life-saving Vitamin A to rural Ugandans. These bananas “were generated in Uganda, by Ugandan scientists, from Ugandan varieties, and for the benefit of the Ugandan people” (Mbabazi et al. 2019). However, there remain barriers to the safe distribution of this new crop. While a Genetic Engineering Regulatory Bill (formerly called the The National Biotechnology and Biosafety Bill), which provides for the safe release of GMOs through a regulatory process, has passed the Ugandan parliament twice, the President has failed to sign the bill, despite indications of support.

The language of this proposed bill would establish biosafety oversight committees, regulations for testing, and a process for the safe release of new GM crops. In the bill, the safety of GMOs is ensured by two committees, an institutional committee, and a national biosafety committee. The institutional committee would be composed of experts from the institution where the development of the GMO is to take place. This committee must approve applications for each consecutive level of testing: contained or greenhouse testing, confined field testing; and testing for full safety and risk assessment. Applications for testing would include information such as the location of experimentation, the intention of the experiment, the protective measures taken, and the associated risks. Once these tests have been performed, the researchers may apply for the new crop to be released to the public. The application for release is sent to the national biosafety committee, which is composed of scientific experts from Uganda. The national biosafety committee would then make a recommendation to the Uganda National Council for Science and Technology. A decision, informed by the Biosafety committee’s review, will then be made by the Uganda National Council for Science and Technology about the release of the GMO. This regulatory process gives the Ugandan government authority over which GMOs to allow inside the country and prevents unwanted outside corporate interference in the food system. The bill also contains protocols for the unintentional release of GMOs and GMO inspectors. The bill provides an effective structure for regulating GMOs. The prosperity gained through the GM bananas will likely make up for the financial burden of paying for this regulation in time. To offset the initial cost of the program, the government may need to reexamine its budget, borrow from other countries, or request financial assistance from international organizations. (The National Biotechnology and Biosafety Bill)

It is critical that Uganda passes this bill. The bill has received support from the parliament twice, once in 2017 and again in 2018, and some think that it is only a matter of time before Uganda passes the bill. As Erostus Nsubuga, chief executive officer and chairperson of Agro-genetic Technologies predicts “Uganda will pass the biotechnology law, especially after Kenya starts harvesting Bt maize, Uganda will see the benefits of adopting these technologies and follow suit” (Agaba 2021). To accelerate the adoption of this technology, outreach needs to be done within political circles and communities. The institutions that have developed the GM plants could work with biotechnology institutions in Kenya to develop a report on the success of GMOs in Kenya since Kenya has allowed GM crops (Andae). This report could be given to the parliament in an effort to retable the bill

and could be given to the president in an effort to convince him to sign the bill. However, parliamentary support was never the problem, and the President's hesitancy likely stems from his worry about how farmers and the public would respond to the bill. In order to settle the hesitancy of both the President and the people, Ugandan scientists must be at the forefront, sharing their knowledge, motivations, and safety procedures. There is no need for non-Ugandans to be involved in this deliberation and discussion. Ugandan scientists developed this technology for their neighbors. Adoption and regulation of this technology should be decided based on the expertise of the scientists and the desires of communities. Scientists can work with agricultural government organizations to organize feedback and support. Ultimately, if popular support is as high as studies have found, where "80 percent of farmers are willing to consume GMOs," this could serve as a public petition for the bill (Conrow and Lynas 2017).

If the Genetic Engineering Regulatory Bill is passed, distribution of the GM bananas will be the next challenge. The developers plan to give the banana plants to Ugandans for free, so the cost to farmers will not be an issue. Plants could be distributed through governmental institutions and locally, among neighbors. Initially, Uganda's NARO, which has seventeen offices throughout the country, could work with the Ministry of Agriculture, Animal Industry, and Fisheries' Banana Livelihood Diversification Project. Between these two governmental organizations, many farmers could receive plants, but, to continue the distribution of plants, local cooperatives and neighbors can step in. The researchers who developed the Vitamin A fortified banana suggested a clever strategy involving "innovative farmers." These innovative farmers will "be given suckers [banana cuttings]. For every sucker, they will be asked to give away two suckers to neighbors who in turn will be asked to give away two suckers for each one received under the scheme." Local farmer cooperatives, such as those organized by Farm Africa, can also help facilitate this distribution and can help farmers receive the plants they need (Farm Africa). Care for GM bananas should be no different than care for Non-GM bananas, so new cultivation training is not required, but it is still important to inform farmers about how to properly practice biosafety with new GMOs. Each farmer who wishes to start growing GMOs could receive training at one of the government offices. GMO inspectors will also help to ensure the safe use of the new crops.

By distributing wilt-resistant and Vitamin A fortified bananas, Uganda will be able to enhance food security and lessen the rates of VAD throughout the country. Like strong roots support a tree, enhanced food security in rural Uganda can support the entire nation. Farmers who are no longer losing significant portions of their harvest will see more success and will be better able to support their families, due to increased incomes. This can have impacts for generations to come. Families may now have the resources to send their children to school. Children who are well fed and not suffering from the debilitating effects of VAD will be better able to focus in school. Once children receive an education, it is well established that they will be able to gain a better livelihood. Additionally, by developing a regulatory framework for public access to GMOs, Uganda will be prepared to accept GMO crops that are resistant to the impacts of climate change (Wetaya).

Effective release of Wilt-Resistant and Vitamin A fortified bananas will have a tremendously positive impact in rural Uganda, allowing farmers to better provide for their family's health and well-being by eliminating crop losses due to banana wilt disease and by reducing Vitamin A deficiency. Uganda's government must pass the Genetic Engineering Regulatory Bill, utilize government stations, and support farmers to safely distribute these important plants.

Works Cited

Afedraru, Lominda. "Ugandan Scientists Poised to Release Vitamin-Fortified GMO Banana." *Alliance for Science*, 30 Oct. 2018, https://allianceforscience.cornell.edu/blog/2018/10/ugandan-scientists-poised-release-vitamin-fortified-gmo-banana/.

Agaba, John. "GM Crops: Kenya and Nigeria Progress as Uganda Falters." *Alliance for Science*, 24 Aug. 2021, https://allianceforscience.cornell.edu/blog/2021/08/gm-crops-kenya-and-nigeria-progress-as-uganda-falters/.

Andae, Gerald. "Kenya Approves GMO Cassava for Farming after Years of Research." *Business Daily*, 24 June 2021, https://www.businessdailyafrica.com/bd/news/kenya-approves-gmo-cassava-for-farming-after-years-of-research-3448024.

Bendana, Christopher. "Uganda Faces Heavy Losses without GMO Banana, Economist Warns." *Alliance for Science*, 25 Nov. 2019, https://allianceforscience.cornell.edu/blog/2019/11/uganda-faces-heavy-losses-without-gmo-banana-economist-warns/.

Cerier, Steven. "Uganda's Costly Dithering on GMOs." *Genetic Literacy Project*, 15 Sept. 2021, https://geneticliteracyproject.org/2021/09/15/ugandas-costly-dithering-on-gmos/.

Conrow, Joan, and Mark Lynas. "Uganda Biotech Law Opens Door to Disease-Resistant GMO Crops." *Alliance for Science*, 9 Oct. 2017, https://allianceforscience.cornell.edu/blog/2017/10/uganda-biotech-law-opens-door-to-disease-resistant-gmo-crops/.

Doucleff, Michaeleen. "Will GMOs Help Protect Ugandan Families Against Hunger?" *NPR*, 25 June 2013, https://www.npr.org/sections/thesalt/2013/06/17/192789454/will-gmos-help-protect-ugandan-families-against-hunger.

"Education." n.d. Accessed August 22, 2022. https://www.unicef.org/uganda/what-we-do/education.

*Farm Africa*. https://www.farmafrica.org/. Accessed 24 Mar. 2022.

Hamilton Kennedy, Scott. *Food Evolution*. 2016.

Kozicka, Marta, et al. "Reassessing the Cost-Effectiveness of High-Provitamin A Bananas to Reduce Vitamin A Deficiency in Uganda." *Frontiers in Sustainable Food Systems*, vol. 5, 2021, https://www.frontiersin.org/article/10.3389/fsufs.2021.649424.

"Learn Facts about Uganda, Poverty, and Development." *Opportunity International*, https://opportunity.org/our-impact/where-we-work/uganda-facts-about-poverty. Accessed 22 Mar. 2022.

*MAAIF Agricultural Extension Services - Ministry of Agriculture, Animal Industry and Fisheries*. 13 Oct. 2019, https://www.agriculture.go.ug/maaif-agricultural-extension-services/.

Mbabazi, Ruth, et al. "Pro‐vitamin A Carotenoids in East African Highland Banana and Other Musa Cultivars Grown in Uganda." *Food Science & Nutrition*, vol. 8, no. 1, Dec. 2019, pp. 311–21, https://doi.org/10.1002/fsn3.1308.

Mwesigwa, Alon. "Can a GM Banana Solve Uganda's Hunger Crisis?" *The Guardian*, 12 Dec. 2017, https://www.theguardian.com/global-development/2017/dec/12/gm-genetically-modified-banana-uganda-hunger-crisis.

*NARO Ug | National Agricultural Research Organisation*. https://naro.go.ug/. Accessed 30 Mar. 2022.

"National Biosafety Committee (NBC) Inspects NARO's Confined Field Trials of Transgenic Bananas with Enhanced Levels of Pro-Vitamin A." *National Banana Research Program*, https://www.banana.go.ug/news/70-national-biosafety-committee-nbc-inspects-naro-s-confined-field-trials-of-transgenic-bananas-with-enhanced-levels-of-pro-vitamin-a. Accessed 4 Apr. 2022.

Ocimati, Walter, et al. "The Risk Posed by Xanthomonas Wilt Disease of Banana: Mapping of Disease Hotspots, Fronts and Vulnerable Landscapes." *PLOS ONE*, vol. 14, no. 4, Apr. 2019, p. e0213691, https://doi.org/10.1371/journal.pone.0213691.

Paul, Jean-Yves, et al. "Banana21: From Gene Discovery to Deregulated Golden Bananas." *Frontiers in Plant Science*, vol. 9, Apr. 2018, p. 558, https://doi.org/10.3389/fpls.2018.00558.

Segawa, Nakisanze. "Insurance Lifeline Cuts Risk — If Only Farmers Knew About It." *Global Press Journal*, 4 Jan. 2022, https://globalpressjournal.com/africa/uganda/uganda-agriculture-insurance-program-farmers-knew/.

"Surveying Nutrition." *Centers for Disease Control and Prevention*, 14 July 2020, https://www.cdc.gov/nutrition/micronutrient-malnutrition/projects/uganda.html.

*Survival of Xanthomonas Campestris in Soil.* 1974, https://www.cabi.org/ISC/abstract/19751317367.

*The Banana Livelihood Diversification Project (2015) - Ministry of Agriculture, Animal Industry and Fisheries*. 3 May 2019, https://www.agriculture.go.ug/the-banana-livelihood-diversification-project-2015/.

"The GMO Bill Puts the Future of Uganda under Threat: Slow Food Offers a Different Way Forward." *Slow Food International*, 19 Dec. 2017, https://www.slowfood.com/gmo-bill-puts-future-uganda-threat-slow-food-offers-different-way-forward/.

*The National Biotechnology and Biosafety Bill*. 18, 2012,

https://biosecuritycentral.org/static/57ee3011134b425e50c1e24df4573815/biotechnology___biosafety_bill_

_2012__3_.pdf.

*The Uganda National Household Survey 2019/2020*. Uganda Bureau of Statistics (UBOS), 2021.

Tripathi, Leena, et al. "Genetically Engineered Bananas Resistant to Xanthomonas Wilt Disease and Nematodes." *Food and Energy Security*, vol. 6, no. 2, May 2017, pp. 37–47,

https://doi.org/10.1002/fes3.101.

"Uganda." *The World Factbook*, Central Intelligence Agency, 8 Mar. 2022, https://www.cia.gov/the-world-factbook/countries/uganda/#introduction.

*Uganda Economy: Population, GDP, Inflation, Business, Trade, FDI, Corruption*. //www.heritage.org/index/country/uganda. Accessed 23 Mar. 2022.

*Uganda Geography, Maps, Climate, Environment and Terrain from Uganda | - CountryReports*. https://www.countryreports.org/country/Uganda/geography.htm. Accessed 22 Mar. 2022.

*Uganda: Government*. https://globaledge.msu.edu/countries/uganda/government. Accessed 22 Mar. 2022.

*United States - Age Dependency Ratio (% Of Working-Age Population) - 2022 Data 2023 Forecast 1960-2020 Historical*. https://tradingeconomics.com/united-states/age-dependency-ratio-percent-of-working-age-population-wb-data.html. Accessed 23 Mar. 2022.

Wetaya, Richard. "Uganda Edges toward Accepting Biotechnology as Climate Challenges Mount." *Alliance for Science*, https://allianceforscience.cornell.edu/blog/2021/10/uganda-edges-toward-accepting-biotechnology-as-climate-challenges-mount/. Accessed 22 Mar. 2022.