Enhancing Resistance in High Yielding Adapted Germplasm to Major Wheat Soil Borne Diseases

The World Food Prize Foundation
2015 Borlaug-Ruan International Intern
International Maize and Wheat Improvement Center (CIMMYT) Soil Borne Pathogens Program
Eskişehir, Turkey

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Contents

Introduction

Growing up in India, I saw poverty on the streets every day as people with sunken cheeks and frail bodies asked for food. While this isn't representative of all of India, the hunger was difficult to overlook. I expected the issue to disappear when I moved to America, but it was simply a different scene from the same story. In the middle of a freezing winter in Iowa, men, women, and children stood in lines outside the local food pantry, waiting for a warm, nutritious meal. I was shocked that this issue is so prevalent even in one of the most developed countries.

I got involved in various volunteer opportunities to help reduce hunger in my local community including meal packaging, canned-food drives, and volunteering at the local soup kitchen, but I had a strong desire to do more. For most of my life I have lived in Cedar Rapids, Iowa. Live in a state known as the agricultural capital of the world and having a large corn field right next to my house gave me a singular view that food is abundant for many. It wasn't until I was introduced to the World Food Prize (WFP) organization that I began to understand the enormity of food insecurity. When my AP biology teacher, Mr. Brad Horton discussed an opportunity to get involved in WFP, I was excited for a chance to impact the global community. In my research paper presented at the Iowa Youth Institute, I focused on water scarcity and its impact on rural farmers in Andhra Pradesh, India. I developed a deeper understanding of the issues causing food insecurity through the research done for that paper, my interview with a farmer from that region, and the various symposia at the state youth institute. Jo Luck, the keynote speaker and 2010 recipient of the World Food Prize, inspired me with the impacts she brought around through Heifer International.

I found out that I made it to the Global Youth Institute (GYI) on my birthday and I couldn't have asked for a better gift that day. I eagerly awaited the chance to meet other students passionate about fighting food insecurity. It was a great opportunity to interact with scientists, farmers, and corporate officials from around the world leading this movement. Sitting next to these individuals, I learned that today's generation must invest in this fight to be able to feed the projected population of 9 billion by 2050. I also conversed with Borlaug-Ruan International Interns from previous year and learned about this 8 week internship abroad to research issues related to food security. Hearing about those students' experiences, their contributions, I decided to apply for the same internship.

Brief Background on CIMMYT Turkey

I spent my 8 week internship at CIMMYT Turkey's soil borne pathogens (SBP) program. This program collaborates with the International Winter Wheat Improvement Center (IWWIP) to improve winter wheat germplasm to tackle root rot diseases. CIMMYT began as a pilot program in the 50s when Norman Borlaug worked in collaboration with the organization to develop short-stemmed varieties of wheat that are resistant to rust disease. CIMMYT has now evolved into a global organization looking to make the next "Green Revolution" through its work around the world. Their ultimate goal is to create responsible and sustainable methods to combat global food insecurity. SBP CIMMYT Turkey program contributes to this goal by identifying strains of wheat resistant to various soil borne pathogens and develop integrated pest management systems for farmers both local and international.

There are many worksites around Turkey. I worked in Eskişehir in CIMMYT labs that is a part of the Turkish Ministry of Food Agriculture and Livestock research institute.

Goals and Missions of the Program

During my stay in Turkey I had the chance to learn about the International Winter Wheat Improvement Center (IWWIP) which is a collaboration between CIMMYT, International Center for Agriculture Research in Dry Areas (ICARDA), and the Turkish Ministry of Agriculture. The program's main objective is "To develop winter/facultative wheat germplasm for the region of Central and West Asia. IWWIP also facilitates the winter wheat germplasm exchange for the global breeding community."

During the 8 weeks, I worked with the Soil Borne Pathogens Program (SBP) under the supervision of Dr. Abdelfattah Dababat and Dr. Gül Erginbas-Orakci. The program's goal is to identify wheat strains that are resistant to a host of pathogens. I worked with Root Lesion Nematodes (RLN) *Pratylenchus neglectus* and *P. thornei*, Cereal Cyst Nematodes (CCN), and two species of Fusarium (*F. culmorum* and *F. pseudograminearum*). While each pathogen detrimentally effects yield, they each impact the wheat in different ways and requires different procedures to analyze and determine resistance.

Figure 1: At the Transitional Zone Agriculture Research institute entrance, Eskişehir, Turkey. (Picture Credit: Joe Barry)

Working on Soil Borne Pathogens is a challenging since most of the disease symptoms are on the roots of the plants which aren't readily visible in the field and most of the analysis require microscopic examination. In addition, there are several confounding variables in the field that make it difficult to determine if the pathogen alone is causing the observed effects or if other variable play a role in that as well.

The SBP program at CIMMYT Turkey tests various wheat germplasm provided by CIMMYT Mexico wheat breeding's program and IWWIP to determine germplasms' resistance to various soil borne pathogens. The new germplasm is first screened in the growth chamber and greenhouse before the open field evaluation. The yield trials are set up in the field under naturally or artificially infested and non-infested field conditions during wheat growing season

(October-June) in Turkey. The plants are harvested upon maturity and the seeds weighed to quantify yield loss caused by each pathogen by comparing both (inoculated and non-inoculated) field sites. For plots being tested for either nematode, soil samples are collected at sowing and at harvesting to investigate the tolerance/resistance reaction of that line. For the plots being tested for crown rot, the stems are pealed for a visual rating. Based on the findings, a decision is made on the most resistant germplasm to the specific disease to be used in both the breeding programs and for international distributed to the international collaborators.

Background on my Mentors and Colleagues

I did my internship under the able guidance of Dr. Abdelfattah A. Dababat and Dr. Gül Erginbas-Orakci. Dr. Dababat received his PhD from University of Bonn in Germany in 2006 and specializes in plant pathology and nematology. He is based in the CIMMYT and ICARDA offices in Ankara and frequently travels to all the CIMMYT worksites to manage the fieldwork. Having grown up on a farm, his passion lies with working in the fields and seeing the fruits of the months of lab and computer work required beforehand. Dr. Erginbas received her PhD in 2010 from Osman Gazi University and is a plant pathologist specializing in crown rot disease. She is based in Eskişehir and runs the CIMMYT SBP lab. She travels to various field sites like Yozgat and Konya to determine the visual rating for hundreds of wheat strains.

Under the mentorship of these scientists, I was introduced to various projects in CIMMYT Turkey and contributed to both the lab and field work. Most of my work was with Sevil Yavuz (Sevil Hanım), Ekrem Çelik (Ekrem Abi), and Ümit Rüzgar (Ümit Bey), who I have to deeply thank for becoming my Turkish family and teaching me the ins and outs of each protocol and procedure. We worked with each other daily, setting up experiments, analyzing soil samples, harvesting, and taking çay (tea) breaks together.

I also worked with Joseph Barry during my 8 weeks. He is in his first year of his PhD and is setting up experiments in both Turkey and Australia. In addition to expanding my understanding of the soil borne pathogens, he became a great friend. We arrived in Turkey at the same time and got to experience the culture together and figure out this ins and outs of living in a different country. While I loved learning Turkish, it was nice to have someone to talk to in English whenever I wanted.

The Research

My contributions to the research at CIMMYT Turkey involved many projects. Through my work I gained a wealth of knowledge about CIMMYT, agricultural research, and lack of availability of resources. I developed an appreciation for the hard work put in by this team to contribute to the fight for food security.

Greenhouse Harvests

During my first week in Eskişehir, I harvested various germplasm of wheat and barley from the greenhouse. These grains require 8 months to grow under the ideal conditions of the greenhouse and the seeds were harvested with the use of a thresher. Though I have been surrounded by farms most of my life, I have had quite the urban upbringing. This first week helped me get oriented with plant terminology and structure. These fundamentals became particularly useful when separating wheat from barley in the field.

Since CIMMYT is an international organization, there is significant collaboration between the different work sites. The seeds from each plant were carefully labeled and prepped to be sent to collaborators where the wheat and barley would be planted and further analyzed for properties that can make them viable in various conditions and regions around the world (Figure 2).

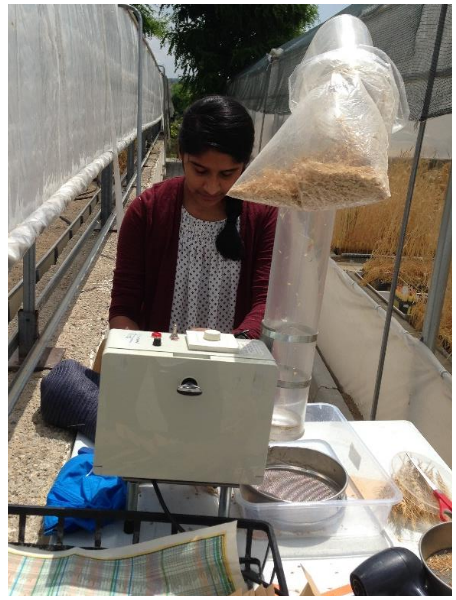

Figure 2: Threshing wheat from the greenhouse to send seeds to CIMMYT Mexico. (Picture Credit - Sevil Yavuz)

During this first week, I got introduced to Sevil Hanım and I was immersed in Turkish. We learned to communicate through hand gestures and I learned the words tamam (okay), yok (absent: often used when talking about a plant with zero yield), tohum (seed), and evet (yes). She helped me get comfortable with the lab members very quickly.

Soil Borne Pathogens

Working in the Soil Borne Pathogens Program, a majority of my work focused on cereal cyst nematodes, root lesion nematodes, and fusarium. While each of these pathogens impacts the plant differently, all of them significantly reduce yield.

Cereal Cyst Nematodes

Cereal Cyst Nematodes (CCN) are a parasite that damages the roots of wheat, barley, oats, and rye. In 2001, nematodes alone caused $118 billion in losses globally (McCarthy, 2009).

Occasionally CCN infected plants can be identified visually because of stunting of plants or scattered patches of growth in the field. Economically the most significant CCN species are *Heterodera avenae, H. filipjevi and H. latipons* (Nicol and Dababat, 2009). Past studies have established that Cre genes indicate resistance to species of CCN, however, germplasm with these genes have only shown moderate resistance to the Turkish *H. Filipjevi* populations (Imren et al., 2013). SBP program at CIMMYT Turkey collects cysts from fields historically infested with CCN, extract cysts, enhance hatching, and then inoculates plants to later determine the germplasm’s resistance or lack thereof.

Over years of testing, certain plots have been identified as CCN positive in the CIMMYT fields at different location in Turkey. I began collecting soil samples from the field. Cores of soil are collected and then washed using the floatation method (shown in Figure 3). First the soil sample is flooded with a large volume of water and stirred. Once the mixture has settled for 20 seconds, the top water is poured into a double sieve apparatus. The cysts from the soil float in the water and are then collected in the sieves. The upper sieve has a 250 µm mesh size and the bottom sieve is 850 µm. The mixture left on the second sieve is collected. The sample is observed under a stereomicroscope and the individual cysts are hand-picked with forceps. During my hours collecting cysts under a microscope, I found it to be quite the scavenger hunt. Among similar looking debris, I delicately collected each cyst. The white cysts are female nematodes carrying eggs. Once the female dies, the outer layer turns brown and protects the eggs until they are ready to hatch. The cysts were placed in a refrigerator at 4°C and will be stored there until they are needed during the next planting season. At 4°C these cysts lay dormant. A fluctuation between 4°C and 21°C (room temperature) stimulates the hatching of juveniles. The concentration of juveniles is counted and the solution is either concentrated or diluted with water to get 300 juveniles per ml of tap water.

Figure 3: Washing soil samples to collect cereal cyst nematodes using the flotation method. (Picture Credit: Sevil Hanım)

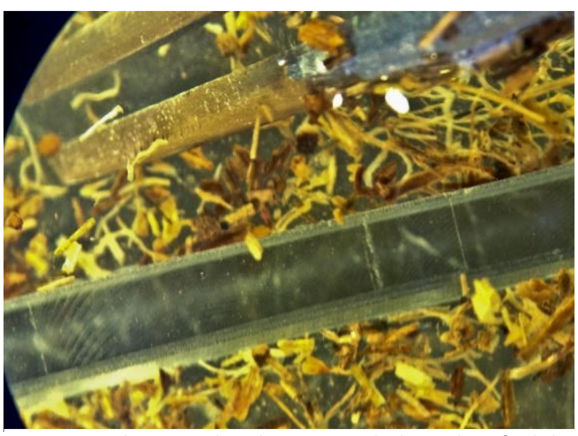

Figure 4: Debris in a chamber to search through to find the cysts of CCN.

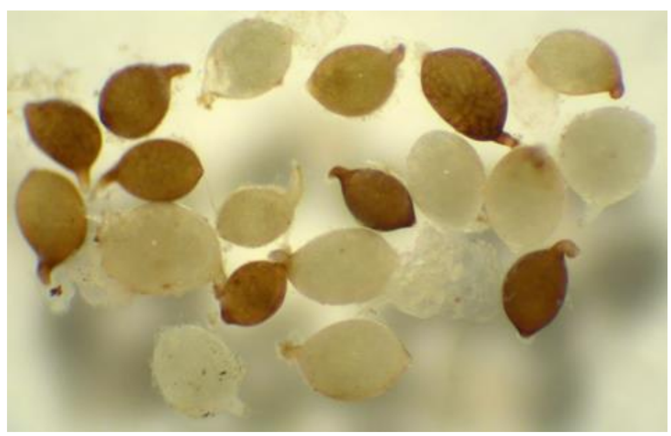

Figure 5: Cysts of CCN.

During this period, wheat seeds were germinated (Figure 6) for the various germplasm we received from other organizations in Turkey and around the world. The seeds were planted in a standard tube (16 cm in height x 2.5 cm in diameter) with three replicates of each germplasm. The tubes contained a soil mixture of sand, field soil, and organic matter in a ratio of (70:29:1,

v/v), respectively. One ml of inoculum was evenly dispersed amongst the three holes in each tube to infect the plants (Figure 7). These tubes were then placed in a growth chamber with artificial light and were watered periodically. In the growth chamber the plants get 16 hours of light daily, temperature of 23ºC ± 2 and 65% ± 5 of relative humidity. Plants are harvested after nine weeks of nematode inoculation and cysts are extracted by procedure detailed above. The cysts are counted to determine if a line is resistant. The growth chamber is ideal for initial analysis because most extraneous variables can be controlled for and these experiments can continue throughout the year.
The experiment I set up in Turkey did not reach maturity before I left due to the 9 week growth period. In the midst of planning for the harvest season occurring this month, the analysis of the resistance of each germplasm is ongoing.

When analyzing the germplasm grown in the growth chamber, any tube with 5 cysts or less is considered resistant. Having five cysts would indicate that of the 300 juveniles that initially infected the plant only five females survived to the stage of maturity. The resistant germplasm will be tested in the field to verify viability in a natural environment as well as to test its tolerance reaction under high and low disease pressure.

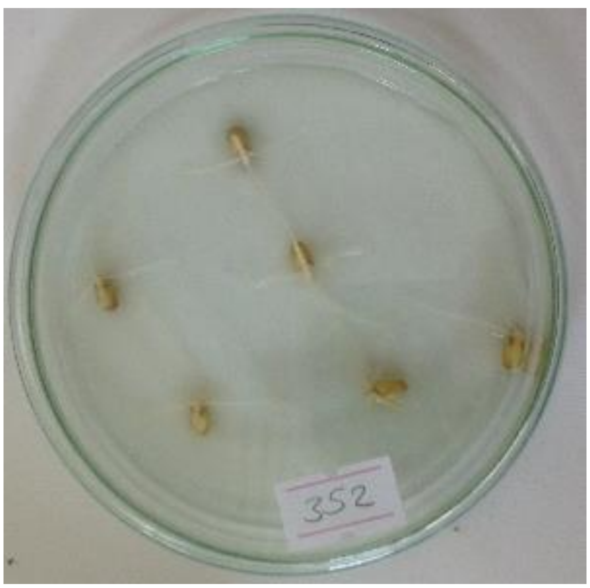

Figure 6: Germinated wheat seeds for growth chamber testing. (Picture Credit: Sweta Sudhir)

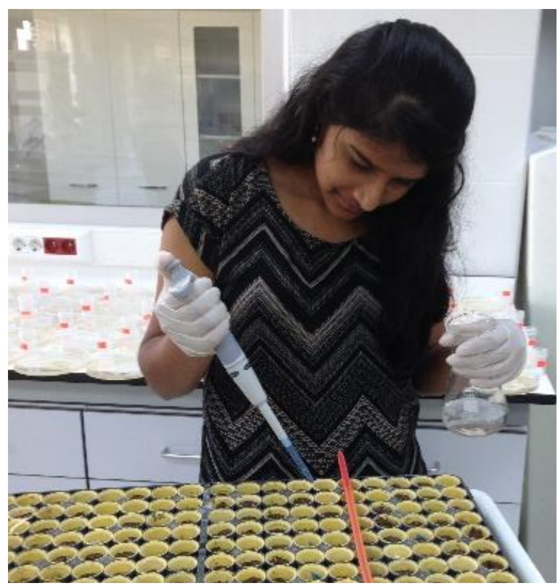

Figure 7: Inoculating wheat plants with CCN after germinated seed is planted. (Picture Credit: Sevil Hanım)

Root Lesion Nematodes

Root Lesion Nematodes (RLN) is another soil borne pathogen that devastates crop yields in Turkey and around the world. *Pratylenchus thornei* is the predominant species of RLN in Turkey (Toktay et al., 2013) and can cause up to 19% yield losses in this region. Due to the wide range of hosts RLN can infect, crop rotation isn't an effective method to reduce infestation; resistance in germplasm is considered economically most viable in the long run. As the name suggests, RLN infiltrate the roots of wheat plants and reduces the plant's yield. RLN infected plants can visually be identified by dark brown-black lesions on the surface of the root and a chlorotic (yellowish), stunted plant (Nicol et al., 2010).

Over years of testing, certain plots have been identified as RLN positive in the CIMMYT fields in Turkey. At the beginning of my internship, I went to the field and collected soil cores in the field with Mr. Ümit Rüzgar and analyzed them in lab. I got to repeat the following analysis process multiple times during my stay for field trials, greenhouse experiments, and for cultures. The RLN extraction process is done using the Baermann technique (Figure 8) and it capitalizes on root lesion nematodes' tendency to migrate towards water. In this process, the soil sample is placed on filter paper supported by a wire dish. A petri dish is placed underneath the setup. The soil sample and roots are cut and flooded with water in the petri dish. As the water drains to the bottom petri dish, the RLN follow the water. After the samples have been allowed to rest for a few days and the water has drained, the remaining water is placed through a suction pump with a 20 micron sieve. The sieve is used to catch the nematodes and then they are washed into a sample tube. I spent several hours walking around the lab, where every spot on the tables was filled with petri dishes, flooding each sample with water. After a while I realized I was building strength in my thumbs as they would be very sore the following day.

Figure 8: Setting up the RLN Baermann technique with my colleagues. (Picture Credit: Rola Omar)

Root lesion nematodes were extracted from the soil samples I collected from the field plots during my first few weeks. These RLN were used to make cultures where the nematodes would replicate. The nematodes from these cultures were used for inoculation. The culture is done on carrots and was a fascinating process to watch and help with. Large carrots are peeled and placed in a 95% alcohol solution for 10 minutes. They are then sterilized by being placed in a fire that burns the alcohol off and then they are peeled again. Afterwards, the carrot is cut into discs that are 0.5 to 1 cm in thickness. The peeler and knife are repeatedly sterilized by placing in alcohol and then burning. My favorite aspect was watching the carrot, knife, and peeler catch fire! All of this is done in a laminar flow hood. Once the carrot disks are cut, they are placed in a sterile petri dish. The collected RLN from the Baermann technique are placed in a 1% streptomycin solution for one hour before use. They are then rinsed three times in distilled water and then examined under a microscope. A single root lesion nematode is selected and placed on each carrot disc. The petri dishes are then labeled and sealed with Para film. They are stored in an incubator at 18°C till multiplication of the carrot culture and then the multiplied culture is stored in a fridge until it is needed for inoculation.

When analyzing to determine resistance of germplasm, the RLN collected in the tube from the suction pump are counted. If the final nematode population over the initial nematode population is less than one the germplasm is deemed resistant.

Crown Rot

Crown Rot is the disease caused by fusarium, a fungus focused on at CIMMYT–SBP program. CIMMYT-SBP program has been screening wheat germplasm for their resistance for *F. culmorum* and *F. pseudograminearum*. Crown rot can be identified by basal stem browning and white heads. Fusarium prevents the flow of xylem (water) and phloem (sugars and proteins) up the stem of the plant, reducing yields severely. Crown Rot disease can cause a 25-58% reduction in yield (Smiley et al., 2005).

Figure 9: Fusarium spores being cultured on wheat bran. (Picture Credit: Sweta Sudhir)

Figure 10: Visual rating scale for crown rot quantification. (Picture Credit: Sweta Sudhir)

Fusarium spores are cultured on wheat bran and then used to inoculate plants (Figure 9). I got to plant the germinated seeds to test for resistance to crown rot. Unlike RLN and CCN where 3 replicates are planted, 5 replicates are planted for Fusarium. After growing for 9 weeks, the plant is removed from the roots, the outer stalks are peeled off, and the browning at the base of the stem is quantified. This is a visual rating done from zero to five based both on the darkness of the tissue and the how high up the stem the browning extends. One indicates a plant that is completely resistant to the *fusarium* and five indicates a plant is highly susceptible (Figure 10). The scale below is dependent on the browning percentage on the basal stem: 1: 1-9%, 2: 10-29%, 3: 30-69%, 4: 70-89%, 5: 90-99%. Then lines are ranked based on this, from resistant to highly susceptible as follow**;** **R** – Resistant, **MR** – Moderately Resistant, **MS** – Moderately Susceptible, **S** - Susceptible, **HS** – Highly Susceptible. (Figure 10).

While I was in Eskişehir, I spent many hours peeling the outer stalks off the wheat stem with growth chamber, greenhouse, and field trial experiments (Figure 11). During the hours of work I got to converse with my colleagues and learn more Turkish. I also got to record the ratings in our leather-bound field notebook often.

Figure 11: Peeling the outer stalks off the wheat stem with Mr. Ekrem and Sevil Hanım. (Picture Credit: Halil Öz)

Working with Joe

Joe's PhD project is also related to crown rot disease. He worked with two species of fusarium to better understand how a co-inoculation would impact a wheat plant. Crown rot is a prominent issue in both Turkey and Australia with the opposite species dominant in the two regions. I spent a week working with Joe on his research and assisted with tube labeling, weighing dry stems, and helping grind the samples. Qualitative PCR is being run on the samples to determine how much of the stem is infected based on species.

Since the experiment is ongoing and the results from the trial this year are currently being analyzed, the data isn't available yet. I look forward to hearing the outcome of this specific research in the coming months and am excited to see Joe publish a paper with his findings.

Field Experience

Figure 12: Working in the field with workers in Konya, stripping the stems of wheat plants. (Picture Credit: Dr. Erginbas-Orakci)

Field trials are used to verify the resistance of germplasm and to test their viability in a natural environment. Planting occurs in October because we work with winter wheat which is required vernalization. The seeds are planted in two plots, one that is inoculated and one that isn't to serve as a control. When I first arrived in Eskişehir I looked out the lab window that overlooked the fields from above and saw a sea of green plants. I walked through the fields and learned how to distinguish wheat from barley and saw the white heads of plants with crown rot disease. Over the course of the following weeks I witnessed the color change to a rich golden brown. Harvest season began about 5 weeks into my stay in mid-July.

The first week of harvest, I travelled to field sites in the cities of Yozgat and Konya where I got to see how different the culture can be from one city to the next. At Yozgat, I spent my first day labeling bags for harvest indicating site, plot and germplasm. Then I went to the fields and saw the harvest take place. Each bag was meticulously ordered and I weighed them to determine yield. In the field I helped strip the wheat stems and helped with the quantification. At the field sites I worked with Dr. Dababat and Dr. Erginbas-Orakci. When quantifying the crown rot, we developed an efficient system where I would arrange the wheat bundles in numerical order by germplasm and hand them to Dr. Erginbas-Orakci. She would give an average rating for the bundle, and Dr. Dababat would record the ratings in the field book. We only had a week to do this at both field sites so we got to work long days in the field usually finishing right before Iftar (the dinner meal that breaks Ramadan).

Figure 13: Right before working in the field with my two mentors, Dr. Dababat and Dr. Erginbas-Orakci.

I met many workers in the field and I have to commend them for their relentless work. Though we had relatively normal temperatures for the region, it was still between 90°F and 100°F and some of the workers were even fasting for Ramadan. Once we got back to Eskişehir, it was time to begin harvest and analysis. My last two weeks were spent in the fields harvesting, rating crown rot, and analyzing soil samples in the lab. I worked with the SBP staff well over 8 hours a day and learned how to innovate solutions to maximize efficiency as we fought against rain predictions that would ruin our results. I also assisted Dr. Erginbas-Orakci in transferring all the data recorded in the fields to excel sheets.

Impact of my Research

Walking away from my internship this past summer, it is extremely rewarding knowing that I contributed to the fight for food security. Every day spent harvesting in the hot fields, every hour spent washing soil samples, and every minute spent collecting cysts took us one step closer to improving the lives of our future generation. The resistant strains I helped identify will be adapted by farmers along with other integrated pest management systems to improve yield. With the staggering amount of yield losses soil borne pathogens cause, any step towards progress will make an impact. By testing hundreds of germplasm at CIMMYT, I was able to help eliminate germplasm that would be more harmful than beneficial by taking up field space and not producing sufficient yield. My work with Joe is helping establish a basic understanding of the way in which *fusarium* infects plants which will go a long ways towards developing effective solution that attach the issue from the base. By identifying resistant wheat strains and suggesting integrated pest management solutions to farmers, we are providing long-term and economically sustainable methods to increase yield. This research can be related to regions outside of Turkey as well, improving global food security. It was an honor for me to get to work at CIMMYT, an organization fighting to end world hunger around the world.

Figure 14: Working in the field with SBP staff

Personal Impact

When Ambassador Quinn told us we would all be different when we came back, I expected that to mean I would feel a change in me while I was in Turkey. I expected there to be a very difficult transition that would help me realize that I was evolving into a new person. The individuals I was with made the cultural transition almost seamless. While each intern will admit to having a rough patch here or there, the hospitality and humility that surrounded me, flushed out any memories of difficulties. I was extremely happy after the initial weeks of adjustment. I didn't realize quite how much I had changed until I came back to America and talked with my friends and family. I had felt so assimilated into the culture some experiences in a short period of time that didn't strike me as significant or abnormal until I shared these stories at home and saw shocked expressions on my friends' and family's faces.

I want to share my personal growth before jumping into the academic growth. Despite talking to the previous intern who went to CIMMYT Turkey, I didn't quite realize how independent I would be. For the first time in my life, I wasn't in my own house, or with extended family, or even anywhere near either of these two. I was thousands of miles away, living by myself, getting groceries, cooking, cleaning, and managing my finance and free time independently. I didn't have a rigid schedule of extracurricular after work each day and weekends were entirely mine to spend as I chose. Now I shouldn't overstate this since I did still have guidelines for my own safety in a foreign country, but this is more freedom than I have been allowed in my 17 years. Learning how to handle this independence helped me gain an appreciation for all that my parents do for me and also gave me the assurance that I don't need to be worried about living away from home in college. I learned that independence truly does come with a lot of responsibilities as well.

The generosity of the Turks increased my trust in other people and their optimistic and cheerful attitude definitely made a difference. Even my colleagues who worked two jobs to provide for their family would come into work after a late night and continuously make me laugh. They seemed to have the spirit that no matter what problem you are in, don't let that negativity rub off on your friend.

My academic growth was more apparent to me while I was in Turkey. The background reading Dr. Dababat provided me with gave me the stats on the enormity of the issue of food insecurity but it was the work in the field that helped me get my mind around the concept. My first week in Eskisehir, I harvested seeds with Sevil Hanım that would later be sent to collaborators worldwide. When we got to the middle of the potted wheat plants, there were many that had produced no seed. We got empty spike after empty spike and it was very evident because of the difference in the noise the thresher made when seeds were and weren't present. This is when I learned the Turkish work "yok" meaning absent. I can't even count how many times I said "tohum yok" (no seeds) that day. After a particularly long streak of plants without any seeds, we got a wheat plant with many seeds and both Sevil Hanım's and my face lit up. Thinking back on this day, I realize that if I was so disappointed about not having seeds in a few trials a farmer's despair must be a thousand folds greater when they have reduced yield because that is their sustenance and livelihood. This experience gave me a more encompassing view of food insecurity than any paper or research I had done till that point.

This summer also reemphasized the importance of research. The daily lab work I partook had the potential to improve the lives of farmers and the food insecure around the world. This summer confirmed that I want to continue research and aid the fight for food security, but it also showed me that there are more ways to help in the fight for food security than agriculture alone. I realized I can contribute by pursuing a career in medicine which has been a childhood dream of mine. This World Food Prize Borlaug-Ruan International Internship has helped me develop and appreciation for the enormity of food insecurity and helped shape my future career path. I look forward to continuing to contribute to the fight for food security.

Cultural Experience

When I first arrived in Turkey I spent the night with Dr. Dababat's family. They made me feel comfortable, and gave me the 101 on Turkish culture. I had a great time playing UNO with the children and watching them dance.

In Eskişehir, each morning I would wake up around 7 to warm, bright sunlight flooding my room. I lived independently in a guest house across the street from the institute in a gated compound. The main institute buildings and housing were on a hill that over looked the fields on one side and more hills on the other side. Beauty of the region was breath taking. Each morning I went in the SBP lab, greeted my colleagues with a "Günaydın, nasılsın" (Good morning, how are you?) and would begin the day's work.

I quickly learned I would be expected to stay on my toes and move from task to task depending on the schedule. No matter what work we were doing, we would always take a çay (tea) break at 9:30 and again at 15:00 where we would all gather in the break room and converse with each other over tea and snacks. During these breaks, I found out Candy Crush and Facebook are not only popular in America, but around the world. We often played Turkish music on the radio and conversed during our work. If there was a long silence or I hadn't spoken in a while, Ekrem Abi and Ümit Bey would start talking quickly in Turkish and mention my name till I curiously looked up at them. Other times Ümit Bey would begin singing loudly and off-pitch to make me laugh or he would begin dancing, encouraging me to join in. Sevil Hanım was always singing merrily and definitely took the role of mother-of-the-group.

During our hour lunch break, Büşra Abla, another lab member, would take me to the Institute's restaurant where we were served a delicious meal with bread, soup, fresh salads, some sort of pasta or rice with vegetables and meat, and of course dessert. Each meal was delicious and the kitchen staff was kind enough to set a vegetarian meal aside for me.

After the work-day, I occasionally went to the city center with Joe. The institute compound was about 20 minutes away from the city. We went there for groceries, restaurants, and entertainment. The city is beautiful with a river flowing in the middle with pedestrian friendly walkways all around. In fact much of the heart of the city doesn't allow cars.

Figure 15: Walking along the river in Eskisehir. (Picture Credit: Joe Barry)

The city name Eskişehir directly translates to old city. Aptly, ancient relics could be found all around the liberal college town. While a majority of the population is Muslim, most of the younger women don't wear a hijab and dress like any western country. Clothing seems to be important for individuals and always dresses very nicely.

Joe and I got to explore much of the city going from side ally markets to large malls. Joe enjoyed a burger joint he found and took me there often, while I took him to the more traditional restaurants. I developed quite a love for fasülye (a bean dish) with rice and became increasingly fond of fresh baklava. I was very surprised to see quite a few stores that looked like they were dedicated solely to prom dresses; upon inquiry I was told that women wear these gowns to weddings.

Early on in my internship, Joe and I were harvesting seeds from the green house samples on a hot day. Members from another lab, Volkan and Özgür introduced themselves and insisted we take a few breaks from the heat. They got to know the places I had visited and offered to take me out that weekend. We had a phenomenal time in the city. They took me to a mosque constructed in 1525 where I had to wear a hijab and take my shoes off to go inside. The architecture of the building fascinated me. They also introduce me to Es Park (a mall I frequently went to thereafter) and took me to a famous baklava and ice cream shop in the city. I loved the ice cream, but its texture is far different than what we have in America; it is chewy and sticky. Overall I was further impressed by the hospitality of the Turkish people.

Figure 16: Özgür and Volkan introducing me to Eskisehir. (Picture Credit: Waiter at the restaurant)

Figure 17: Spending time with Ümit Bey and his family right before an Iftar dinner.

The day after I arrived in Turkey, Ramadan started. This meant that no one in my lab ate or drank anything all day long and the restaurant was closed. I knew I would have to cook for myself going into the internship but it definitely took me a while to figure that out. The first evening of Ramadan, I walked into the kitchen where my colleague Ümit Bey and his wife were preparing their meal for Iftar, to ask them a few questions about where everything was located in the institute. At the end of our conversation Ümit Bey invited me to dinner with his family; I gratefully accepted since I had barely scraped together a lunch for myself earlier that day and had no plans for dinner. I had a lovely time with his family, especially the two kids. By the next morning Ümit Bey called me his daughter and told me I was required to eat dinner with his family every night. I will never forget how much this meant to me, being in a foreign country away from my family. In the coming weeks the kids helped me quite a bit with my Turkish and I in-turn helped them with their English. I would point to an object in the room and say “bu ne” (what is this), they would tell me the Turkish word and I would tell them the English word. I realized how uniting the Iftar meals are during this period. I also got a chance to join my colleagues and their families for a large Iftar meal on July 4th.

On several occasions Dr. Dababat explained the significance of Ramadan to me. He said it was to help humans identify and understand the struggles of those in poverty and hunger on every day. He added that people are exceptionally charitable during this season. To me the idea of Ramadan highly resonates with the message of the World Food Prize organization which is to understand and improve the lives of those effected by food insecurity. For this reason, I tried fasting for one day and I was very appreciative of my dinner meal that night.

Figure 18: 4th of July Iftar meal with SBP CIMMYT Turkey Program

As soon as Ramadan ended, the vibe in lab became even more exuberant. We would have chocolate and treats for çay break and I tried to contribute by baking various chocolate cookies and brownies for my lab.

In addition to working with my colleagues, I met several college interns at the institute. All of them were very friendly and we would go out together on the weekends. By the end of my internship, I felt like I had a Turkish family which made the good-byes extremely difficult. Prior to this internship, I never realized how close of a relationship you can build with a group of people in eight weeks especially with such a significant language barrier and cultural differences.

Figure19: Visiting a mosque constructed in 1525 (Photo Credit: Volkan Alveroğlu)

Figure 20: Spending time at Es Park (Photo Credit: Joe Barry)

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Figure 21: Çay break with the interns on my last day in lab.

Figure 22: Güle Güle Eskişehir. I hope to be back soon!

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