The Impact of Atmospheric Conditions on Stomatal Conductance Using Fully Irrigated and Water Restricted Varieties of Potato and Sweet Potato

By:
Lavina Kalwani
Katy, Texas

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INTERNATIONAL POTATO CENTER
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Personal Introduction

My name is Lavina Kalwani and I am from Katy, Texas. Currently, I am a first-semester freshman at Rice University, a private university in the heart of Houston, Texas. My intended majors are Chemistry and Cognitive Science. I hope to earn a B.S. in Chemistry and a B.A. in Cognitive Science. Before moving to Katy, I lived in Johnston, Iowa, where I first learned about the World Food Prize through my sophomore year chemistry teacher. There, I was matched with a mentor who helped me construct my initial paper for the 2015 Iowa Youth Institute. I was selected to attend and through the Iowa Youth Institute, I learned about the Borlaug-Ruan Internship program. The program appealed to me initially because it combined my interests in travel and research with my desire to extend my skills beyond the classroom and start interning or working.

The next year, I applied to the Texas Youth Institute and was selected to attend. After attending the 2016 Texas Youth Institute, I was extremely excited to find out that I was chosen to represent Texas at the 2017 Global Youth Institute. I knew that attending the Global Youth Institute was a prerequisite to applying for the Borlaug-Ruan Internship program. The more I researched about this program, the more interested I became in applying. I saw students my age making real world impacts in an environment that is unfortunately rarely presented to high schoolers. I was extremely keen on studying food security through an internship to gain the context and true understanding that is often lost when simply researching food security issues using resources like the library and the internet. The Borlaug-Ruan Internship program seemed to provide a way to conduct meaningful research in a cultural environment I was unexposed to – it was an opportunity that would absolutely not have been possible without the generosity of the World Food Prize program.

For me in particular, any opportunity granted by the Borlaug-Ruan program would have fit one of my interests – as a STEM major, I was looking forward to the placements that involved lab and field research, and as a passionate human rights advocate I could see myself working for an organization that approaches food security through a policy lens. An invaluable factor of the internship for me was the fact that the Borlaug-Ruan internship is designed around traveling to another country to study. I felt like this experience would be unquantifiable and bring a perspective to the research I would conduct in a way that is simply irreproducible in the United States.

My personal interests in travel and experiencing different cultures also drove me to apply for this internship. I had little to no experience in most of the countries the Borlaug-Ruan interns go to, and no idea what to expect in terms of culture, people, and day-to-day life. I am a firm believer that in order to truly understand and engage with world issues in an increasingly globalized society, a person must first gain a world perspective by traveling and experiencing different cultures. Thus, the Borlaug-Ruan program offered that opportunity to gain a better world perspective (and become a better global citizen) in a safe and conductive environment. It allowed me to combine the cultural and social aspects of traveling with the day-to-day experience of working and studying in another country, something that I had not had the chance to experience before.

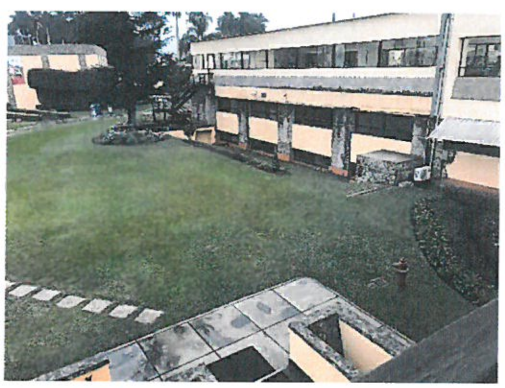
Program Background

The International Potato Center

I spent my internship in Lima, Peru. Lima is a coastal city on the western side of the Peruvian border; it is also the capital city of Peru. I worked in a district named La Molina, which holds the International Potato Center (CIP). CIP opened in 1971 as a research institution dedicated solely for potato and sweet potato cultivation (International). It was opened in Lima, Peru because the origin of the potato is along the Andean coast and the founders wanted to keep true to the potato's origin (International).

CIP conducts research in a variety of different fields, including genetic modification, photosynthesis analysis, cryogenics, and everything in between. I was fortunate enough to visit their gene bank, which is one of the largest in the world for potato seeds. Here, they preserve seeds of thousands of potato and sweet potato varieties. They also clone seeds to test DNA modification. CIP has agreements with several organizations to grow seeds in the gene bank and ship the sprouts (still in test tubes) for further study. CIP also archives potato and sweet potato plants in their headquarters (International). They dry and press a sample of each species and file it in a temperature-controlled room. Periodically, the files are reorganized, and it may be discovered that species have become extinct, or that new ones have been found.

The complex itself consists of orange-peach colored buildings centered around a large courtyard and adjacent to a field. It is right in the middle of the city, so apartment buildings and even universities are located across the street. My lab was a small one room building in the middle of the field. It was housed near greenhouses and attached to a concrete platform, making it an ideal location for studying plants in the field, in pots, and in controlled environments.



The International Potato Center, Lima, Peru

As a Borlaug-Ruan intern, I was assigned to the Crop and Systems Sciences (CSS) division. My assignment was to study the stomata conductance rate in the different varieties of the potato and sweet potato when placed under different water irrigation levels. Essentially, I was studying the impact of water management on plant health. Two main questions needed to be answered: how does light saturated maximum stomatal conductance (gs_max) vary along the day in potato and sweet potato and when is the most appropriate moment to take leaf temperature as a proxy of gs_max.

While I do not fully know why I was assigned to this division, I do know that a similar study answering these questions was conducted by CIP the previous summer (June through August of 2016) and the results did not match the previously established literature. Thus, the team in Peru was looking to retry the experiment and compare results from different years.

As an intern, I worked with the graduate student who carried out the experiment the previous year. The previous study conducted by him did not include the sweet potato trials – in fact, such a study was not conducted until my experiment – so the difference between stomata conductance rates in the potato versus the sweet potato was studied as well. By conducting the experiment to answer these two questions, CIP hoped to gain insight into the effect of irrigation levels on stomata openings, which would help in water management.

Colleagues and Host Family

The person who conducted the study in 2016 was Mr. Javier Rinza, a graduate student at the National Agrarian University in La Molina, Lima, Peru. I worked him the most over the summer, since my experiment was largely based off his previously established work. At the time, he was working on his master's thesis, which related to the stomata conductance rates in different crop varieties. Mr. Rinza was from the northern part of Peru but moved to Lima in search of better educational opportunities, which he found at the National Agrarian University. I found Mr. Rinza to be an extraordinarily kind and genuine man who truly enjoyed the work that he did and enjoyed teaching his knowledge to other people.

I interned under Dr. David Ramirez and Dr. Roberto Quiroz, both head scientists for the CISS division. Dr. David Ramirez, unfortunately, had to leave for a two-month trip just a few days after my arrival. He continued mentoring me through weekly Skype calls. Dr. Quiroz was more involved in the administration and logistics than in field work, and so I did not interact with him on an everyday basis. He did ensure that I was able to complete my experiments as laid out in the beginning of the summer. Both Dr. Ramirez and Dr. Quiroz smoothened the transition between studying in a school environment and working as a research intern, as well as the transition between learning in the United States and learning in Peru.

While Dr. Ramirez and Dr. Quiroz were my mentors on paper, my true mentor (in addition to Mr. Rinza) was Ms. Wendy Yactayo. She worked directly under Dr. Ramirez in the CISS division. We would interact at least a few times a week to go over what I was doing, my progress, and any concerns that came up. She taught me about research in the field of agriculture and used her own experiences to reflect and advise me.

In addition to being a mentor, Ms. Yactayo grew to be my friend. I learned that she was not only a successful researcher, but she had a passion for salsa dancing – such a strong one that she regularly competed on the international level. As of right now, she is ranked the eight best salsa dancer in the world and the first in Peru. She was generous enough to give me a few salsa lessons throughout the course of the summer. We would finish work for the day, head over to her office, and practice right there amid stacks of research material. At time, we would be accompanied by Ms. Cecilia Silva Diaz.

Ms. Diaz, who we affectionately called Ceci, had only been part of the CIP organization for a few weeks before I arrived for my internship. She was an undergraduate student, also at the National Agrarian University, studying biology. She was in the final year of her bachelor's degree, and hoped to go to university in Brazil for her Masters. Other than myself, she was the youngest person on the team. She quickly befriended me, and as the person in the team who spoke the most English, became my unofficial translator whenever I was lost in communication.

Cecilia Diaz (right) and myself (left) on the field surrounding our lab.

Although not scientists, Nicolas and Jesus were the last two integral members of my team. As electricians, they helped the rest of us set up every part of our experiments, from attaching thermocouples to laying down irrigation piping. Nicolas and I would the Peruvian sport of fronton during lunch breaks or after work, and I really enjoyed learning this new sport. It's similar to squash, but it takes place outdoors. Before coming to CIP, Jesus worked as a guard for a national reserve called Lomas de Lachay. I had the opportunity to visit Lomas de Lachay during my stay, and it was absolutely stunning – it looked like it had come straight out of a fantasy novel like the Lord of the Rings. Both Nico and Jesus were friendly and treated as equals by the other members of the team, which was a refreshing break from the American mentality of work place hierarchy.

Right: Cecilia (left), Jesus (right), and myself (center) adjusting the thermocouples in the potato experiment.

Left: Cecilia (center), Jesus (back), and myself (front) taking wavelength readings of the potatoes.

Of all the wonderful places I visited and cultural events I was able to participate in, none of it would have been possible without the guidance and support of Ms. Martha Hueres. Truly one of the kindest people I met this summer, she surpassed my expectations of accommodation. Ms. Hueres always made sure I was taken care of, the logistics for everything I was doing and everyone I was with was in place. She took me around Lima herself several times just to learn more about me and to let me learn more about Lima.

After work, I would take a bus to Miraflores, a district in Lima about an hour away from CIP. Miraflores is a district right on top of the coastal cliffs of the city, so I would spend many evenings looking out into the Pacific Ocean. In Miraflores, I stayed with two women named Monica and Cotty. They were childhood friends in northern Peru who just happened to meet years later in Lima. Monica, ironically enough, completed her undergraduate degree and worked for a few years in Houston, Texas. Cotty didn't work at CIP, but rather in the beauty industry. Both of them were extraordinarily accommodating and made the Borlaug-Ruan program extremely rewarding. We explored Lima all the time, they introduced me to their families, and we even took trips to nearby cities.

In my experience, it was the people I met that made the Borlaug-Ruan internship remarkable. They were more kind, genuine, and accommodating than I ever could have expected. Never have I connected with people more quickly or more strongly than I did through the Borlaug-Ruan program. I felt a true connection with nearly everyone I met, and I can definitely see myself going back to Lima just to see some of my friends again.

For my last day, my team took me out for lunch. Pictured from left to right is Ms. Wendy Yactayo, Mr. Javier Rinza, Jesus, myself, and Ms. Cecilia Diaz. Nicolas was taking the photograph.

Responsibilities and Contributions

As an intern at the International Potato Center, my main tasks centered around running my potato and sweet potato experiment. Every morning, I would collect the thermocouple and sensor readings from the previous day. I would spend the rest of the morning and part of the afternoon organizing these data sets into Excel charts that could more easily be read and worked with. For the rest of the day, I would work on the broader week-by-week analysis that we were collecting.

This often included running programs in MATLAB or R, although usually it involved taking the daily Excel sheets and arranging them to run analysis on week-long data.

Once a week – usually on Fridays – the entire team (including myself) would work together to take stomata conductance readings and pictures with thermal cameras. Taking stomata conductance readings is a time-intense process, so we would have to come to work early and leave late. Later in the summer, we were able to obtain a second machine to take the readings with. Instead of finishing in less time, we elected to obtain more data points with this second machine so that we could have a more accurate analysis. The machine collected data on photosynthesis and florescence levels alongside stomata conductance rates, which was useful for projects the other team members were a part of.

Right: A weekly reading of stomata conductance rates, photosynthesis levels, and florescence.
Left: (From left to right) Mr. Javier Rinza, Ms. Cecilia Diaz, and myself preparing the plants for stomatal readings.

The thermal cameras, although not nearly as time intense as the stomata conductance readings, were still a day long process because we needed data on the daily cycle of temperature. Thus, both of these objectives were combined into a once-a-week procedure that I completed with the help of my colleagues.

Mr. Javier Rinza (left) and myself (right) using a cardboard box as a calibration trial using infrared thermography with FLIR cameras.

Near the end of the summer, I turned my focus to creating charts and graphs to represent all the raw data that was collected. I spent most of my mornings continuing to take daily readings, but my afternoons were spent deciding which data sets to use, how to turn them into graphs, and then taking calculations like standard deviations. I would submit these to Dr. Ramirez for review, who would critique them and send them back to me for revisions.

Research Report

Topic

The impact of atmospheric conditions on stomatal conductance using fully irrigated and water restricted varieties of potato and sweet potato.

Abstract

The potato and sweet potato are vital staple crops to the entire Andean region, and are especially relevant to the Peruvian diet. Stomatal conductance rates (gs_max), which determine cellular respiration, are impacted by abiotic atmospheric factors on a daily and seasonal cycle and may differ according to water irrigation levels. Experiments with one variety of potted potatoes (Canchan) and seven varieties of potted sweet potatoes (Tanzania, Muganda, PER7348, ACIAR81, TWN662, TWN658, USA696) conducted at the International Potato Center (CIP) from June-August 2017 included two levels of water irrigation: full irrigation and water restriction.

Measurements for atmospheric conditions were taken (using HOBO) alongside temperature readings, gs_max, and photosynthesis rates (using Campbell, FLIR, and LI-COR), then analyzed using coding programs (R, MatLab) and graphing tools (Excel and SigmaPlot). In contrast to previous literature, a positive correlation was found between leaf temperature and vapor-pressure deficit (VPD) in all rounds of testing. Water restricted Canchan potatoes had gs_max levels significantly below that of fully irrigated plants (0.081-0.227 mol H2O/m2.s). As the time Canchan potatoes were kept under water restriction increased, the gs_max decreased and the potatoes had less resistance to solar radiation related factors (Tc-Ta, Tthermoc). Similar effects were found in the sweet potato crops, although each variety had slightly different results, indicating different resistance levels. A future focus on the nuanced irrigation levels that allow for maximum gs_max without water waste would allow greater insight into water management and optimum potato and sweet potato cellular respiration levels.

Introduction

The International Potato Center studied the stomatal conductance rates in potatoes and sweet potatoes. In plant leaves, stomata are openings that allow cellular gas (CO_2 and water) exchange to take place. Stomatal conductance rates are determined by how open the stomata are at a given point, which in turn affects the level of water loss that can occur. These rates are affected by variety of factors, most notably air and leaf temperature. In our experiment, we looked at how atmospheric conditions (especially how much light) impacts the stomatal conductance rates at different times in the day, and what atmospheric conditions are ideal for maximum conductance.

We took measurements using plants that were fully irrigated and plants that were under water restriction to understand the role of water management in stomatal conductance.

This topic is of great value when it comes to planting in the field, as atmospheric conditions determine the ability to calculate stomatal conductance and thus determine ideal conditions for cellular gas exchange. By understanding the amount of light ideal for plants (and the amount that causes damage in accordance with different water restriction levels), farmers can anticipate the radiation's impact on their crops and plan accordingly. They can manipulate their water usage to obtain high yields without wasting water, and adjust their usage with weather conditions to obtain favorable stomatal conductance conditions. From a research standpoint, understanding the impact of light and water in stomatal conductance can help determine conditions for maximum growth and maximum yield. Keeping conditions at the highest ideal for the entire plant cycle could allow researchers to gradually manipulate the size and amount of the stomata, eventually bringing a new generation of plants with larger stomata and thus higher productivity.

The experiment was set up so that there was one variety of potatoes (Canchan), half with full irrigation and half with water restriction. There were also six varieties of sweet potato, with the same full irrigation and water restriction set up. Thermocouples were attached to a select number of potatoes and sweet potatoes in order to take leaf temperature readings. A meteorological station placed near the plants took humidity, air temperature, air direction, air velocity, and radiation level readings. The data collected by dataloggers was downloaded daily onto a computer. A portable photosynthesis system was used to take photosynthesis and conductance readings one to two times a week. We then used tables and graphs to analyze these data sets, focusing on the relationship between two or more factors (ex. the time of the day and radiation levels). This design is an accurate way to analyze the different factors that affect stomatal conductance because we were working directly on the plants to obtain readings.

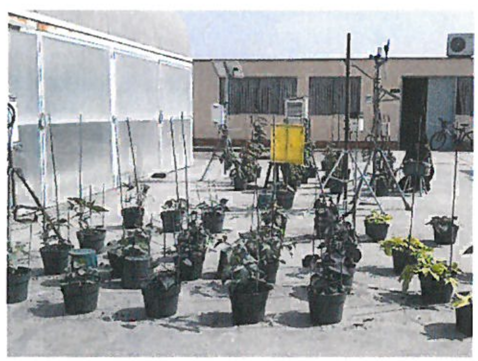
The outcome was as expected – the highest stomatal conductance occurred in the mornings (with low temperatures) and decreased as the radiation became more intense. The initial test (taken June 23rd) anticipated this outcome in potatoes, and further trials confirmed it. Enough trials and data points were collected for detailed analysis. Water restriction, the effects of which became more apparent as the trial went on, drastically lowered the stomatal conductance in both the potato and the sweet potato. The seven sweet potato varieties did show differing levels of resistance to the restricted water. This was displayed in their stomatal conductance difference between the irrigated and water restricted plants, some of which had a more dramatic change than others.

The sweet potato and potato followed the expected daily cycle of gs_max as related to temperature and sunlight, although the sweet potato showed more resistance as its shifts were not as dramatic. The vapor pressure deficit on the potato plant was expected to have a positive trend, as established in previous literature, but instead showed a negative trend. Further studies need to be done to determine the cause of the unexpected negative trend. These results can be used to generate new experiments that focus on the impact of ideal conditions on stomatal conductance throughout the entire plant cycle or explore ways to circumvent unfavorable conditions caused by uncontrollable factors.

Ultimately, studying stomata conductance changes when placed under environmentally unfavorable conditions such as water restriction provides insight into improving water management. The development of more efficient water management techniques will allow farmers to maintain healthier crops for longer periods of time and will allow them to adjust alongside natural disasters, unfavorable irrigation technology, and any other obstacles that interfere with water management. This in turn will strengthen food security on a local and national level by maximizing the irrigation resources a community has available to them. It would make international food security more balanced by bringing nations that are currently struggling to a more even playing field, allowing each nation, whether currently supporting or being supported by others regarding water management, to become more autonomous in the way they approach food security and water management issues.

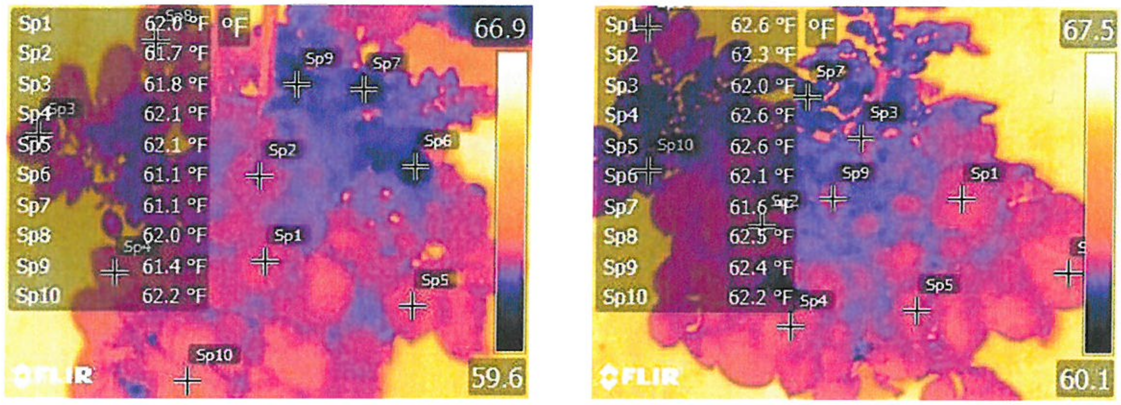
Materials and Methods

Eight fully irrigated Canchan potatoes were kept in the same environmental conditions as eight Canchan potatoes under water restriction. Each week, the fully irrigated potatoes were watered, while the water restriction plants were not irrigated throughout the entire experiment, so as to replicate drought conditions. Similarly, seven varieties (four plants of each variety) of sweet potatoes were studied. These varieties were Tanzania, Muganda, PER7348, ACIAR81, TWN662, TWN658, and USA696. Of each variety, two were placed under water restriction and two were kept fully irrigated. The sweet potato study began approximately three to four weeks after the potato experiment was underway.



Right: Sweet potato experiment set up, all varieties shown
Left: Potato experiment set up, Canchan variety

Every day, environmental readings were taken using thermal cameras, temperature sensors, and humidity sensors. These cameras and sensors were attached to two datalogging systems, Campbell and HOBO. A computer and USB cord were used to download the data directly from the dataloggers. Roughly every week, photosynthesis levels, florescence, and stomata conductance rates were taken using LI-COR, a portable photosynthesis machine. Alongside the weekly readings with LI-COR, a FLIR thermal camera was used to take leaf temperature readings. It was initially calibrated to a cardboard box before being used on the plants. During the parts of the day where the sun was out, a tray of cold water covered with a wet rag was also kept in the frame to use as a reference point.

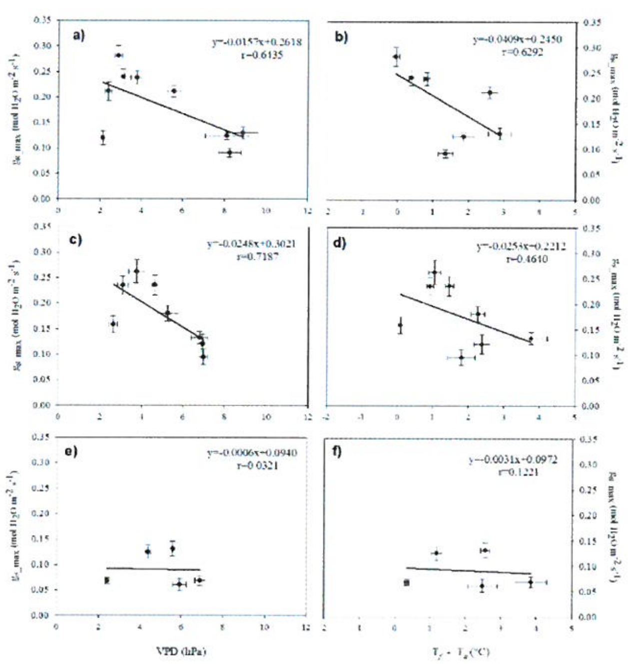


Examples of FLIR thermography that was used in later analysis of leaf temperature.

All the data was collected in raw form and converted to Excel spreadsheets. Excel graphs were used solely for analysis purposes. Further analysis that was beyond the scope of Excel was run on coding programs R and MATLAB. These programs were used to find the relationship of the derivatives of different data points and other key factors. Final graphs of publication quality were created using SigmaPlot.

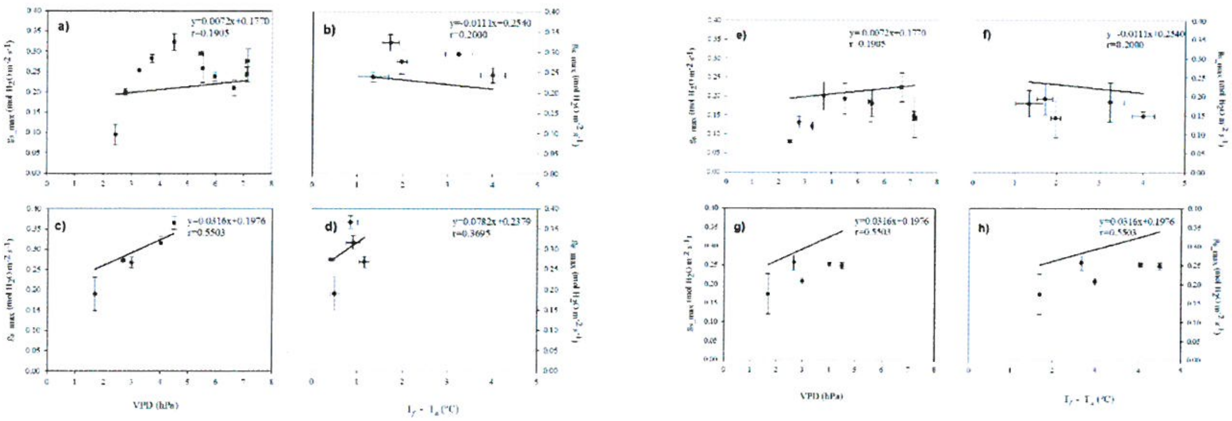
Results

The data found for Canchan potato plants contradicts previous research articles. The values show a negative trend when comparing vapor pressure deficit (VPD) to gs_max, and in comparable research articles they depict a positive trend. Further research must be done to pinpoint the cause of this discrepancy.



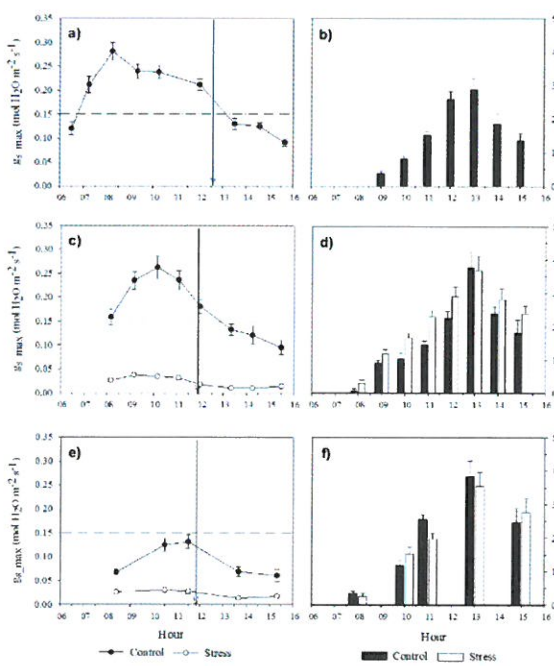
Graph of VPD vs gs_max in Canchan potatoes, depicting a negative trend.

The sweet potato plants, which had not been previously included in stomata conductance studies, depict a positive trend for vapor pressure deficit, albeit with a relatively high standard of error.

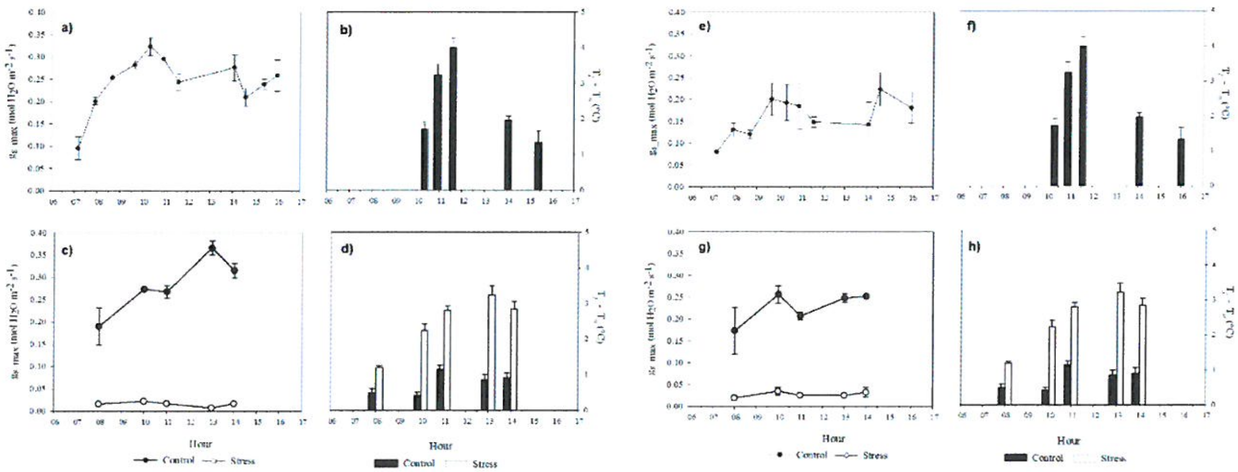


Graphs depicting gs_max vs VPD in sweet potato plants.

The gs_max levels on both crops followed the expected trend of steadily rising in the morning, peaking shortly after noon, and slowly descending as the afternoon progressed. This pattern is caused by the fluctuation of temperature and sunlight, which rise gradually, peak in the early afternoon, and lower throughout the afternoon and evening. The descent on the sweet potato was not nearly as dramatic as that on the potato, and at points the gs_max even rose.



Hour vs gs_max on Canchan potatoes.



Hour vs gs_max on sweet potatoes.

Discussion and Conclusion

The discrepancy between the studied potato plants and previously published data could be due to differing environmental conditions, although more research should be done to fully understand why the discrepancy occurred. The data from the sweet potato offers new insight into a crop whose stomata conductance was previously not studied, although more data should be collected from a variety of environments before drawing broad conclusions. The sweet potato plants appear to be more resistant to temperature and sunlight changes, as the stomatal conductance did not decrease as dramatically in the afternoon as the Canchan potatoes did.

The extremely low stomatal conductance rate in water restricted plants in both crops highlight the critical need for water management and the impact drought-like conditions have on plant health. It would also be an interesting point of future study to see the nutrient level of potatoes with different water management systems – this is the current project of Dr. David Ramirez.

Final Reflection

Improving Food Security

The first step of improving food security is to understand the food and resources we have. Without optimizing food production and improving plant health, all other aspects of food security are simply an attempt to cover these underlying issues. As water management is a part of understanding and utilizing our resources, the stomata conductance rate study completed by CIP falls under this critical aspect of food security. It gleaned insight into how crop health is affected by differing water levels, which will become an increasingly important part of food security as water becomes more scarce, polluted, and harder to obtain.

From another perspective, this research helped strengthen the bond between CIP and the World Food Prize organization. Both of these organizations are working toward similar goals of food security, and so a partnership between these organizations (and other entities that also have similar goals) is essential to greater food stability. Through partnerships between CIP, WFP, and other similar entities, we can foster research into more nuanced and critical aspects of food security.

The stomata conductance study helped food security not only on this broad, theoretical level, but it also strengthened the concrete, technical aspects of food security as well.

The discrepancy between previously established literature and our results, although not ideal, do provide a further pathway into stomata conductance exploration. We now believe some of these discrepancies were caused by the unique climate of Lima, which is a technically a desert climate but located on the coast. Further study into to stomata conductance rate using these incongruent results as a baseline would give a clearer explanation into how climate interacts with irrigation to affect stomata conductance. Thus, the study can be viewed as a stepping stone into more impactful research centered around food sustainability.

Personal and Professional Growth

Throughout the summer, I was working continuously on one very niche aspect of plant health, but through that, my skills in biology as a whole grew tremendously. I was able to understand the reactions of light, water vapor, and other environmental factors on different parts of the leaf in a way I never would have imagined being able to at the beginning of the summer. Through a combinations of reading articles and textbooks on advanced biology and seeing the results of my own experiments, I gained a level of comprehension on biology that goes far beyond the classroom.

Also through the experiment, I gained a greater understanding of water management. Before this summer, I knew water management was an essential part of crop vitality, but I never realized the striking difference that irrigation can cause. Week after week, I could see the physical changes in the crops as half of them began to droop and eventually die, while the other half were just as robust as they were at the beginning of the trials. Seeing that physical difference really put the importance of water management into perspective.

When taking the stomata conductance readings and analyzing the data, the effect irrigation can have on crops became even more apparent. Now I could not only see the crop on a macro level, but I could see the stomatal changes on a micro level. The amount and speed of conductivity that dropped from the water restriction plants throughout the summer was absolutely staggering. Putting the data into Excel and SigmaPlot graphs gave a physical, quantifiable face to an otherwise unnoticeable change. It gave a true meaning and even a sense of urgency to the work that we were doing.

Outside of the experiment, I definitely learned how to better interact in both a field and team environment. I had never worked in a field before, so learning how to dig, plant, and navigate on an agricultural field was a truly unique and exciting experience. I slowly learned how to take samples from fields, which have to be done in sets that are randomly distributed throughout sub-plots of the field so as to obtain unbiased data. It was interesting to note how each sub-plot, although a few feet apart from each other, differed in terms of soil quality and water content.

Discussing the planting of potatoes for a project lead by Mr. Javier Rinza and Ms. Cecilia Diaz

Before the Borlaug-Ruan internship, I had interned in a couple other places. However, I had never interned in a team-oriented environment before – my experience was mostly working on a computer at my own desk or cubicle. I came in knowing I enjoyed team activities, which I did through extracurriculars and class courses. However, working in a team for an internship proved to be very different from participating in team-oriented extracurriculars.

Throughout the summer, I learned how to discuss and solve problems together, relay information from one team member to another, and make sure that everyone was on the same page before moving forward with a project. I came to understand how each person functioned individually, with their own tasks they needed to complete, but how they still came together as a group to coordinate projects as needed. That was something I hadn't seen before in extracurriculars, where everyone has the same project they are there for and everything they do is centered around that common goal.

My lab experience before the Borlaug-Ruan internship was limited, and gaining that exposure before going to college gave me the opportunity to pursue more advanced laboratories at Rice University that are typically restricted to undergraduates, and especially to freshman. I'm now working in a laboratory I really enjoy but probably would not have been able to work if not for the Borlaug-Ruan program. It also proved to me that I do enjoy lab work and I could see myself researching in a lab as a career.

This was nearly the exact opposite conclusion compared to a different internship I completed a few years prior. There, I was stuck inside a cubicle working on a computer all day and I realized it was not the environment I wanted to be in for my career. Thus, this past summer was really satisfying in that I knew I found a career path I could see myself enjoying, and this made me feel confident in my chemistry major before entering college. A lot of students do not have the opportunity to explore the real-world experience of working in a potential field of interest before entering college, so I am very thankful to the WFP and their Borlaug-Ruan program for giving me that opportunity.

On a more personal note, the program in Lima was the longest stretch of time I had gone without living with my family and the first time living independently. Even though I had Monica and Cotty to look after me and assist me in any way they could, I was ultimately left to my own devices most evenings and weekends. I learned how to cook for myself and do laundry, two things I had never had to do before.

I found out that living independently (or near independently) was really about two things: maintenance and initiative. I had to maintain the standard of living I wanted, meaning I had to keep up with tasks like laundry and cleaning my room (even when they got mundane and repetitive). I also had to take initiative for the things I wanted. If I wanted to go somewhere, I had to do the research. If I wanted to eat, I had to make or get the food – I couldn't expect anyone to bring it for me. While this is certainly not a groundbreaking realization, it was the first time in my life I was faced with the freedom and responsibilities that come with living independently.

The daily interaction I had with people also helped me grow on a personal level. Normally, I am a quiet person who keeps to herself, but the structure of the work that I did forced me to interact with others for hours at a time, weeks at a stretch – something I had not really done before. I learned how to navigate conversations and how to distinguish between times where small talk was acceptable and times when the focus needed to be on work. I learned how to keep up with work or social situations involving multiple people, all with their own opinions and ideas on how to go about whatever the discussion was about. I learned how to interact in a way that I had never done before. I believe this is an invaluable skill in both social and work situations, and I'm glad I got to refine this skill.

Beyond simply interacting, I learned how to interact with people from different backgrounds than me. While I do meet and enjoy talking to people from different backgrounds, I usually don't have the opportunity to do so in situations where I am the foreigner or the odd one out. In Lima, my differences to others were glaring, but provided opportunity for conversation and mutual understanding.

It was great learning about all the different ways and times people found their way to CIP, whether it was a few weeks ago like me, or decades ago like Ms. Hueres. We ended up having a lot in common, and at one point we even bonded over American politics. I was surprised that Peruvians knew so much about America, since I came into Peru knowing very little about their culture. It opened my eyes to how different nations view the United States and the unbelievable reach that American politics has on other countries. A natural development of this was learning not to judge what a person may or may not know.

One other point of personal growth that I am particularly proud about was my improvement in fluency. I had taken high school Spanish for about three years, and while I knew I wasn't great, I was expecting it to serve me well in Peru. Surprisingly, I barely made it past the first few minutes on my first day before realizing how poor my speaking and comprehension was. I decided to use the fragile base in Spanish I did have to start better language acquisition.

I told my coworkers to speak to me solely in Spanish and accept responses in the same. With some, this wasn't an issue because they didn't speak English and with others, it became almost a game of realizing when we were regressing into English and quickly reverting to Spanish again. Due to this semi-immersion experience I took upon myself, I was practicing Spanish for several hours a day with native speakers. By the end of the summer, I felt I had markedly improved my Spanish speaking skills.

Outlook on Food Security

As the summer progressed, I came to an important realization: food security isn't this one big problem that can be solved by walking through hypothetical scenarios; it is a complicated and nuanced issue with a lot of moving parts. Solving one tiny fraction of one part of the problem, as I started to with my study, can take years to fully understand and even more to implement. Seeing tangible steps toward food sustainability is a long process that has and will take decades to fully resolve, if full resolution is even possible.

While writing papers for the state and global youth institutes opened my eyes to this problem, it also made it seem like all the information needed to resolve these issues was already available and all we needed was some dedicated problem-solvers to put everything in place. Attending the state and global institutes made me motivated to solve these issues and convinced me that others believed the same. However, actually researching was a double-edged sword. On one hand, I knew that people were working towards the goals discussed in the paper and institutes; real change and progress was happening. On the other hand, this change was happening far slower than I could have ever expected, with steps miniscule to what I was expected.

The Borlaug-Ruan internship did remind me that food security is an issue that is active in the scientific and policy community, but it also brought attention to the fact that change is not as sweeping or gloried as I thought.

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