The Basis of Food Security, and the Prospect of Providing Added Value Crops for Diversification

Preliminary Results

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Acknowledgements

My summer in Taiwan at the AVRDC – The World Vegetable Center, has been the single most educational, challenging, interesting, and sobering experience of my life, and I suppose I have a few groups and individuals to thank for providing me with the ability, advice, and encouragement required to complete this internship.

To start off, I feel that I should thank Dr. Norman E. Borlaug. Dr. Borlaug and other individuals such as Dr. M. S. Swaminathan have been the true individuals to actually start green revolutions, that is, periods of extremely quick agricultural advancement and development. In addition to being the recognized leader of the green revolution in the United States, Dr. Borlaug was an amazing humanitarian and researcher, and an individual many have aspired to be like. On the same token, Mr. John Ruan, and the entire Ruan family deserves the thanks of every single intern for the last 18 years, for being fully involved in, and for funding the World Food Prize and its associated programs, especially those involved in youth outreach.

Now, there are of course other individuals involved with the World Food Prize and the Global Youth Institute, who are directly responsible for my participation with the AVRDC. I believe that the one with the most weight on her shoulders, is Lisa Fleming. Lisa is not only involved with the Global Youth Institute Event, held each year in October, but she also coordinates the entire application and selection process for both the Borlaug-Ruan Interns, and the USDA Wallace Carver Internships. Coordination was not her only job, however. Lisa is basically a maternal figure to all of the interns, constantly answering questions, as well as providing whatever support is necessary, such that each intern is able to enjoy their time as much as possible. I am incredibly grateful that she sacrificed so much of her time to helping individuals like myself gain a foothold in the world. Additionally, I would like to thank Ambassador Kennith M. Quin, Libby Crimmings, Keagan Kautzky, Jacob Hunter, and all of the other individuals involved in keeping the World Food Prize, and as a result, the youth outreach programs running smoothly.

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There were many other individuals who truly deserve my thanks on behalf of all their efforts which led to a pleasant stay in Taiwan, such as Lydia Wu, who coordinates all of the interns at the AVRDC. Another group of people who deserve a large thank you, are the nutrition specialists, who helped me source large amount of data, and will be continuing to do so even after I leave. The summer interns I spent my time with, from Taiwan, Germany, Argentina, and

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One last group of people from the AVRDC whom I owe a large debt of gratitude to, are the field workers who manage nearly all of the crop production at the AVRDC. Although many of these workers are well over fifty years old, they work harder, and are much more dedicated to their jobs than just about any other group I have ever interacted with.

When I look for people who have truly influenced where I have gone in life from an educational standpoint, I can see two primary individuals. The first of these is Chad Eastman, my chemistry teacher from high school. He is one of the primary people to have pushed my interest in all things involving science, and has given me extremely helpful advice. Another individual who has had a profound influence on me is Patrick Brennan, my New Visions Life Sciences Teacher from BOCES. Pat was the first person to introduce me to the World Food Prize, and after he did so, he constantly encouraged me to get out of my comfort zone, allowing me to access a potential I never knew I possessed.

Now we can move on to those on the home front, who I really owe everything to. To start, I would like to thank my family. My three siblings mean the world to me, and I would not be half the person I am without their influence. Although I may not have enjoyed it at the time, my parent's high expectations and encouragement to do great things is the only reason I stand where I do. I also owe a large amount to my grandparents, as they have been largely supportive of everything I have ever done. My friends at home also deserve their fair share of recognition, as they provided endless hours of messaging, video chatting, and phone calls. Another individual who has always been a family friend and inspiration to me, is Sonnie Sampson, as she has constantly given me sound advice and encouragement, as well as assisting me with many matters involving the World Food Prize.

As you can see, there have been many people who have influenced me, and caused me to develop a strong work ethic, a passion for knowledge, a value for friendship, and the personality I have today. For this, I will never be able to repay them, but I will constantly strive to do my best, with the intentions of making them as proud as possible.

Introduction

Personal Introduction

After reading the acknowledgements, I hope you are wondering, "Who is this individual, and how did he get to be where he is?". I will certainly attempt to answer that question as completely as I can; however, even I do not fully know the answer yet. That being said, this summer has truly allowed me to explore myself, and to come to the ultimate realization that I can be whatever I want to be, and I can do whatever I want to do, I simply have to put out the effort. I should note that this paper is not intended to be a simple research report. Instead, I wrote this paper with all the frill and wordage necessary to create a mental connection between you and I. I want you to be able to understand how I perceive the information and experiences around me, and more importantly, how I apply it to my life.

We can start out with my past. I was raised in a mid-sized family, with three older siblings, in Ovid, New York; a fairly rural location. When I say rural, I really do mean quite rural. My house is centered between a 120 acre organic vegetable, fruit and meat farm, owned by my uncle, and a 150 acre cash crop and draft horse farm. If you still are unsure of the setting, just imagine that the nearest hospital is over a 20-minute drive, and the nearest city is roughly 45 minutes away.

Now, I grew up in a relatively large family, with one older brother, and two older sisters, all of whom I am incredibly close to. Unfortunately, being the youngest meant that I was typically the last of all the children to accomplish something, whether it was learning to swim, ride a bike, or simply gain the same privileges my older siblings had. This gave me the mentality that I constantly had to outshine them in every way I could, even if I was restricted in age. My parents made the decision to homeschool my entire family. This meant that we were together 24 hours a day, 7 days a week.

During these early years, I really did not take my education very seriously. I completed my studies, of course, but I was much more interested in reading fictional books and spending exorbitant amounts of time drawing, building things with my hands, and enjoying the outdoors. It was only after I began one of my later jobs that I realized the world was much larger than I expected, and that really, I was quite insignificant in the scheme of the universe, especially if I kept up my current attitude. This leads me on to one of the most important parts of my early life; work.

I began my first job when I was 9. It was not a glamorous job by any means. I spent my spring, summer, and fall working with my brothers and sisters on a farm, performing simple, but grueling tasks such as transplanting crops, clearing rocks from the fields, and picking fruits and vegetables such as beans, peas, tomatoes, and potatoes. Of course, being only 9, I was paid a meager amount of money, because the work I did was relatively poor in quality.

Regardless of how little help I was when I was younger, this farm work was really my first exposure to agriculture. One of the first things I remember thinking was, "This is terrible. Why would anyone want to spend their entire lives performing difficult work like this, just to sell their

produce for a paltry amount of money?". To this day, I remember my back aching while picking miles of snap peas, and wondering, "Is this all agriculture is?". It was in that point in my life, that I decided, even if my life depended on it, I would never be involved in agriculture. It was simply too much of a risk, with too much work, and almost no profit, even during good years. Despite being exposed to a variety of other practices in agriculture and horticulture, this opinion only changed during my senior year of high school.

Now I mentioned, earlier that I was a fairly sheltered child. During her sophomore year of high school, my sister, who was incredibly interested in music studies, decided that she no longer wanted to be homeschooled, an instead resolved to attend a boarding school to specifically study music some 600 miles away. It was this experience that showed me, if you applied yourself, you could certainly go places, even during high school. A combination of this, and the fact that all of my siblings were leaving for college within the next few years, prompted me to transfer to the local public school for my junior and senior year of high school. This school was by no means renowned for its academics, primarily because the graduating class was only around 50 students on average, as a combination of 4 towns. As soon as I began my courses, I realized that I could actually enjoy school when I was consistently given difficult material to learn. About half way through the school year, my chemistry teacher asked me to look into the New Visions Life Sciences program, and to consider it for my senior year.

New Visions Life Sciences is an educational program run by the TST-Board of Cooperative Education Service. It selects 15 students who are interested in pursuing a higher education in the life sciences from the three surrounding counties. These 15 students meet every Monday and Friday at Cornell University, where they have basic classes such as environmental science, English, and government. During the middle of the week, instead of attending their regular school, they are placed in various research labs at Cornell, and are required to complete a project before the year is over.

During the end of my junior year, I decided to apply to New Visions, and after a brief essay and interview, I was accepted. As a prerequisite, all students were asked to read *Enough: Why the World's Poorest Starve in an Age of Plenty*, written by Roger Thurrow, and Scott Kilman. This book introduced me to the Green Revolution, and its initiator, Dr. Borlaug, but more importantly, it showed me just how miserable of lives some individuals live in developing countries, and how people like myself, who were born into privileged circumstances, can help to improve their lives through agricultural development.

In addition to reading the book, the New Visions instructor asked us to construct a six-page research report entailing food security and the factors affecting it in a specific developing country. While I am sure he mentioned it at some point, I didn't actually realize that the paper was for the World Food Prize. In fact, I did not really even know what the World Food Prize was; I simply assumed that it was a summer project which would eventually relate to my courses in the fall. Little did I know that this single paper would open up a world of opportunities for me in the following months.

During my first week of classes, I discovered that despite having already written the paper, I would be required to give a brief presentation on my topic at the New York Youth Institute, in partnership with the World Food Prize and the Global Youth Institute. Of course, having been homeschooled, and completing just one year of high school, I was absolutely terrified of public

speaking, especially in front of adults who would be analyzing my every word. Despite these feelings of inadequacy and fear, I invested enough time and effort in my presentation, that I was selected to represent the New York Institute at the 2014 Global Youth Institute event in Des Moines, Iowa.

Leading up to my departure, I completed some minor research on the World Food Prize and the Global Youth Institute, but I did not truly understand what the big deal was about. Sure, food security is important, and sure there are plenty of organizations trying to help stabilize and improve the global food system, but why should I be involved? Aren't there plenty of scientists, researchers, and celebrities involved in those practices? It wasn't until I actually flew out to Iowa and was exposed to people who work with food security and global development daily, that I realized that most other students my age probably thought the same as I. That, is the primary reason I am currently striving to become more involved in global development, instead of simply sitting on the sidelines and waiting for others to resolve the issue.

When I was at the Global Youth Institute in 2014, I noticed a group of distinguished students who seemed much more mature than the rest of us, despite only being a year or two older. I noticed that they were able to see the discussion and speeches through different eyes than the rest of the attending students. I asked my supervisor about these students, and he told me that they were most likely interns from the previous summer, but he encourage me to strike up a conversation with them to inquire. Of course, I was still incredibly bashful at this time, so I failed to do so, but I did find out from others that there would be presentations by these students later during the event.

When I went to these presentations, I was astounded. These students were only a year or two older than I, but they seemed so experienced, so aware of the world around them. In their short internships, they accomplished so much; research, cultural awareness, even exposure to large jumps in global development. I knew in that moment, that I wanted to participate in this internship program. Luckily, after the application process, and customary interview, I was selected for an internship site in Taiwan, at the Asian Vegetable Research and Development Center, more commonly known as the World Vegetable Center. Little did I know that this internship would drastically shape my opinion on agriculture, global development, and my role in both of those issues.

AVRDC-The World Vegetable Center

The AVRDC, more commonly referred to as the World Vegetable Center, is a nonprofit research organization founded in 1971. It focuses on eliminating hunger, poverty, and increasing food security through research and the implementation of consumer recommendations. Although its primary research center is in Taiwan, it also has divisions in East and Southeast Asia, West and Central Asia and Oceania, and West, Central, Eastern, and Southern Africa. In their own words, the AVRDC has taken on the mission of, "…alleviating poverty and malnutrition through the increased production and consumption of nutritious, health-promoting vegetables". The AVRDC is also home to the worlds larges public vegetable germplasm collection. It currently contains over 61,000 accessions from 155 countries. Nearly 20% of these accessions are indigenous vegetables. Of course, the Genebank is not only charged with storing the seed, they

also keep information on the accessions, distribute seed packets to public and private researchers, and propagate their supply to keep up with the demand.

The AVRDC focuses on vegetables while alleviating hunger, as they are our primary source of nutrition, and are also the largest source of income for smallholder and subsistence farmers. Both developing countries, and developed countries are focused on by the AVRDC, with the intention of not only improving the yields, resistances, and tolerances of crops, but also the diets and farming practices of the inhabitants. By taking this approach, practices and crops developed by the AVRDC have been shown to be extremely effective in both developing and developed countries.

The Indigenous Vegetable Unit

I was assigned to the indigenous vegetable unit at the AVRDC, as the individuals in charge if intern placement noticed my extensive field work experience, and thought it would be a fitting place. This placement gave me the opportunity to experience agriculture in a completely new light, as well as an introduction to the entire scientific process for field experiments, from designing the experiment, all the way to collecting and analyzing the data.

The indigenous vegetable unit plays an extremely important part in improving the diets and farming practices of those in developing countries. Indigenous vegetables are often underutilized when it comes to crop and subsequently, diet diversification. They are often quite resistant to various stresses such as flooding and drought, and typically have the ability to adapt to a variety of environments within their native zone. Unfortunately, they are often pushed out of the typical crop rotations in developing and developed countries as new fruits and vegetables come into play (Ebert, 2011).

At the AVRDC, the indigenous vegetable unit is primarily charged with the identification and promotion of specific indigenous vegetables. They not only do this for Taiwan, but also for developing countries all around the world. Most of the research they conduct revolves around the identification of native vegetable species, specifically looking at yields, resistances, nutritional content, appearance, and taste. They often source data such as taste and appearance through public trials. Once sufficient data is collected, the indigenous vegetable unit will select the most appropriate accessions for promotion. Promotion is incentivized in private and commercial markets, on both the farmer and consumer levels. Promotion is one of the most difficult processes of vegetable development; however, the indigenous vegetable unit counters this effectively through the use of extension, developing efficient farming practices, and creating new recipes for consumers to use.

Supervisors and Collaborators

Supervisors played a large role in my personal and professional development during my internship at the AVRDC. My closest supervisor, and indeed the first individual in the indigenous vegetable unit I met was Ms. Yun-Yin Hsiao, who was more commonly referred to as Ruby. Ruby, an assistant vegetable specialist in the indigenous vegetable unit, was in charge of me at all times, and she did a fantastic job managing me during my stay. She oversaw all of the work I completed, helped to keep me on schedule, gave me suggestions when needed, set up my work experiences, and secured all the supplies I needed for my experiments. While all of this was important for my research project, she helped me in a much more beneficial way, by allowing me to experience all aspects of Taiwanese agriculture on a very personal level.

Ruby grew up in Southern Taiwan, not far from Tainan, where the AVRDC headquarters is located. Nearly all of her agricultural experience came from the weekend trips to her grandparent's rice farm, where she was allowed and encouraged to take part in the farming activities. She attained her B.S. in agriculture from National Chung Hsing Univeristy in 1995, and her master's degree in science in the same topic in 1998. She has held two different positions in the AVRDC since 2002.

Now, there were some initial problems during my initial interactions with Ruby. During the first two weeks of my internship, I was primarily just wandering around, wondering what I was doing, and what the primary purpose of my project was. One of the main reasons for this, was the language barrier that existed between us. During this initial period, I was flying nearly blind on my project, simple completing tasks as I was instructed. It almost made me feel as if I had only a very small purpose at the AVRDC, and gave me a poor prospective outlook on my internship at first. This barrier took some time for me to overcome, but once I had passed it, communicating was no problem, and Ruby and I were able to work very efficiently together. What I learned from this experience, was that I simply had to have the gumption to ask questions when I was unsure of something.

As I mentioned, Ruby gave me a very comprehensive outlook on the agriculture in Taiwan. Nearly every week, she took me one place or another to show me different aspects of agriculture, such as the Si-Lo wholesale market. Near the end of my stay, she even took me to visit her old family farm in Daling, where she explained the old farming practices, and how they have been improved over the years. On many of these trips, she also arranged mentors who knew a great deal about the economics and production behind the crops, and as many of them could not communicate in English, Ruby stepped in to translate. Ruby also had one of those constantly bright personalities, always pushing me to explore Taiwan with my friends, while constantly peppering me with special fruits and foods. Overall, I grew very close to Ruby as a mentor, and I am very grateful to have been placed under her supervision. Pics of si lo, family farm

Dr. Peter Hanson, the head tomato breeder, as well as the Global Theme Leader for Breeding, has been working for the AVRDC for over 22 years. He served as my primary supervisor, but from a more administrative position. One exceptionally special aspect about Dr. Hanson, is that he was one of the only native English speakers on the AVRDC campus, meaning that he was incredibly helpful during my first few weeks in Taiwan, when my struggles with communication

were the most apparent. He exposed me to my first bit of Taiwanese culture at the Dragon Boat Festival, and helped me a large amount with my project and final presentation at the AVRDC.

Later in my internship, I began working on nutritional analysis with the nutritional lab. Without hesitation, the scientists working there immediately took me in, and made me feel as if I were part of the lab. Despite our difficulty in communication due to the nature of scientific jargon, we were able to work quickly and efficiently together. They helped me to prepare samples, taught me important protocols, and assisted with data collection. Currently, they are hard at work preparing and analyzing all the nutrient samples I left behind.

Research

First Project

Of course, as part of my internship, I was asked to complete as much of a research project as possible in the two short months I was there. Taiwan is known for having wonderful climates for growing fruits and vegetables; however, with the frequent monsoons, dry spells, and pests, any new fruit or vegetable to be introduced must have a high resistance to abiotic and biotic stress, such as flooding, draught, insects, and fungal infections. One vegetable which was already partially evaluated and had been selected for field trials because of its high resistance, was *Vigna uniguiculata* (vegetable cowpea). Ten accessions of vegetable cowpea had been selected for the field trial, as they were thought to be the most likely to succeed based on previous trials. Of these ten accessions, we wanted to test and select only those which stood out from the rest in terms of yield amount and product quality. These accessions of vegetable cowpea were as follows: VI060274, VI060275, VI060276, VI060277-A, VI060277-B, VI060281, VI060282, VI060284, VI060285, and VI060287. For this crop, I was first asked to do a yield analysis, with the intentions of doing both a consumer evaluation and a nutrient content analysis. The field trial had already been set up prior to my arrival, in a randomized complete block deign, with three replications. Experiments had been mirrored in both conventional and organic growing conditions.

As stated earlier, farmers in all around the world are looking for more ways to earn a sustainable income. One of the easiest ways to do this is to introduce improved underutilized crops that are economically feasible to grow and resistant to common diseases, pests, and inhospitable climates. Unfortunately, the farmers themselves cannot simply select a new kind of crop to grow, because this is too much of a risk. Instead, research organizations like the AVRDC take a scientific approach to determining which variety of a crop should be grown, based off its stress resistance, yielding ability, nutritional capacity, and consumer acceptance. Only after all of these factors have been assessed is the prime accession released to the farmers with a solid recommendation.

For the yield recording, 50 flowers were selected from each accession, bringing the total number of selected flowers to 150 after all 3 replications had been reviewed. Each flower that was

selected was tagged with it's accession number, and a date indicating when it had been tagged. All the flowers were only tagged if they were in similar states of maturity, and had little to no apparent damage or malformations. While it would have been the most scientifically accurate to tag all accessions on the same day, this was impossible, as the accessions did not flower at the same time, and the flowers were only open for a few hours in the early morning, meaning that we would need a large amount of labor to be able to accomplish the tagging.

After tagging, we waited five days for the beans to mature, then began to harvest. The harvest schedule was set such that we could select beans on the 5^{th}, 6^{th}, 7^{th}, 8^{th}, and 9^{th} days of maturity. Only ten beans would be selected from each accession. Once harvested, the beans would be evaluated in terms of their singular weight, length, thickness, width. If there was extra time, the beans were also going to be subjected to a digital photo analyzer to look at color, and also to give a number based on pest damage.

Tagging Vegetable Cowpea Flowers

All of the data from this experiment would have been quantitative, meaning that it could have easily been crunched through a program such as R or SAS to distinguish differences between the physical characteristics. If the study worked as planned, there would either have been a significant difference between the accessions, or a similarity among them.

The first shortcomings of the experiment came when we were initially tagging the flowers, and we noticed that there were very few, and that it was quite difficult to find 150 flowers per accession. We thought this was primarily an effect of the flowering season, and that the plants were simply not flowering in full force because it was before their natural flowering season. In addition, this was when we first realized that the flowers were only open quite early in the

morning, and that they closed just 1-1.5 hours after this. Despite this, we managed to tag enough flowers to begin the experiment. Problems began appearing after we began to harvest the mature pods. On the first day of harvesting (the fifth day of maturity), the number of pods present seemed to be quite lacking, but it was not until the second harvest day that an official count was performed. Of the 150 flowers tagged, less than ¼ of them remained on the plant, and the rest had dropped of the plant with the tag still attached.

It was assumed that that the flowers dropped off simply because of the mechanical disturbance caused by tagging the flower. At this point, we decided to stop tagging flowers regularly, until we discovered a method of tagging that did not cause the flowers to desiccate and drop off the plants. In the following period, a small side experiment was begun to find a method. Despite all methods employed, such as simply not touching the flower while tagging, tagging the peduncle instead of the flower itself, or tagging the stem of the plant below the flower, the flower managed to fall off roughly 75-90% of the time. Because of this, we ruled out mechanical disturbance as the main cause of blossom drop. After some literature review, we discovered that legumes such as cowpea have a sensitivity to extremely high temperatures, despite their ability to survive drought quite well. If the temperature rises above a certain temperature for a sustained period of time, a malfunction in pollen transfer will cause the blossoms to drop off. Due to the drought occurring in Taiwan during the spring and summer of 2015, we assumed that it was the cause of the blossom drop.

Of course, we had already invested quite a large amount of time, energy, and resources starting this project, and we did not want to abandon it with absolutely no results, based sole on an assumption. As such, we simply waited for a few weeks to see if the weather would cool down, or if the plants would begin to produce more viable flowers. Unfortunately, after waiting for the better part of 3 weeks, we decided that we should accept the experiment as a loss, and gain what little data we could.

As mentioned earlier, only 10-25% of the flowers remained on the plant after blossoming. This meant that to continue the experiment under the initial conditions, we would have to initially tag between four and ten times as many flowers, which was unfeasible, as the plants were not producing enough flowers to sustain that practice. It was at this point, we decided to close the experiment. The experiment itself was not considered a complete failure; instead, it simply told us that vegetable cowpea plants have a reduced rate of blossom retention during periods of extreme high temperatures.

Second Project

At this point I was already over halfway through my internship, without a true project to work on. For roughly a week, I read through various papers on the growth and flowering of legumes, and on the importance of indigenous vegetables to food security. Unfortunately, this did nothing to improve the project I had been working on. I remember sitting at my computer wondering, what can I do with what I already have? I went a step further and thought, what could a farmer possibly do if their entire crop of vegetable cowpeas were performing as terribly as ours? Of course they could have planted another crop earlier in the year, but what if they had not had the foresight, or what if it had failed as well? Additionally, they could put in another vegetable in,

but it probably would take some time to mature. After doing some literature review, I discovered that you can easily use most legumes to grow a secondary product of sprouts. Although mungbean and soybean sprouts are commonly consumed in Asia, there had been very few studies done regarding their growing cycle, yielding amounts, or nutrient content. The process itself for sprouting was quite simple, and it seemed to be a promising mini-project; something I could probably complete in my last 3 weeks at the AVRDC.

I quickly learned; however, that beginning a project with no idea of the protocols involved was extremely difficult. Luckily, Ruby used some of her connections to find individuals who already had some experience with starting sprouts. After observing the general procedures, we obtained Dr. Hanson's approval, and decided to order the necessary materials and begin the experiment as soon as they arrived.

Unfortunately, due to our limited resources and time, we could not afford to use all 10 accession in the sprouting assay. Instead, we selected the five accessions we expected to do the best. These accessions were selected based solely on size, as legume sprouts derive most of their nutritional content from the original seed. The accessions we used were as follows: VI060274, Vi060275, VI060284, VI060285, and VI060287.

Methods

The methods employed for the sprouting assay were fairly simple; however, they required a large amount of pretesting and adjusting before we could create a standard protocol. After the accessions were selected, we ran an initial with just one accession to test the viability of the seed stock, and to give us a baseline on seed requirements for future experiments.

To begin the process 40 grams of seeds were weighed out for each accession and placed into plastic containers. Due the the potential statistical variation, each accession was replicated three times. Seeds which were cracked or otherwise deformed were removed prior to weighing. After being placed into the containers, 500mL of deionized and distilled water was added to each container to completely cover the seeds. The seeds were soaked for a total of 8 hours, to help jump-start the germination process. After soaking, the seeds were spread into plastic baskets lined with a presoaked water absorbent cloth. The baskets were then fit into a secondary container, used to catch any drips from the basket. Following this step, the seeds were misted with more deionized and distilled water, after which a third opaque plastic container was fitted over the top, to block out light and to keep moisture in the container. Each container of seeds was lightly sprayed with deionized water three times per day to provide adequate moisture for sustained germination and growth. The containers themselves were set up in a randomized complete block design, under 24 hour florescent lighting, in a room that kept the containers at 25°C.

The sprouts were left undisturbed, to grow for a total of 96 hours, interrupted only for watering and photo records. Following the 96^{th} hour, the sprouts were harvested, and transferred to secondary containers. The sprouts were weighed immediately, and then sent to the nutrition lab for further analysis. At the nutrition lab, half of the sample was used for an ascorbic acid test, and the other half was freeze dried with the intention of performing a full nutrient content analysis in the future.

To begin the vitamin C analysis, 20 grams of the sprouts were prepared through the traditional chopping method. These 20 grams were initially frozen, due to the amount of preparation required for the samples. The following day, each sample was thawed, and transferred to a blender, where it was pureed for 3 minutes in a 80mL solution of metaphosphoric acid. Following the blending, the sample was transferred to a plastic centrifuge tube and spun at 7000rpm for 10 minutes. After centrifuging, there was a clear difference between the supernatant, and the vegetative material remaining at the bottom. The supernatant was filtered through common filter paper into a glass test tube. Following the filtration, 0.3mL of the solution was transferred to a separate glass test tube. This last step was replicated three times, two tubes for the true content, and one as a blank to ensure that the protocol worked. To each of these tubes, 1.7mL of metaphosphoric acid was added, and it was vortexed to mix.

In a separate process, a set of standard solutions was made by which the samples would be measured against, simply to ensure the reliability of the reagents. To make to standard, 0.05 grams of ascorbic acid was placed in flask, and dissolved in 50mL of metaphosphoric acid. This initial solution needed to be diluted to 70% its original concentration. To do this, 1000mL was transferred to a second flask, and an additional 50mL of metaphosphoric acid was added. This diluted solution was then transferred to a clean 100mL beaker, and the standards were made from it. A 20%, 40%, 60%, 80%, and 100% standard was made by mixing the opposite proportions with metaphosphoric acid. All of these standards were mixed completely though vortexing.

The standards were then included in the processes of the samples from this step on. To begin, on drop of a 0.2% 2,6 dichlorophenolindophenol sodium solution was added to each sample and the standards, turning them a light pink. Following this step, 2ml of a 2%thiourea solution were

pipetted into the samples and they were vortexed to mix. After mixing, 1mL of 4% 2,4-dinitrophenylhydrazine was added to all tubes, except the blanks of the samples.

Once the 2,4-DNPH was incorporated, all of the samples were placed in a 37°C water bath for 3 hours, except the blanks. After the 3-hour duration, the samples and the blanks were placed in ice water, and cooled for 10 minutes. Once the cooling process was complete the samples were mixed through vortexing, 5mL of 85% sulfuric acid was added, and the samples were vortexed again. Following this, 1mL of 4% 2,4-dinitrophenylhydrazine was added to the blanks only, and they were thoroughly mixed through vortexing. All of the samples were then allowed to rest at room temperature for 30 minutes, after which the optical density measured with a spectrophotometer.

Results/Conclusion

Many of the results obtained from this project were simply preliminary results, and should not be trusted in terms of final conclusions. That being said, we did gain significant data in terms of how to complete a sprouting assay in the future for a full yield and nutrient analysis. One of the first, and most important pieces of information gained from this experiment is the proper growing conditions as entailed in the "methods" section.

During this initial experiment, we planned on observing three characteristics. These characteristics are; the wet weight from each accession, indicating yield, vitamin C content of each accession, and the growth patterns of cowpea sprouts. The data for the project itself, although it was replicated enough times to be reliable, is not necessarily completely trustworthy, simply due to a lack of reliable controls, and the inability to completely control or automate the growing conditions.

The measurement we were most interested during this initial phase of the project, was the growing habits of vegetable cowpea sprouts. By setting up those 15 trays of sprouts multiple times, we were able to see which accessions had the most desirable growing patterns, and which ones were not fit for sprouting. The data, as shown in the supplementary material (Figure 2), indicated that accessions VI060-274, VI060-284, VI060-285, and VI060287 were all relatively well suited for sprouting, while accession VI060-275 was not. AccessionVI060-275 was from a different collection of older seeds, so it is possible that the lack of germination is simply to this.

The other two measurements, those being the wet weight of each accession, and the ascorbic acid content, were not true data points. The idea with getting this information was simply to show us that we could easily perform the procedures required to gain the data, and also to smooth any bumps in the protocols prior to performing the second experiment. That being said, it was also useful to acquire the data, as it is a practical way to measure whether our future attempts are growing properly or not. The wet weight, shown in Figure 3, indicated that all accessions had viable yields, except accession VI060-275, as there was no sprout weight due to the absence of germination. Vitamin C content, obtained through the measurement methods described above, showed adequate levels of ascorbic acid, giving them support for further nutrient analysis (Figure 4).

It was known going into this project that we would most likely not be able to retrieve a complete data set. Instead it was intended to be a pioneer project, one off of which future experiments could be based if the results from these experiments proved to be promising. While we gained preliminary results regarding the nutritional content of the vegetable cowpea sprouts, we more importantly were able to take an in-depth look into exactly how to perform a trial involving sprouts, as show above in the methods. This information will allow us to set up further experiments to analyze the nutritional content of vegetable cowpea.

Personal Remarks

Interviews

As I mentioned earlier in my personal introduction, I have always been interested in agriculture. I specifically enjoy talking with those who actually perform the task of cultivating the land, caring for the plants, and harvesting their crops. Through my experience in New York, I found that these the small farmers, those who actually complete the backbreaking labor required, often have the best connection with the land, and typically care the most about the sustainability of their farm, the environment around them, their community, and virtually everyone who comes in contact or is affected by their produce or practices. By talking, working, or generally interacting with those who toil in the earth, I believe that you can gain an incredibly valuable opinion regarding the economic, environmental, and social effects of agriculture.

I found that this was absolutely no different in Taiwan. Although I could not communicate with the field workers, short of a few halting Chinese or English words, I thoroughly enjoyed every moment I worked with them. Simply by observing, I could see that despite looking elderly and weary, they worked harder, were more honest, and had better intentions than many.
Although I could not directly communicate with these fieldworkers, I decided to obtain a few of their opinions regarding farming ideology and food security. It was agreed that the easiest and most efficient way for me to do this would be to draft a short survey which Ruby would translate to Taiwanese. From that point, the field workers could record their answers on paper, which Ruby could then translate back to English. While the intention was to present the survey questions to 10 individuals, I was only able to obtain 4 of the responses as of the time this paper was written, simply due to the time it took to translate the surveys. A sample of these survey questions is included in Figure 1.

Despite this small number, I was able to gain an inspiring insight about the lives of the field workers. Of the four survey responders, ages varied from 62 to 46 years old. You must remember that these individuals are performing backbreaking wok every day under full sun, in a climate where temperatures often reach 100°F in the summer months. Not only are these workers towards the senior side, but some have also been working the fields at the AVRDC for over 40 years, in addition to work at home. Despite these conditions, all of the workers truly enjoy being employed by the AVRDC, as it is safe work with a reliable income.

When asked more specific questions about the state of agriculture in Taiwan, the participants answers varied, although there were some unifying thoughts and concerns. One of the primary

questions I learned from, was what concerns the workers had about the current and future state of agriculture in Taiwan. While some of the responders voiced opinions about issues similar to those in the United States, such as increased applications of pesticides, high rates of pollution, and the increasing age of the farmer, all had at least one comment about the farming technology in Tawian. From what the responses said, Taiwan has a very productive and innovative technological and research sector, especially for agriculture. Unfortunately, many of the advances in crop management and new plant cultivars are quickly introduced to China, where farmers readily adopt them. This action disadvantages farmers in Taiwan, as it is often more expensive to grow crops in Taiwan than in China. Ultimately, it means that the farmers in Taiwan face a greater competition, causing much of the food in Taiwan to be imported from China, instead of grown locally. Many of the field workers believe that this is an unsustainable practice which negatively impacts the farmers, and eventually the people of Taiwan.

While many of these troubles are daunting, I have absolutely no doubt that if the rest of the farmers in Taiwan possess similar attributes to the field workers, they will be quick to propose a policy solution which benefits all of Taiwan. Individuals who maintain these characteristics, such as honesty, kindness, humbleness, and the motivation and work ethic to put in decades of hard work are who should be trusted when making important policy decisions. Farmers with these personal qualities simply tend to think about all facets when making a decision, such as how it affects different groups of people, while at the same time looking at the impacts on the environment. If the farmers of Taiwan utilize their available resources and take a public stance on the issues they feel passionate about, there is very little they cannot do.

Travels and Culture

Being homeschooled for the greater majority of my life, meant I was slightly sheltered in my earlier years. In fact, prior to my internship in Taiwan, I had never even ventured outside of the United States, except to Canada (which doesn't really count when you live in New York). As such I was incredibly excited, but also ever so slightly anxious about breaking out of my small rural town and venturing out into the world. Of course, there was the initial nervousness of actually making my flights on time and finding my way through airports larger than my hometown, but there was also the prospect of experiencing an entirely new culture. Luckily, I was sent to what may be the friendliest country on this planet. Every individual who I encountered recognized me as the confused (and probably lost) American, and offered to help me as much as they possibly could, even if they could not speak the same language.

As for my travels in Taiwan, I don't believe I could have been more satisfied. People at the the AVRDC, both employees and interns constantly offered to take me on trips around the island People at the AVRDC constantly offered to take me on trips around the island, many of which I accepted, although I wish I could have had more time to enjoy them. One of my very first trips was to Kenting, a national park covering much of the southern end of Taiwan. On these trips, I was immersed in the culture, scenery, and food of Taiwan, but I was also able to see how food made it from the farm to the consumer firsthand in and island nation. Whether I was observing a farm in the mountains, attending a brightly lit festival, or snorkeling near tropical islands, these trips gave me a much better understanding of Taiwan, and the Taiwanese people.

Reflection and Outlook

Of course, since the work I did for the AVRDC was preliminary, there is a great deal of potential for the project. For the future, there will most likely be a second experiment, this time gaining full data for growth rates, net weight, and appearance. This experiment will also provide us with much more complete nutrition results, allowing us to compare them to more common sprouts, such as mungbean or soybean. If those results are promising, it is possible that the AVRDC would complete a consumer evaluation of the cowpea sprouts, and promote the accessions that rose above the rest. However, this path is uncertain, as each step relies on the one before it.

As I spent a fair amount of time on both projects, I was able to glean some information which I will be able to apply to my future career. First, and foremost, I discovered that if you have limited time to complete a project, and there is even the slightest chance of failure, you should have a reliable backup plan. Additionally, prior to starting a project, you should do as much research as is necessary, instead of fumbling blindly the entire time. If there little to no literature regarding your topic, it is always advisable to use all available resources.

This entire summer was a learning experience for me, and there were many events from which I was able to obtain several important life lessons. One of the most important of these, is that when you are presented with what looks to be an amazing opportunity, do not hesitate to act upon it, otherwise you will most certainly regret it. Along the same lines of thought, I discovered that if you wish to rise above and beyond, you must truly apply yourself, and not wait for other to take action. Another vital lesson I leaned, is to simply take the initiative, and ask questions when you do not understand something, or are curious. Moving away from the research, I also discovered that you should never turn down the opportunity to explore a new country, and never be afraid of getting lost, as one way or another, you will learn something. Lastly, and probably the most crucial lesson I learned, is that food security is a worldwide issue, to which there is no one solution.

As a final note, I would like to offer my sincere gratitude to all of those involved in shaping my experience this summer. First, to Dr. Borlaug, for giving me a role model to follow. Lisa Fleming, also played a major role, by helping me every step of the way. Ambassador Quinn, John Ruan, and all of the staff of the World Food Prize and Global Youth Institute all deserve many thanks for their involvement, as well as everyone at the AVRDC for their hospitality. I truly hope that I represented Dr. Borlaug and everything the World Food Prize stands for the the highest degree.

Supplementary Images

Field Worker Survey
AVRDC – The World Vegetable Center

1. Gender and age ☐Male ☐Female ___ Years Old
2. Did you receive any formal education? If so, to what level? 教育程度
   ☐識 字 ☐小學Elementary ☐ 國中Junior High ☐高中Senior High ☐五專Junior College
   ☐大學University/College ☐研究所以上MSc/PhD
3. Where did you grow up? 成長的地方
4. Were your parents or other family farmers? Were you raised in an agriculture rich environment? 父母或其他家庭成員是農民嗎？是否在農業環境豐富的地方長大？
5. If so, did you take part in any agricultural activities? 承上題，若是，是否參與了任何的農業活動？
6. How long have you worked at the AVRDC? 在亞蔬的工作年資
7. Do you have other employment besides the AVRDC? 除了亞蔬，是否還有其他兼職
8. Where else have you worked, and how did you end up being employed by the AVRDC? 來亞蔬之前的工作是？為什麼想來亞蔬工作？
9. Do you think that there are any issues with how people farm in Taiwan? 你認為台灣人民如何從事農業？
10. Do you believe that the Farmers Association helps in Taiwan? 你相信台灣的農會體系是有助於農民的？
11. Can you see the positive effects the AVRDC has on farmers in Taiwan? 請舉例你認為是亞蔬對台灣農民的積極/正向之作為/效益
12. Do you have any concerns about the future of agriculture in Taiwan? 你對台灣未來農業的看法
13. Any other comments or opinions about food security in Taiwan? 你對台灣糧食安全的看法

Figure 1. *Field Worker Survey*

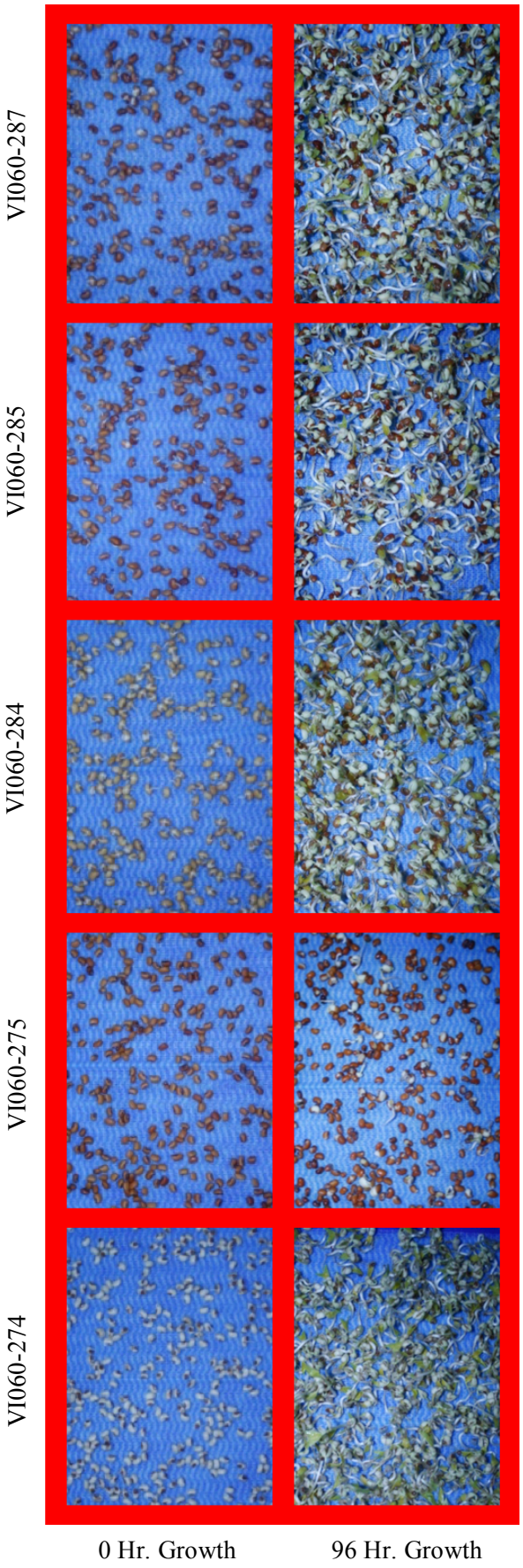

Figure 2. *Sprouting Viability*

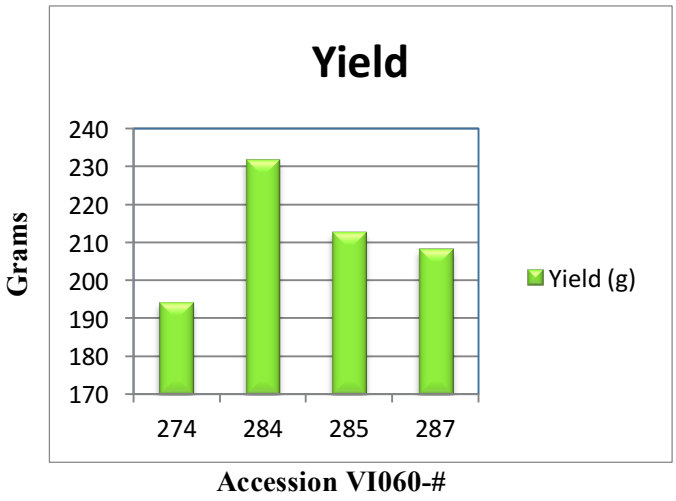

Figure 3. *Wet Weight of Sprouts*

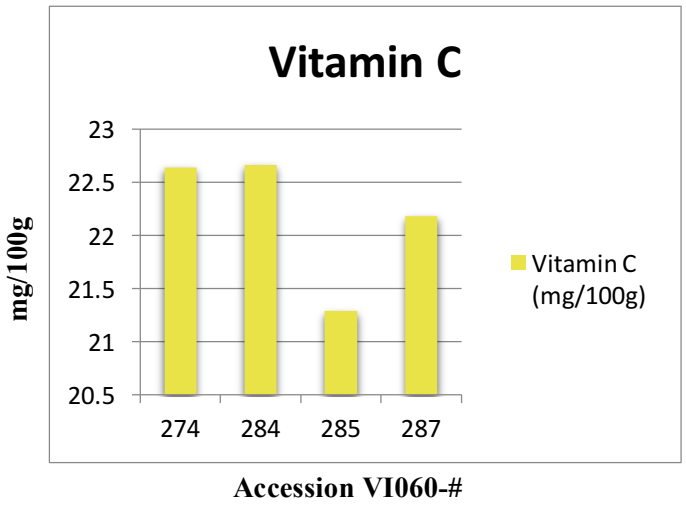

Figure 4. *Vitamin C Content*