



International Center of Potatoes

La Molina, Lima, Peru

Borlaug-Ruan Internship 2011

Vera Zhao

Ames High School

Ames, IA

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Introduction

Helping out with third world countries and eliminating food insecurity has always been big interests of mine, dating back to the 4th grade. I remember going on the Heifer Foundation website and donating all I had in my piggy bank, which would be only a couple of dollars, in hopes that I was making a difference. When I was in 8th grade, I wrote a persuasive letter about donating money to non-profit organizations to help out the impoverished in Africa. When I entered high school, I joined my school's anti-poverty and anti-hunger club called SHEPH (Students Helping to Eliminate Poverty and Hunger) and attended a hunger banquet, and listened to numerous speakers regarding the club's focus. During the summer before my junior year, I traveled to China, in order to teach English in the impoverished, rural areas of China for two weeks. I had many different experiences with the issue of poverty and food insecurity, but I was never able to take a scientific approach to helping with hunger. The summer before my senior year, I was finally able to fill that gap and travel to Peru on the Borlaug-Ruan internship.

When I was in 8th grade, I read an article in my local newspaper about a girl who traveled to Peru for an internship. I went online and searched the "Borlaug-Ruan" internship that she went on and immediately became interested in applying for the internship when I reached high school. Little did I know, I would have the chance to travel to the same location she did, on the same exact internship, just three short years later. In order to do that though, I had to attend the Global Youth Institute in 2010, which required a paper on food security. I wrote my paper on food security issues in China, which the summer before gave me a lot of material to work with. When I attended the Global Youth Institute, I was fascinated to meet hundreds of other students my age that had the exact same interests as me. I felt extremely privileged to hear world-renowned speakers such as David Beckmann and Jo Luck talk about their fight against poverty. The symposium fueled my desire to apply for the internship, which I worked hard on for two months. Before long, I was accepted into the Borlaug-Ruan internship program and placed in Lima, Peru.

I was thrilled to travel to Peru, mainly because I had the chance to talk to Avanthi Ajjarapu, the previous intern who traveled to Lima, and she got me excited for my future experience in Lima. However, I was a little apprehensive, because I was worried that my internship would require a lot of technical, scientific knowledge that my high school classes wouldn't have prepared me for.

Arrival in Lima, Peru

The day I left for Lima, I forgot any hesitation I had about the daunting task of doing research among learned professionals. Instead, I let my excitement consume me. My plane ride was not too lengthy, except that my flight was delayed for two hours in Atlanta, which meant that instead of arriving at one am in Lima, I arrived at three am instead. My driver, who picked me up at the airport and was incredibly nice, maneuvered swiftly and smoothly through the tight streets of Lima. When I arrived, my host family got me quickly settled in and I fell into a deep sleep. The next day, I finally had the chance to do formal introductions and I met Ida, my primary host mother, her daughter Milena and her husband Erwin. There were at least thirteen people living in the house, and I met all of them. They included cousins, sisters, brothers-in-law and the mother of Ida, as well as two maids. I met my two other host sisters, the daughters of Jacqueline, one of Ida's sisters. Their names were Cristina and Sol, and the three of us, along with Milena, quickly got along very well. We spent the first day watching American movies and talking about their schools and family. I was surprised to learn that they knew so much about American pop culture and quickly felt ashamed that the children in America knew little to none about other countries' mainstream cultures.

Centro Internacional de la Papa

My first day of work was a whirlwind. I woke up at 6:30 am, because Ida, Milena and I were supposed to leave for work and school at 7:15. Ida works for a different organization than me but it is located right next door to CIP, so it was easy for her to drop me off at work every morning. The car ride to La Molina takes generally around thirty minutes, so it wasn't too long of a drive over. First, we had to drop off Milena at her Italian language school, which was on the way to La Molina. Finally, I arrived at CIP. I met with Edda Echeandia, who gave me a big tour of CIP and gave me more background information on the history of CIP. It was founded in 1971,

and its main objective since then has been to reduce poverty and attain food security and development of countries through scientific research related to the potato or other tuber crops. CIP has many locations besides the one in Lima – there are research centers in Huancayo, San Ramón, and many other countries. CIP has a wide variety of scientists, with people from Germany, China, Korea, Canada, and other countries in South America besides Peruvian researchers.



Pictures of CIP's courtyard.

My Research

After the tour, I was introduced to Dr. Jurgen Kroschel, who talked to me about the Division that I would be working in, Crop Management. He introduced two possible projects for me. Both projects involved data collecting that would eventually go into a bigger pool of formerly collected results.

Project 1

The first project I helped out with involved working with the potato tuber moth (PTM), called *Phthorimaea operculella*. It is usually 6 to 7 mm long and is one of the highest pests in potato crops. It has worldwide distribution, but is usually found in warm areas. It is native to South America and has spread to many areas of the world and is considered the most

economically significant potato pest in the Third World, specifically in potato storage. *P. operculella* has four stages of development: egg, larva, pupa and adult. According to Chur, under 24.7°C laboratory conditions, the life cycle can be completed in approximately fifty-five days. The adult female usually places the eggs in the buds, stems or leaves of potato plants. Occasionally, they place eggs in cracks in the soil near the stem base or they store directly on surfaces with depressions. Larvae feed at the birth leaf mesophyll or cortical tissues by drilling and digging into tubers, producing galleries. At the end of the larval stage, it leaves the tuber and finds particles of sand or earth to form a pupal chamber.

One of the biggest ways to reduce PTM is through use of the endoparasitoid called *Copidosoma koehleri*. The species originates from South America and is distributed in countries such as Brazil, Argentina, Chile, and Uruguay and in the coast and mountain ranges of Peru. *C. koehleri* has four developmental stages: egg, larva, pupa and then adult. The female *C. koehleri* deposits its egg inside the PTM eggs. When the host larvae is in its 2nd instar, which is the second 'stage' in its larvae form, the egg of *C. koehleri* starts dividing and developing. The host larvae dies when about 40 *C. koehleri* emerge from their egg and start feeding on the host's tissues, until they fully consume the host. Afterwards, they start pupating in one mummy, which is the name of their shared pupa, and when the mummy is done developing, the *C. koehleri* adults leave the mummy. Essentially, there are about 40 clones of the first *C. koehleri* that injected its eggs into the PTM larvae. Because of this, all of the clones are one gender.

Temperature is a very important factor in the dynamics of populations, influencing the geographic distribution of animals and in special 'animals' such as insects, it affects the growth and development of the population. To analyze the effects of temperature, my project called for life tables to be made and studied. To do so, 100 *P. operculella* eggs were exposed to *C. koehleri* adults for parasitism. When neonatal larvae emerged, we put them into individual 2x2x2 inch plastic boxes with a small potato. I left the boxes in an incubator of 35°C and I evaluated the development and mortality of the larvae daily. When I first put the larvae into the plastic boxes, they were incredibly miniscule, about as big as a period at the end of a sentence. Within a week, they had grown to be 1-2 cm long. I had to record whether the larvae were still alive or not, using a 'L' for alive, a '–' (dash) for when I couldn't see it, and a 'D' for dead. There were two ways to tell whether the larvae were still living or not; firstly, if I saw the larva moving outside the potato that would mean it was alive. Secondly, if I couldn't find the larva, it would most likely

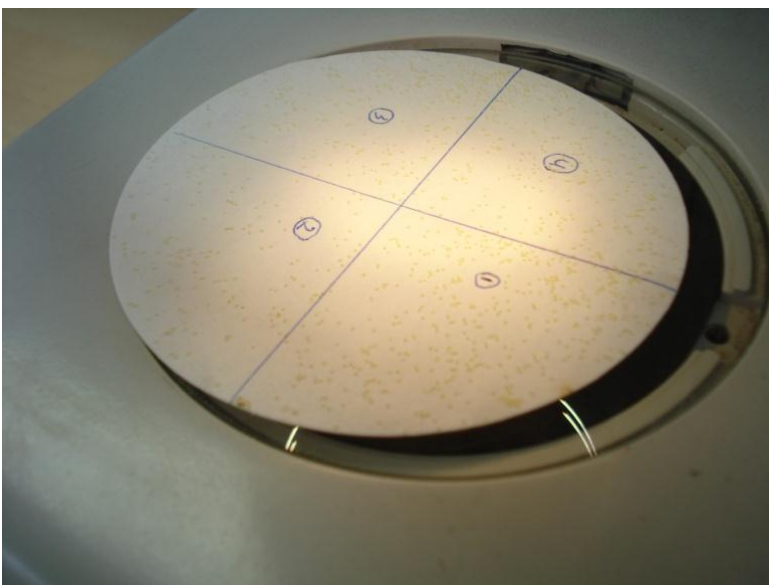
be inside the potato, so I'd have to search all around the surface of the potato to find excrement, because the larvae defecate when they drill into the potatoes.



C. koehleri adults.



C. koehleri parasitizing *P. operculella* eggs



P. operculella eggs (yes, the little yellow dots!)

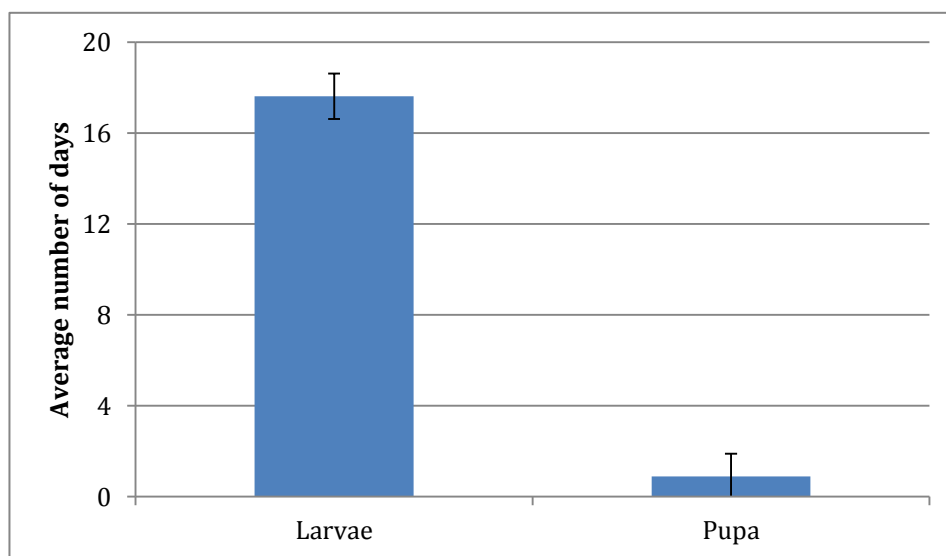


C. koehleri mummies and some emerging adult *C. koehleri*.

This continued on for about another two weeks, before some of the larvae started forming pupa. I could notice this, because they'd crawl into the little card board squares we had put into

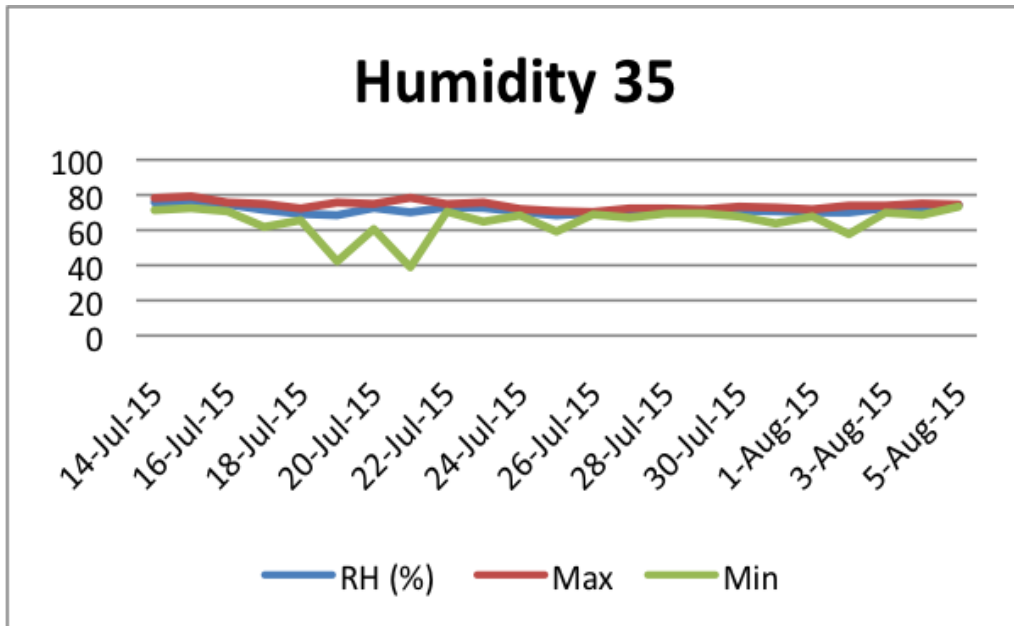
the 2x2x2 boxes and they'd form some kind of silky spider-web type substance outside the cardboard box.

Another week afterwards, I cut open the potatoes under a microscope and looked for any larvae in the potatoes, and I was supposed to record those down as well. I took the life table I had made with the potatoes and saw that *C. koehlerii* doesn't develop in 35°C, though PTM does. However, PTM larvae does not fully develop, only up to its pre-pupate form. They usually die while pupating, so I found a lot of dead half-larva/half-pupa insects. This is also because the PTM larvae leave the potato to pupate, and once they're outside of the potato, the temperature is too hot and they die (the potato's temperature inside is much less than 35°C).

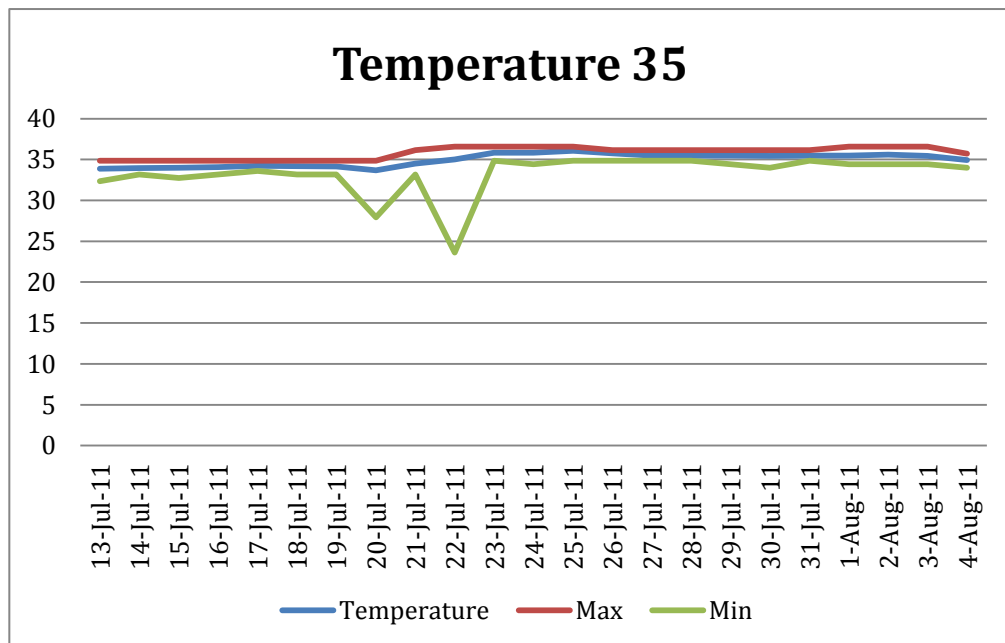


The average number of days that the surviving 55 *P. operculella* spent as a larvae and as a pupae

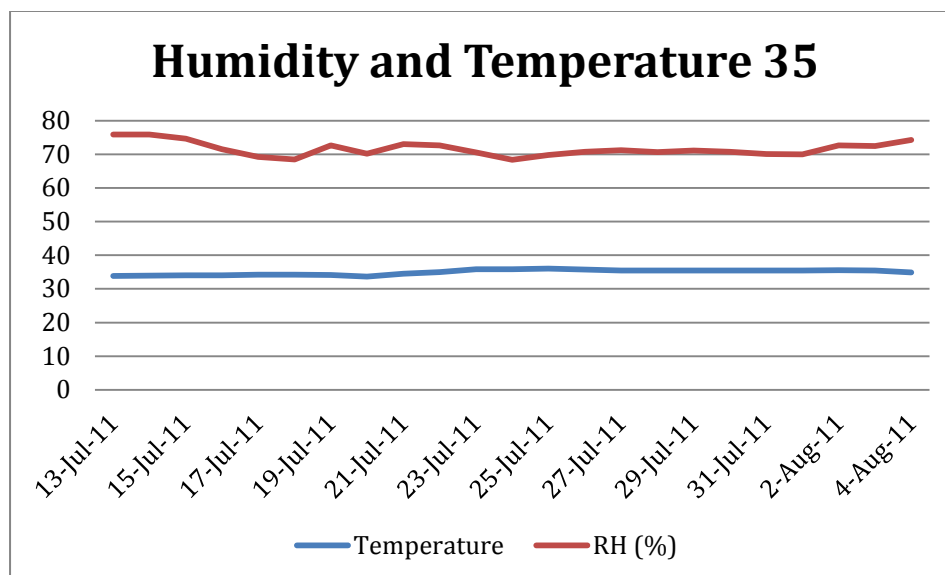
We tried to keep the temperature at 35°C and the humidity at about 70% for the entire duration of the experiment, but it was really difficult to make sure it didn't fluctuate, especially when people open and closed the door of the incubator. There were some really odd numbers that appeared too, for example, the humidity once dropped from 75% to 34% in the course of one hour and then back to 73% again in another hour. I am unsure what the reason for the immense fluctuations is, aside from somebody possibly removing the buckets of water we had in the incubators to produce humidity.



Humidity at 70% for each day; the blue representing the average humidity, the red representing the maximum humidity for that day and the green depicting the minimum humidity for that day.



Temperature at 35°C for each day; the blue representing the average temperature, the red representing the maximum temperature for that day and the green depicting the minimum temperature for that day.



The average humidity and temperature for each day.

The main significance of this project is that the results helped broaden the data pool for software that CIP uses called ILCYM. This was developed in CIP to predict if and how PTM can develop in certain environmental conditions. CIP is doing the same with parasites now, to predict if parasites can survive in certain environmental conditions too. CIP is trying to use biological control, which is the use of natural enemies to control a pest, by introducing native parasites into new areas. The problem is, because the environment differs, only sometimes do parasites establish. More often than that, they fail. The researchers at CIP have already done quite a bit of research on the matter and found that the optimal developing temperature for *C. koehlerii* is 20-25°C. They also found that PTM develop quicker in higher temperatures, as its metabolism is faster. However, they only conducted research on temperatures from 15-30°C, missing the extremes. Although they know temperatures at which *C. koehlerii* can develop, they also need to check the temperatures that they think the parasites won't develop, which include extremes such as 10°C and 35°C. As important as it is for CIP to know what conditions the parasites do survive in, it's just as important to know what temperatures they don't survive or develop in as well.

This contributes to improving food security because when scientists have to anticipate climate change, instead of wasting time and money doing trial and error tests, they can use software such as ILCYM to figure out if certain parasites can actually develop. Currently, CIP has used data from the software to distribute parasites in places like Nepal. They've released the

mass-reared parasites into the country with much potential to be established. These parasites have a significant impact on crop management, because they really do help reduce pests and increase yield in crops. They also improve the quality of the harvest. Having this data on the effects of temperature change on development helps CIP predict which environmental conditions are optimal for parasites, meaning they could introduce these parasites to many 3rd world countries all around the globe.

Project 2

I contributed to a second project that involved working with the same species of PTM, *P. operculella*. A common way to prevent this pest is by using commercial insecticides. However, the insecticides are not only costly, but dangerous to the farmers' health as well. The project I helped with hoped to test two methodologies of an effective bio-insecticide formula against PTM in storage based on *Btk* powder reformulation, called talcum-*Btk*.

I took the powder *Btk* and mixed it with a powder called talc and created a solution that Octavio, my mentor for this project, called talc-dry. I did the same thing again, but added one liter of water to it to make a wet solution. The reason I had to do this is because the wet solution is usually a more optimal combination than the dry solution, but it raises a problem because it needs more equipment and machinery to produce in high quantities. Octavio and I left the wet solution to dry for a couple of days, and once it was dried, it turned into a dry powder, much like the dry solution. We took these two separate solutions and diluted them down, creating 5 different mixtures for each solution. The mixture for the dry solution contained .015 g of *Bt*, the second mixture contained .00375 g of *Bt*, the third .0009375 g of *Bt*, etc. We coated 500 g of potatoes (100 g for each plastic bowl) for each mixture and for each solution to create fifty different trials. We also created two control trials, one with no powder on the potatoes at all, and the other with only talc on the potato. In addition, we created a trial with the commercial talcum-*Btk*, as a comparison to the two other solutions that we tested. Afterwards, we put 50 larvae into the plastic bowls that the potatoes were in.



Wet solution (before it dried) on the left, dry solution on the right. The brown powder is the *Btk*.



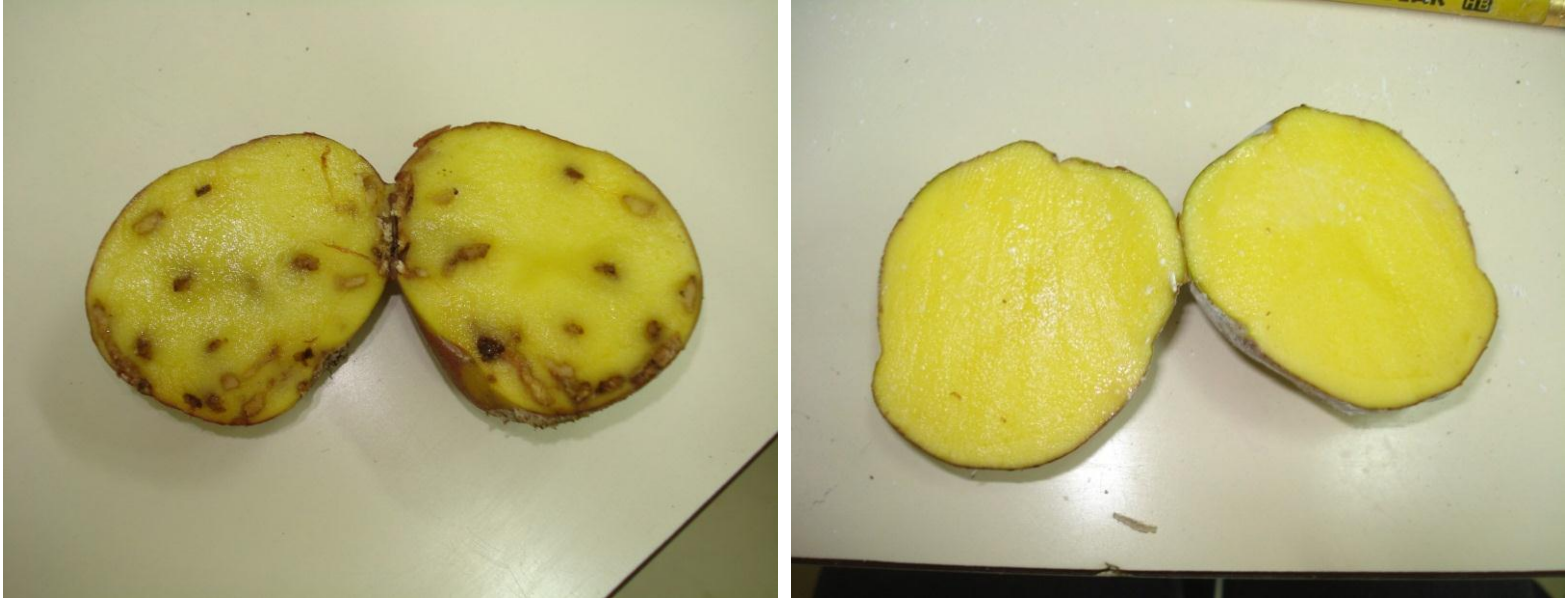
Our 50 different trials.



Me mixing the two different mixtures.

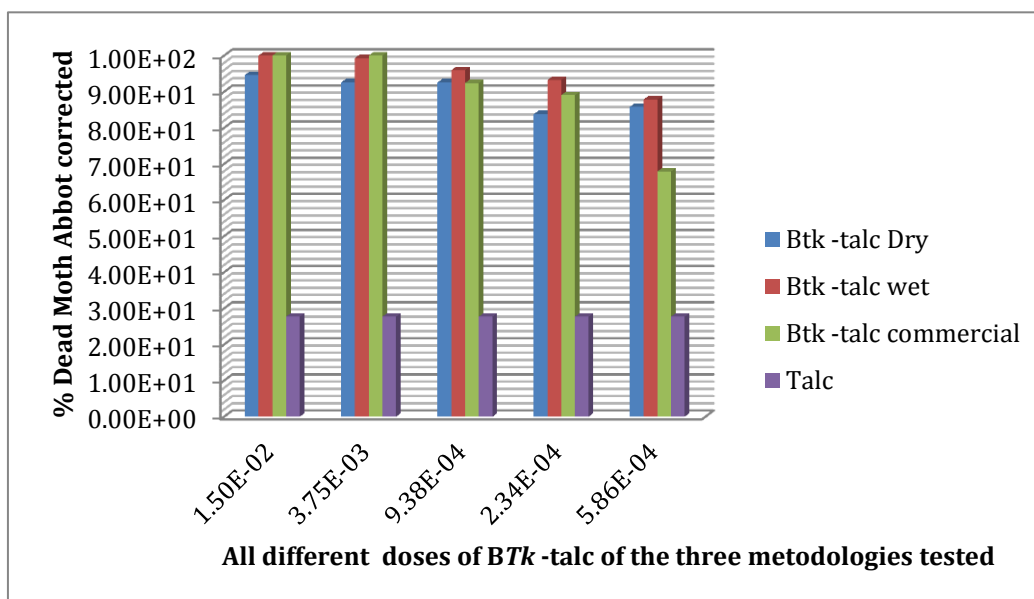
Octavio and I let the potatoes sit for 18-20 days, before going back to check up on the larvae. I had to count how many living ones were in each trial. It seemed to me that the number of living larvae or pupae was lowest in the first trials, where there was the highest concentration of *Btk*. The number of living larvae or pupae seemed to get higher and higher as the mixtures

became more diluted. The trial with no powder at all had the largest amount of living larvae and pupae, while the talc had less, which wasn't that surprising because the talc powder, although having no known effects on preventing pests, acted as a form of barrier for the potatoes.



Potato that had been damaged by PTM (left) and potato that wasn't damaged (right).

Afterwards, I entered my data into an excel spreadsheet and saw that the commercial insecticide seemed to do the best out of the three, but not by much. The wet solution seemed to do better than the dry solution, as hypothesized, while the dry solution seemed to be the least effective of the three, but still had a 95% mortality rate. Then, my results were run through ANOVA and we found that the coefficient variability among the different diluted mixtures was 4.17, which is very low. The value of variability should be in the range of 10-20 in order to show significant difference between all the mixtures. We were able to come to the conclusion that the amount of *Btk* in a mixture was could vary and you would still get the same result. We also found that there was no significant difference in efficiency among the three different mixtures we tested: dry, wet and commercial.



The four different solutions that we tested, and the percentage of mortality, using the Abbott formula.

These conclusions are very important, because when applied, a lot of resources can be saved. For example, since the amount of *Btk* in a mixture is negligible, this could save a lot of money and a lot of *Btk* powder. It could also lead to more *Btk* mixtures, as there would be more bacteria to be used. Also, since there was no significant difference between the three mixtures, then a lot of money could be saved in that case as well. As stated above, the wet mixture uses a lot of expensive machinery in order to produce in bulk. Since the dry mixture works just as well as the wet one, there would be no use for the wet mixture after all. The dry mixture has essentially the same results as the commercial mixture too, which means that the dry mixture can be a lot safer, as it doesn't use any chemicals.

This solution, developed by CIP, will potentially go to a company to market it. The company, SERFI SA, has already expressed heavy interest in the product. This project that I have contributed to will evidently help food security a lot, as it provides a healthy, cheap way for farmers to control pests. This will increase yield in crops and better quality in the harvest for a low cost. It has no chemicals, which means it will not harm the farmers that use it or us, who consume the produce that are being sprayed with insecticide. If a company does go around producing this dry solution, it could be mass distributed around the globe, definitely advancing crop management techniques.

Other Contributions

I spent the first two weeks of my time in CIP doing a rotation, so I got to work with a lot of different people in Division 4, doing different tasks. For example, I worked on rearing flies, using a small vacuum. I also planted some haba plants and frejol plants in order to collect pupa of leaf-miner flies, which are also common pests of potato tubers. These flies would deposit their eggs onto these plants. After this, I would take some of the plants that were already grown and I cut them so that they fit in a bin. Then, sand was put into the bin, so that the leaf-miner fly larvae would come out and develop into pupa on the sand. I would have to carefully brush off any pupa stuck on the leaves of the haba plants. The pupa and sand were then sifted so that all that remained were pupa.



The small vacuum used for rearing flies.



The beans of haba plants. They are parasitized, which explains the vibrant color.

Places Around Peru

El Centro de Lima

One of my favorite places in Lima is the Plaza Square of Lima. It has beautiful architecture, reminiscent of that in Europe. The buildings are all brightly colored and there is a beautiful cathedral located in the middle of it all. When I went there with my host family, we took a bus tour, called “Mirabus” that showed us all around the plaza.



El Catedral de Lima



Palacio Municipal de Lima, otherwise known as Lima's city hall.

Lunahuaná

The Bartolinis took me to Lunahuaná as well. It is the largest town of the Lunahuaná district and is located in western Peru. It is known for its outdoor activities such as canoeing and rafting. It is an extremely beautiful place with lots of mountains and rivers (and seafood!), and I found it to be one of my favorite places that I visited in Peru.



Ida, my host mother, and I

Conclusions/Reflections

My adventures in Lima have had a profound impact on me in many ways. On a scientific level, I found that even though contributing directly to developing countries is important, ie building houses or teaching at schools, the work done thousands of miles away is just as significant.

I saw how working in a scientific laboratory really requires the participation and cooperation of all members and how everyone grows to become a family. At CIP, during the end of every month, the Division would celebrate everyone's birthday during that month. It gave a sense of community, which was a very important sentiment that surrounded CIP.

On a global perspective, this experience gave me the opportunity to see a developing country, something that I have never had much firsthand experience with. When the Bartolinis took me out one time, I saw a bunch of small shacks on the side of the road. It was striking to see how a block over, there were mansions. Seeing this discrepancy made me realize that, although Peru is progressing quickly in many ways, it still needs help to further decrease the poverty inflicted on most of its citizens.

I had the wonderful opportunity to learn about a different culture, one that I've never interacted with before. I was there for the 100th anniversary of the excavation of Machu Picchu, and it was extremely inspiring to see how proud Peruvians are of their culture. They're still very attached to their Incan history, and do their utmost to respect and maintain the culture.

I also saw how people my age lived in a different country. My three host sisters, who were all around the same age as me, provided a learning experience. As I said, I found it fascinating that they knew so much about American culture, new and old, when children in America barely know anything about other countries, let alone their traditions or pop culture. It struck me as very unbalanced. Not only did they make me realize this, but it was interesting to see how their ideals and values were different from mine at times. Above all though, there were many similarities between them and me. On the most basic level, we're all still teenagers, and we all still like to go to the mall on weekends or hang out at friends' houses. We still find our parents unreasonable at times and we still argue with them. This holds true for families too – the dynamics are still the same, whether in Peru or in Iowa. They're all supportive and trusting of one another and love each other no matter what. Despite being separated by many countries, Peru and Iowa are still so similar, with all the same fundamental human responses and needs.

On a personal level, I saw how lucky I was to be from America. Seeing people in need, who could barely secure food for a day made me see how much I took for granted in America (as cliché as that sounds). Every day, the last thing I worry about is whether I have food. I always just assume I'll have a hot dinner waiting at home for me. To know that people around the world are starving every day is humbling. Even not being able to use hot water when washing my face in the morning was a struggle! It made me realize that I need to appreciate everything that I have in my life even more.

The best thing this experience has brought me though, is the people I have encountered. I met so many new people who were all very nice and hospitable to me. I learned about their families and their lives and I grew to see them all as very close friends, which made leaving very difficult. They were the ones who truly made my experience unique and special and I will always remember them.

Attending the World Food Prize Symposium also introduced me to many people who care about preventing poverty. I've met other teenagers around my age, who show it's never too early to start making a difference, and I've met very accomplished, impressive adults who show that preventing food scarcity is never a lost cause. This, combined with the amazing adventures I had in Lima, along with the enlightening research I did in a scientific laboratory, made for an unforgettable experience that only the Borlaug-Ruan internship could have brought me.

Works Cited

- Hyun Seo, Jeong, Joo Sang Yeo, and Hyung Joon Cha. "Baculoviral Polyhedrin–Bacillus Thuringiensis Toxin Fusion Protein: A Protein-Based Bio-Insecticide Expressed in Escherichia Coli." *Wiley Interscience* (2005): 166-72. Print.
- Kroschel, Jurgen, and Octavio Zegarra. "Attract-and-kill: A New Strategy for the Management of the Potato Tuber Moths *Phthorimaea Operculella* (Zeller) and *Symmetrischema Tangolias* (Gyen) in Potato: Laboratory Experiments towards Optimising Pheromone and Insecticide Concentration." *Wiley Interscience* (2010): 490-96. Print.
- Lagnaoui, A., V. Cañedo, and D.S. Douches. "Evaluation of Bt-cry1Ia1 (cryV) Transgenic Potatoes on Two Species of Potato Tuber Moth, *Phthorimaea Operculella* and *Symmetrischema Tangolias* (Lepidoptera: Gelechiidae) in Peru." *CIP Program Report* (2000): 117-21. Print.
- Moscardi, Flavio. "ASSESSMENT OF THE APPLICATION OF BACULOVIRUSES FOR CONTROL OF LEPIDOPTERA." *Annual Review* (1999): 257-89. Print.