AFIYET OLSUN:

Tackling soil borne pathogens and alleviating hunger one nematode and fungi at a time.

2014 BORLAUG~RUAN INTERNATIONAL INTER

SPONSORED BY: THE WORLD FOOD PRIZE FOUNDAION

Placement: International Maize and Wheat Improvement Center (CIMMYT) Soil Borne Pathogen division in Eskişehir, Turkey

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1. Acknowledgements

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First and foremost, I would like to thank **The World Food Prize Foundation** and the people who work day and night to make it the prestigious institution that it is today. I would also like to thank the following individuals for their unique contributions:

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Many more friends, family members, and teachers deserve thanks for all of the support they have given me throughout the years. Everyone listed above will remain in my thoughts and heart as I advance in my education.

Picture 1: Myself talking with a former BRI Intern and an Iowa Precision Agriculture Farmer at the 2013 GYI. (Picture by the World Food Prize Staff)

2. **Introduction**

2.1 Personal Background

I didn't grow up on a farm. I was raised in a blue-collared Iowa city called Marshalltown. I am two generations removed from the nearest farming relative—my great-grandfather who ran a modest but diverse crop and livestock operation. My high school didn't offer any agriculture classes nor did it have an FFA chapter. However, I am not in the minority. Rather, I am a part of the majority of my fellow Iowans and Americans who grew up in an urban setting; a city where the main vegetation consists of Kentucky bluegrass and assorted varieties of lawn trees. The main animals are domesticated dogs and cats. So the question naturally arises, "why would a student with no agriculture background be so interested in soil, crops, and global food insecurity?"

Global food insecurity is an issue that affects us all. Each and every human is touched in a variety of ways both locally and globally when it comes to sustainably feeding our growing planet. The facts and figures on global food insecurity are staggering, yet show improvement in recent years. *The State of Food Insecurity in the World 2014* published by the United Nation's Food and Agriculture Organization is reporting that there 805 million people who are chronically undernourished. That number, from 2012 to 2014, is down by more than 100 million over the last decade. This clearly shows that progress is being made in an area that desperately needs it. However, the stakes are growing as the population climbs to 9 billion by the year 2050. Personally, I saw a way of alleviating the current hunger and malnutrition crisis through my studies in agronomy and general agricultural science. I hope to one day apply my knowledge and be a part in the complex solution that is needed to address this problem.

2.2 The Early Stages

My interest in international agriculture was sparked by the nomads of Mongolia. Mongolia has one of the fastest growing economies thanks to recently discovered minerals. The sudden development of these minerals has negatively impacted local water sources, which in turn effects the farmers and nomads who are now facing major losses. This life changing information was relayed to me from the Iowa Public Radio station I was listening to in my truck as I drove from school to my home. I didn't think much about it at the time; however, looking back this is the moment I became passionate about global issues that are minor or even non-existent to many. It was this one issue that sparked my passion. Months after hearing about the struggle of the Mongolian nomads, my high school teacher, Susan Fritzell, encouraged me to write a paper for an organization called the World Food Prize. I had heard of the foundation and the internship as she

has had several other students attend the Global Youth Institute (GYI). I immediately knew that I wanted to look into water quality and shortage issue in Mongolia.

After looking beyond the National Public Radio segment and into other more in-depth articles, I discovered the issues that made my topic so complex. Factors ranging from the economy to education to healthcare were all encompassed in this water issue. I composed my paper and submitted it to the Iowa Youth Institute (IYI). While attending the IYI, I had a phenomenal time talking with professors from Iowa State University, feeling the inside of a rumen from a fistulated cow, and of course presenting my paper. During the summer I revised my paper and submitted it again—this time to the GYI.

Three days in October was all it took to convince me (even more) of my passion. A lot of events had led up to those three days, but the GYI and Borlaug Dialogue are nothing short of life changing. Somewhere in the back of an over-packed conference room while listening to Tony Blair, the former Prime Minister of the United Kingdom, talk about leadership in the African continent it hit me—I am at the epicenter of where global food insecurity can be solved. It was in downtown Des Moines, Iowa where the dialogue that will lead to global food security took place and will continue to take place until the job is done.

I, in that moment, had a choice to make. I could be a fly on the wall, observing and listening carefully to what other people had to say. Or, I could be an active participant and help shape and direct the discussions. I chose the latter by asking questions to further my understanding of past, current, and future issues. At dinner as I sat with CEOs, researchers, and politicians, all of which had an interesting perspective on global food insecurity. I participated in discussions offering my opinions and ideas. It is through these discussions that I gained the confidence to present my paper and look towards the Borlaug-Ruan International Internship the following summer.

By the time I got to the intern presentations held at DuPont Pioneer, I was convinced that I could make an impact through the BRI internship program—I just needed to decide what would be the best fit. Due to my interest in soil and the Near East region, I was instantly drawn to the poster regarding the Soil Borne Pathogens Division of CIMMYT in the Republic of Turkey. After some research and convincing my parents to let me leave the country for eight weeks, I applied with fingers crossed. Months of waiting passed followed by an interview that was more laid back and less stressful than I had been telling myself. More waiting followed. It was just before a cold tennis practice that the news came: I would be spending my summer working for and, more importantly, learning from researchers at CIMMYT-Turkey. That night, overjoyed and knowing I wouldn't be able to sleep, I started lining up what I thought I would need for the trip.

3. Research and Work: CIMMYT-Turkey

Picture 2: The CIMMYT-Turkey lab is a part of the larger Turkish Ministry of Food Agriculture and Livestock research institute. (Picture by Elfinesh Gebremariam)

3.1 Organizational Overview

The International Maize and Wheat Improvement Center, often represented by the Spanish acronym CIMMYT, is a non-governmental research organization. The Global Wheat Program of CIMMYT was founded by Dr. Norman E. Borlaug in the early 1960s and focused on researching wheat varieties as well as educating area farmers on how to best utilize practices that are currently available. Through this NGO and program, the Green Revolution took flight and helped save 1 billion lives from starvation.

Today, CIMMYT partners with many NGOs, nations, and programs to accomplish its goal of alleviating hunger around the world. The Soil Borne Pathogens division of CIMMYT-Turkey is a joint partnership with the International Winter Wheat Improvement Program (IWWIP), the Turkish Ministry of Agriculture and Rural Affairs, and the International Center for Research in Dry Areas (ICARDA). These organizations work together in order to research the pathogens that cause disease and yield loss in wheat.

A fundamental goal of CIMMYT is to inform farmers on how to get the best yields while caring for the land they depend on to feed their family and earn an income. Because of this mission, CIMMYT has a long tradition of brining the newest technologies, techniques, and plant varieties directly to those who need it. In Turkey, I got to see experience this first hand. Early on in my internship I had lunch in a large open warehouse where farmers from around the area had come to see the latest in wheat production. The farmers were taught new techniques and shown new varieties of wheat that are resistant to drought and soil borne pathogens. Throughout my internship I was reminded of how valuable the work I was helping with really was. The data I helped collect and the experiments I aided with would be used to provide the farmers with a more stable crop and income.

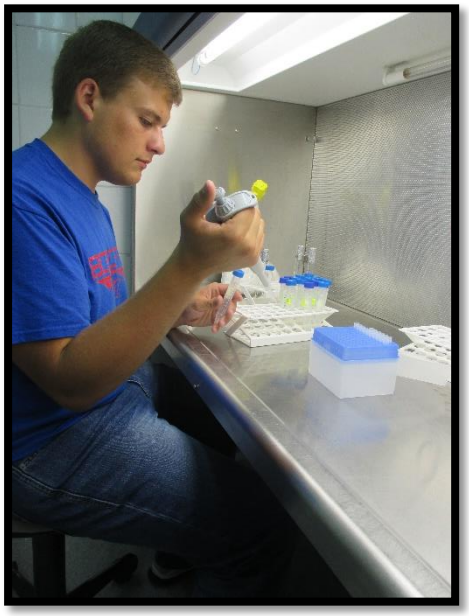
3.2 Daily Work

The SBP division at CIMMYT-Turkey focuses on several disease-causing agents that are spread through the soil from plant to plant. While there are a plethora of soil borne pathogens that affect wheat, CIMMYT-Turkey researched a fungus that causes crown rot as well as root lesion and cereal cyst nematodes. Both the fungus and nematodes cause detrimental yield loss and can ruin a harvest. Throughout my eight weeks in Eskişehir I was able to work with three of the many soil

borne pathogens that are currently putting food security at risk. To help support and guide me I had many wonderful supervisors and mentors. My main supervisor was Dr. Abdelfattah "Amer" Dababat, a plant pathologist and nematologist with CIMMYT and ICARDA in Ankara. While in Eskişehir, Dr. Gül Erginbas Orokci, a plant pathologist focusing on crown rot, was my supervisor. Throughout my time at CIMMYT-Turkey several Ph.D. candidates came to Eskişehir to conduct research. Each one will be introduced with their correlating area of study.

3.2.1 Crown Rot

Crown rot disease goes by many names (dryland crown rot, foot rot, and root rot), but is caused by a handful of specific fungi, *Fusarium culmorum*, *F. pseudograminearum*, and *F. graminearum* (Erginbas, Gul, et al.). The *Fusarium* fungus can inhibit wheat yields by blocking the transportation of nutrients within the xylem and phloem of the plant. The fungus attacks the crown of the plant, where the stem and the roots join, and prevents the flow of water, sugars, micro, and macronutrients from the roots to the leaves and head. This reduces the overall yield of the plant and can mean a devastating harvest for the farmer. The fungus can be identified in the field by the white, shriveled head of the wheat plant that is often times premature. If the plant is infected and removed from the soil, a honey brown to black color can be observed on and near the crown region.



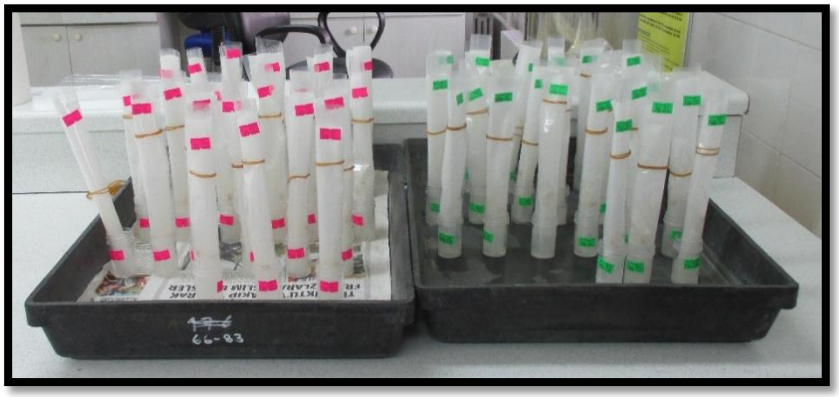
Picture 3: Here I am pipetting spore solution onto slides that will then be counted by Elfinesh. (Picture by Elfinesh Shikur)

Picture 4: Here the pre-germinated wheat seeds are laid out ready to be inoculated with the spore solution. (Picture by Adam Willman)

I had the great fortune to work with a Ph.D. candidate from Ankara University on the three fungi listed above as well as several others. Although attending school in Turkey, Elfinesh Shikur Gebremariam is originally from Addis Ababa, Ethiopia. While in Turkey she is studying several types of pathogenic fungi that cause crown rot. Her many experiments have spanned several years and include four months in the United States at Washington University in Pullman, Washington as a part of the Borlaug Leadership Enhancement in Agriculture Program (LEAP) Fellowship she was awarded. Because Elfinesh's work is quite lengthy, I was only able to observe and assist in a small portion. However, she was kind enough to give me a full overview of the work that had been done prior to my arrival and an explanation of what was to come after my departure.

The first experiment I assisted with involved the testing of the aggressiveness of different varieties of the *Fusarium* fungus. In a vented hood in the back of the

CIMMYT-Turkey lab, I sat alongside Elfinesh and 52 vials of spore and water solution. The objective of the day was to dilute or concentrate the solution to get a certain number of spores per one milliliter of water. As I prepared the slides, Elfinesh counted and calculated the number of spores in the solution (see picture three on pg.7). She would then report to me on how I was supposed to correct the solution in order to get it to the desired concentration. This was repeated for all of the 48 vials of *Fusarium culmorum*, the three vials of *F. pseudograminearum,* and the one vial of *F. graminearum*. Once the spore solutions were the correct concentrations, we were able to set up the experiment.



Picture 5: Once inoculated, the wheat plants were rolled up and placed in tubes. This is just a fraction of the overall experiment. (Picture by Adam Willman)

The next day Elfinesh and I, with the help of a lab worker named Sevil Yavuz who was referred to as Sevil Hanım out of respect, set up the experiment as follows. First, pre-germinated wheat seeds that had been sprouting in an incubator for the past few days were laid out on segments of paper towel that were then placed on sheets of plastic (see picture four on pg. 7). Three seeds were placed on each sheet of plastic and three sheets of plastic were designated for each fungus variety. Second, Efinish came around and used a micropipette to apply a small amount of spore solution onto each individual seed. The three seeds, paper towel, and plastic were then all wrapped up, secured with a rubber band, labeled, and then put into a small plastic tube for watering (see picture five). This entire procedure was repeated for each type of fungus and the whole experiment was duplicated in order to obtain reliable results. Once all of the tubes were filled, the plants were placed in a growth room for several weeks and watered as needed (see picture six).

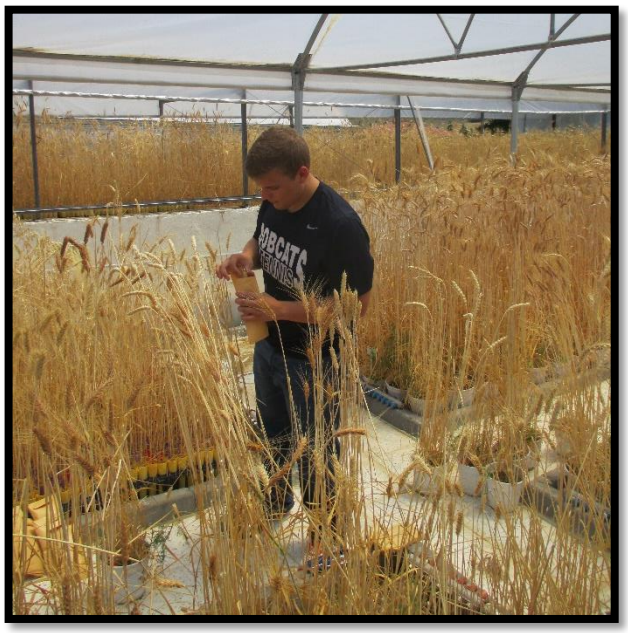
Picture 6: The wheat plants needed to be watered by hand every couple days. (Picture by Elfinesh Shikur)

While waiting for results from this experiment, Elfinesh studied the morphological characteristics of the different varieties of the *Fusarium* fungus. Before my arrival, Elfinesh had taken soil samples from around Turkey to try and isolate the different varieties of *Fusarium* fungus. She had identified many variations of the fungus through molecular and morphological analysis. I assisted in the morphological analysis in several ways. I helped Elfinesh grow more fungus from isolated known samples using wheat bran as a medium. The spores that

were grown on water agar were transferred to the wheat bran to allow for multiplication. These spores would be used later on in different experiments. Spores were also placed on potato dextrose agar (PDA) in order to study the pigmentation, growth rate, and color of the aerial mycelium. These secondary characteristics—color, pigmentation, and growth rate—can be used to identify different strains of the *Fusarium* fungus with the help of the primary characteristics. The primary characteristics include the presence or absence of microconidia, the size and shape of the microconidia, as well as the formation of a chlamydospore. This was an ongoing project throughout my time at CIMMYT-Turkey.

Picture 7: The fungus appears pink around the seed when it is present. (Picture by Adam Willman)

For the morphological study of *Fusarium*, Elfinesh had to study the growth rate of aerial mycelium after 72 hours in a dark environment. In order to promote reproduction of the spores to be used in further testing, the fungus was introduced to a bag of wheat bran and exposed to equal amounts of light and dark. Different varieties could be identified based on the color of the fungus. In addition to its unique colors, I found that each variety also had a distinct smell. Some of the bags smelled similar to pumpkin and cinnamon, while others had a definite rotting odor. This was not recorded as a part of the results. It was simply an interesting observation that made the work interesting and somewhat risky as neither one of us knew what smell we were going to get when we opened the bag.



Picture 8: Each individual wheat head needed to be hand-picked and placed in the corresponding envelope. (Picture by Dr. Gül Erginbas)

Once the wheat in the growth room was mature enough, it was ready for scoring. Dr. Erginbas and Elfinesh used a standard one through five scale to establish how pathogenic each strain of fungus was. As Dr. Erginbas and Elfinesh scored the wheat, I recorded the numbers on a data sheet. Nine hundred and thirty six wheat plants were inoculated and scored, plus several control plants that were inoculated with distilled water. A score of five represented the most pathogenic a variety could be. The crown was very dark if not black and in many cases the plant was dead. A score of one, on the other hand, showed little to no signs of infection and was healthy. Once the data was collected, Elfinesh calculated the numbers and identified the most pathogenic variety. She is using this data to find

the most aggressive type of *Fusarium*. Elfinesh will then test the most aggressive strains on different types of wheat to find the most resistant wheat species. This information will be used by plant breeders to create more resistant lines of wheat. The data obtained by Elfinesh is being used for her future publications and doctoral thesis. Therefore, I cannot publish many in-depth facts or figures. I eagerly await reading her findings in an upcoming journal.

Beyond Elfinesh's Ph.D. research, CIMMYT-Turkey also focuses on crown rot. I was able to help Dr. Erginbas collect data on wheat scoring during the greenhouse harvest. After collecting the wheat heads and placing them into individually marked envelopes, the wheat plants were then cut to a manageable height, the roots striped of soil, and the crown scored by Dr. Erginbas. This was all done in the heat of the greenhouse, just outside under the shade of a tree, or in a makeshift hut made out of wood and cardboard. Like before, Dr. Erginbas would judge the wheat on a scale from one to five and I would record the results. Later, I would enter the data into a Microsoft Excel spread sheet for further analysis.

Picture 9: One hundred grams of soil was measured and used to collect and count the number of cysts present. (Picture by Jiang Kuan Cui)

3.2.2 Cereal Cyst and Root Lesion Nematodes

Cereal cyst nematodes (CCN) (*Heterodera avenae, H. filipjevi, and H. latipons*) are pathogenic parasites that interfere with the development of different cereal grains such as wheat, oats, and barley (Dababat, Amer, et al.). These nematodes form cysts around the roots of the plants and provide an environment where the juveniles are able to grow. Once mature, the young hatch and enter the surrounding environment. The females penetrate the root system and begin feeding while the males remain in the soil. The females then start reproducing to continue the cycle. This process can prove to be devastating to the plant because of the interference with the plants ability to obtain and transport nutrients from root to head. Farmers who discover CCNs in their fields have a limited number of options to reduce the populations to a manageable rate. These possible solutions available to farmers include the following: 1) crop rotations with species that cannot be infected by the nematodes and 2) the use of wheat varieties that have been identified as being resistant to infection. Both of these options are being researched and tested by the SBP division of CIMMYT-Turkey.

Picture 10: Each soil sample had to be washed and filtered through two sieves a total of three times. (Picture by Jiang Kuan Cui)

I was counting nematode cysts within my first week at CIMMYT-Turkey and I didn't stop until my last week. The time spent on counting nematode cysts represents their importance in combating field loss and increasing yields. Farmers can be devastated if their fields become infected. Luckily, several scientists are working to screen resistant wheat varieties.

Dr. Dababat oversaw and assisted with the work of both a Ph.D. student from Ghent University named Fateh Toumi and a Ph.D. student from the Chinese Ministry of Agriculture named Jiang Kuan Cui. While at CIMMYT-Turkey, Fateh studied the populations of CCNs from different regions. The process and procedure used was a standard that includes washing the soil and counting the number of cysts present in the left-over debris. First, individual soil samples of the same mass were put into a bucket. Then, water was added and mixed to ensure the soil and debris were suspended. The mixture was then carefully poured through two sieves of 250 micrometers and 850 micrometers. This process was repeated three times for each sample to ensure maximum transfer of cysts from the bucket to the sieve. The debris was then collected into small sample bottles. After the collection, the samples were taken to a microscope and laid out on a special slide. The number of cysts were then counted and recorded. A sample with higher cyst counts was said to be more susceptible to infection while a sample with fewer cysts was more resistant. Fateh used this process and cross-checked his data with results he had obtained while working in other labs. Because he is a Ph.D. student working on his thesis, I, again, cannot publish any results and have to speak in broad terms. I look forward to his many publications to come.

Picture 11: Soil was placed in the white container with filter paper while the roots of the plant were placed in the gray container with filter paper. Both were saturated with water to collect nematodes. (Picture by Jiang Kuan Cui)

After Fateh had left, a Chinese student from Beijing named Cui came to study nematodes and improve his English skills. Cui commented that he was fortunate to meet me because he could listen to and be corrected by a native English speaker. Fateh, Elfinesh, and Cui all encouraged me to correct their pronunciation of certain words. Cui and I learned side by side about the different lab functions CIMMYT-Turkey partakes in to understand and combat CCNs and RLNs. Beyond the soil

Picture 12: Dr. Dababat, Cui, and I collected soil samples from the fields surrounding the town of Eskişehir in order to see the verities and amounts of nematodes present. (Picture by Dr. Erginbas)

washing and cyst counting, Cui and I set up experiments to extract RLNs, gathered soil samples, collected nematodes for future use, and studied the different types of nematodes present in soil samples.

In mid-July, a doctor named Mustafa Cakmak visited the SBP division and showed Cui and I some of the morphological characteristics of different nematodes. Dr. Cakmak could tell the different types of nematodes apart based on the layout of the body and how it was shaped. I started to pick up on some key things; however, graduate students spend several years learning the subtle differences. I was simply satisfied to be able to distinguish between male and female. Dr. Cakmak reiterated why nematologists count nematodes—however tedious it may be. Plants that have a lower nematode count are more resistant and therefore produce a higher yield. These plants, once identified, will be passed along to wheat breeders who will then try to select the gene and cross it with another favorable trait.

About three fourths of the way through my internship, Dr. Dababat and Dr. Erginbas took Cui and me to area fields to collect soil samples. Dr. Dababat would park the car as Cui and I ran out into the field. We would pull up the wheat plant by the stem and shake the soil that clung to the roots into a paper bag. We would do this multiple times in the same field running in a zig-zag pattern to get a representative sample. Once we had enough soil we would write the location on the bag and head off to the next field. After collecting around 40 samples, we headed back to the lab. Over the next few days Cui, Sevil Hanım, and I would wash the samples. Cui was in charge of identifying the nematodes present and recording the results. I used some of the samples to collect nematode cysts for future use.

Picture 13: Wheat seeds were germinated before planting in order to minimize complications due to poor seed health. (Picture by Adam Willman)

Near the end of my stay in Eskişehir, Dr. Erginbas helped me set up my own experiment. I was first given 14 wheat varieties of unknown susceptibility to CCNs and four wheat varieties of known susceptibility or resistance. I germinated seven wheat seeds from each variety on a wet paper towel in an incubator set at 27.5 degrees Celsius for about two days. After the seeds were germinated, I

planted them in growth tubes with 70 percent sand, 29 percent soil, and one percent organic material. Each variety was replicated three times to ensure a true representation.

After the seeds were planted I inoculated them with nematodes. This process involved taking cysts that were collected earlier and extracting the juveniles. The juveniles were extracted by using the roots of an infected plant. The roots were cut and placed in a small dish that had a filter at the bottom. The dish was then put in another dish where water was able to sit and saturate the roots. The juvenile nematodes swim from the roots through the mesh and into the dish of water. I then counted the number of juveniles per milliliter and adjusted the ratio until I had 300 juveniles per one milliliter. With this solution, I inoculated each seed with one milliliter of distilled water and 300 nematodes. The plants were then placed into the growth room. Due to the length of the growing time, I am still awaiting results.

Pictures 14 and 15: (From left to right) each seed was inoculated with 300 juvenile nematodes and then placed in a growth room. (Picture 14 by Dr. Erginbas, picture 15 by Adam Willman)

Shortly before my arrival, CIMMYT-Turkey purchased a unique scanning system and software program that can image and study the root system of plants. I was in charge of learning how to use the program to collect data regarding the roots of wheat plants that were also being screened for CCNs. The objective was to see if a correlation existed between root morphological characteristics and the number of nematodes. I was tasked with scanning the roots and collecting the data. CIMMYT-Turkey will continue to use this program in an experimental way to see if a correlation can be identified.

3.2.3 Field Work

I was able to experience a field day put on by the Turkish Agricultural Institute early on in my internship. At this field day, area farmers were invited to come to the research fields and learn about what the different divisions of the institute were working on. The overall goal of the day

was to educate farmers on what best practices they should use as well show them the latest varieties of different crops being tested. During this time I was able to meet with several breeders that included the head of the International Winter Wheat Improvement Program (IWWIP) Dr. Alexey Morgounov, Director of CIMMYT's Global Wheat Program Dr. Hans-Joachim Braun, and a wheat breeder named Dr. Beyhan Akın. These doctors not only presented the research they are working on, but also seemed very interested in the work the SBP division was doing.

Picture 16: The CIMMYT-Turkey SBP division along with several guest students and doctors got to experience a field day. (Picture credit unknown)

During this field day, I was able to hear from agronomists, plant breeders, and plant pathologists. The agronomists were looking at how efficient different wheat plants were at using water and cooling off during hot and dry periods. They measured the temperature of the plant canopy and compared it against the air temperature of the surrounding area. The research team was looking to see if photosynthesis was still occurring under stressful conditions. If it was, the team hypothesized that the root structure would be deeper and more efficient in obtaining water and nutrients. Other doctors were working on developing synthetic lines of wheat that are resistant to disease and can tolerate stressful conditions. The field trials of these wheat varieties were quite extensive and are expected to take several years.

Picture 17: These wheat varieties are being tested for their resistance to environmental factors such as heat and drought. (Picture by Adam Willman)

After one of the field days, Elfinesh, Cui, and I were able to have dinner with Dr. Akın and Dr. Morgounov along with several Ph.D. students. We were celebrating Dr. Akın's birthday and had a feast to match it. The conversations I had with the people at that table have influenced my educational path. Hearing from so many doctors and doctoral candidates who are passionate about their work was beyond inspiring.

4. Cultural Exchange

4.1 Work Days

Each day at CIMMYT-Turkey presented me with an opportunity to learn something new and foreign. I would walk the short 100 or so meters from the guest house to the institute lab

around 7:50 every Monday through Friday. I would be greeted by other workers with a friendly günaydın, or good morning. Because the internet was only available in the lab building, my phone would start ringing with all of the notifications, emails, and messages I had missed while at the guest house. I'd respond to a few and wait for Dr. Erginbas or Elfinesh to give me my marching orders. On some days, I would already know what needed to be done—mainly washing and counting cysts, other days were a complete surprise. I learned quickly to be prepared for anything. I became accustomed to switching tasks at the drop of the hat, because several people were conducting different research projects within the same lab. Many times I would be counting or washing and Elfinesh would need my help with inoculating wheat bran, scoring wheat, or anything else. I found the changing tasks frequently to be a nice break on some of the longer days. I also appreciated the change in pace and subject matter that it provided.

No matter whom I was helping or with what task, at 9:30 a.m. and 3:00 p.m. we stopped working and drank çay, or tea. Over the course of 30 minutes or so, I would see the whole institute walking the halls to the corner where the çay was brewing. It was extremely nice to have that break in the day. We often had a small snack while we drank and talked about the day. Sevil Hanım or Dr. Erginbas would bake traditional Turkish food like baklava and a pastry like bread with lentils and cheese in the middle. Both Sevil Hanım and Dr. Erginbas were excellent cooks.

For lunch, some of the workers and I would head off to the cafeteria on the institute grounds. There they would have a wonderful lunch consisting of soup, salad, and main dish of rice, beans, chicken, beef, or a combination of those. It was always delicious. When Fateh was there he showed me how to really eat lentil soup—with lemon juice and paprika. It transforms the soup from bland to mouthwatering.

I must add an important note. My two-month stay with CIMMYT-Turkey fell around the holy month of Ramadan. Muslim coworkers who chose to fast during this time could not eat or drink from early in the morning (before sunrise) until sunset, which was around 8:30 p.m. During this time the lunchroom was closed and didn't serve any meals. Although we still observed the tea break, the çay was not prepared. Because Elfinesh, Cui, and I are not Muslim, we were able to eat and drink during the regular break times. I tried to not eat or drink in front of those who were fasting out of respect. For lunch during Ramadan, Elfinesh, Cui, and I would go back to the guest house and prepare a meal or eat leftovers from the night before.

Picture 18: The view of the river that ran through Eskişehir was stunning from this second story balcony. (Picture by Adam Willman)

4.2 In the City

The city of Eskişehir is a lively and youthful city. Yet, it still holds true to its Turkish translation, "old city." A short ride on minibus number 23 and I was transported from the rural

research institute to an urban center filled with all of the smells, sounds, and sites you would expect in a major city. The cultural center of the city lies along the Porsuk River that runs through the heart of the city. Restaurants and stores line both sides as trees and walking paths run along the artificial bank. One on my first lunches in Eskişehir was at a restaurant overlooking this river.

Picture 19: This mosque was built in 1525 and had amazing architecture. It also served as a cultural hub for the city. (Picture by Zafer Şabon Tunca)

It was refreshing to have all that I needed within walking distance. It seemed as though I could acquire anything that I needed from food, to clothes, to cultural gifts, and more. Several times a week Elfinesh and I would head into town to pick up groceries from several markets depending on what we were planning on cooking in the coming days.

Beyond the shops and markets, Eskişehir has a wonderful historic side. I was able to explore the city with a doctor from the institute named Zafer Şabon Tunca. Zafer took me to an older part of the city where the houses were built according to the Ottoman style. The houses are newer but resemble what they would have looked like during that time period. I could tell that this part of the city was rich in culture. This idea was confirmed when I was fortunate enough to visit and explore the inside of a mosque built in 1525. We stopped by a bazaar nearby where a woman was doing a traditional water panting. This art form is unique to Turkey and uses colored oil on a liquid water canvas. It was truly breathtaking.

4.3 A Culinary Exchange

Throughout my time in Turkey, I was able to experience a blend of cultures that included China, Ethiopia, the Middle East, and of course Turkey. One of the greatest exchanges of culture involved the meals we shared. From day one I was able to experience the wonderful culinary adventure that Turkey had to offer. This mixture between a Middle Eastern and Mediterranean diet is full of flavor and color. I can honestly say that I did not dislike any of the food I ate while in Turkey. I greeted each new meal with an open mind and an empty stomach and always came away satisfied. Some of my most vivid memories are of the meals I was able to share with my colleges and friends. I could write a book about the foods I encountered; however, I will just detail a few of my favorite meals.

My second night in Turkey was spent at Amer's house with his family in Ankara. In the mid-afternoon Amer left to pick up Fateh from the airport while his wife Shaymaa made dinner. I helped his kids with their English homework and talked with some family back home. When Fateh arrived he immediately acted like he had been to Amer's house a dozen times. I later learned that this is simply Middle Eastern culture and the polite thing to do. I got to talk with Fateh a little

before dinner started, but learned so much more once the table was set and the food was ready. Shaymaa had cooked a traditional Arabic meal with a main dish called maklouba, which translates from Arabic to mean upside-down. This dish has to be prepared a certain way in which the chicken and rice that are cooked have to be inverted at some point. To go along with the maklouba, Shaymaa had prepared rice and beef wrapped in grape leaves that were amazing. As with almost every Turkish or Middle Eastern meal, bread was served along with some fresh vegetables, cheese, and yoghurt.

After dinner Fateh, Amer, and I sat down to watch one of the World Cup games. After about 20 minutes Shaymaa brought out more food in the form of nuts. Pistachios, corn, almonds, hazelnuts, and sunflower seeds were passed around along with çay. After we finished the nuts, it was time for the fruit: cherries, grapes, bananas, and apples. The night ended around 1 a.m. with a full stomach and a cup of Arabic coffee. That night, one of my first in a foreign country, definitely set the bar pretty high for food adventures that followed. Amer and Shaymaa were wonderful hosts and made me feel at home over a thousand miles away.

While in Eskişehir, Elfinesh Fateh, Cui, and I cooked a lot. My favorite meals came from when we would blend cultures and culinary knowledge. Fateh, Elfinesh, and I made a pizza one night from scratch. I made the dough from flour, water, and salt while Elfinesh made the sauce from tomato paste and a special Ethiopian pepper. Fateh prepared the meat, vegetables, and cheese. The whole process took several hours but allowed us to talk and share stories and experience from our home countries. We all agreed that the pizza was amazing and that it tasted even better because we spent so much time preparing it from scratch.

Picture 20: Doro Wot cooked by Elfinesh, Cui, and I consisted of chicken, egg, yogurt and a special sauce. (Picture by Adam Willman)

Another meal prepared with no real plan in our mind turned out to be fried chicken and potatoes—an American staple. Elfinesh, Cui, and I noticed that we had flour, eggs, onion, chicken, potatoes, and oil. After some creative thinking I came up with the idea to bread the chicken and bake it. Elfinesh had some spices that we were able to use to enhance the flavor. Again it took a while to bread and bake the potatoes and chicken; however, it was well worth it in the end. Baked chicken wasn't the only non-Turkish food we prepared for a meal, however. Elfinesh wanted to share a traditional Ethiopian meal that she prepares for her family around holidays. I eagerly agreed and offered to help in any way I could. The dish is called Doro Wot which is essentially chicken with sauce. Elfinesh baked the chicken with some oil, thyme, and oregano. She also hard-boiled several eggs. I helped with the sauce, which included tomato paste, a special type of Ethiopian pepper, oil, garlic, and onions along with salt and black pepper. The

sauce was cooked for a long time to allow for the flavors, especially the spice, to mellow and combine. Once the eggs and chicken were cooked, they were added to the sauce. After about 15 minutes the dish was ready to be served with yogurt and bread. Traditionally this meal is eaten without the use of utensils. I gave it a try and remained relatively clean. It is through these meals that I learned the most about cultures, history, policies, human nature, and much more. No matter how hot the day had been or how tedious the work was, I could always look forward to the next meal.

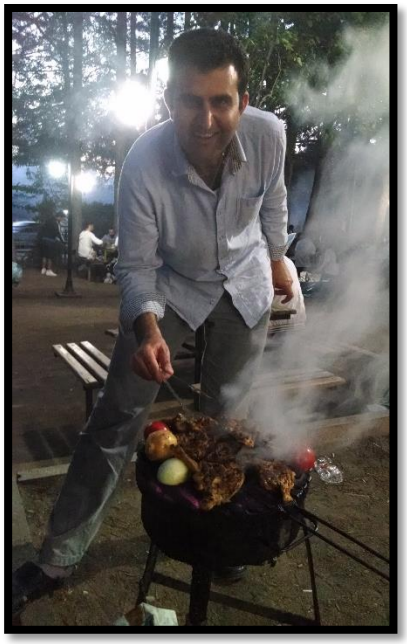
5. Personal Growth and Going Forward

Picture 21: The people in lab threw Ömer and me a birthday party during one of the tea breaks. Pictured from left to right: Elfinesh, Ömer, myself, Gül, Sevil Hanım, and Cui. (Picture credit unknown)

Ambassador Quinn warned each intern and their families that we would change over the course of our two months abroad. He was right. I am a different person now than when I first boarded the plane in Des Moines in mid-June. I knew that I had changed and even noted it in the journal that I kept throughout the internship experience. Near the end of my experience, I sat atop a hill around midnight thinking about the last few weeks. I wrote the following in my journal underneath a wind turbine that was pumping water into the nearby fields: "I've changed. Turkey has changed me and I've taken note. But will others? Will my friends know that I'm not the same person as in high school? Will my family expect me to be the same person that got on the plane over seven weeks ago? Surely they can't!" This type of self-assurance and existential questioning became a major part of my experience in Turkey. As I was gaining independence and spending time alone and away from people I knew, I started to find out who I was and what I wanted in life. I stepped off the plane as a different person, and yet I was surrounded by people who supported and encouraged me every step of the way.

The men and women I met while in Turkey shaped me through their words and actions. The scientists I met were passionate about what they were doing. Fateh and Elfinesh would work long into the night on their projects, making sure they were done with precision and accuracy. I quickly understood the importance of the work that was being done based on how people conducted themselves. As for myself, many hours and even days were spent standing at a sink washing soil samples or staring into a microscope counting cysts. The work could be at times tedious and trying. My eyes would start to sting after just a few hours of counting. My feet, legs, and back would become sore after standing on a wooden pallet all morning. However, every time I felt the slightest

notion of discomfort I thought of the millions of people who would be going to bed hungry that night. I thought of the farmers who will be benefiting from the pest resistant wheat varieties that will be breed based on the data I was collecting. I thought of Dr. Borlaug and how he worked tirelessly to create the miracle wheat that helped save a billion lives. I didn't need to look far for more inspiration--I was surrounded by it every day. My greatest resources for my upcoming year in college came from the doctoral students who are pursuing the highest degree in their field. I was reminded that even with a doctorate, publications and papers could make or break you. After talking with Elfinesh, Cui, Fateh, and several others, I have decided to pursue higher education in the form of a masters and doctorate. The work I did at CIMMYT-Turkey has led me to explore the areas of plant breeding and plant pathology.



Picture 22: Fateh was an amzing cook and friend who had many stories to share. (Picture by Adam Willman)

I will end with where my experience officially began—my supervisors. Amer and Gül were more than mentors; they became my family. They had a wealth of knowledge that ranged from plant science, to policy, to culture, to religion and beyond. The meals shared, the car ride chats, and the office work will remain with me for a long time. Teşekkür ederim Gül and Amer—more than you know.

Picture 23: Dr. Gul Erginbas and Dr. Amer Dababat. (Picture by Adam Willman)

6. Works Cited

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