Kathryn Budell
Pius X High School
Lincoln, NE
Kenya, Factor 1

The Kenyan Paradox: Hi-Tech Bio-Improvements to Humble Farming Techniques to Increase Crop Yield and Develop Nutrient Quality

Improving crop yield is a challenge throughout most of Africa, and Kenya presents a unique set of circumstances to complicate the puzzle. Kenya advances a stark set of contrasts that illustrate the pertinent issues – geographical, sociological, and meteorological to name a few. Some of the most notable contrasts are in the weather patterns which affect farm productivity, crop nutrient content, and overall crop yields. With the introduction of innovative bioengineered plants, as well as, practical improvements to increase crop yields, there is hope for the rural Kenyan farmer to bridge the gaps in nutrition and yield to provide more than a subsistent existence.

Kenya is a nation composed of a paradox…two worlds functioning within the same borders. Urban Kenya is fast-paced, cosmopolitan, and is the hub of the entire region of East Africa. The capital of Nairobi, with industry and international organizations sheltered within its borders, has become one of the most prominent cities in Africa. Nairobi has "relatively advanced agricultural and industrial sectors and substantial foreign exchange earnings from agricultural exports and tourism" (Rural Poverty in Kenya).

Rural Kenya, only miles away from the bustling metropolis, paints a completely different picture. This Kenya is sheltered by wooden beams and mud huts. Its people cook their food in primitive ovens. Electricity is minimal in these bucolic areas. Nearly half of Kenyans are "unable to meet their daily nutritional requirements". (Rural Poverty in Kenya) In comparing urban and rural Kenya, these two different pieces of the same society silently pass, one without ever acknowledging the other. Nairobi seems to have disconnected itself from the rest of the country, with its ever growing economy and urbanization. Its populace, dwelling in the urban city, is well-educated and well-fed, while the children being raised in villages in rural Kenya are given a basic education and primitive meals.

Rural Kenya survives on the very basics. There is no electricity in the homes; some children walk an hour to get to school; and their meals consist of rice, white bread, and chapatas, or Kenyan tortillas (Akerman). Most families are subsistence farmers; they grow crops not only to trade in the markets, but food for themselves as well. The people living in rural Kenya face many challenges. These people are more susceptible to disease and health problems than those living in the city. Gastrointestinal issues, bouts of malaria, respiratory infections, cholera, and HIV are common problems striking the residents of shanty towns (Kenyans). There is often no running water, and people live by natural light and kerosene lamps. Often, with the small amount of food they eat each day, they are not getting the nutrients they need to survive. There is a lack of a native subsistence crop that fulfills nourishment needs. These rural families, normally consisting of a father, a young mother, and on average four children, are living on a very minimal income (CIA World Fact Book). Most of these people are illiterate; those that are fortunate enough to go on to be educated generally enjoy an increased status and income in their society. Tribal animosities and feuds mainly from the instigating tribes called Luo and Kikuyu cause a source of considerable conflict inside Kenya (Rural Poverty in Kenya and Tribal Tensions Dim Hope for Kenya). Most people that make up Kenya's poor rural people are men and women such as subsistence farmers called smallholder farmers, herders, farm laborers, unskilled and semi-skilled workers, households headed by women, people with disabilities, and children whose parents or other relatives have died of HIV/AIDS (Rural Poverty in Kenya).

Generally, Kenya has one of the most agreeable climates in Africa. Due to the fact that Kenya is about 5,000 feet above sea level, this moderates temperatures that would be expected to be higher due to

Kenya's latitude (Kenya Season and Climate). However, in recent times, "changing global weather patterns make transitions between rainy and dry seasons unpredictable" (Kenya Season and Climate), thus adding a degree of climate uncertainty that may affect the typical rural Kenyan. During the months of December through February, the dry seasons occur (Kenya Season and Climate). This is exemplified through the average of 84 degree (Fahrenheit) weather and hot, dry air. March through May is the rainy season. These months are illustrated by the average temperatures ranging from 73 through 86 degrees (Fahrenheit) and very cool nights (Kenya Season and Climate). There is heavier rain during this March to May period. The months from June through November are the in-between months, with rain appearing periodically and the dry air coming in as well. These lengthy arid seasons may result in the failing of crops and the overall decrease in crop yield.

Rural Kenyans, through the efforts of scientific advances with collaborators around the globe, have an opportunity to move beyond subsistence cropping. They have the chance to increase their crop nutrient values as well as yields in order to change their family dynamic. First, with the aid of a certain bioengineered root, the cassava plant, they will be able not only to increase their harvest of crops, but they will also be able to nourish themselves with this plant fortified with the vitamins and minerals they need to survive. Second, with the adoption of different cropping methods imported from other areas of the globe, rural Kenyans may be able to increase crop yields to improve their standard of living.

Cassava

The cassava plant is currently the sixth most produced crop in terms of global production, and is "the staple for millions of people in the poorest and most negligible regions of the world" (Cassava). This plant produces roots that, when eaten, give a wide amount of carbohydrates and vitamin C. The roots can be stored in the earth for up to twenty-four months and not deteriorate (Cassava). The cassava plant is perennial, and thus the labor impact is minimal as there is no need to replant the cassava year after year. The cassava root is very hardy and grows well in arid land where the soil is low on nutrients, where cereals and other crops cannot grow (Cassava). This resilient nature makes it a good crop to grow in the dry seasons of Kenya. Every part of the cassava plant is nutritious. The root is not the only thing that is eaten; its leaves are commonly eaten as a green vegetable, which gives an easy source for vitamins A and B (Cassava). While the cassava root has many desirable qualities to it in its raw form, there are a few points of caution in its use.

Cassava is highly contaminated in secondary metabolic toxins called cyanogenic glycosides. This causes some disadvantages in the production of this crop, seeing that, when not properly prepared, it is poisonous. There are processes that the growers of cassava undergo so that the poisons are removed prior to consumption (Cassava). While there are researchers trying to breed a non-poisonous variety of cassava, farmers prefer the toxic type (Cassava). The toxic cassava wards away pests and creates its own kind of pesticide and herbivory.

It is estimated that 70 million people rely on cassava for their uncomplicated food (HarvestPlus: Cassava). Although it is a staple in many rural poor homes, it does not provide a broad spectrum of nutrients. While the native cassava plant is fortified with vitamins A, B, and C as well as carbohydrates, it is still lacking in nutritional value. There is not much other nutritional value in cassava. Cassava is poor in protein. It is also not very filling. There are zero milligrams of cholesterol in raw cassava and no saturated fats. It is very low on any other vitamin and mineral. It has less than one percent Daily Value in fats and two percent Daily Value in proteins.

Cassava still has many positive things to it in its raw state, but there are still many disadvantages to it. A group of researchers are working internationally not only in the United States, but also with governments

and Third World countries to create a bioengineered cassava plant infused with the nutrients needed that were once absent in the root and discard the negatives from poisons and post-harvest deterioration.

BioCassava Plus

BioCassava Plus is a program committed to redesigning the raw cassava plant and bioengineering it to be rich in nutritional value (BioCassava Plus). The goals BioCassava Plus, which is ultimately funded by the Gates Center, hopes to achieve with the cassava root are to be able to inject enhanced qualities of vitamins A and E, zinc, iron, proteins, as well as reduced quantities of toxins with delayed post-harvest deterioration (BioCassava Plus). They work alongside many Third World African and South American countries to research their work with the cassava root. BioCassava Plus has asked that the University of Nebraska-Lincoln help them achieve this goal by having them sub-contract BioCassava Plus and their undertaking the bioengineering of the cassava root. Their strategy is to "manage cassava in a manner that ensures subsequent availability and accessibility at an affordable cost to African farmers and consumers who will benefit from nutrition-enhanced cassava" (BioCassava Plus). The University of Nebraska-Lincoln has agreed to contribute its expertise to this program to create a new, bioengineered cassava plant that can be the answer to the malnourishment troubles of Kenya and other sub-Saharan African nations. Currently, BioCassava Plus has partnered with the Gates Foundation, the University of Nebraska-Lincoln, the Kenya Agricultural Research Institute, and the Kenyan government to achieve these studies on a root that could be able to eradicate the challenge of ending hunger in Kenya.

BioCassava Plus organized seven objectives for the bioengineered cassava plant. Objective Number One was to generate and field test a variation of cassava improved with dry weight and iron (BioCassava Plus). Their other objectives are: to conduct mandatory food and environmental safety calculations and studies for genes and proteins in iron-fortified cassava, recognize demographic, geographic and the health characteristics of the people who are most likely to profit from iron-enhanced cassava and measure the bioavailability of each nutrient (BioCassava Plus). Also to organize the farmers, processors, and the public for the acceptance of the enriched cassava, generate and test a cassava variety in Kenya that is impervious the cassava diseases of mosaic disease and brown streak disease when infused with proteins and iron (BioCassava Plus). BioCassava Plus also plans to conduct necessary bio-safety calculations for the cassava product in Kenya that is resistant to the cassava diseases, and to involve Kenyan scientists in the development of making the transgenic cassava and its institution which will hopefully be effective on the rural Kenyan's diet (BioCassava Plus).

With this bioengineered cassava plant, humans will be able to absorb bio-fortified nutrients such as vitamins A and E and necessary proteins. Also, with the bioengineered resistance to the secondary metabolic toxins, farmers will not need to prepare the root properly in order to get rid of the poisons. This adaptation to the cassava plant will negate the naturally-occurring pesticide and herbivory the farmers approved of, but the advantages of having a nonpoisonous crop that will not need to be properly prepared after harvest outweighs the absence of one natural pesticide or herbivory to keep it growing in the ground. Rural Kenyans can plant the cassava and leave it in the ground for two years without the fear of it deteriorating. Also, with the bioengineered cassava, the root will not decay as easily during post-harvest. These major setbacks to the raw cassava plant will be eliminated with the new, bioengineered cassava root. While cassava is currently an established crop in Kenya, this plant variety could very well be the answer to malnourishment in Kenya and other sub-Saharan countries.

Crop Improvement

The bioengineered cassava plant could be the answer to malnutrition in Kenya, but the question is how to keep the cassava growing and actually increase the yield of cassava and cereal crops. One factor could

very well be the answer: inexpensive nitrogen fertilizer. This fertilizer generated by researchers in Kenya, Tanzania, and Zimbabwe has been able to help produce crops in arid regions where the soil is quite poor.

The Kenya Agriculture Research Institute (KARI) has been working for the last fifteen years on improving the fertilizers needed in the regions of Kenya, Tanzania, and Zimbabwe. Researchers have undertaken the bioengineering of one specific fertilizer called biological nitrogen fixation (BNF) (Mugabe). Because of the densely populated rural areas, Kenyan farmers are moving further and further into less fertile soil and father away from the fertile western plateaus. This causes crops to fail due to the poor soil quality. Even if there are marginal amounts of nitrogen in the arid soil that more and more farmers are sowing on, the new variety of non-expensive fertilizer will improve the quality of the earth that they plant on (Mugabe). An ancillary issue to fertilizer is cost. Some scholars have indicated Biofix technology – where selected Rhizobium strains are more efficient in nitrogen fixing than other conventional methods – may be a solution due to the lower costs of the Biofix solution. (Odame)

Kenya has one of the world's fastest population growth rates (Rural Poverty in Kenya). The capital of Nairobi is not only densely populated, but the rural areas are as well. About 79 percent of Kenya's population actually lives in the rural areas and relies on agriculture for most of its income (Rural Poverty in Kenya). Asia is also likewise, a densely populated area, with most of their overall population living in rural areas. One practice that Asian rural farmers undergo to increase their crop yields is to "prime their seeds" before planting them. The Asian governments that established these practices hope to see improvements in the production of crops, seeing as they implemented the practice for the highly-populated rural areas to see growth and improvement both in their communities and in their crops. In contrast to the highly technical engineering of the BioCassava research, the process of "priming seeds" involves presoaking the cereal crops, either in water or in phosphate fertilizer (Helping Rural Farmers). This practice is quite common in rural Asia, but not as common in Africa. Researchers are working with western Kenyan farmers to make the process bearable by presenting it as an inexpensive commercial method (Helping Rural Farmers). This process has been proven to work in Asia. Likewise, the process of priming seeds should work quite well.

Most sub-Saharan African crops suffer from a weed called the Striga weed. This weed "particularly attacks cereal crops and robs it of nutrients" (Helping Rural Farmers). This weed is quite common in Africa, causing a decrease in crops when it comes to harvest time. The effect the weed causes on crop yield is intense; it causes the poverty of the livelihood of rural farmers (Helping Rural Farmers). The weed plaguing Africa can be eradicated through a naturally-occurring fungus that precisely attacks the Striga weed and kills it, leaving the host completely unharmed (Helping Rural Farmers). This can relieve African farmers from a harmful, common weed that has been plaguing sub-Saharan Africa for decades. Improving crop yield is an essential part to eliminating rural Kenyan hunger. This naturally-occurring fungus might just be the answer to part of the struggle Kenyan subsistence farmers face when trying to improve crop yield.

With the combined help through the naturally occurring fungus that destroys the infamous Striga weed, the Asian practice of priming seeds before planting, and the new inexpensive fertilizer: biological nitrogen fixation, Kenyan farmers can be relieved from minimal crop yields. Priming seeds can ensure the growth of the plant before it even drops into the soil, the fertilizer can ensure that the crops will grow, even in arid soil, and the fungus can ensure that the crop will prosper and keep growing without the fear of the Striga weed and other villainous weeds destroying the crop and the overall yield at harvest. These factors to improve crop yield will prove positive to the already fortifying bioengineered cassava plant as it will grow in the arid regions of new Kenyan fields. These new elements can guarantee the safe and positive growth of the cassava plant so that there can not only be well-fed Kenyans, but Kenyans that have a bountiful wealth of crops in years to come. Even in the perennial droughts that are ever growing in severity, the cassava plant can be confirmed as being a good crop to rely on.

Thomas Jefferson once wrote in a letter to John Jay on August 23rd, 1785: "Cultivators of the earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous and they are tied to their country and wedded to its liberty and interests in the most lasting bands" (Smoky Mountain Heritage Farm). The farmers of Kenya provide food not only for themselves, but for the whole of the country as well. These planters deserve to have the greatest advantage to increasing their crop yield as well as harvesting the best possible crops they can through nutrient fortified plants such as the cassava.

One of the goals for Kenya is to eradicate the hunger in the nation by 2015. So far, Kenya is off track with meeting that challenge. They have trouble not only having enough food to feed the whole nation, but also giving the people the best nutrients in their food. Kenya has trouble providing this, because of the disadvantages through droughts from December through February, the infamous crop destroying weed called the Striga weed, and the poor soil quality in the arid outskirts of once fertile plateaus. These problems can be met in the future though the process of priming seeds, this naturally-occurring fungus that targets the Striga weed, and the new inexpensive fertilizer BNF, which could solve the problem of poor soil. This will increase the crop yield of rural Kenyan farmers significantly in the future. The cassava plant would be a good crop to have in these new future settings. The raw cassava plant has its own positive traits, but the cassava plant that will be fortified with the necessary proteins, carbohydrates, vitamins A,B,C, and E along with other necessary fats generated by the researchers at BioCassava Plus might be the plant that will get Kenya back on its feet in the years to come.

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