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Ethiopia, Factor 1: Plant Science

Ethiopia: Improving the Technology for Plant Science Utilizing CRISPR-Cas9

Finding a way to feed nine billion people by 2050 is a major challenge for farmers, ranchers, and corporations involved in agriculture, and it will affect everyone in the world. Every person who eats food should be concerned. As of the year 2000, 37% of Earth's land was agricultural and 11% of that land was used to grow crops. Results show that 1.8%-2.4% of agricultural land will be lost due to urban expansion by 2030. In Africa, most land that will be lost is twice as productive as national averages in its crop yields (The Habitable. Web). This loss of land needs to be considered, because one of every eight people go to bed hungry every night. "*Hunger and malnutrition have devastating consequences for children and have been linked to low birth weight and birth defects, obesity, mental and physical health problems, and poorer educational outcomes." -Marian Wright Edelman* `

A typical farm family in a rural area of Ethiopia has about five people in the family: a mother, father, and three children. The woman usually leads the household. Ethiopians eat food that they grow and eat a communal supper. These suppers consist of families from the community coming together, where each family brings a different dish. They grow corn, teff, wheat, barley, sorghum, and millet (PAA. Web). They also eat plantains and enset. Some do not eat pork because of their religious beliefs. Many people in Ethiopia do not have access to safe water. In 2005, 47% of males and 33% of females, ages six and older have some education.Consider this important because lack of education is equal to not understanding how new genetic advances will help them.

Also in 2005, 62% of households did not have a toilet in their house, and 86% of households did not have access to electricity (ETHIOPIA TREND. Web). This is important to know, because Ethiopians do not have access to safe health care or safe water. This limits their hygiene which has a great effect on their health. They cannot be productive to store their crops in a safe place if a problem were to occur. They would not have access to running water, air conditioning, refrigeration, and will limit communication accessibility.. Most farms are less than 2 hectares (a hectare is equal to 2.47 acres). Agriculture related jobs make up 85% of employment in Ethiopia. Soil erosion, depletion of organic matter in the soil, and plant-nutrient supply make up the top problems for agriculture in Ethiopia (Sustainable. Web).

Plant science affects the productivity of agriculture by improving drought resistance in crops and increasing crop yields. Some families export their crops and goods for money, while others grow it to feed their family, and some families do both. Plant science plays a big role in food availability and quality, because the science is evolving to be able to change the DNA of any crop that can produce better quality of food faster and with less rainfall. Improving plant science can help fix the problem of Ethiopians receiving enough food with adequate nutrition because of

the amounts of proteins in food. Also, finding a way to overcome the drought using genetics in the DNA of the crops would help feed Ethiopians with good nutrition.

The technology used in plant science is ahead of its time, with Ethiopia suffering because of their lack of technological advances. This situation does put them at a further disadvantage in growing crops successfully. The soil is sometimes eroded because of the land and soil type. This problem is starting to be solved with the use of scientists working on new technologies in other countries.

Plant science is measured by the amount of soil eroded, the production of the yields of the crop, and the resistance to disease and drought. This can be measured in inches, feet, acres (or hectares), and the number of seeds/fruits produced per crop. Also using historical graphs and data charts can help track the improvement of this factor.

Improving crop yields and disease/drought resistance in crops would increase the amount of food available to the people. Creating a drought resistant crop that can produce increased yields and be more plentiful in its production will help the people of Ethiopia, because rural families grow their own crops, partially to sell for money and partially to feed their communities. They have an average annual rainfall that is ⅓ the amount of rainfall that Kansas gets annually. They receive about 1 foot, 8 inches of rainfall. The rainfall will help preserve the environment by not ruining the soil, and the crops planted can help keep the soil in place. This will help farmers be able to produce food more rapidly. Poverty will lessen because farmers will be able to sell their crops for profit.

The climate is important to consider when growing crops for food and money. Growing plants can also be tough when the population is growing rapidly. Another issue for growing successful crops is water scarcity, which is already an issue for farmers trying to grow and maintain food, because they depend on the rainfall (Sustainable. Web). Less than 10% of the land today is being irrigated (Ethiopia-Project. Web). Urbanization is not a big factor affecting Ethiopia due to the amount of rural land area where people live there.

A way to improve plant science in the future and to keep improving crop yields and crops resistant to drought and disease is to use CRISPR-Cas9. CRISPR is an acronym for “clustered regularly interspaced short palindromic repeats.” This new technology (currently being tested) enables geneticists and medical researchers to edit different sections of the genome by removing, adding, or altering sections of the DNA sequence. It is faster and more economical, accurate, and more predictable than previous techniques of editing DNA and has a wide range of potential applications.

“CRISPR experiments can be designed to leave no fingerprint, or exogenous DNA in the plants. From a regulatory standpoint, the USDA should accept (rice) plants with small deletions or mutations in their genomes as safe for field tests,” says Dr. Yang, associate professor in genetics, development, and cell biology at Iowa State University. In fact, CRISPR was one of the finalists for the Time Magazine for “Person of the Year,” in 2016 because of its potential for the future. This is ironic, because it is not a person, but is so important that a quality newspaper company would allow CRISPR to compete. “It is the wave of the future for plant breeding,” says Willie Vogt, writer of Farm Industry News magazine from February 2017. Using guide RNA, a small piece of predesigned RNA sequence with a longer RNA scaffold CRISPR-Cas9 will be able to repair damaged genes.

The guide RNA is designed to find and bind a specific sequence in the DNA. The guide RNA has bases that are complementary to the target DNA sequence in the genome. In theory, the guide RNA will only bind to the specific sequence. CRISPR is the gene editor, and Cas9 is an enzyme that acts as molecular scissors that can cut two strands of DNA at a specific location in the genome so that it can be edited. The guide RNA finds the damaged gene, leads the CRISPR-Cas9 to it, then the Cas9 cuts the damaged gene. At this stage the cell recognizes that the DNA is damaged and tries to repair it. Scientists can use this DNA repair machinery to make changes to one or more genes in the genome of a cell (What is. Web). One area where CRISPR could provide amazing benefits is to enhance the protein levels of each plant grown. Eating protein enriched crops could help Ethiopians to build healthier, stronger bodies.

One advantage of using CRISPR-Cas9 is the applicability across a wide range of organisms. Editing for research purposes does not require the same level of stringency as those for therapeutic applications. Also, any plants or animals undergoing genome editing will need to be carefully vetted. The Animal and Plant Health Inspection Services, a part of USDA, is the regulatory body overseeing this use. (GEN. Web)

"While CRISPR works in barley and rice, CRISPR editing in wheat has not worked in our hands," say Dr. Luo. (GEN. Web.) "The Ethiopian phrase '*gebs ye ehil nigus'* means that barley is the king of crops due to its wide range of uses and to emphasize its suitability for preparing many of the known traditional dishes and beverages of Ethiopians. Barley is the fifth most important cereal crop in Ethiopia after teff, maize, sorghum, and wheat." (Revisit. Web.)

"Various barley foods and drinks play an important role in the socioeconomic and cultural life of Ethiopians, but detailed descriptions related to their preparation and their socioeconomic and cultural roles are not well-recorded and documented like most of the Ethiopian cultural foods. Foods such as *ingera*, *kita*, *dabo*, *kolo*, *genfo*, *beso*, *chuko*, *shamet*, *tihlo*, *kinch*, and *shorba* are the most commonly known traditional Ethiopian barley-based foods. These products are prepared from either roasted whole grain, raw and roasted-milled grain, or cracked grain as main, side, ceremonial, and recuperating dishes." (Revisit. Web.)

Researchers are looking for new ways to fight germs like Clostridium difficile, a bacterium that can cause fatal infections in hospitals and nursing homes. They are doing this because resistance to antibiotics is growing in the United States. One option is a "CRISPR pill" that instructs harmful bacteria to self-destruct. It is also being used to craft cheap and simple diagnostic tests. Some scientists are even working to find a way to use CRISPR as an ultra-precise antimicrobial treatment to "specifically kill your bacteria of choice," says food scientist Jan-Peter Van Pijkeren of the University of Wisconsin-Madison. (GEN. Web.)

CRISPR was actually discovered in bacteria. The system is an immune defense bacteria used to fend off invading viruses called bacteriophage. Pijkeren's idea is to use bacteriophage to send a false message to C. difficile, one that causes the bacteria to make lethal cuts into its own DNA. (GEN. Web.)

CRISPR is so appealing in the use of drugs, theoretically because it would be very specific to kill a single species of germ while leaving beneficial bacteria intact. Broad-spectrum antibiotics, kill off good and bad bacteria both, which is not the goal of the antibiotic. In fact, the overuse and abuse of conventional antibiotics is what leads to resistance in the first place.

Another reason CRISPR is so appealing is because, “Advances in CRISPR-Cas9 technology has made genome manipulation accessible for just about any research lab in the world. One method that is especially promising is the use of a DNA-free system to perform genome engineering in plants. In this sort of system, the RNA guide is bound to recombinant Cas9 protein and added directly into cells as a ribonucleoprotein (RNP) complex, with no use of plasmids or other DNA-based expression cassettes,” says Dr. Behlke; M.D., Ph.D., CSO of Integrated DNA technologies.

The national governments are to help fund this project. Also, service organizations, agriculture-related organizations, universities, and other service cooperatives will help fund and donate money for this new technology. International research agencies will be in charge of researching new ways to use CRISPR-Cas9, and find what CRISPR-Cas9 is capable of and what its downfalls are. Since CRISPR-Cas9 is a genetic technology, the DNA would be edited inside of the seeds before the farm families plant them. They will be ready and easy to use. Rural families would be responsible for caring for these crops they have grown, and documenting a day-to-day journal of the growth and development of the plant.

The plant scientists and researchers would travel abroad to help teach the farmers how to maintain and care for the newly edited crops. As for urban families, it is their responsibility, when eating these crops to test if they can see, taste, smell, or feel a difference in the crop, and report it. The production and documentation of these crops should be checked every five years by the average to measure usefulness towards the consumer. If there is a problem they should contact local governments to let the researchers know what the problem is.

The crops should be funded for five years under review by a board of scientists and researchers, checking every month for productivity. They will also look for flaws in the new crop. After five years, if no major problems occur, the funding source would need to change.

In conclusion, the most efficient way to help feed Ethiopian people and lessen poverty for rural farm families is to modernize the technology used in editing the genes of the crops they are growing. The world population is growing at a faster rate than food production is increasing.

Along this note, agriculture land is also being taken, sold, and bought, for the use of urbanization. Ethiopia is plagued by food insecurity, access to safe water, lack of education, and access to health care. Utilizing the new advances in technology that CRISPR has to offer will increase crop production and decrease food insecurity, for not only Ethiopians, but the entire world.

“Modern technology has become a total phenomenon for civilization, the defining force of a new social order in which efficiency is no longer an option but a necessity imposed on all human activity.” -Jacques Ellul.

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