The Great Overcoming in Kenyan Agriculture

ICIPE: International Center of Insect Physiology and Ecology

Mbita Point, Kenya

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Table of Contents

Acknowledgments

Reflection

My time spent as a Borlaug-Ruan International Intern will forever have an impact on my life going forward. Reflecting on my time in Kenya, the word “overcoming” keeps coming to mind. Overcoming barriers were found in my research, personal experiences, and even in the Kenyan people.

Life in Africa can be very difficult with limited access to resources that are viewed as daily essentials in American culture. While I struggled to adjust to new norms, I grew a deep appreciation for the people of Kenya. I was also able to observe how hard they worked to achieve things I have immediate access to back home, such as clean drinking water.

Throughout my research I had to keep adjusting and revising my work to account for language barriers. When surveying farmers, I had to be mindful of words or phrases that may translate to the Kenyan language of Swahili and have an entirely different meaning. The truth of research is, it takes constant perfecting.

Perhaps the biggest hurdle was the lack of accurate records kept by farmers. Instead of simple asking, “How much do you make from selling your cereal crop in a season?”; I had to break it down into 5 separate questions to get the most reliable response. I found that there was no such thing as a point-blank answer with Kenyans. Every answer has a story or explanation behind it. That was something that frustrated me at first but then slowly I realized how much value their stories added to my research and experience in Kenya.

It was humbling to work personally with the farmers. Having the opportunity to observe their daily lifestyles and be invited into their homes added an essential element to my research. It

wasn't until I began to make connections with the farmers that my research began to tell a story. The story of Kenya and the struggle of overcoming barriers in Kenyan agriculture.

Credits

Firstly, thank you ICIPE staff for hosting me and making sure my 8 weeks in Kenya were safe and full of opportunities. I would like to thank the ICIPE extension workers for their dedication to my research through connecting me with farmers and serving as translators. Thank you, Dr. Khan for supervising my work and ensuring that I was conducting research that I was passionate about.

Matilda, thank you for being my "African Mother." From making sure I was always safe and well taken care of but also that I was also able to truly experience the Kenyan culture. My research would not have been possible without your mentorship.

I would like to thank my family and friends back in the states for their constant outpouring of encouragement. With a such great support system in my life, it makes it easy to follow my dreams. Even if that means leaving them behind to conduct research in Africa for 8 weeks.

Thank you, Ambassador Quinn, for believing in the next generation by providing them with opportunities to learn about the importance of agriculture on a global scale. Without the World Food Prize Organization and their involvement in my education for the last 3 years, I would honestly not be the person I am today. They have provided me with constant guidance and professional opportunities to better myself as an agriculturalist and global citizen.

I would like to especially thank Crystal Harris for her dedication in ensuring my safety and working out all the details and accommodations of my internship.

Abstract

My time as a Borlaug-Ruan International Intern was spent researching the positive impact of push-pull farming technology developed by ICIPE on the lives of Kenyan farmers. I interviewed farmers from different villages all over Kenya to better understand how push-pull farming has contributed towards an overall improved livelihood for those who choose to adopt the technology.

With an exceptionally overwhelming positive result to my initial hypothesis, I went on to tackle the question of "If push-pull farming is proven to be a positive investment for farmers, then why aren't more farmers adopting the technology?" By adding an additional hypothesis to my research, I was able to gather results that can be used to help ICIPE better understand how to expand the impact of push-pull farming going forward.

Introduction

Journey to Borlaug-Ruan International Internship

Growing up, I had always had a passion for helping others and one day doing my part in saving the world. When I was little, I thought saving the world looked something like becoming a superhero or maybe even a doctor. As I got older, I realized I could make a greater impact by becoming involved in agriculture and helping to feed the world's growing population.

My first encounter with the World Food Prize Organization was from my High School FFA Advisor who saw my passion for feeding others. She encouraged me to present a research paper at the upcoming 2016 Arkansas FFA State Institute. For months I perfected my paper on how I would solve hunger in an African country. I was able to present that paper to in front of students, teachers, and a World Food Prize Representative who granted me the opportunity to present my paper at the 2017 Global Youth Institute.

I can still remember the feeling of my heart burning with passion throughout my time at the 2017 Global Youth Institute. I presented my research paper and received feedback from experts around the world working in various fields. I left the Global Youth Institute with new knowledge of agriculture and most importantly I learned about Norman Borlaug. Dr. Borlaug is said to have saved more lives than any man to have ever lived through his advancements in agriculture. He was truly a real-life superhero.

Feeling inspired I wanted to continue my growth through the World Food Prize. I was then selected as a 2018 USDA Wallace-Carver Fellow. I spent 8 weeks working at the USDA ARS in Fargo, North Dakota. During my fellowship, I conducted research on methods of meloxicam detection in livestock.

I went on to attend a weeklong Washington D.C Leadership Symposium with other Wallace-Carver Fellows. During that week a met with policy makers, lobbyists, agricultural advocates, diplomats, and many others. But what sticks out the most is a conversation with World Food Prize employee, Keegan. He emphasized that to truly make a global impact; we need to first have global experiences.

Keegan's words compelled me to apply for the Borluag-Ruan International Internship. Something so pristine, I had pushed off my desire to apply for several years over fear of not being selected. However, I believe my experiences with the World Food Prize over the past 3 years have ultimately prepared me for my summer as a 2019 Borlaug-Ruan International Intern at ICIPE in Mbita Point, Kenya.

The World Food Prize has provided me with experiences that have helped me navigate my dreams as a global citizen and agricultural professional. Through these experiences I decided when I grow up, although being a superhero would be thrilling, I want to save the world through agriculture.

Kenyan Agriculture

Throughout my time in Kenya, I have been able to observe the importance of agriculture on the people of its country. With 80% of the Kenyan population being dependent on agriculture (FAO). Majority of farmers are smallholder and grow just enough to survive. However, Kenya is facing a rapid population increase and putting millions of citizens at risk of food insecurity. By 2039, Kenya is expected to reach a population of 81 million people (Kenya 2019). Between 2015 and 2030 alone, Kenya needs to increase agricultural productivity by 75% to meet this growing need (Welborn 2018).

The current Kenyan President, Uhuru Kenyatta, has recognized this urgency to increase agricultural production and has made it one of his "Big 4" goals to reduce food insecurity in Kenya to 0%. To accomplish this, Kenyan people will have to tackle the biggest struggles in agriculture the nation is facing. According to KARI, those are: 1) Outdated Technology, 2) Climate Change, 3) Lack of Infrastructure, 4) Poor Soil Nutrients. If Kenya is unable to tackle these issues, agricultural imports will have to increase from 10% to 25% to feed its growing population (KARI 2019).

International Center of Insect Physiology and Ecology (ICIPE)

ICIPE began with a mission of alleviating poverty, ensuring food security, and improving health of those in Kenya and around the world through research. ICIPE targeted insects because they realized the importance of understanding insects when determining pest management. Insects, are one of the main hinders in agricultural productivity. With proper knowledge of insects, practical management steps can be taken to protect agricultural commodities.

ICIPE works to find safe, affordable, and accessible methods of pest management. By avoiding potentially harmful pesticides, they are also decreasing the amount of money farmers spend on inputs. With the need for increased crop yields, ICIPE is working to give smallholder farmers the knowledge and tools that they need to achieve a successful harvest.

Push-Pull Technology

Professor Zeyaur Khan, "Father of Push-Pull", is a Head Research Scientist at ICIPE in Mbita Point, Western Kenya. Dr. Khan was inspired to find a way to increase food sustainably without using pesticides that could possibly harm the environment. In 1998, he planted the first Push-Pull

plot. Push-Pull technology was designed to protect cereal crops, primarily maize and sorghum, from the devastating striga weed and stemborers.

Striga weed is a parasitic plant that robs the host plant of all nutrients by attaching to the crop roots. Striga is difficult for farmers to terminate since the seeds can remain dormant in the soil for up to 20 years. It's crucial to deter striga with the current population growth as it is estimated to threaten the food security of 100 million people in the region (ICIPE 2019).

Stemborers larva burrow themselves inside the stem of the maize, making them difficult to treat with pesticides. The moths of stemborers lay their eggs on the moths of the maize leaf. Maize is Africa's most important food crop and stemborers create losses averaging 20-40% but up to 80% in the crop. Preventing these maize losses could increase harvests to feed an additional 27 million people in the region (Sengenet 2015).

Push-Pull is a simple farming method intended specifically for the smallholder farmers of Africa. It gets its name from the relationship of pushing away and pulling in pests created by the companion plants, native African Napier grass and Desmodium. Desmodium is the push. It is planted between the rows of maize and releases a chemical that causes suicidal germination in striga weed and deters stemborers. The napier is the pull. It attracts stemborer moths to lay their eggs however napier grass can't support the life of the larva. Ultimately ending the stemborer lifecycle. Napier grass is planted 3 rows deep around the maize and desmodium as a perimeter.

Push-Pull has continued to adapt to the needs of farmers since 1998 and will continue to. With a goal of reaching 1 million farmers by 2020, push-pull has to keep evolving to meet the needs of farmers. One example, ICIPE has even worked to develop a Climate Smart Push-Pull to assists farmers through the recent hardships that come with climate change. Switching from the original

silverleaf desmodium to a more drought tolerant Greenleaf desmodium. Greenleaf desmodium was even proven to produce more fodder and have higher nitrogen fixating abilities than the original silverleaf. The new Brachiaria grass can survive four months with no rainfall and temperatures of greater than 30 C (ICIPE 2015). Push-Pull has even overcome other setbacks such as napier stunt disease, lack of desmodium germination, and red spider mites. Along with scientific setbacks, ICIPE has to work to overcome cultural and political barriers in expanding Push-Pull.

Methods

My Research

Throughout my 8 weeks with ICIPE, I focused my research on the livelihoods of farmers before and after adopting Push-Pull technology. I wanted to be able to prove or disprove my hypothesis of, “If farmers adopt Push-Pull technology, then they will experience a better quality of life than Non-Push-Pull farmers.”

I analyzed farmers livelihoods by gathering data from before and after adopting Push-pull in regards to: maize yields, price of maize, profit from companion plants, amount of livestock, livestock byproducts, additional occupations to supplement income, daily consumption, quality of meals, and education of children.

During the course of my research while interviewing farmers, I began to realize that Push-Pull was clearly making an impact on farmers lives. However, ICIPE is still far away from reaching its goal of 1 million farmers by 2020. This prompted me to create a follow-up hypothesis, “If Push-Pull farming technology is proven successful, even then there are still cultural, scientific, and political barriers to overcome to reach the adoption rate of 1 million farmers by 2020.”

I was able to identify constraints in expanding Push-Pull technology by interviewing ICIPE scientists, ICIPE extension agents, Push-Pull farmers, and Non-Push-Pull farmers.

Thesis

New Agricultural Technology must overcome scientific, cultural, and political barriers even after being proven successful. Regardless if you have the perfect technology for an upcoming agricultural setback, it is not as simple as just getting farmers to adopt the technology. There are

many outside factors that need to be accounted by and worked around before farmers will willingly adopt new technologies.

Objectives

For my main hypothesis, "If farmers adopt Push-Pull technology, then they will experience a better quality of life than Non-Push-Pull farmers," I have selected 3 key objectives.

1. Compare the livelihoods of farmers before and after adopting Push-Pull technology
2. Analyze livelihoods of farmers across age, gender, and location
3. Prove or disprove hypothesis using data collected that Push-Pull farmers have better livelihoods than Non-push-pull farmers

For my follow-up hypothesis, "If Push-Pull farming technology is proven successful, even then there are still cultural, scientific, and political barriers to overcome to reach the adoption rate of 1 million farmers by 2020."

1. Collect information on constraints of expanding Push-Pull from various perspectives
2. See if constraints fit into the three categories of scientific, cultural, and political
3. Prove or disprove hypothesis using survey responses from ICIPE scientists, ICIPE extension agents, Push-Pull farmers, and Non-push-pull farmers

Procedure

1. Interview Push-Pull farmers on livelihoods before and after adoption of Push-Pull technology.

2. Analyze the following from Push-Pull farmers surveys:
    a. Change in kilograms produced of maize
    b. Change in price of maize
    c. Change in income from selling maize
    d. Additional income from push-pull companion plants
    e. Change in amount of livestock
    f. Change in livestock byproducts such as milk and eggs
    g. Change in income from selling livestock byproducts
    h. Change in main source of family income
    i. Change in quantities of meals
    j. Change in diversity of meals
    k. Change in number of children farmer is able to afford to send to school
3. Once data is analyzed, conclude if push-pull farmers have better livelihoods than non-push-pull farmers.
4. Interview ICIPE scientists on their experiences in scientific, cultural, and political barriers in push-pull and how they have been overcome in the past as well as how they plan to overcome them in the future.
5. Interview ICIPE extension agents on what makes spreading push-pull technology to new farmers difficult as well as explain farmers concerns with push-pull that they have seen throughout their work.
6. Interview non-push-pull farmers with knowledge of push-pull and ask why they have decided against adopting push-pull technology.

7. Analyze survey results from ICIPE scientists, ICIPE extension agents, and non-push-pull farmers to determine if the barriers of expanding push-pull can be narrowed down to scientific, cultural, and political constraints.
8. Verify results by holding a focus group discussion with both push-pull and non-push-pull farmers.

Results and Discussion

Results

My research firstly focuses on the livelihoods of farmers before and after adopting push-pull technology. I gathered data through a 15 to 20-minute survey with questions strategically picked to indicate if the farmer was food insecure and living in poverty.

The average push-pull farmer interviewed was a female, 50 years old, married, producing maize, never made it to secondary school, and has been a push-pull farmer for nearly 8 years. The average cereal crop production increased from 216.07kgs of maize produced before push-pull to 581.07 kgs produced after push-pull. The increase in maize production has allowed the farmer to go from making 2,044.64KSH* a season from their cereal crop to 7,961KSH.

I was also able to discover that farmers were able to use their companion plants to produce fodder to improve their livestock and even make a profit from selling the surplus fodder. Those who decided to sell their additional surplus made an average of 7,440 KSH a season. However, majority of farmers decided to keep the fodder produced from the companion plants for their own animals. Farmers reported seeing healthier livestock and increased animal byproducts using fodder produced by push-pull. Farmers with dairy cattle were only collecting 2.25L on average before Push-Pull but after Push-Pull they were able to collect nearly 6.5L a day. Healthier animals creating increased byproducts allows a farmer to create a profit and expand their farm with the surplus. On average farmers only owned 15 animals before Push-Pull but after adopting push-pull that number doubled to nearly 31 animals. Farmers who were once only producing

*KSH= Kenya Shilling (1,000KSH = 10USD)

barely enough animal byproducts to support their animals were now able to generate a surplus of animal byproducts to sell at market. The average yearly livestock revenue before Push-Pull was 4,212.20 KSH that then increased to 83,520 KSH after adopting Push-Pull.

With this increase in surplus Push-Pull provides through increased maize production, companion plants, and increased animal byproducts; it can now be observed how the farmers spend their new income to create a better life for their families. Before adopting Push-Pull, only 67.75% of farmers were able to make enough money farming to be full-time farmers. The other 32.25% of farmers were forced to supplement their income by finding other part-time jobs. After Push-Pull now 96.77% of famers surveyed are making enough of a profit to farm full-time.

Education for their children is something that has become very important for Push-Pull farmers since most of them never even made it past primary school. Before Push-Pull, only 39.92% of farmers reported being able to send their children to school. After Push-Pull, 100% of farmers reported that they were now able to afford school for their children.

Another component of a more successful farmer is the changed composition of their meals through quantity and quality. Before Push-Pull, only 43.33% of farmers could afford 2 meals a day every day of the week for their families. With the added surplus from Push-Pull now 100% of farmers have reported being able to consume not just 2 meals a day but 3 meals and some can even take a 4^{th} meal for tea. When asked, nearly 100% of farmers reported that with their surplus they are able to afford proteins, fruits, sugar, vegetables, and more foods that show signs of a balanced diet.

Throughout my surveys, I began to observe several barriers that Push-Pull has had to overcome in expanding across Africa. I narrowed down the barriers in expanding Push-pull technology to scientific, cultural, and political constraints.

Since 1998, there have been several generations of Push-Pull. One of the biggest setbacks in Kenyan agriculture has been climate change. ICIPE realized they had to create a generation of Push-Pull that was both heat tolerant and drought resistant. The adoption of climate smart push-pull has made it easier for farmers since they are confident that their companion plants can withstand the changing climate of Africa.

While ICIPE had adjusted to the threat climate change, there are still scientific advancements that need to be made to perfect Push-Pull technology. ICIPE is currently having to adjust their Push-Pull technology to withstand napier stunt disease and infestation of the red spider mites.

Napier stunt disease does it exactly what it sounds like, stunting the growth of several varieties of napier grass. It is caused by a bacterium, phytoplasma, the inhibits the napier from taking up essential nutrients. This disease is nothing new but however since the late 1990s it has been rapidly spreading. Napier stunt disease is spread when a leaf hopper bites the infected grass and then travels to another grass. By 2002 the stunt disease had been reported to impact about a quarter of napier grasses. It's crucial for ICIPE to find a solution and continue to use pesticide free push-pull to fully protect maize crops. (ICIPE-Napier Stunt brochure)

Red spider mites are another recent pest jeopardizing the spread of push-pull technology. The red spider mite attacks various grass types as well as other night shade plants. Red spider mites are seriously hindering the productivity of these effected plants. The napier grass has also been the recent victim to red spider mites. Farmers reported to ICIPE that the spider mites jeopardize the

fodder even after harvest. Farmers are struggling to find methods of storage to prevent spider mites from attacking their fodder. It's imperative that ICIPE finds a solution to this because fodder has become the primary source of nutrients for the farmers' livestock. Red spider mites could hinder food security by attacking fodder, decreasing animal health, and thus decreasing animal byproducts consumed by the farmer's family.

Kenya is very rich in culture and clings on to religious traditions and well as tribal norms. You can often find farmers will only interact with those of their tribe and similar culture. This can make it difficult to group farmers. Gathering farmers into groups is essential in spreading Push-pull for several reasons. Overall, grouping farmers requires less time and a better use of already limited resources. ICIPE staff find it most efficient to teach a large group of farmers about push-pull rather than visit each farmer individually. Being in a farming group, also allows a support group and a sense of accountability for upkeep of the push-pull plot.

However, the biggest reason for grouping farmers is the distribution of desmodium seed. Farmers have limited access to transportation and safe roads to find an agro-veterinary store that sells desmodium seeds. Even the farmers who can find desmodium seeds, can't afford to purchase them. ICIPEs solution to this setback is, they provide first time push-pull farmers with free desmodium seed. However, offering free desmodium seed means you must also distribute the free seed. This has proven to be a setback for ICIPE. With limited staff and poor roads for transportation, it makes it difficult to deliver seeds to each individual farmer. Farmer groups makes it easier by providing a centralized distribution center for seeds.

Each village in Kenya offers its own unique culture. This makes it very difficult to predict how each village is going to welcome push-pull technology. Sometimes, getting farmers to adopt

Push-pull is the easy part, but keeping up with the maintenance is where most farmers struggle. Once a farmer stops tending to their companion plants and they die, there's no getting them back without purchasing new seeds. Migori County is an example of a traditional community. Every 5 years Kuria land, Migori county holds a circumcision ceremony. This ceremony requires time consuming preparation. It interferes with field activities as it is seen as taboo to farm during this time. Often causing the companion plant of push-pull to suffer. That is just one example of tradition getting in the way of push-pull upkeep.

Another cultural constraint is inheritance of estate after the passing of a farmer. Traditionally, land is separated between all of the children or sons when a father passes away. With each generation, the land inherited keeps getting smaller and smaller. To the point that some famers don't even own plots large enough to establish a proper Push-Pull plot. Another problem with inheritance of estate is when the farmer passes away who practices Push-Pull, his children inheriting the plot could not be interested or have knowledge in push-pull farming. Without adequate land size or knowledge of Push-Pull, it can be difficult to continue for the next generation.

Kenya is still a relatively young nation, having only established their independence in 1963. With that comes its own set of barriers to work through as a country. One major political constraint is corruption from within causing repercussions for innocent farmers.

The Kenyan government has tried a solution to government employees unlawfully collecting money. Their solution? A change in currency. This would force all citizens of Kenya to provide proof of their income at the bank when exchanging their old currency to new. That way, if you are exchanging more money than the government thinks you should be earning, they can

intervene and check for fraudulent earnings. However, Kenyan citizens were only given a 4 months' notice to make the change to the new currency. When conducting a farmer focus group, most farmers weren't even aware of the change in currency. The new Kenyan shillings share striking similarities with Tanzanian currency. Most farmers won't accept the new currency in fear that it is the Tanzanian currency which is worth far less than Kenyan currency.

Another recent political change impacting farmers, is the recent change in tax brackets. Kenya decided it needed to tax 2 million more citizens to reach Kenya's growing needs. 1 million of those citizens will be smallholder farmers. Farmers making more than 11,180KSH a month with be taxed 10% of their income. This discourages farmers from wanting to produce a surplus in fear of becoming qualified to be taxed. Once the farmers are subject to taxation, corrupt tax collectors can request more money from the farmers than what they actually owe. Farmers are reluctant to produce a surplus, as they know the added income may cause them to be eligible to the heavy taxation.

ICIPE has presented the Kenyan government with the Push-Pull farming technology to show that integrated pest management can be successful without the use of harmful pesticides. However, even after proving the benefits of Push-Pull, ICIPE has received little assistance in expanding the technology from the government. In fact, with the recent increase in revenue from the revised tax brackets the Kenyan government is providing more pesticides for farmers. This could perhaps be one of the biggest constraints in advancing push-pull, not having government support.

Discussion

I was able to conclude that farmers have adopted Push-Pull technology have an increased quality of life compared to farmers who choose not to adopt Push-Pull. Supporting my main hypothesis,

“If farmers adopt Push-Pull technology, then they will experience a better quality of life than Non-Push-Pull farmers.”

Something remarkable is that the average Push-Pull farmer is female. In a nation that is quite male dominated, it is difficult to find successful female farmers. However, ICIPE wanted to use Push-Pull to empower the women of Kenya. I was even able to interview a Push-Pull farmer who was able to provide for her children using the technology ICIPE gave her after the passing of her husband. This is important because typically following the death of a father or head of the house hold, the responsibility lies on the sons to take care of the family sometimes leaving them to drop out of school to. It is also essential to target female farming groups because in this region of Africa, land is typically passed down father to son.

ICIPE finds its most successful to empower female farmers using a farming group with both males and females. Here’s why, it’s essential to teach men to work alongside women as equals. That is just another reason why farming groups are so essential to the success of expanding push-pull and their goal of empowering female farmers by providing equal opportunities.

It was crucial to prove that once push-pull farmers experienced an increase in income, that I could prove that their new income was making a positive impact on the lives of farmers and their families. Probably the most inspiring results were the increase in farmers who were able to afford to send their children to school after push-pull and the increased quality and quantity of meals for push-pull families. Because of push-pull, 100% of families who chose to adopt the technology could now afford to send their children to school. Also because of push-pull, 100% of families who chose to adopt could afford 3 or more meals a day and more nutritious foods for a balanced diet.

Another important statistic, before push-pull only 67.75% of farmers could farm full time but after push-pull 96.67% of farmers are able to farm full time. What may be overlooked but this statistic has a deeper importance. When farmers can't afford to farm full time, they're forced to get a second job to supplement their income. Often times, these jobs are riskier especially for the females. One farmer, told a story of how before push-pull she had to work selling items by the railroads to send her children to school. She told us stories of how dangerous it would be and how she feared for her safety. Sometimes she feared she wouldn't make it back home to take care of her children. But now, because of push-pull she was able to return to farming to full time and still make enough money from her push-pull surplus to send her children to school.

Even with the success stories of farmers, the adoption rate of push-pull by 2018 was only around 205,000 farmers (ICIPE- push-pull presentation). This falls shorts of the anticipated 1 million push-pull farmers by 2020.

Once I concluded my first hypothesis as correct, I was then able to analyze the results for my follow-up hypothesis. With the results collected from ICIPE scientists, ICIPE extension agents, push-pull farmers, and non-push-pull farmers, I was able to support my follow up hypothesis: "If Push-Pull farming technology is proven successful, even then there are still cultural, scientific, and political barriers to overcome to reach the adoption rate of 1 million farmers by 2020."

I began first by looking into the research completed by ICIPE in regards to push-pull technology and then the ongoing research to try and detect scientific setbacks that may have hindered the adoption rate of push-pull technology.

Napier stunt disease, NSD, was a setback that not only intervened with effectiveness of the napier grass to attract moths but it was also potentially harmful to the livestock. Without a

constant supply of napier fodder, it put the livestock at risk of lack of essential nutrients that they desperately need to maintain milk production.

ICIPE acted quickly and was able to gather genetic information from thousands of insects and plant samples to detect for the presence of NSD. This was accomplished using a Polymerase Chain Reaction (PCR) machine. This allowed for ICIPE to test new Napier grass varieties and detect to see if the grasses are carriers of the disease or if they are resistant to the disease. ICIPE was able to discover two varieties of Napier grass that were completely resistant to NSD.

Research on Napier Stunt Disease is still being continued even after the discoveries of the 2 resistant varieties. ICIPE wants to ensure that farmers are educated on selecting the right NSD resistant grasses as well as hygiene practices to keep NSD from spreading any further. ICIPE is also continuing their research to ensure that the phytoplasma doesn't shift to attack other crops during this process.

Red spider mites, are an ongoing constraint for push-pull farmers but ICIPE is on the verge of finding a solution. ICIPE, planted various grass varieties nearby a large and local farming group that they work closely with. There, the grasses were monitored and examined for the red spider mites. Once it was determined which grasses were resistant, ICIPE staff arranged a farmer field school. There, farmers filled out a survey and reviewed the different grasses presented by ICIPE.

This is just another way of showing how essential it is to group farmers. It allows ICIPE staff to gather mass farmer feedback using less resources. In addition to getting feedback from both push-pull and non-push-pull farmers, ICIPE was able to give updates on proper upkeep of push-pull plots.

ICIPE has also come to realize that grouping farmers is just the first part of distributing desmodium seed. While putting farmers into groups has proven make the distribution of seed easier, there are still only so many ICIPE extension agents who can distribute seed. Send-a-Cow, one of ICIPE's collaborator, also assists in distributing the desmodium seed to farmers. However, Send-a-Cow even reports that they have difficulty receiving an adequate amount of desmodium seed in a timely manner to fulfill the needs of their push-pull farmers. ICIPE is aiming to make the seed more accessible by connecting with more agro-veterinary stores across Kenya. They hope in the next few years that farmers can buy their desmodium seed as easily as their maize seed.

Since 1998, ICIPE has presented the Kenyan government with the push-pull farming technology to show that integrated pest management can be successful without the use of harmful pesticides. However, even after proving the benefits of push-pull, ICIPE has received little assistance in expanding the technology from the government. In fact, with the recent increase in revenue from the revised tax brackets the Kenyan government is providing more pesticides for farmers. This could perhaps be one of the biggest constraints in advancing push-pull, not having government support.

This research was essential in demonstrating that advancements in agriculture go far beyond research and introducing new technologies to farmers. Although I only focused on demonstrating barriers in Kenyan agriculture, my research was intended to show that each country offers its own unique setbacks. Especially in a developing nation, it becomes much more difficult to introduce a new form of technology regardless of how success it has proven to be when tested.

References

ICIPE. (2015). Climate-smart push-pull. PDF. Location: Nairobi, Kenya.

ICIPE. (2019). Desmodium intercropping eliminates striga threat and improves food security in Africa. PDF. Location: Nairobi, Kenya.

Kari. (2019). The Major Challenges of The Agricultural Sector in Kenya. Retrieved from: https://www.kari.org/the-major-challenges/.

Food and Agriculture Organization (FAO). Kenya at a Glance. (2019). Retrieved from: http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/.

Welborn, L. (2018, June 18). Food security under threat in Kenya - Kenya. Retrieved from: https://reliefweb.int/report/kenya/food-security-under-threat-kenya.