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### **Ethiopia: Increasing Ethiopian Tef Production by Introduction of a Row Seeder**

I like the word cultivating. It means to prepare and improve land for raising crops. Cultivating is an action. It will take action to feed the world. The action I have chosen to focus on is the building of a tef seeder. Tef is as small as a grain of sand, yet it is the major food crop eaten in the developing country of Ethiopia. To prepare myself for building the tef seeder, I learned all I could about this country then narrowed my focus to Mishig, Tigray (in northern Ethiopia). Lastly, I improved my knowledge about engineering a tef seeder. With my mind cultivated, I developed a Tef seeder from readily available materials that will allow small scale Ethiopian farmers to plant tef in rows. After testing this seeder at the University of Minnesota Fields, it's promising that this small innovation can help feed the world.

Ethiopia is located in the horn of Africa. The land varies from hot deserts to cool highlands. Ethiopia has a population of 84.7 million people and an annual growth rate of 2.6% (for a comparison, the USA's growth rate is 0.899%). This makes Ethiopia the second most populated country in Africa (Ethiopia Profile).

The economy of Ethiopia is highly centered on agriculture. Over 80% of the workforce is involved in agriculture and contribute 41% of the country's GDP ("Background Note: Ethiopia."). Although agriculture makes up 75% of the country's exports; problems have stricken the country's agriculture system and hinders food production that could potentially be much more profitable. The problems include: unpredictable rainfall, drought, undeveloped water resources, poor transport infrastructure and deforestation, colonization, international markets and tariffs (Board on Science and Technology for International Development; from now on noted as BSTID). One of the facts I found very interesting and concerning is that 80% of Ethiopians work in the agricultural sector and live more than a day's walk to the nearest road (New Agriculturist). If we could shorten that distance all across the country, the flow of product would widely increase and help the current economy.

East Africa's government has tried to boost Ethiopia's economy by clearing off land for investors and relocating the people from the land they've used for decades to areas with "better access to clean water, health and education" (Epatko, Larisa). These families think otherwise. Under the government's new Villagisation program, 3-4 villages are being moved at a time to places closer to roads and services, but the people say they are not being compensated (Vidal, John). One woman interviewed for a PBS documentary called: *Ethiopia: A Battle for Land and Water* commented on this subject saying:

"When we left our farm, our crops were ready for harvest, but they told us to leave them in the field, that we would find plenty of corn and other food in the new place we were moving. But they don't give you enough food to fill you up. They give you food in a small container but it can't even feed a family for a day".

The Ethiopian government owns the title to the land, but I believe that the land is for the people to use. The government calls the land 'abandoned' because the population is so low ("Ethiopia: A Battle for Land and Water"). It is these farmers that contribute to a large amount of the country's GDP. I believe that giving Ethiopia's land resources to foreign capital is causing people to distrust the government. People need rulers they trust to lead them out of this epidemic of malnourishment.

Drought and unpredictable rainfall are consistently the largest problems in Ethiopia. Farmers without watered crops may lose productivity. People without water struggle to stay alive. The country as a whole

does not lack water; poor water distribution is to blame. Ethiopia actually has Africa's second largest water source (United Nations 2). Soil erosion, deforestation and infertility are also major factors contributing to the country wide malnourishment. Key Development Forecasts for Ethiopia calculated that 42 percent of the people in Ethiopia are malnourished. Almost three-fourths of this percentage are children.

Along with agriculture, livestock is one of Ethiopia's largest exports. Ethiopia has the largest population of livestock in Africa. Expansion of this industry is constrained because of inadequate nutrition, disease, insufficient data, and inadequate information on how to improve animal breeding, marketing, and processing.

The morbidity rate has been at 1% for years (Death Rate, Crude), due to high incidence of infectious diseases, low immunization coverage, shortage of health facilities, limited access to basic health care, and extremely low access to sanitation.

Typical rural Ethiopian families consist of: the head of the household (father), the caretaker for the children (mother), 4-5 children, and elder relatives. Children are socially responsible to take care of their parents as they get older and in a given household there may be generations living in the same home (Mohr). Typical Ethiopian families need an income of 61 USD per month to sustain life, but even with two wage earners in the family, the average income only amounts to half the income needed for subsistence living (Ethiopia, Encyclopedia of the Nations). Families try to combat health issues that come along with malnourishment, but typical subsistence farm families have no access to health care.

In poor rural areas, farming practices are passed down from generation to generation. This makes for little innovation or experimentation. Higher production of nutritious food is the goal of every single farmer in Ethiopia. Introducing new seeding practices is one way they can increase the yield without depleting soil, without using more water, and without making farming more laborious.

Depending on how close the nearest school is, typically children in the rural community under the age of 13 go to school. Food for Education is a program serving kids one balanced meal a day for going to school, and many times this is the only full meal they get. Children over the age of 13 typically do not continue their education, but help out in the fields. Many may not have even one full balanced meal a day. Studies have shown that only half of the male population is literate and female literacy is even lower, ranging from one-third to two-fifths (Ethiopia, Encyclopedia). Less education for women is a distinct disadvantage to the entire family because women are naturally the caretaker and the less they know about nutrition, the more disadvantage to their family. Education helps women better their combination of food and ability to balance nutritional elements. There may be a decrease in malnourishment if people were more educated about nutrition, but as long as the challenges of subsistence farming remains, the vicious cycle is going to continue.

Tigray is the region I have chosen, known for its' highly unpredictable rainfall. Agriculture in Tigray is very important, 65% of the land is under cultivation (the left over 35% is taken by forests, pastures, homes and wasteland). Over 95% of the cultivated land is farmed by small scale farmers.

Environmental problems, deforestation, poor nutrition education, low access to health care and soil infertility are the leading barriers typical rural families must overcome. The village I have decided to study is Mishig because all of these barriers are shown in the everyday life of the inhabitants.

The village is centered in Ethiopia's dry lands. The closest local market place is 21 km away (Beyene, Gibbon, and Mitiku Haile). An average adult walks 5km/hr, making the 21 km trek take 4 hours and 12 minutes, tops ("How Far Is That?"). The population of Mishig is very high, at 430 people per kilometer.

The farming land is fragmented into sections, which average to 0.13 hectares each. Typical households have land properties that vary from 0.05 to 0.94 ha.

In the mixed farming system of Mishig, cereal crops provide the majority of their livelihood. The most commonly farmed cereals there are: tef, barley, horse beans, field peas, chickpeas, lentils, flax, and amaranth (Beyene, Gibbon, and Mitiku Haile). The typical diet for a farm family is: bread (made from grains like millet, sorghum, wheat, and tef), injera (spongy bread made from tef flour), home-grown vegetables, and occasionally meat. Most commonly, main dishes are thick stews and bread with which to sop up the sauce.

The focus of my research has been on *Eragrotis Tef*, commonly known as tef. The production of tef is more than all other cereals, making up a quarter of the country's total cereal productions. Every year, 1.4 million hectares of tef are planted by Ethiopian farmers, which produce 0.9, million tons of grain (BSTID). If good agronomic practices are followed, yields can get to 2,000-2,200 kg per hectare, even though the national average in Ethiopia is 910 kg per hectare (BSTID). Earlier I said that tef is as small as a grain of sand, and it really is. There are over 4,000 seeds per gram and 1.3 million seeds per pound. The seeds are so small that the size alone makes the crop hard to deal with. Preparing fields, seeding, threshing, winnowing and grinding such a tiny seed by hand is very laborious.

Tef is grown in Ethiopia either as a staple or as a standby. As a standby, farmers wait until their main crop (maize, wheat, etc.) shows signs of failing, then sow tef as a backup source of sustenance in case of a crop disaster. As a staple, farmers plant it like other cereals, but typically sow it late and harvest well into the dry season. In traditional farming practices, tef gives about the same yields as wheat in Ethiopia. Tef holds an invaluable attribute for poor farmers; tef grain is very hardy or grows under harsh conditions.

Other than rice, tef is able to withstand wet conditions better than any other cereal. Tef even may grow in partly waterlogged plots, as well as on acidic soil (BSTID). Even in the most notoriously hostile environments, tef continues to perform well, whether it's planted on black cotton soil, to clay, to vertisols. Tef is also known as a "nurse crop" because the plant is non-weedy, and covers the ground quickly, it has potential to help erosion near river banks and other erodible sites (BSTID).

I decided to start looking at possible ways that I could help the agriculture system, and started with the fields. Because tef seed is one of the smallest grains, small scale farmers broadcast the seed. It takes almost twice as much seed to broadcast a field and the farmer will get poorer yields than if he or she planted the seed in rows. I will use what I have learned and develop a seeder that is inexpensive and reliable to use for tef in Africa. After volunteering in 2011 at the U of M fields, in the Lost Crops of Africa plot, I found tef to be difficult to handle. At the U of M, the tef was planted in rows, but after just one month, the tef began to grow together. That is how I got inspired to build a seeder of my own to find a way for Ethiopian farmers to be able to get higher yields, use less seed, while being more efficient.

Before I started designing my seeder I made lists of all I wanted my seeder to be. First, I wanted it to be made out of readily available materials, like: plastic bottles, bicycle tires, old car tires, metal, screws and nails, and wood or sticks. Secondly, I wanted the seeder to meet certain needs, like: un-costly, made out of materials that are easy to access, easily duplicable design, reliable design, durable for years of use, to give farmers noticeably better results than broadcasting, easy to use, ability to use it without tractors or oxen, and light weight.

I had no idea what was currently available to small scale Ethiopian farmers when it came to small seeders, so I gathered up all of the commercially available small seeders in the United States that were under 100 dollars to test their accuracy and seed flow rate. I made up my own test to collect data on the seeders

accuracy and seed flow rate. I found that the seeders that were closer to the ground were more accurate, and the seeders that had a small gage for the seeds to flow through had the best seed flow rate.

After many prototypes, the seeder I designed is pictured like this: four plastic liter bottles, top down, evenly distributing seed because the aluminum slips feed an even stream of seeds into the soil. Underneath, the plank holding the bottles are furrowing screws to dig a little ditch for the seed to fall into and creates a vibration against the soil to ensure the device doesn't clog. Furthermore, every part of this seeder is readily accessible to Ethiopian farmers. Even the smallest of subsistence farmers, without oxen, could benefit from (and make their own) seeder.

I believe that if one hundred Ethiopian farmers used this seeder, it could raise the production of tef on their farms to the point where this seeder could transform the way tef is being processed currently in the country. Farmers are inherently wise about their crops and they would be able to evaluate this method in a very short time. I surmise that anything that clearly raises their food production practices could become, through word of mouth, the new way to plant tef in Ethiopia. To take this vision further, if farmers would use these seeders for five years, during that time they would experience a wet year, dry year and so on, to the point where they could rely on this seeder over the old farming method, of broadcasting.

Although the farming practices in Ethiopia have stayed the same for years, I believe that more efficient planting of tef seed could improve the nutrition and benefit farming families financially because using this planter will make the work more efficient. Energy demand and pollution are two major factors that are actually enhanced by my seeder because there are no fossil fuels involved in running this seeder, nor fertilizer product needed to make tef grow to its fullest potential.

Increasing crop yield by the use of this tef seeder is probably best if it can be shown. To introduce this seeder to a select group of farmers, have them build their own seeder and incorporate it into the next year's crop and have them see for themselves the benefit of planting tef in this manner is the best way to effectively convince them to plant in rows. These farmers could be emissaries to easily go out and teach other farmers how easy the planter is to make, and use. The practice of planting tef in rows could easily help to increase crop yields.

Let's think big shall we? Nutritional security is possible for the world. Ethiopia could use community food sovereignty to feed their people instead of leaning on the unfair and unpredictable global market. If farmers could organize cooperatives, each led by an educated leader whose magnificent aim is to feed Ethiopians. Governments and world leaders would have to take note and cooperate. I can envision a distribution system whereby individual families could be assured of a completely nutritious meal every day. I think of the exemplary charity Feed My Starving Children in America. Ethiopia could pattern a complete nutritional packet, after studying locally accessible food products. This supplement could be added to whichever grain is locally grown and available.

Human beings who are fed nutritious meals think better, work better, and play better. So much is known today about food, its balances and its benefits. To take that knowledge to a destitute country, like Ethiopia, could benefit the entire world.

Big results begin with small steps. First taking the tef design to Ethiopia and teaching a few small subsistence farmers how to build one and use one and also measure their success against previous results. With a big picture ever present in my mind, then I could encourage the farmers to show other farmers this innovation.

It is hard to make changes when you are a subsistence farmer. Education is a key link to making choices and adopting agricultural practices that can improve yields and nutrition. Food for Education is a successful program that allows children to get some education. I believe that increasing the age that education is a requirement from 13 to 16 would be the single most important decision that could help the

entire country. Rural families should be able to send their children through age 16 and know they would get a meal in school. Planting tef in rows is an innovation that would be better received the more educated the farmers are. One exciting thing about the tef seeder is that it can be made from materials that are readily available to small scale farmers. Planting in rows and not broadcasting means that the tef can be weeded, and lodging is not such a big issue. Partnering with NGO's that are already in Ethiopia would be one way to get word out about the seeder. Another way to get the seeder into the hands of the people would be to go from village to village and give one person a seeder and train them to make the tef seeder. When their yield is increased, they can be the hub of their villages' tef seeder distribution center. There are many people in the United States that want to help solve global food issues. Giving people a tangible way to help by adopting a village or sending teams to help implement this seeder could be a win-win situation. Empowering Ethiopian farmers to increase their yields on land that is already being used is a key to helping to feed the world. It may be a small change. But many small changes together can be the difference between malnourishment and supplying enough food for the people of Ethiopia.

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