# A Peruvian Adventure: My Summer at CIP

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## I. Acknowledgements

First, I am deeply grateful to Dr. Norman Borlaug and Mr. John Ruan for providing me with the opportunity to travel to Lima, Peru and work for two months as a Borlaug-Ruan International Intern. Their vision and dedication have opened my eyes and the eyes of many other students to the world of food security problems. Through my internship in Peru, I have gained new perspective on food security problems as well as increased determination to solve them. I also extend my heartfelt gratitude to Lisa Fleming, whose constant support and care throughout the summer helped me adjust to and thrive in a new environment. I would also like to sincerely thank Ambassador Quinn and everyone at the World Food Prize Foundation.

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Finally, I would like to thank my family for their support and love. Thank you for always encouraging me to pursue my interests, even when it means traveling a continent and two time zones away from home.

## II. Introduction

In October 2008, I had the opportunity to attend the World Food Prize Youth Institute as the first student participant from California. Participating in the Youth Institute was an incredible experience, as I had a chance to interact with other students and talk to them about my opinions and to hear their opinions as well. This exchange of ideas greatly increased my perspective on food security. The last day of the Youth Institute, I listened to the presentations from the 2008 Borlaug-Ruan interns and was amazed by the range and depth of their research. I wanted to research food security problems and to gain a different perspective on the issue. After completing the application process, I was thrilled to learn that I had been selected as the 2009 Borlaug-Ruan Intern to the International Potato Center (CIP) in Lima, Peru. Thus began one of the most exciting adventures of my life.

## III. Lima

The rest of junior year passed by quickly, and by June 13th, I was on a plane to Lima. My first thoughts upon arriving in Lima were a confusing mix of excitement and nervousness. After successfully navigating my way through the airport, collecting my luggage, and making it through customs, I spotted the driver waving a CIP sign with my name. During the ride from the airport to the Bartolini's home, I practiced some Spanish with the taxi driver. I did not arrive at the Bartolini house until around 1:00 AM, and when nobody responded to my first few knocks I felt slightly concerned. After a few knocks and several shouts of "Señorita Allison está aquí" from the driver, Percy, Ida Bartolini's brother-in-law, answered the door. After entering the house, I was warmly greeted by Ida Bartolini, my host mother for my two months in Peru. Ida introduced herself, kissing me on the cheek, a Peruvian custom I would become familiar with by the end of my stay. At 2:00 AM, I finally went to bed, exhausted by a long day of traveling and excited for the days to come.

## IV. CIP

A day after my arrival in Lima, I started my first day of work at the International Potato Center (CIP). CIP is located in La Molina, a district of Lima. It was founded in

1971 to address issues of food security and poverty through research on potatoes, sweet potatoes, and other Andean tubers. CIP is a member of the Consultative Group on International Agricultural Research (CGIAR). Before arriving at CIP, I had communicated briefly with my advisers, and read the information and papers they sent me. However, I was still unsure of exactly what my project would be. As I learned during the orientation, I would be working with Drs. Graham Thiele and Guy Hareau in Division 1 of CIP, also known as Impact Enhancement. In total, CIP consists of 6 distinct divisions, each focusing on a specific aspect of tuber research. Impact Enhancement, as its name suggests, focuses on evaluating the economic impact a technology such as a new potato variety or pesticide has had on a potato growing community. My project was to analyze the economic effects of potatoes in China. While studying the economic effects of potatoes in China while working in Peru might seem illogical, it is actually a project based on many years of collaboration between CIP scientists in Peru and China. I began my project by conducting a literature review of scientific papers already published regarding potatoes and China. This literature review gave me the basis for my project, which consisted of two main parts. In the first part of my project, I analyzed the effects of abiotic factors on yield and overall production. In order to analyze the effects, I compiled data sets and created mathematical models of the data. I also used Geographic Information System (GIS) software to create maps overlaying the data sets. In the second part of my project, I analyzed the potential of potato processing to increase food security and income for poor rural farmers.

## V. Research Results

### *Potatoes*

Potatoes share a long history with China. Introduced in the 1600s to China by Dutch merchants, the potato has played a large role ever since (Qu and Xie 22-23). The potato was initially introduced to the Penghu Islands of Taiwan and was gradually adopted by farmers in the Taiwan Strait and then by farmers along the coast of China, finally spreading to Central and Western China. However, the full extent of the potato's potential in China has not yet been realized. China is already the largest potato producer in the world, by both area cultivated and total production, harvesting 4,436,700 hectares

and 56,196,000 tons of potatoes in 2007 (FAOSTAT). Yet China's average yield is slightly lower than the global average with 14.35 tons/ha compared to 16.74 tons/ha (Qu and Xie 383). Moreover, China's average is considerably lower than the average yield for developed countries. The average yield in the U.S. in 2007 was 44.58 tons/ha and the average yield for the United Kingdom was 40.19 tons/ha (FAOSTAT). China's current low yield means that there is great potential for expansion of potato production, even if the amount of land cultivated is not significantly increased. An increase in potato production can have many benefits. These benefits are especially relevant today, as factors such as climate change and population growth threaten China's food security. Additionally, the potato has great potential as not only a food security crop, but also as a poverty alleviation measure. It can increase both dietary and financial stability by acting as a food source and as an income source.

In this paper, I will address the economic aspects of potato production in China. I will analyze the effects of specific abiotic factors on potato yield. I will also cover the importance of other factors such as the varieties of potato and availability of clean seed. I will analyze how the current patterns of urbanization and the increasing preference for processed food will change the potato economy in the future. Finally, I will discuss how the potato can increase food security in China, and how it can be used as a path out of poverty for rural farmers.

***Background***

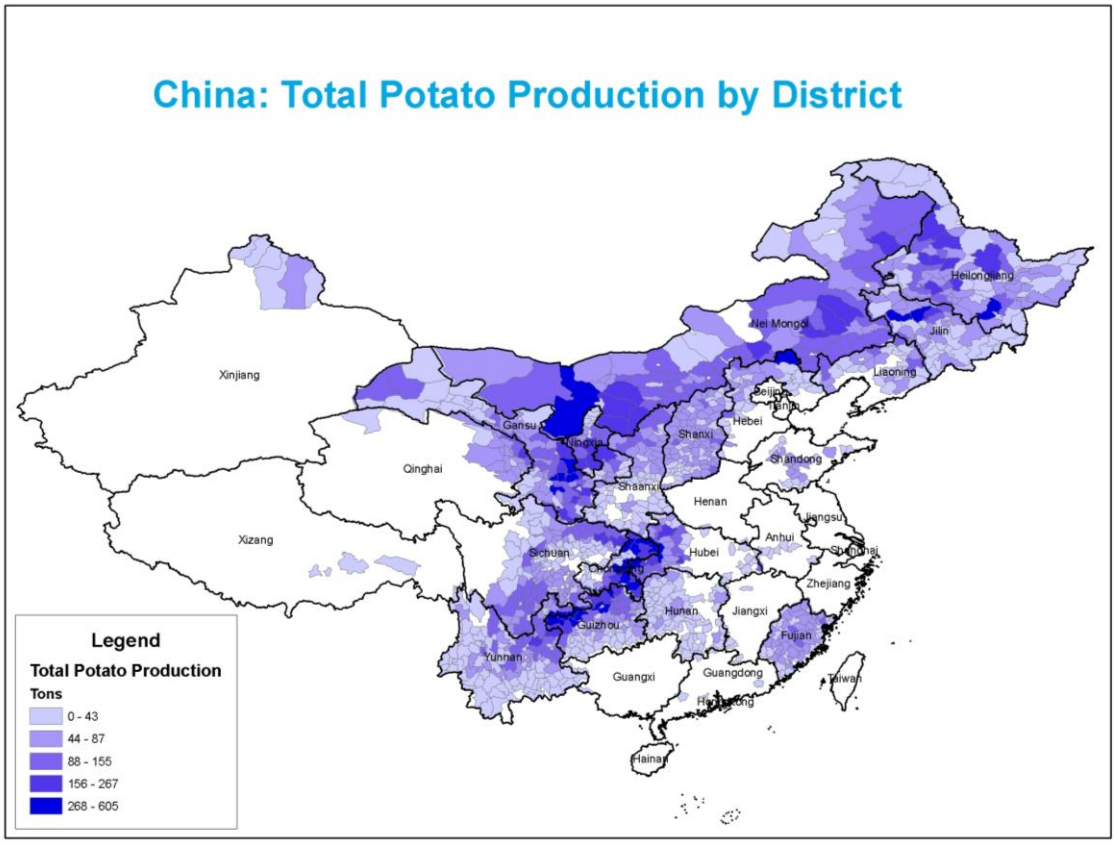
Currently, potato production in China can be divided into four main zones of cropping on the basis of geography and planting methods. Figure 1 shows the different levels of potato production by district in China. In order to create the maps in this paper, I worked with Diana Giraldo of CIP to overlay data regarding production at the district level with the boundary lines of each district, resulting in an image color-coded by how high potato production levels are.

***Investigation of the effects of climate and other factors on potato production in China***

As mentioned earlier, China's average potato yield is only 14.35 tons/ha, compared to the global average of 16.74 tons/ha and the United States average of 44.58

tons/ha. It is important to look at the causes of China's low potato yield in comparison to the rest of the world. If the causes are known, then targeted improvements, such as using

**Fig. 1:** Potato production by district in China




**Note:** This map was created by the author and Diana Giraldo using data from the CIP GIS database

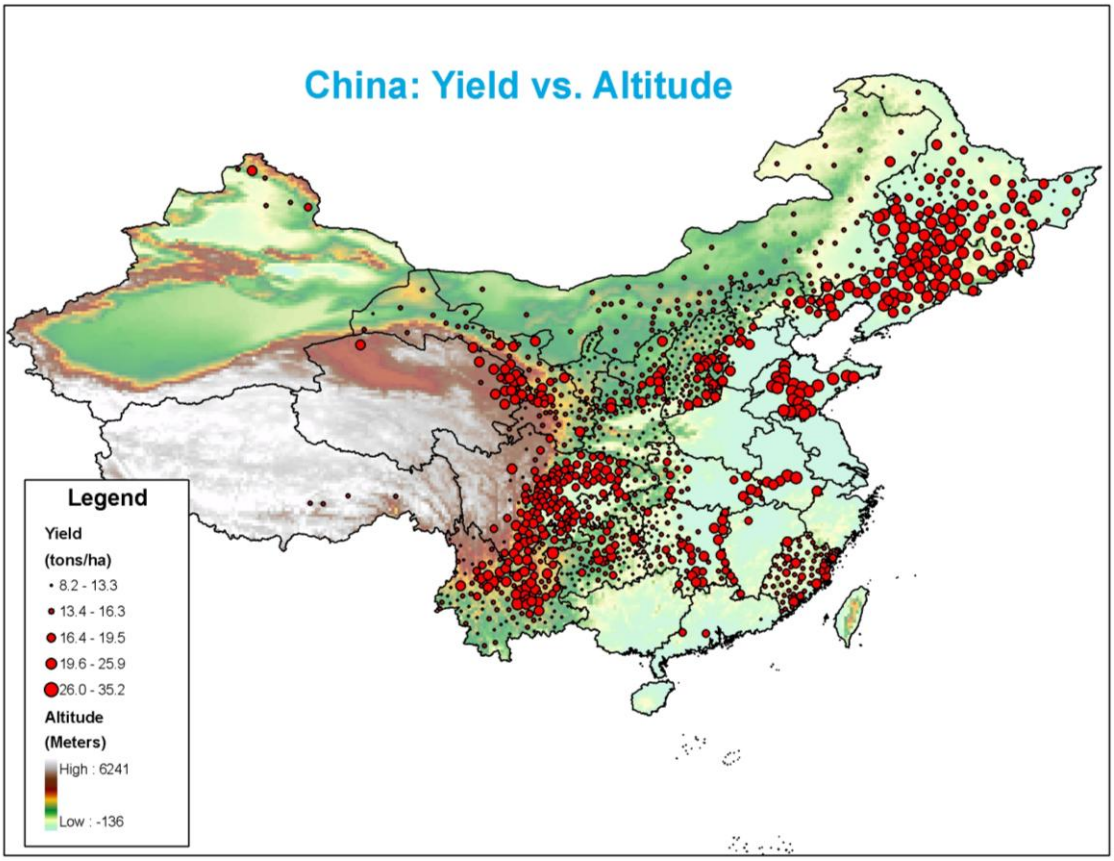
different varieties or building more irrigation systems, can be made. Improvements to potato production would have significant benefits, including increased food security and decreased poverty. Reaching the full potential of potato production in China can greatly improve the lives of many, and if the improvements are aimed correctly, the benefits can be targeted to help the poor. For this reason, it is critical to understand the factors that affect potato production.

*Climate*

One distinguishing characteristic of potato production in China is the enormous range of growing conditions in China. Altitude is one abiotic factor that varies widely throughout China's potato growing districts. Many potato varieties are well suited to high

altitudes because high altitudes inhibit the development of diseases such as late blight.

**Fig. 2:** Map of China: Yield vs. Altitude

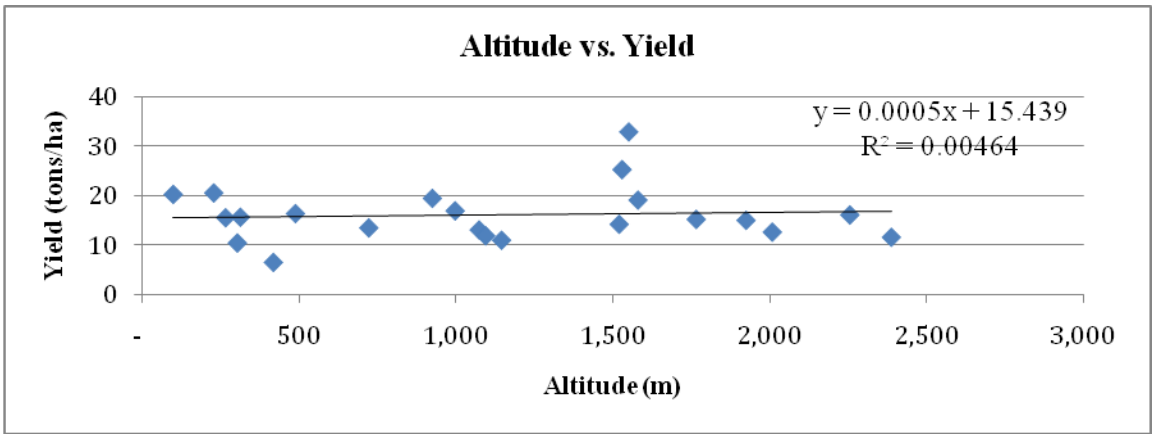



**Note:** This map was created by the author and Diana Giraldo using data from the CIP GIS database

Higher altitudes also tend to be characterized by cool summers, a condition suitable for potato growth. For this reason, I expected to see a high correlation between altitude and yield. To test my hypothesis, I performed a regression analysis (Fig 3). First, I processed the data from the Chinese Academy of Agricultural Sciences (CAAS) database as well as from the International Potato Center (CIP) Geographical Information System (GIS) database to obtain the averages for both altitude and yield by province. I obtained 22 data points, each representing either a province or autonomous region and its average altitude and yield. Hainan, Henan, Jiangsu, Jiangxi, and Tibet are not included because they are not potato growing regions. The regression revealed that there was no statistically significant correlation between altitude and potato yield at this level of aggregation. The regression equation: $y = 0.0004x + 15.439$ has an $R^2$ value of only 0.00464, suggesting

that there is no significant correlation. The $R^2$ value is the correlation coefficient between the two variables, in this case altitude and yield.

**Fig. 3:** Graph of altitude vs. yield

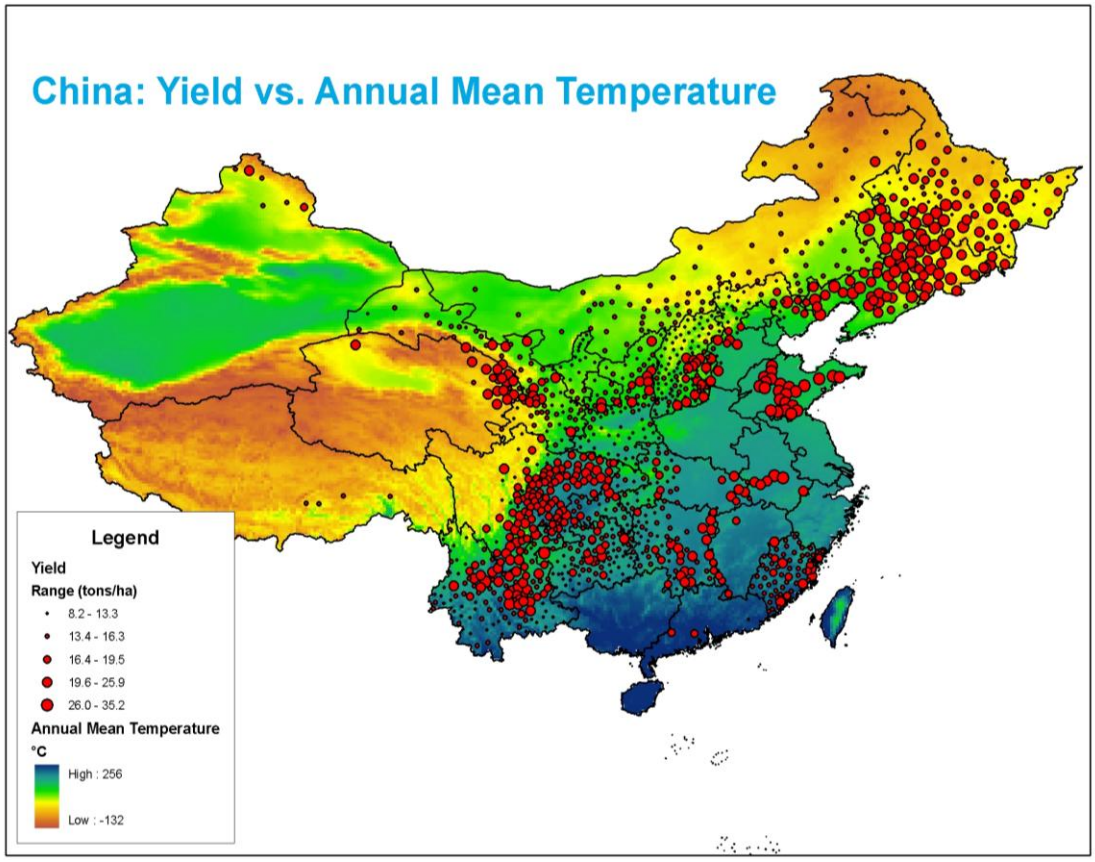



After performing an analysis of variance (ANOVA), I found that the significance F for the regression was 0.763. For a regression to be statistically significant, the value of F should be less than 0.05. According to the regression I performed, there is no correlation between altitude and yield in China. This contradicts my initial hypothesis that higher altitudes would have better conditions to grow potatoes and that higher altitudes would correspond to higher yields. However, the regression performed was limited in that the information used for both yield and altitude was a provincial average. The data points are average values for each province and thus may not be an accurate representation of the actual effects of altitude. Another caveat of my analysis is that each province may have used different potato varieties that are optimized for each location. Ideally, the analysis would compare the yield from a single variety, but such datasets are not available. Finally, the regression does not measure the other effects of altitude. It focuses only on the correlation between altitude and yield. Though altitude does not appear to have a large correlation with yield, it does have a significant effect on potato production. For example, potatoes grown at higher altitudes are more suitable for use as seed. Thus, altitude is an abiotic factor that has important effects on potato production as a whole, though it does not have a major influence on yields. Clearly, even if altitude does play a large role in potato yields, it is acting in conjunction with many other factors.

Another climatic factor that influences potato production is temperature. Temperature is an important factor in potato production because diseases and pests thrive

in certain conditions. Late blight for example requires a humid and hot environment. Also, in addition to influencing disease development, the temperature of a region also helps determine potato sprout and emergence rate (Pavek et al.). A thorough

**Fig. 4:** Map of China: Yield vs. Annual Mean Temperature



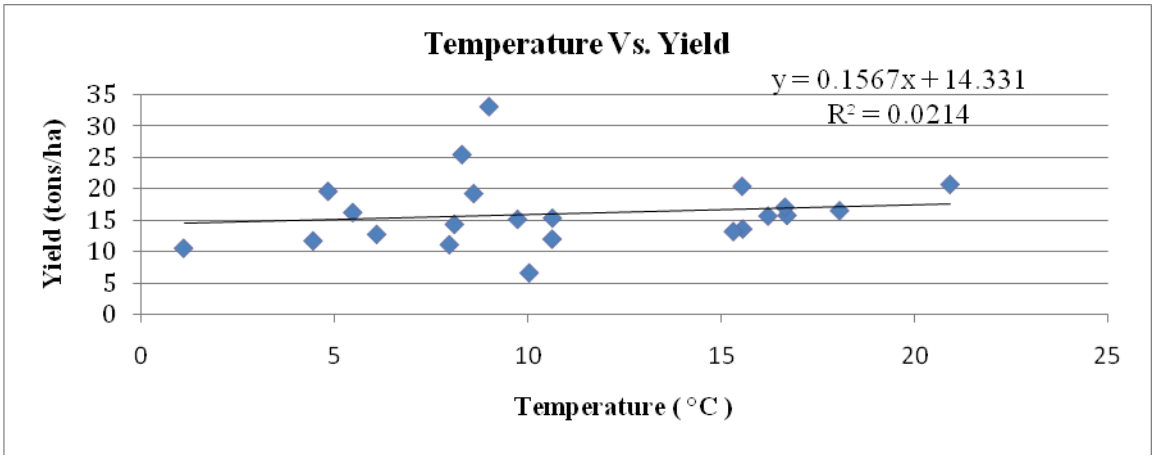

**Note:** This map was created by the author and Diana Giraldo using data from the CIP GIS database

understanding of the temperature of a region is necessary for both farmers and researchers in order to select the correct variety for a particular zone.

I performed a regression to see if there is a high correlation between annual mean temperature and potato yield. The equation that resulted, $y = 0.1567x + 14.331$ had an $R^2$ value of 0.0214, indicating a higher correlation between temperature and yield than altitude and yield. However, an ANOVA revealed that the significance F for this regression was 0.516, still much larger than the 0.05 value necessary to qualify a regression as statistically significant. Though temperature is known to have a significant

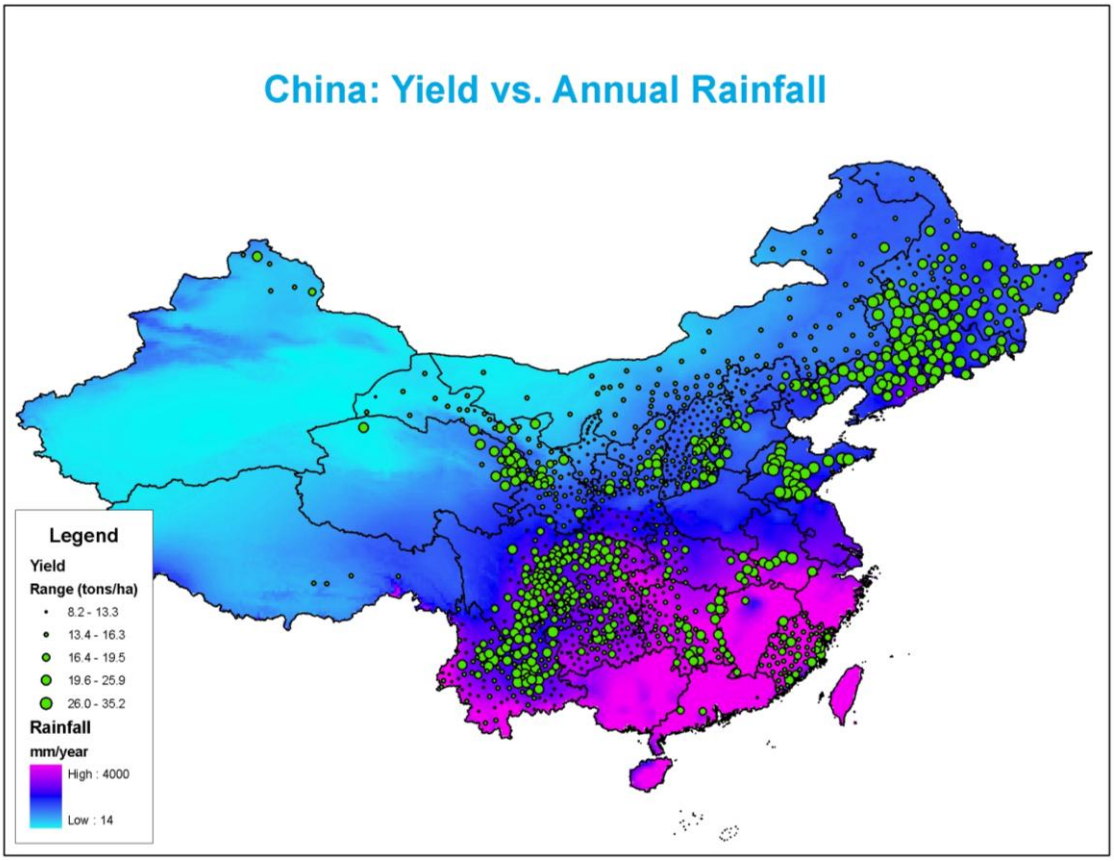
effect on potato production, the regression performed suggests that for the data set tested, temperature does not have a high correlation with yield. However, the same problems that applied to the regression performed on altitude and yield also apply to temperature and yield.

**Fig. 5:** Graph of temperature vs. yield



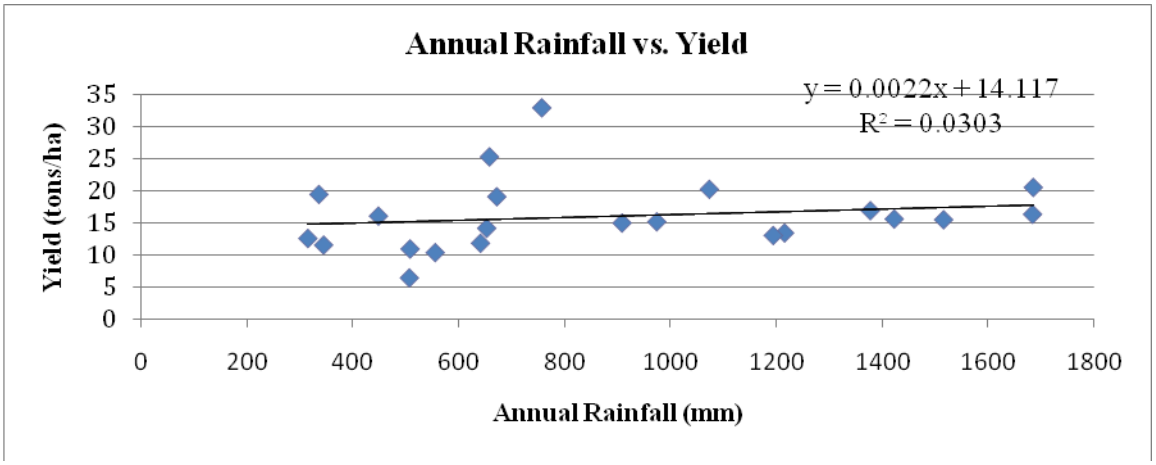

Rainfall is another significant factor in potato production. 60% of China's arable land is considered dry (Gomitzki). The potato's high drought resistance relative to other crops makes it a prime option for farmers. However, potatoes still require water to thrive, and must receive that water from either rainfall or irrigation. For potato production to occur, farmers must have some consistent water source. Conversely, water can also hinder potato production. Excessive or early rainfall can promote the development of tuber-destroying diseases, rendering the crops inedible (Chujoy). Indeed, both Figures 6 and 7 indicate that the highest yields can be found in the regions with medium levels of rainfall. I conducted a regression analysis, which produced the equation $y = 0.0022x + 14.117$. This equation has an $R^2$ value of 0.0303 and a significance F of 0.439. The results of the regressions I performed indicate that it is difficult to find a high correlation between yield and any one climatic factor. Yield is affected by a complex combination of all the factors. Moreover, climatic factors may not have a strong effect on yield, but can still affect other critical aspects of potato production such as disease levels.

**Fig. 6:** Map of China: Yield vs. Annual Rainfall




**Note:** This map was created by the author and Diana Giraldo using data from the CIP GIS database

**Fig. 7:** Graph of annual rainfall vs. yield



*Seed Systems and Irrigation*

Climate, though certainly a key factor in determining the amount and manner of potato production is by no means the only factor that plays a main role. Infrastructure is another important factor in determining if farmers are able to reach the full potato production potential. Currently, only 20% of China's potato production area is planted with healthy virus-free seed (Jansky et al. 61). The current system of unregulated seed trading has the potential to spread viruses and further decrease yield. There are no regulations in place to monitor quality. Anyone from research institutes to companies to individual farmers can produce and sell potato seed (Jansky et al. 61). Additionally, technologies such as virus elimination and detection have not been mastered by many seed producers. Even the technologies that are well developed, such as tissue culture for minituber production, often do not have the capacity to meet demand (Jansky et al. 61). In comparison, the United States has strict quality standards that must be met before certification. A quick transition from China's current seed situation to that of the United States is not feasible. However, China must at least begin to develop and implement an organized seed system.

Another important infrastructure issue is access to irrigation. One possible explanation for the lack of correlation between rainfall and yield is that irrigation can negate some of the effects of low rainfall. A 120 to 150 day potato requires 500 to 700 mm of water and lack of water results in lowered yields (IYP). With 60% of arable land considered dry, an irrigation system is critical to ensure higher yields.

*Additional Inputs*

Another potential explanation for the low correlation between the climatic factors and yield is that other inputs have a significant effect on yield. The use of fertilizer dramatically increases yields. According to the CIP Potato Atlas, most potato farmers in Zone I do use fertilizers. However, in China's other zones of production, farmers may not be aware of the benefits of fertilizers or they may not have access to fertilizers. Pesticides are another important input. Though potatoes are the most pesticide-intensive crop, most farmers in the Northern Cropping region (Zone 1) do not use any pesticides on their potato crops (Theisen). The lack of pesticide use is a major factor in China's low yields because pest infestations can greatly lower yields.

*Varieties*

The variety of potato used also has significant effects on yield. It is important that farmers select the variety best adapted to the climate of the region. Different varieties have different strengths and weaknesses. For example, Jizhangshu 8, a popular variety grown in China has high yield and a good flavor, but late maturity (Thiele et al. 23). Different varieties vary in disease resistance, yield, flavor, and other factors.

CIP-24 is one variety that had a large effect on potato production. CIP-24 proved to be adaptable to the varying conditions in China, and was especially suited to China's dryland potato production systems with hot days and cool nights (Bofu et al. 35). When severe late blight struck the area from 1989 to 1990, CIP-24's popularity surged due to its high late blight resistance compared to Kexin 1, which had previously been the most popular variety in the area (Chujoy). CIP-24 is now produced in Gansu, Ningxia, Inner Mongolia, Hebei, Shanxi, and Yunnan provinces, which encompass a wide range of natural conditions (Bofu et. Al 35). A CIP case study calculated that the rate of return on investment was 65%, with annual net benefits exceeding $4.5 million (Bofu et al. 46). Also, less quantifiable benefits of CIP-24 included a significant increase in food security for the poor, especially in Northwest China due to CIP-24's stable-yield and adaptability to less fertile environments. As the example of CIP-24 demonstrates, the variety of potato selected can have dramatic effects on yield and production and ultimately, on the farmers growing it.

Cooperation 88 is another variety that has had a large impact on Chinese potato farming. Before the release of Cooperation 88, potato farms in Southwestern China were dominated by one potato variety, Mira ("Annual Report 2001"). Since farmers only planted one variety, they were entirely dependent on it. Mira, after years of planting, had significantly compromised disease resistance. Its susceptibility to late blight had lowered yields to 6 to 7.5 tons/ha from 18 to 22 tons/ha. When Cooperation 88 was introduced, its late blight resistance was one reason it quickly spread (Chujoy). Another reason was its extremely high yield of up to 60 tons/ha ("Annual Report 2001"). In 2001, 20% of all potato production land in Yunnan was devoted to Cooperation 88("Annual Report 2001"). By 2007, over 120,000 hectares were planted in China ("A Million Hectares"). Like CIP-24, Cooperation 88 is one variety that has greatly changed the statistics of

potato production over a large region, showcasing the importance of potato variety and also of genetic diversity on yield and production.

*Significance*

The above factors all have significant effects on potato yield and production. In order for China to have the same yields as developed countries and to reach the potato's full potential, farmers, researchers, and government officials must work together to develop a planting system that is best suited to each individual planting zone. Maximizing the yield is crucial for food security, especially for the poor living in rural China. In rural areas, potato accounts for a significant portion of nutrient intake ("Annual Report 2001"). Thus, any improvements to yield would benefit poor farmers, allowing them to have a more steady and plentiful food source, and perhaps even allowing for a surplus to sell for income. In short, understanding the factors that affect yield is an essential step toward improved yields, which in turn is an essential step toward improving the quality of life for rural Chinese potato farmers.

***Effects of Social and Economic Changes on Potato Production***

In previous paragraphs I discussed the effects of environmental and varietal factors on potato production. Social and economic changes in a society also have dramatic effects on potato production. In the next section, I focus my discussion on the effects of urbanization and policy-making on potato production.

*Urbanization and Changing Consumption Patterns*

The future of the potato in China will be heavily influenced by urbanization. Urbanization has already been accompanied by a dramatic shift away from traditional Chinese diets to more westernized diets characterized by fast food and other convenience foods. According to the Washington Post, an ACNielsen Corp. survey found that 41% of the adults in China eat fast food at least once a week. As Chinese children reach adulthood, they will bring with them their fast food habits, which are far more entrenched than those of their parents. Fast food consumption will increase even more as a result. Fast food chains account for 75 % of frozen French fry (FFF) consumption in China. Inevitably, expansion in fast food chains will have a notable impact on the potato processing industry.

The current breakdown of the usage of potatoes grown in China does not match the image of China as a large consumer of processed potatoes. Most of the potatoes grown in China are not for processing. 60% of potatoes are used for table consumption and animal feed. On the other hand, only 22% of potatoes are processed into starch, chips, or FFF. The remainder is either used for seed or lost due to the lack of good storage technology (Sanchez et al. 6). It is mostly imported processed potato products that supply China's fast food restaurants. As of MY06-07, the United States supplied 70% of China's frozen potato market ("In China"). However, the balance between imports and domestic production is fluid because China is projected to rapidly increase production of processed goods. China is expected to produce 70,000 metric tons (MT) of FFF in MY08/09, an increase of 8% from the previous year (Sanchez et al. 4).

An increase in demand for potatoes to process, a gap that needs to be filled in domestic production, potentially large revenues from sales to urban consumers: all the factors add up to an important economic opportunity for small farmers. The current increase in potato processing will have many lasting consequences for small farmers. One effect will likely be an increase in contract farming, an agreement between a large processor and individual farmers. Contract farming has the potential to mutually benefit small farmers and the processors, by providing market access to farmers and a dependable supply of a crop to the processor (Guo et al.). Another benefit of contract farming is that it can facilitate the spread of technology by connecting small farmers with tools they would otherwise not have been able to access (Miyata et al. 1). However, contract farming is not without its drawbacks. One problem is that contract farming can pass more risk to the producers (Miyata et al. 1). Another is that sometimes, at least initially, contractors favor large farmers.

Who the contractors decide to work with and who benefits largely depends on the policy choices that are made. The government's role is critical to linking contractors with small farmers. A study carried out by IFPRI revealed that 70% of contracted farmers learned about the opportunity through their local government. If the benefits of contract farming in the past in various countries are also applicable to China, contract farming can greatly improve the quality of life of poorer farmers. According to one study, the increase in profits for peanut farmers in Senegal working with contractors amounted to 55% of the

revenue of a non-contract farmer (Miyata et al. 4). This increase in profits translates into greater food security and financial security.

Contract farming can also benefit farmers by increasing their knowledge and improving their techniques. Because large contracting firms have ties to businesses such as fast food chains and supermarkets, they have to meet certain quality standards. In order to ensure that their products meet these standards, many contracting firms provide the farmers with quality seed as well as education about pesticide usage. Education about pesticide usage is particularly important in China. This is one example that demonstrates the many links between the social and the chemical aspects of farming. Though pesticides are particularly important for potato farming, they are useless if the farmers are not aware of how to use them properly. If educated about pesticides, farmers can improve their yields and further improve their food security.

Though contract farming has potential for potato farming in China in the future, currently, many major snack food companies such as Frito-Lay still have not formed strong relationships with local suppliers due to quality issues. Many potatoes produced in China do not meet the strict quality regulations for size, color, and shape. However, if the success of contract farming in Senegal can be duplicated in China, it will be worth investing in for the Chinese government. If the central policy-makers support contract farming by, for instance, helping the processors pay for input costs for rural farmers, they could help direct the benefits of contract farming at small farmers. With the right policies, urbanized China's demand for processed potato products can be used to benefit small farmers.

*Policy*

China's government policies will play a significant role in the future of potato production. One key policy developed by China's National Development and Reform Commission (NDRC) requires that China maintain 95% self-sufficiency for grains ("NDRC Says 95%"). So far, the policy has been well implemented, with the goal reached in every year from 1998 to 2008 ("China 95% Self-sufficient"). However, the State Family Planning Commission in China predicts that the Chinese population will continue growing until it reaches 1.6 billion ("China Population Prediction"). To support

this new population, while still reaching the 95% self-sufficiency goal, China needs a way to produce more food on the same amount of land, which is already under strain.

One way China can meet the 95% goal is to improve potato production through the improvement of infrastructure. In the above analysis of factors affecting potato production, I stated that a good seed system is necessary to achieve maximum yields. The effect of government policies is demonstrated by Yunnan's successful seed system. In Yunnan, the Provincial Department of Agriculture has invested in technologies such as tissue culture and virus-free seed production. It has also subsidized seed tubers of certain varieties and offered loans to farmers in order to encourage the use of clean seed ("Annual Report 2001"). As a result, new and improved varieties have spread quickly throughout Yunnan. However, the same is not the case in many other provinces, such as Sichuan where the provincial government does not invest much in seed systems. This difference in policy explains why Cooperation 88 spread more rapidly throughout Yunnan than other provinces, allowing farmers in Yunnan to benefit more from Cooperation 88's high yield and late blight resistance.

Another way for the Chinese government to support potato production is to offer agricultural subsidies. The history of agricultural subsidies in China is very brief. China's first agricultural subsidies were introduced in 2004 (Gale et al. 2). Subsidies for high quality grain and soybean crops were introduced and agricultural taxes were removed (Heilig et al. 13). Subsidies for potato production could include either direct payments for producing potatoes or subsidizing the cost of quality potato seed. Investing in potato production by means of subsidies offers many significant returns. The Chinese government is particularly interested in using the potato in arid areas where other crops such as wheat and maize have significantly decreased yields. As China's population increases and arable land decreases, investment in potato production is increasingly important. China has only 10% of the world's arable land on which to support 21% of the world's population (*Agricultural Policy Reform*). In order to feed the population, China needs a minimum of 120 million hectares of arable land (Qian). Also, China needs to increase its food production by 20% in twenty to thirty years. Such an increase will only be possible with a crop able to withstand drought. Government investment in potato production is urgent and important for maintaining and increasing China's food security.

***Importance***

*Food security*

The potato will play an important role in increasing China's food security. As discussed earlier, the Chinese population is still growing and will continue to do so for years. China hopes to increase potato production from the current 70 million tons to 120 million tons (Mackey). According to Dr. Pamela Anderson, the Director General of CIP, China will need 100 million tons of new food annually. The government hopes that half of the 100 million tons will come from potatoes (Mackey).

*Poverty*

The potato also has great potential to help poor rural Chinese farmers. The potato's resilience and ability to tolerate the harsh conditions of many poverty counties better than other crops make it an ideal candidate for improving the lives of the poor. Poverty counties in China tend to be characterized by steep slopes, high altitudes, and low temperatures, characteristics that potatoes not only tolerate, but also thrive in (IYP). 30% of poverty counties have slopes greater than 30 degrees whereas only 15% of non-poverty counties do. The average altitude of the poverty counties is 1633 meters compared to an average of 566 meters in non-poverty counties. Additionally, the average temperature of the coldest month for poverty counties is -10 degrees Celsius compared to -7 degrees Celsius (Heilig et al. 8). It is difficult to produce large quantities of any other crop in these conditions.

In addition to being able to survive in harsher climates, the potato is also a good profit source. The current demand for processed potato goods has in some areas driven the price of potatoes higher than the prices for grain crops like wheat and rice. Of course, for the benefits to go to the poor, the government must play an active role in increasing market access for the poor by improving infrastructure and establishing policies to encourage large companies to work with small farmers. The government should also invest in potato research. The benefits of improvements to potato agriculture, such as the introduction of better varieties (disease resistant, high yield, etc…) will be directed toward the poor. Of the 592 counties designated "poverty counties" by the Chinese government, 492 are growing potatoes. Though these counties only make up 32.5% of the

total number of potato growing counties, they form 58.13% of total planting area (Qu and Xie 397). With so many poverty counties growing potatoes, an investment in potato production will also be an investment in poverty alleviation. By subsidizing potatoes rather than other crops such as wheat or soybeans, which are not as widely grown by the poor, the government can have a larger impact on poor farmers.

***Conclusions***

The importance of potato production is increasing in China. However, China's production levels are still hindered by its low yields. Many factors affect yield and overall potato production. However, as demonstrated by the regression analyses I conducted, each factor alone does not necessarily have a high correlation with yield. This reflects the complexity of potato farming in China; no one factor itself is responsible for a region's yield. In conjunction factors like altitude, temperature, rainfall, infrastructure, inputs, and seed variety have a significant effect on potatoes. Thus, in order to maximize yield, it is important to analyze all aspects of production, from the land on which the potatoes are grown to the types of potatoes grown. Apart from environmental factors, social factors such as urbanization will also influence potato production by shifting consumption patterns to more processed potato goods. This shift can increase income for small potato farmers if government policies encourage companies to work with the small producers. Other government policies that can help the poor and improve the efficiency of potato production include improving infrastructure such as seed systems. Through the development and implementation of good policies and techniques based on a thorough understanding of the factors affecting potato production, China can create a sustainable and beneficial potato production system.

## VI. Exploring CIP

In addition to my main research project in Division 1, I had the opportunity to visit other divisions within CIP to learn about and help out with their projects. This opportunity gave me a better perspective on how interdisciplinary CIP's work is. One of

**Photo 1**: Harvesting leafminer pupae

the divisions I spent time working with was Division 4, or Integrated Crop Management (ICM). One of my favorite memories of working in CIP is of working in the entomology lab. Entomology is the branch of zoology dealing with insects, and up until working in the entomology lab, I had always tried to avoid contact with insects as much as possible. After Dr. Norma Mujica briefed me on the main goals of the entomology lab, I was assigned a job harvesting leafminer fly pupae from potato leaves. Given my initial aversion toward insects of all kinds, the fact that this job was done sans gloves made it somewhat disagreeable to me. However, I quickly adjusted to the work, and by time I had collected all the pupae from several trays of leaves, I was enjoying the work. This experience is representative of my whole time at CIP and in Peru. Though I learned a lot about insect life cycles as well as procedures for experiments, much of what I learned was not knowledge in the traditional sense of the word. I learned how to overcome my fear of insects in just a short period of time. I also learned about Peruvian culture as I listened to the Cumbia music blasting throughout the laboratory.

Another wonderful experience was working in Division 2, which is devoted to genetic resource conservation. I learned about the multiple conservation methods used in order to ensure that at least one copy of the genetic material survives in the case of a disaster. I was amazed to see how painstakingly each individual specimen had been catalogued and stored in each of the different conservation areas.

Finally, my work in the Geographic Information System (GIS) division gave me new skills and knowledge, and at the same time reinforced my realization of how important interdisciplinary research is. Dr. Hareau, my adviser introduced me to Henry Juarez, the director of the GIS at CIP. After learning the basics of GIS, such as its uses, I worked with Diana Giraldo. Diana taught me how to use arcGIS, a software program that

allows users to create maps overlaying information from various data sets. I worked with Diana to create maps of China overlaying climatic data with yield data. These maps are much more informative than the original data sets themselves because they allow the viewer to compare two variables to see if there is a relationship. They also show what the variables correspond to geographically, so a viewer can see where the provinces are located in relation to each other. Though my project was based in Division 1 and focused on the economic aspect of potatoes, working with the GIS allowed me to present large data sets in a more informative and accessible manner.

**VII. My Travels**

During my two months working at CIP, I had the privilege of traveling with researchers to different locations in Peru. These trips allowed me to see the actual effects of research done at CIP because, as I realized, applying laboratory results to the field does not always produce the desired effect.

Peru can be divided into three distinct geographical regions: *la costa*, *la sierra*, and *la selva*, or in English, the coast, mountains, and jungle respectively. Each region differs dramatically in terms of not only which crops are planted, but also in the planting methods used. My first trip outside of Lima was to Cañete, which is located about two hours south of Lima and is part of *la costa*. I went with Dr. Norma Mujica and Marcelo, two researchers from the entomology lab to perform an experiment testing whether certain nematodes could be effective sweet potato pesticides. When we arrived at the field station, I was shocked to see the extent of the damage. Every sweet potato Dr. Mujica examined was completely rotten, blackened inside with white grubs tunneling through. The nematodes produce chemicals that, at least in the lab, prevent development of the grubs, eventually leading to grub death without harming the sweet potatoes or the humans who consume them. To test how well the nematodes worked in an actual field, I helped Dr. Mujica prepare the nematode solution and I then sprayed the solution onto the sweet potatoes. Traveling to Cañete was a wonderful experience through which I learned the importance of testing technologies developed in the lab to ensure that they function when applied to the fields.

**Photo 2**: In front of the potato fields in Andahuaylas

My second CIP trip was to Andahuaylas, which is situated high in the Andes Mountains at an elevation of over 3500 meters. This time, I traveled with Drs. Merideth Bonierbale and Walter Amorose of Division 3 to document a harvest of native potatoes and special varieties developed by Drs. Bonierbale and Amorose. It was incredible to see the tremendous variety of potatoes planted in the mountains. There were potatoes with red, purple, and blue rings and patterns in place of the more common cream or yellow colored flesh. A particularly memorable variety, *Pumamaqui*, actually has the shape and appearance of a puma's hand. Observing the large differences between farmers in the same country reminded me of one important challenge for CIP researchers: targeting technologies for specific locations, planting schedules, and agricultural techniques.

My final opportunity to explore Peru outside of Lima was not with CIP researchers but rather with the Bartolini family. Ida invited me to travel with her family to Chiclayo for the *Fiestas Patrias*. The twelve-hour drive was a perfect opportunity to get to know Peru's coastline, which I soon learned consisted mostly of desert and a few patches of extremely tropical areas where an occasional river passed by. By the time we finally arrived in Chiclayo, I had seen almost all of Peru's coastline north of Lima. After spending time with Ida's brother Oscar and his family in Chiclayo, we drove north for five more hours until we reached Punta Sal, a scenic beach located just two hours from the border with Ecuador. Punta Sal strongly reminded me of my home in San Diego, with nice weather and beautiful beaches.

## VIII. Culture

**Photo 3:** Petting a newborn calf in Chiclayo

One of the most important things I learned about during my internship was Peruvian and global culture. From my first night in Lima, the Bartolini family welcomed me into their home, making sure that I was adjusting well and taking care of me while I was a continent away from my own family in San Diego. Ida Bartolini, my host mother, was kind to me, patiently listening to my Spanish and helping me learn and improve it. She, her husband Erwin, and her daughter Milena introduced me to Peruvian life. Living with the Bartolinis definitely shaped my experience into a rewarding and fun time. I greatly enjoyed my lengthy conversations with Maria Luisa, Ida's sister, over coffee or tea. Some of my fondest memories are of our late-night discussions about anything from classic Spanish literature to movies. We also talked about noticeable cultural differences between the United States and Peru. One major difference both Maria Luisa and I noticed was the prevalence of *machismo*, the idea that men should be the breadwinners and bosses while women stay at home. Maria Luisa often told me about her work for the UN World Food Programme and she mentioned how *machismo* dramatically affected life in rural areas where food was scarce. She explained to me how men were traditionally the first to be served, meaning that the impact of a bad harvest would mostly be felt by the women. These conversations with Maria Luisa gave me a better perspective on food security in Peru, and how specific cultural differences such as *machismo* can influence food security. Jacqueline, another of Ida's sisters, also lives in the house with her husband Percy and their three daughters Christina, Sol, and Maya. The Bartolinis

**Photo 4**: Spending time with Aaron and Maya

jokingly referred to Maya, an energetic and funny seven-year-old, as my little follower because she would spend so much time in my room talking, watching TV, or singing.

In turn, I shared my American and Chinese culture with everyone I met. One wonderful memory is playing games with Maya and her sisters and cousins and teaching them "Down by the banks," a game I learned in elementary school. Also, I taught Maya some Chinese vocabulary as she helped me practice my Spanish. By practicing my Spanish with Maya, Ida, Maria Luisa, and all the other kind members of the Bartolini family, I was able to communicate comfortably and confidently by the end of my internship. My two months in Peru speaking Spanish daily gave me the confidence and fluency that textbook Spanish could not. Coincidentally, the same CIP driver picked me up from the airport on my first night and dropped me off on my last night. One of my proudest moments was when the driver told me "¡Has aprendido castellano Allison! (You have learned Spanish!)"

## IX. Reflections

Working at CIP gave me more insight into the complexity and depth of research necessary to address global food security issues. Living in Lima, I witnessed firsthand the large disparities in income and belongings within a single city. The ramshackle "invasiónes" on the edges of the city stood in stark contrast to the modern and expensive buildings in Miraflores and San Isidro where I lived. Many students in poorer families, especially those living in the Andes or in rural areas, do not attend school regularly, while affluent families in Lima send their children to private schools. Farmers in the Andes do not have as much variety in their diets, eating meals consisting mainly of potatoes, while city-dwellers have access to a much wider variety of fruits, vegetables, and meat. Even

within the borders of Peru, there exists great hunger and need for increased food security. Working in Division 1, the economics and impact enhancement division, I learned about the great consequences a single decision or change can have. Introducing a new variety of potato to China, as I learned, had large effects on yield, overall production, and thus, food security. Also, I was surprised to see how urbanization has shaped food security in China. When I realized that the increased demand for processed potato products in large cities would necessitate massive increases in potato production, I proposed that linking small farmers to large contractors could increase their standard of living. My summer working at CIP as a Borlaug-Ruan Intern has opened my eyes to the complexity of many deeply entrenched hunger issues, but more importantly, it has also challenged me to develop my own ideas and solutions to address these problems. The people that I met, the places that I traveled, and the events that I experienced have defined my internship at CIP and have given me new insight into potato research and its applications to global food security.

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