Nathan Hansen

2004 Borlaug-Ruan International Internship

China Agricultural University

Beijing, China

Biography

I have a unique perspective on agriculture. I have lived all my life on the small family farm that my father has run for most of his life, and which my grandfather farmed when my dad was a boy. My father has spent the last ten years trying to make a living as a farmer and failing because as the dairy farms get larger in America, the price of milk goes down, lowering his income. He doesn't have the money to get bigger and hire more workers and considers it an insult to that he has to. The family farmer is being pushed and bought out of business in my area. Most of our friends and neighbors have closed down to make room for the two large farms that dominate our small town.

My hometown is Lewiston, Minnesota. Since most of you are from and know Iowa better, my hometown is located between Rochester and Winona, with Interstate 90 to the south and Minnesota Highway 14 to the north. My hometown has a population of 1,800 people, and agriculture industries provide many of the jobs in our town.

I graduated this spring from Lewiston-Altura High School, which has a student population of about 500 students in the grades 7-12. My high school has a big agriculture department and many students in FFA. I am not a member. Seeing how weary and tired my father was, I never planned on becoming a farmer.

In fact until I went on this internship, I had always planned on studying computer engineering and computer science in college. After attending the Youth Institute in October of 2003, living and working at China Agricultural University (CAU) for two months, and attending another conference at the China Academy of Agricultural Sciences (CAAS), I decided to switch my major to agricultural sciences. Because I love and enjoy science so much, working in a lab like the one at CAU is the dream job for me. Working with plants also seems more interesting than typing thousands of lines of characters that few people will ever read or understand as a programmer.

I attended the Youth Institute in 2004 as a senior in high school. The man that got me interested in world hunger and the people trying to stop it, was my science teacher, Michael Bechtel. He brought up world hunger several times in our classes and how chemists were doing amazing work to feed the world's poor. He was the man who brought the WFP to our small school and he took students to the Institute in the two years he taught in Lewiston.

I chose to apply for an internship for a myriad of reasons. One was to see the world and leave my isolated hometown, where public opinion of foreign countries is very low. Another was to get a clear picture of what the hungry really look like. We have all seen the charity commercials on television, but everything seen on television has to be viewed objectively.

I also wanted to see how other countries approach science and research. I wanted to see how the other scientific leaders of the world breed the new crop varieties and develop the technology to feed the poor and hungry, and also what they think of their American counterparts and America itself.

My Internship

I was truly lucky to be assigned on my Borlaug-Ruan international internship to Beijing, China. The location itself is unique, since Beijing is not like any of the other developing nations that other interns have gone to. Beijing is on the far right of the developing line and fast approaching being called a developed country.

In 1974, China was just coming out of the "Cultural Revolution." This period of development had gutted its universities and few people in China had received a higher education. Agricultural science and development had progressed very little from the found of the People's Republic of China.

Under the visionary leadership of Deng Xiaoping, and then former minister of agriculture, He Kang, China worked a miracle. In twenty years, China went from having too little food to eat, to a surplus of food. It took America and Europe over a hundred years to modernize their industrial-era agriculture.

Beijing and China have a split personality; they embody the concept of yin and yang. In downtown China there are enormous towers and shopping centers, with many development projects underway. In a city famous for the number of bikes that people ride, cars are beginning to take over the roads. Every type of car is driven; simple family cars and luxury sedans, even the opulent Hummer can be found in Beijing.

Along the street where I live are two supermarkets, four or five quality restaurants, a wireless phone store, two pharmacies, several quality salons, and even an air conditioner store. Compared to America, where many people still consider an air conditioner an expensive luxury, everyone who lives along my block owns one.

Food can tell you a lot about the living conditions of a people. As a population moves from poverty and subsistence farming to medium income and industrialization, their diet changes. Contrary to Mr. Atkins' beliefs, the main source of calories for working class people two hundred years ago was bread and/or potatoes. Meat was an extravagant luxury only for the rich. As America and England became industrialized nations, the diet changed over from breads and cereals, to rely heavily on meats and fats. That's when obesity became a problem.

China too is making that transition. In the supermarkets, over half of the floor space is devoted to meats and seafood. Every kind and cut of meat can be bought from the butcher, and large tanks hold several different kinds of fish and shellfish. In the restaurants, most of the dishes are meat dishes, and even the rice dishes contain a lot of meat. The conception of rice as the main focus of the meal has changed. Rice is now a side-dish and not eaten at every meal anymore.

If the Yin of China is the increase in middle and upper class people, the yang is the large number of people who still are poor. In China the poor are still mainly the rural people, whose income is one-third

that of a urban person's. In the cities there are poor people as well. I have been stopped on the streets several times by beggars, and was ashamed with myself as I walked away.
On one side of my street are the middle and upper-class businesses and residences. If you walk down the opposite side of my street for one block, you will run into a rundown area of Beijing. There are no apartments here. The people live in one-story and often one-room houses. The area is dirtier and no cars go down these streets. Most streets are too narrow to accommodate anything bigger than a bicycle. Sometimes even three wheelers are too wide.

The restaurants serve less meat; mainly noodles and rice dishes. Chickens live along the side of the street in cages, but they are not raised for meat. Eggs are an inexpensive and good source of protein for these people, so chickens are more valuable alive then dead. The people here are better off than the poor in Africa, or Southeast Asia, who go hunger much of the time and have no access to running water or sanitation. Compared to the wealthy in China though, the poor are a world apart.

The host center for my internship is China Agricultural University. CAU is one of the top ten Agricultural Universities in China, and is host to many national research centers. CAU is the home of the National Maize Improvement Center, and one of their new varieties, CAU 108, is widely planted around China. CAU 108 is also a good example of hybridization and consistently produces a high yield.

CAU owns many experiment stations and test fields all over China. Many of the students who I work with disappear for a week to go and work on their experiments out in the other provinces of China. I visited one of the experiment stations during my internship with my supervisor. There were experimental varieties of cotton, soybeans, and a new type of disease resistant peach. CAU doesn't just do theoretical work, they provide real crop varieties for the farmers of China.

CAU has two campuses in Beijing. The campus where I lived and worked was the West Campus in Haidan, which is very near the summer palace. I worked in the college of Agronomy and Biotechnology, which is right next door to the National Maize Improvement center. My college is headed Dai Jingrui, and my supervisor is a professor in the college and newly appointed assistant director to the new Center for Food Security and Safety, Dr. Li Zhaohu.

Dr. Li is a well respected teacher among the many undergraduate and graduate students at the college. While I was at the college, he mentored eight graduate students, two of which were working on their doctorate. He has attended college in America and did post doctorate work at North Dakota State University.

The laboratories at CAU are a lot like the laboratories I have seen back home and also very different. Most of the people working in the laboratories don't wear lab coats or goggles unless they are working with hazardous chemicals. Most of the students work in t-shirts and sandals. If I would have worn that to lab in my chemistry class, I would have been yelled at and wouldn't have been able to participate.

Everything is done by hand as well. When touring Monsanto, a lot of the work was done by machines. Machines sorted and weighed the seeds, and machines did most of the plating work in the large laboratories. Even in the bigger, national labs, things such as sorting seeds and preparing plates is done all by hand. Even harvesting seeds from the plants is done by hand.

The laboratories are also very similar. Like in the US, contamination is the enemy of the lab and there are several ways to keep things clean. Every laboratory has a good supply of double-distilled water, an oven to dry and kill any bacteria on the beakers washed with the distilled water, and several fume hoods for delicate work.

The labs even look like their Western counterparts. On my tour of college campuses last summer, I saw a couple of lab rooms. If you took the lab rooms from CAU and painted the cabinet doors a different color, they would be identical to the ones that I saw.

The laboratory that I did most of my work in the weed science lab, where most of the graduate students I have met work on their experiments and projects. There are two doctorate students, two master students, and a doctor working on his post-doctorate work in the lab.

I spent most of the first couple of weeks helping out all the students in the lab. I did basic tasks like sorting out seeds and washing up beakers after experiments. Some people would consider this work incredibly boring, and while the work was a little uninteresting, I learned a lot about the rules of the lab, and my future friends.

While the lab work is very serious to the graduate students, they also have a lot of fun when they aren't working. These people spend ten hours or so in the same room, so strong friendships have formed between them. We all shared in jokes, laughs, and the occasional harmless prank of stealing someone's lab keys and scaring them to death.

I learned many things about the students while working with them at the university. Most of them are the sons and daughters of farmers, usually those in the middle or upper ranges of farm income. Most of the farms the students were from had about fifteen acres of land. Most farmers have an average of one or two acres. They also plant more cash-crops than grains on their farms.

There is some gender disparity left in China, but it's hard to locate in the colleges. College is the great equalizer here; many girls are enrolled at CAU. However, the workplace doesn't hire many girls in scientific or specialized positions, especially in agriculture. For that many of the female graduate students work for their masters and doctorate in order to increase their chances of landing a job outside of college. That's why there is a larger proportion of girl students working in the labs. I know two graduate students that are male, compared to six girls who are female.

I worked the closest with a doctorate student named Mr. Wang. He was my interpreter, guide, mentor, and friend for the eight weeks I was in China. During the workweek I spent long hours in the lab helping him with his projects, and on the weekends Wang, his girlfriend Tina, and I would see the sights of Beijing and relax a little in order to prepare for the next workweek. Although he could be a little bit of a screwball at times, I'm still proud to know him and call him my friend.

Mr. Wang's had three major experiments that he was working on when I arrived. He had just finished the fieldwork of one experiment dealing with UV radiation and wheat when I arrived, and was analyzing the data from the experiment. The other two he had not started yet, and I was quickly educated and brought into them.

Mr. Wang treated me as an equal. He did not think of me as just a kid he would have to deal with over the summer, and he valued my questions and comments on his experiments. That made my internship all the more enjoyable, since I wasn't relegated to working on just menial tasks. I got to plan and organize the one experiment Wang gave me as my own, and although he watched over me, he gave me the responsibility of taking care of the entire experiment. That also means that I did have to do the menial things like watering the plants, and weeding them, but it was a price I gladly paid in order to see the results of my hard work.

I learned a lot of chemistry and biology while I was at CAU working with Mr. Wang. Our school used to due basic chemical analysis of plants and foods in AP Biology, and so I knew how to set up a test plate. Here it was taken a whole step further as we had to first freeze the sample in liquid nitrogen, then grind and mash the sample up. After that the fun part of the analysis began with Wang teaching me how to run a centrifuge, and mix the chemicals for an Enzyme Linked ImmunoSorbent Assay (ELISA). Hopefully after all these lessons, college biology and chemistry will be a little easier.

Mr. Wang's larger of the two experiments deals with ultraviolet radiation and the effects it has on weeds and herbicide. Ultraviolet radiation is very big concern for today's scientists. Due to ozone depletion, ultraviolet radiation levels on the earth have been steadily increasing. Even though the amount of ozone depleting chemicals have been greatly reduced, it will take a long time for the ozone layer to repair itself. Estimates show that ultraviolet radiation levels will not return to their pre-1970 levels until at least the year 2050.

Many experiments have been done on ultraviolet radiation's effect on crop plants, but very little has been done on weeds. It stems mostly from the fact that weeds are usually secondary on most peoples minds. But the way UV radiation effects weeds could have a major impact on how crops are grown around the world.

The soybean experiment is a major undertaking and investigates many interactions between weeds, crops, and herbicide. Wang has decided to address these three concerns he has about weeds and ultraviolet radiation: whether UV-B radiation can break down soil applied herbicide and whether weeds natural responses can promote defense against herbicides as well, the effects of ultraviolet radiation on crops natural defenses against weeds, and whether ultraviolet radiation effects the balance between weeds and crops in either's favor.

The first deals with herbicides directly. If ultraviolet radiation can break down soil applied herbicide, new and/or stronger varieties of herbicide have to be developed. If stronger herbicides need to be developed, greater damage to plants and the environment may occur, and new varieties of herbicide tolerant plants will need to be developed through conventional or biotechnological means.

Most plants, in response to heightened levels of ultraviolet radiation, grow thicker and waxier leaves, and develop other responses to protect themselves. Thicker and waxier leaves in weeds may also protect them from herbicide applied to the leave. If the herbicide cannot permeate the leaf, it cannot kill the weed, and weeds gain an advantage over crops in the fields again. This will again require additional research into new types of herbicide.

Some crops have natural defenses against the encroachment of weeds. If ultraviolet light damages the parts of the plant that provides these natural defenses or otherwise hampers them, the balance between crops and weeds tips again in the weeds favor, lowering yields.

There is a tenuous balance between crops and weeds in any field. Modern herbicides and weeding techniques have tipped the balance in the crops favor. If weeds prove to be hardier to ultraviolet radiation, that balance may change, and weeds may retake more of the surface area of the field. If that happens, more or stronger herbicide applications may be needed to control the weed problem.

Wang and I are not doomsayers who believe that weeds will overrun the fields due to an increase in radiation. Farmers have been contending with weeds since agriculture first began. UV radiation may just tip the scale a little or not at all. It's prudence that dictates me must investigate what the effects of UV radiation are on field ecology. That way, if a problem does evolve, we are better informed and armed to deal with it.

Wang's experiment has many stages. I helped Wang with the first stage. It involved growing the plants in greenhouse conditions under four intensities of UV light. Wang has grown soybeans as an initial trial, counting them as "weeds." After exposing the soybeans to UV light for four hours a day for one week, we applied a herbicide effective against soybeans to the leaves of the plant and placed them under the UV light again for three days. These exact conditions were then repeated with four varieties of weeds.

Wang has one other experiment. When he was in one of the northeastern provinces working on his ultraviolet radiation experiments, the farmers came to him with a problem they were having trouble coping with. In northern China, the weather is very cold and chaotic in the spring time. Temperatures can vary widely and spring frosts are common. With this kind of weather, corn is hard to grow in the region, yet many farmers grow it to try and make a living. It is too dry and cold for rice, and though wheat is more suited for the region, corn is more widely grown.

Wang promised to help the farmers and came back to CAU determined to find a way to increase corn's chilling tolerance. There are many papers on the subject. Wang read through them and learned that soaking banana and corn seedlings in salicylic acid protected the seedlings from the cold temperatures. Wang decided to test that chemical and several others to see if he could improve the germination rate of the corn seeds.

The Effects of Three Chemicals on the Chilling Tolerance of Maize: Salicylic Acid, Uniconazol (S-3307) and Abscisic Acid

Wang Shiwen, Nathan Hansen

Abstract

The Northern provinces of China are home to one of the major plains regions of China. As one of the few open areas for growing crops, maximizing productivity per hectare is very important. One of the major crops grown in Jiling province is maize, or corn. Germination of the corn seed is a problem however, due to the chaotic nature of the province's climate. Spring frosts are common, and the cold soil results in a lowered germination rate.

There are two goals of our experiment. The first goal is to find out whether SA pretreatment of corn seeds can increase the germination rate by ten percent over the control in cold temperature conditions. Our second goal is to test and find out whether any of the other chemicals can yield results similar or even higher than salicylic acid.

Corn seeds of the variety CAU 108 were soaked in nine solutions of several chemicals at different concentrations in order to find a way to increase maize's chilling tolerance. The three best chemicals were determined and run through again to find the best concentrations. The three chemicals were salicylic acid (SA), uniconazol (X2), and abscisic acid (ABA). The seeds were soaked for six hours, planted, then placed in a cultivator box set at ten degrees centigrade. The plants were grown in the cultivator for ten days, then they were placed outside to grow normally for four days. Finally, the roots were cleaned and weighed. The stem weight was also measured.

Our results show that abscisic acid at the concentration of 50 mg/L produced the best results. ABA 50 increased the germination rate by twenty-eight percent over the control, and produced plants with a healthier root and stem ratio.

Introduction

One of the biggest factors limiting crop production and yields are plants sensitivity to abiotic stresses such as drought, salinity, and cold temperatures. Most maize varieties grown in China are chilling sensitive. Maize' ideal growing temperature is twenty-five degrees centigrade. Temperatures lower than fifteen degrees damage already growing plants, and severely limit seed germination.

The ability of salicylic acid treatment of plant seedlings to increase the chilling tolerance of the plant is well documented. Banana seedlings treated with 0.5 mM of salicylic acid were able to withstand temperatures as low as five degrees centigrade (Kang 2003). Treatment of maize seedlings has also proven effective against cold stress.

Salicylic acid treatment has negative consequences as well. If treated plants are grown in normal temperature conditions, the excess salicylic acid has an opposite effect, damaging the plant, and lowering yields significantly. (Kang 2003) Because some years are warm and others cold, using salicylic acid to treat corn may be a gamble for the farmers.

Farmers do not have the ability to soak their seedlings in salicylic acid before planting in the field. The practice is simply too labor-intensive. Also genetically modified maize vareities resistant to abiotic stresses including drought, salinity, and low temperatures are still in development and five to ten years away from release. China also has a policy banning the growing of GMO crops that will be used for human consumption.

The first purpose of this experiment is to determine whether soaking corn seeds in salicylic acid before planting can provide the same benefits as soaking the seedlings. The second purpose of this experiment is to see if any of the other chemicals used can provide a higher germination rate over salicylic acid.

Several chemicals were used in the experiment. Abscisic acid is a phytohormone, which is responsible for regulating transpiration, stress responses, germination of seeds and embryogenesis. Most effects of ABA seem to be related to water availability - it apparently acts as a signal of reduced water availability. ABA conserves water by reducing water loss, slowing growth and mediating adaptive responses. However, ABA influences most aspects of plant growth and development to some extent - partly due to interactions with other phytohormones (Cutler 2004). I was unfortunately, unable to find any information about the other chemicals and Wang wasn't able to translate what he knew very well into English.

Materials and Methods

Phase I

Seed Preparation

The seeds were all of the variety CAU 108, which is a hybrid corn variety known for its high yield. It is grown mostly in the central and southern China; its optimum growing temperature is twenty-five degrees centigrade. The seeds were separated into four groups and soaked for six hours in 100mL of distilled water, 0.2 mg/L, 2 mg/L, and 20 mg/L concentrations of salicylic acid.

Planting

Twenty seeds per group were planted in 8 oz. drinking cups filled 3/4 full of dirt. Five seeds planted per cup, totaling four cups per group. They were covered to the top of the cup with more soil and watered with 25mL of water.

The sixteen cups were placed in a cultivator box with the temperature set at fifteen degrees. The seeds were watered when dry and grown for one week in the cultivator. Afterwards, they were grown outside under natural conditions for three days.

Harvesting

After growing for ten days, the corn plants were taken out of their cups and the roots were washed clean of dirt. The number of plants and plant height was recorded, then the plants were separated into roots and stems with a scissors. The root and stem fresh weight was then recorded, and the plants discarded.

Phase II

Seed Preparation and Planting

All seeds were of the same variety as previously. This time the chemicals were split into two groups. Salicylic acid and Giberellic acid was tested in the first group. The second group tested coronatine, uniconazol, fuluic acid, and abscisic acid. Salicylic acid concentrations were 0.2, 2, 20, 50, and 200 mg/L. Giberellic acid concentrations were 1, 10, 20, and 2000 mg/L. The other chemicals were tested with only two different concentrations. Abscisic acid was tested at 10 and 30 mg/L, and uniconazol was tested at concentrations of 50 and 100 mg/L. Coronatine was tested at concentrations of 100 mg/L

The seeds were planted in the same way as before with one change. Eight seeds were planted per cup instead of five. The seeds were placed in the incubator at 10 degrees centigrade and kept there for ten days. They were watered with 25mL of water when dry. After ten days in the cultivator, they were grown outside for three more days.

The number of corn plants with stems above soil were counted on the tenth day in the cultivator and every day afterwards. The corn plants were then removed from the cups, washed, weighed, and frozen for enzyme analysis.

Four one-gram samples each of roots and stems were frozen in liquid nitrogen, then ground using quartz sand, 4mL of 80% methanol, and a mortar and pestle. The samples were stored at four degrees centigrade for twenty-four hours, then centrifuged at 5,000 RPM for thirty minutes..

Phase III

Based on the results of the previous experiments, three chemicals were chosen for Phase III. They were salicylic acid, uniconazol, and abscisic acid. The seeds were pretreated with concentrations of 1, 10, and 20 mg/L of salicylic acid, 10, 30, 50 mg/L of abscisic acid, and 1, 50, and 100 mg/L of uniconazol.

Per cup, the number of seeds was reduced to five, and ten cups per chemical group were planted for a total of fifty seeds planted per group. The plantings were then placed in the cultivator set at ten degrees centigrade for seven days. After seven days, they were taken out and grown for four days more.

Results

Phase I

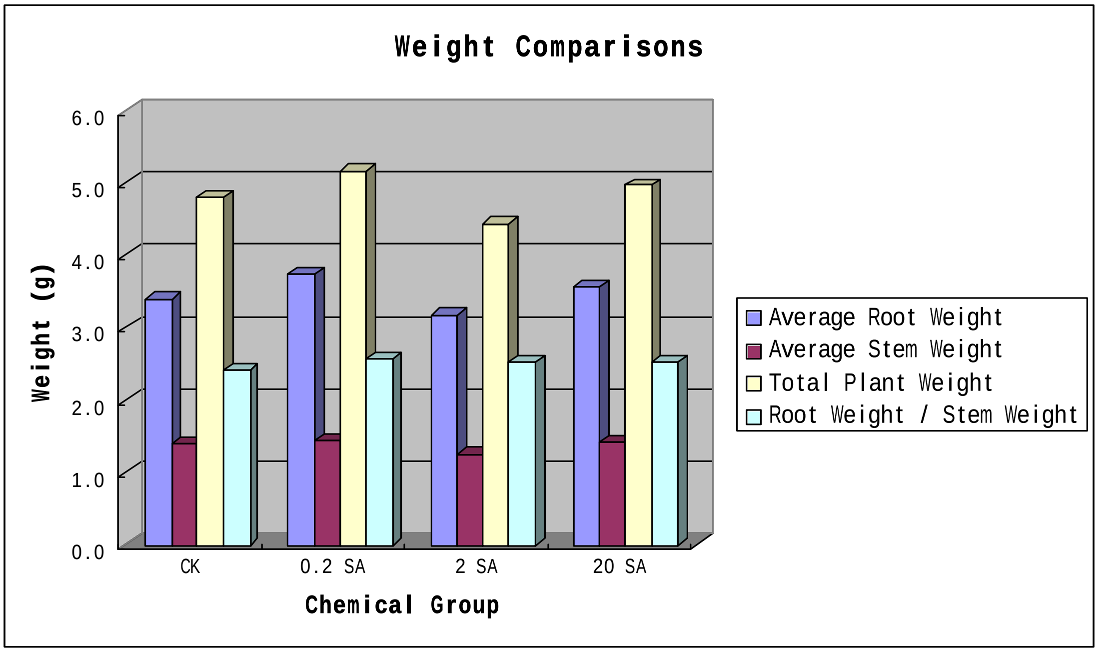
The results of the first phase of planting are shown in Table 1 and Fig. 1. As you can see, the fresh weights of the plants soaked in 0.2 and 20 mg/L salicylic acid are much higher than the control. This is most evident in the roots, where 0.2 SA and 20 SA weighed significantly more than the control. Also, the root to stem ration was also higher, signifying the better root development in the SA treated plants.

Visually, the roots of the SA plants looked healthier, which longer and thicker roots than the control. Visibly, as the amount of salicylic acid used to pre-treat the plants increased, the more apparent the development of the root became.

Also .2 SA and 20 SA had an average germination rate one-half to three-fourths higher than the control. These results show that Salicylic acid pretreatment of the seeds is also effective against cold stress in corn plants. However, the results of 2 SA are inconsistent with the other salicylic acid concentrations.

Table 1: Results of Batch 1

	CK	0.2 SA	2 SA	20 SA
Average Root Weight	3.3978	3.7283	3.1813	3.5578
Average Stem Weight	1.4038	1.4493	1.2605	1.4135
Total Plant Weight	4.8015	5.1775	4.4418	4.9713
Average Germination	3.5	4	3.5	4.25
Root Weight / Stem Weight	2.4200	2.5720	2.5240	2.5170



Phase II

The results of the duplication involving gibberelic acid and salicylic acid again show salicylic acid's ability to protect the plants from the cold temperatures. The results also show a more normal bell-shaped curve. The fresh weights start off low at 0.2 and peak at 20, going back to low levels at concentrations of 200. Even the low-yield results outperform the control except in the case of SA 0.2.

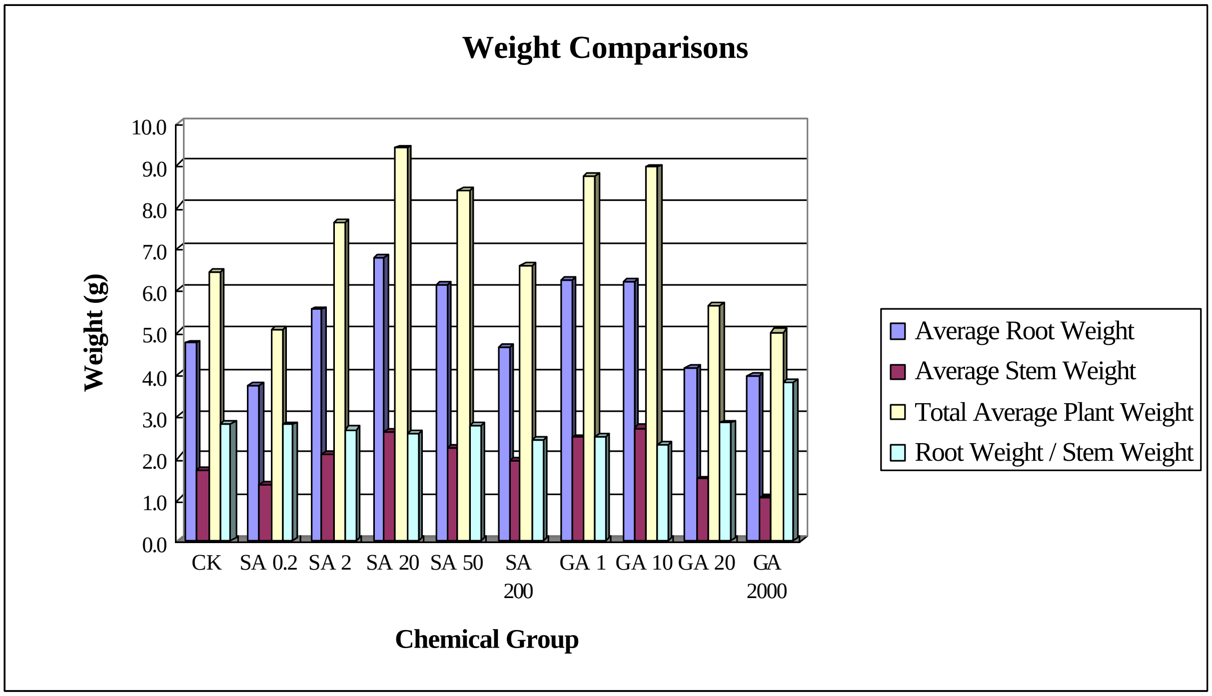
The seeds soaked in salicylic acid also had a higher germination rate than the control. SA 50 had thirty percent increase over the control, and SA 2 had a twenty percent increase. SA 0.2, 20, and SA 200, however had either the same rate or a lower rate than the control however.

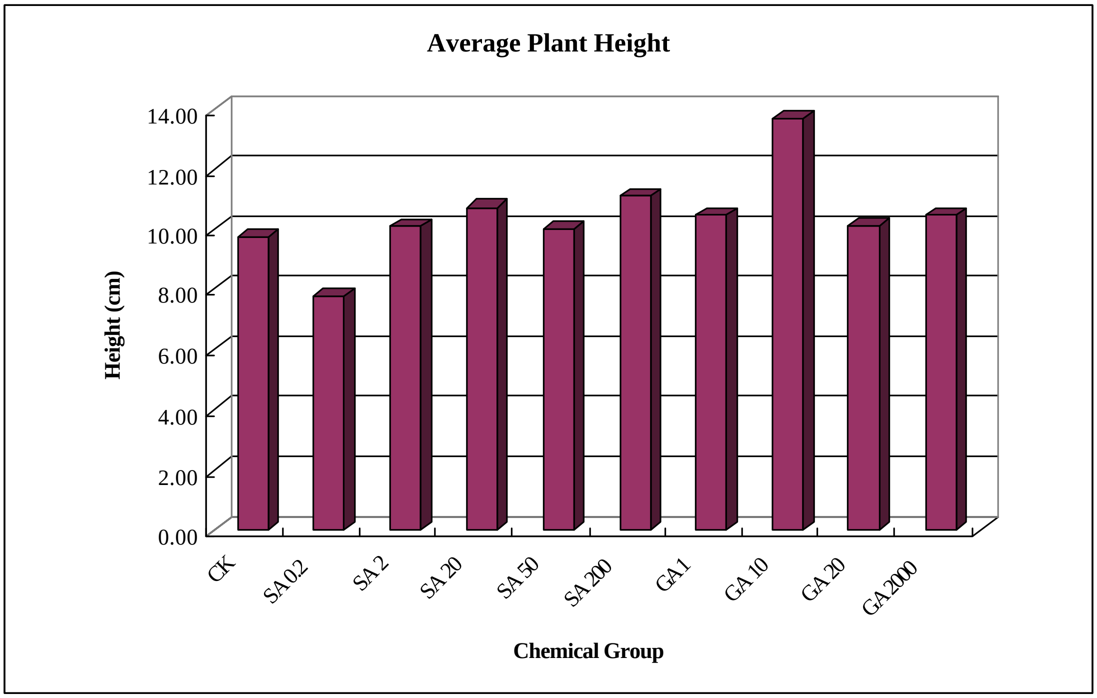
The GA treated plants also performed better than the control, with GA 1 yielding the best results. GA 1 had the highest yield of all the chemicals and concentrations tested, had the second best root weight, and a high stem weight as well. GA 10 also performed well, but GA 20 and GA 2000 performed worse than the control.

The GA plants however have a problem with plant structure. The GA plants were much longer and thinner than the other plants, possibly due to the chemicals nature as a growth hormone. Along with the thin stems, the roots while heavy, were more compact and thicker.

Table 2: Results of GA and SA Testing

	CK	SA 0.2	SA 2	SA 20	SA 50	SA 200	GA 1	GA 10	GA 20	GA 2000
Average Germination	5.33	4.00	6.33	5.00	7.00	5.33	7.33	6.67	5.00	5.33
Average Plant Height	9.75	7.77	10.11	10.73	10.00	11.12	10.48	13.70	10.14	10.48
Average Root Weight	4.743	3.705	5.539	6.775	6.137	4.638	6.258	6.216	4.153	3.951
Average Stem Weight	1.7063	1.3403	2.0767	2.6330	2.2380	1.9207	2.4877	2.7043	1.4773	1.0407
Total Average Plant Weight	6.449	5.045	7.616	9.408	8.375	6.559	8.746	8.920	5.630	4.992
Root Weight / Stem Weight	2.780	2.764	2.667	2.573	2.742	2.414	2.515	2.298	2.811	3.795





The second part of this phase involved testing Fuluic acid, uniconazol, coronatine, and abscisic acid. Here is where my opinion differs from Mr. Wang's. He felt that the numbers for X2 and ABA warranted further investigation and they were the best two chemicals out of the four tested. I disagreed because the numbers were so near the levels of the control plants.

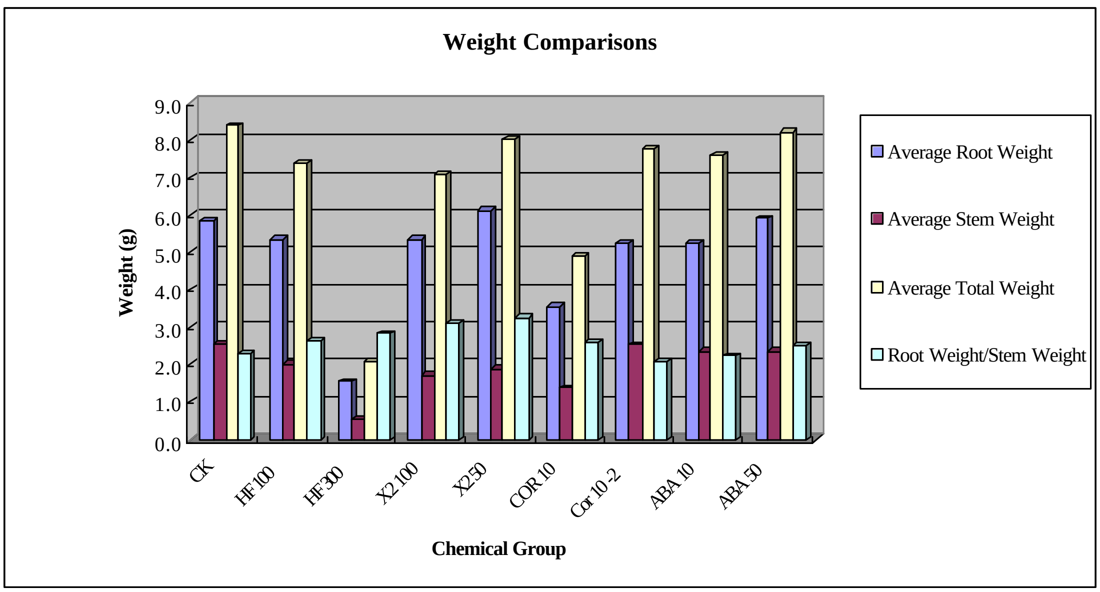
The numbers for coronatine show that it fared the worst of the three chemicals. The fresh weights of the plants are much, much lower than the control. COR 10 had weight values of about half that of the control. While the ratio of root to stem was better, the retarded growth leaves little time for catch-up later in the growing season.

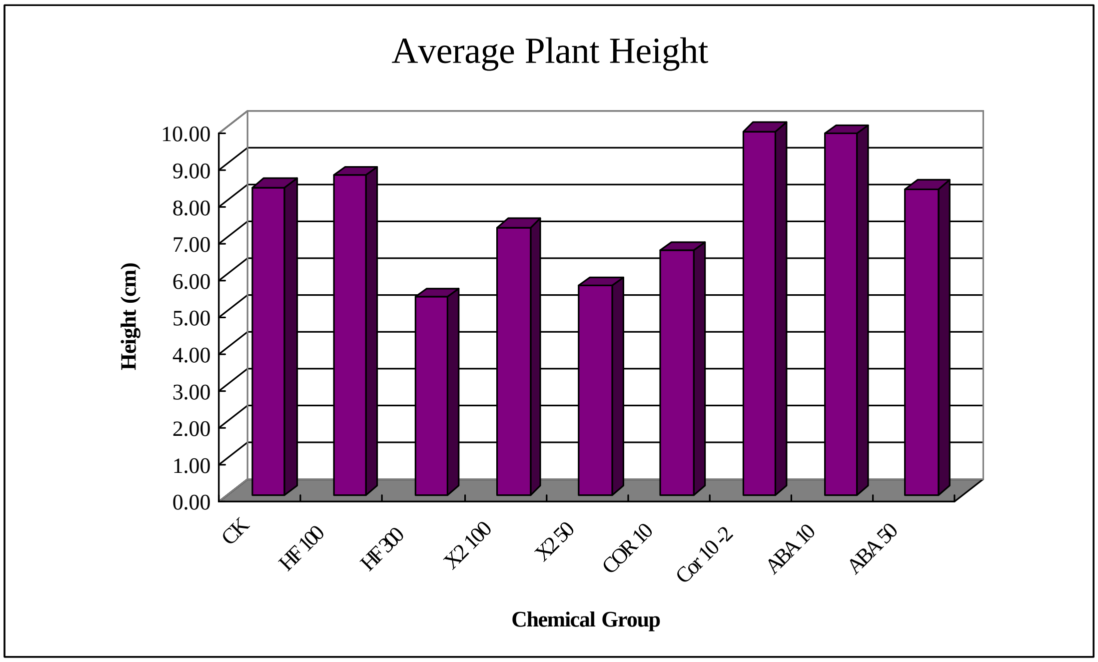
Fuluic acid fared poorly as well. The HF 300 concentration had the poorest results of all the chemicals and concentrations tested. It had a poor germination rate; only thirty-three percent of its seeds germinated. Its weight values were nearly one-quarter the values of the control. HF 100, which fared far better, was still under the control in all its numbers.

X2 placed second best in my opinion, but it was Wang's first choice out of all the chemicals tested in this part of the experiment. X2's numbers were lower than the control in most respects. X2 50 had a higher root weight value than the control. The root to stem ratio was also very high with the X2 plants, better than all the others tested. This was Wang's deciding factor, the fact that the plants had a higher percentage of developed roots than stems.

ABA was the chemical that performed the best to me. ABA 50 had higher root, stem, and root to stem numbers than the control. It also had the most growth. While extreme height is problematic, the height values of the ABA plants were comparable to the SA plants of the previous experiments and not extreme. ABA 50 also had the highest germination rate of ninety-three percent. I don't think X2 is the winner because the main objective of the experiment to me is to increase germination and plant size by ten to twenty percent. X2 had a lower germination rate than the control.

	CK	HF 100	HF 300	X2 100	X2 50	COR 10	COR10 -2	ABA 10	ABA 50
Average Root Weight	5.844	5.352	1.532	5.344	6.124	3.548	5.253	5.253	5.903
Average Stem Weight	2.555	2.030	0.539	1.725	1.880	1.367	2.533	2.348	2.347
Average Total Weight	8.399	7.382	2.071	7.069	8.004	4.915	7.786	7.601	8.205
Root Weight/Stem Weight	2.287	2.636	2.842	3.098	3.257	2.595	2.074	2.237	2.515
Germination Rate	7.25	6.00	2.67	5.75	6.50	6.50	6.50	6.25	7.50



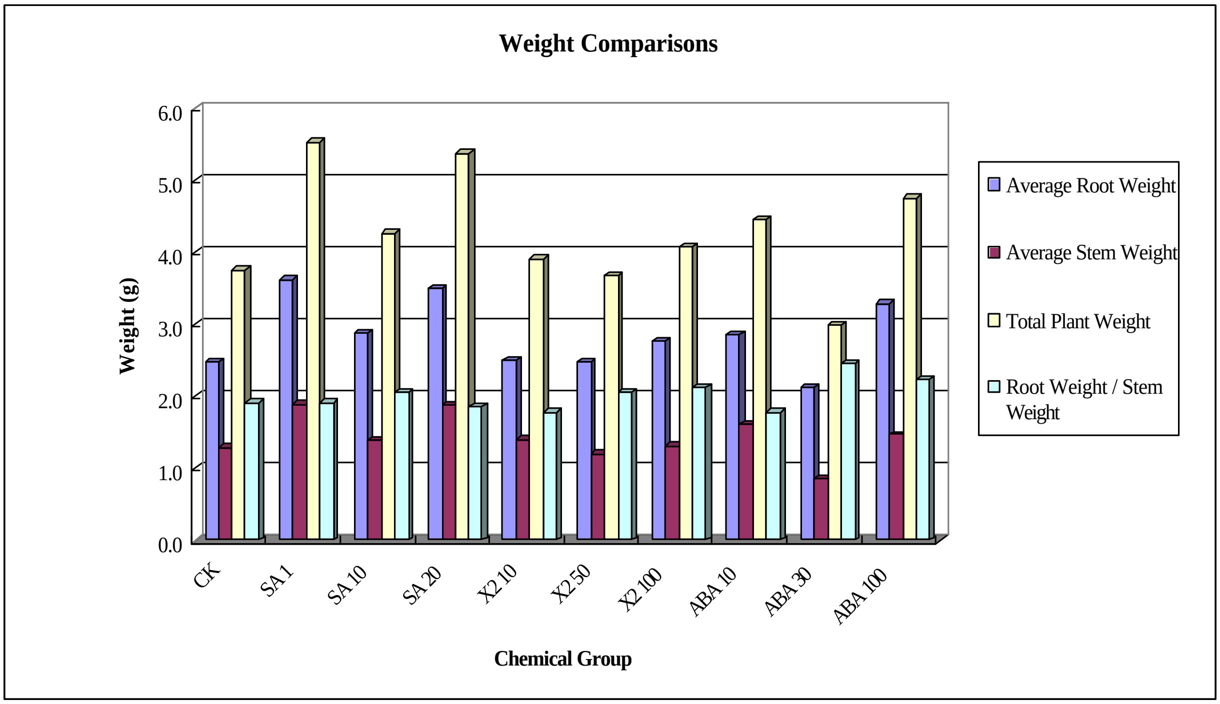


End Result of Phases I and II

Based on the results of the three different experiments, we determined salicylic acid, uniconazol, and abscisic acid to be the three best performing chemical groups. We determined for the final test that we should test each chemical in a three point system, using a two end limits and a middle point for chemical concentrations.

Phase III

	CK	SA 1	SA 10	SA 20	X2 10	X2 50	X2 100	ABA 10	ABA 30	ABA 100
Average Root Weight	2.478	3.636	2.879	3.504	2.508	2.477	2.776	2.859	2.133	3.288
Average Stem Weight	1.289	1.901	1.398	1.881	1.403	1.204	1.308	1.608	0.864	1.472
Total Plant Weight	3.768	5.537	4.278	5.386	3.911	3.681	4.084	4.467	2.997	4.760
Root Weight / Stem Weight	1.922	1.913	2.059	1.863	1.787	2.058	2.123	1.779	2.467	2.233
Germination Rate	3.2	4.4	3.4	4.4	3.6	3.4	3.6	3.8	2.6	4.6



After finishing the third and final run of the experiment, abscisic acid and salicylic acid had the best results. SA 2 and SA 20 both had an increase in germi nation of twenty-four percent over the control. X2 had a germination increase of only twelve percent, and ABA increased by twenty-eight percent. All three chemicals met our first goal of increasing germination by ten percent, and SA and ABA met our secondary goal of increasing germination by twenty percent.

SA had the best numbers when it comes to straight plant weight. The fresh-weight of all the SA concentrations were higher, with SA 2 and SA 20 having a forty-six and forty-three percent increase over the control. The root to stem weight ration remained similar to the control however.

X2 had the least amount of weight difference from the control. This may be due to the fact that the X2 chemical that we used was over three weeks old. I am told by Mr. Wang that that is much longer than its recommended shelf life. The X2 numbers and measurements are added for completeness, but may be compromised.

ABA treated plants have higher numbers than the control, but less than the SA. ABA 150 had the best numbers of the three concentrations tested. It also had one of the highest root weight to stem weight ratios. Visually, the roots of the ABA plants were the best developed, with plenty of thick and thin root appendages.

The best chemical concentration out of the whole experiment, based on the numbers and the visual results would have to be the abscisic acid. ABA 50 based on germination rate, root to stem ratio, and high plant weight, best fits our goals. Salicylic acid comes in second and is a worthy alternative to abscisic acid.

Discussion

Salicylic acid had very good numbers and has the most scientific research backing up the fact that SA increases maize and several other plants abilities to tolerate cold stresses. However, SA has a negative aspect as well. When a corn plant is subjected to cold stresses the SA works correctly and protects the plant. If the plant is not subjected to the cold stress, the extra SA works in the opposite fashion and the plant becomes wilted and damaged. Since springs are random and chaotic, the application of SA would be a gamble. Many farmers do not gamble with their crops, which is their main source of income.

X2 needs to be retested, since in the last phase of the experiment, our supply of X2 was too old and was probably degraded. This assumption in based on the fact that all of the numbers were much lower than the first time it was tested. Since it was tested only twice and we got different results each time, more testing on X2 is warranted, at the very least to validate one of the number sets.

Abscisic acid was tested as a means of finding a solution to this problem. It performed just as well as the salicylic acid, in some cases such as germination, even better. However, ABA's ability as a stress reliever warrants further analysis. We only tested the chemicals effects on the first two weeks of the plants growth. I have no idea what effects ABA has on later development. For this reason, the proposed next phase of the experiment will involve Mr. Wang planted a field of the treated corn and monitoring it over the entire growing season. He will retest all of the chemicals over again; allowing him to get real word numbers.

Another "real-world" bottleneck to this plant would be disseminating the technique for treating the corn and how the farmers would obtain the necessary chemicals in order to treat their own corn. I realize that many of these chemicals are available in the U.S., but they are for hobbyists who plant a small garden with flowers and use the chemicals to help them. Where can a farmer procure chemicals like salicylic acid and abscisic acid at industrial size amounts and prices? Also, can a farmer prepare the solution easily and uniformly in order to receive the correct benefits? Most of the results were very sensitive to the amount of chemical used, and the visible difference between 30mg and 50mg is very tiny.

Also needed are real-world world numbers and data. Numbers in the lab are always very clean because the utmost care is taken to make everything uniform. Testing in field conditions would allow for us to see the results of a little "fudging" of the techniques. Planting large numbers of treated plants in the fields would also solidify the numbers we received in the labs. An acre plot, even with eight or nine different chemical groups, would allow for enormous amount of plants to be looked at and measured, a lot more than the thirty-fifty we have been working with.

References

Abscisic Acid, Ross E. Konig, 1994
http://koning.ecsu.ctstateu.edu/Plant_Physiology/aba.html

Functions of Abscisic Acid, The Plant Biotechnology Institute, Adrian Cutler, May 26, 2004
http://cbr-rbc.nrc-cnrc.gc.ca/abscisicacid/

Guozhang Kang, Changwu Wang, Guchou Sun, Zhengxun Wang, 2003. Salicylic acid changes activities of H202-metabolizing enzymes and increase the chilling tolerance of banana seedlings. Environmental and Experimental Botany 50, 9-15

Horvath E., Janda T., Szalai G., Paldi E., 2002. In vitro salicylic acid inhibition of catalase activity in maize: differences between the isozymes and a possible role in the induction of chilling tolerance. Plant Science 163, 1129-1135

Acknowledgments

The author is very indebted to a multitude of people. My science teacher, Michael Bechtel, The World Food Prize Foundation for selecting me for and sending me to China on my internship, CAU for hosting me and giving me this awesome task to work on, and Dr. Li Zhaohu and Wang Shiwen for trusting me and giving me so much free rein on the experiment. If it wasn't for these guys, I'd still be in the U.S. planning on studying computer chips in college. These internships truly are a life-changing experience.

Final Thoughts

After spending two months in China, I learned all about how naive I am. I knew so incredibly little about this country when I first arrived. Part of it was me trying not to let the American view bias my entire experience. The other is how little they teach you about China in school, and how little it is mentioned on the news.

In school, the only time China is mentioned is usually as a side-note to Taiwan or Hong Kong. China was skipped over in my World Studies class in order to spend more time on India and Japan. The news is only interested in Iraq and China is seldom mentioned, let along in a good light. The images we are given of China are almost thirty years old and represent the Mao era, and the Cultural Revolution.

I didn't know about the summer palace, or even how many people there were here. Not that it would have mattered before I came over. The only people we are told can accomplish anything are the American people and maybe the Japanese. They forget to mention the leaps and bounds of China over the last few years.

My father was amazed the first time that I called him and told him about my apartment which had an air conditioner, a television, and a refrigerator. He told me I was lucky and assumed I had the equivalent of a penthouse suite. He was amazed when I told him many of the Chinese have these "luxuries." We just assume China is very poor.

I learned that America is not the fastest growing nation in terms of development of the economy and education. China's economic growth is a lot bigger than America's. I learned that China was on the forefront of agricultural research, and is even better than America in some areas. I realized that we cannot isolate ourselves. America believes that it is better than everyone else and always will be. China is an upstart that has more labor power than America, and if it keeps growing steadily, a bigger agriculture and an equal economy. Then America will be the little frog in the big pond.

In America, the developing nations are painted as a lost cause. It is assumed that they will just starve. Ways to help them out are never mentioned in schools. It is inferred that they can't be saved. The same was said for China and India. China has made incredibly progress towards becoming a developed nation, and the incredible starvation in India, while not gone, has not increased like in Africa.

But the farmers are still some of the poorest people in China. Its amazing that their income has grown twenty times in the last twenty years. It is also amazing what it must have been like to have an income that small. I can't comprehend living on one hundred dollars for an entire year.

I got to see the farms of Xian one day. It was an eye-opening experience. Two families lived in a two-room house; each family had one of the rooms. The one-child rules are very relaxed for the rural people, the family had three children, surprisingly all female.

Fruit is a cash crop for the farmers, and many people grow peaches as their main source of income. Grain production is still regulated and most farmers grow grain as well, along with vegetables for the family's use. The farms a saw were one or two acres, and were divided in half between grain and fruit orchards. I saw no machinery, not even a little tractor.

It is so hard to put into words what you feel when seeing these farms. By American standards they are very poor. But by Chinese standards, they are pretty well off. And the mind reels at what their life must have been ten or fifteen years ago before the reforms. Seeing the farms was more effective than seeing a charity commercial on television. It was real; I saw everything with my own eyes.

I also learned that food security is a real issue for everyone. Even in places like America, research is needed to keep yields high, and protect plants from disease. It is amazing how some people take for granted how food gets to their table. Some Americans think milk come from a carton, not a cow, and that the supplies are limitless. My stay in China has taught me that agriculture, while not the flashiest or prettiest industry, will always be the most important one.

The young people of CAU and all of the other universities in Beijing are the future of China and their future is bright. CAU is a leader in bringing the world's best agricultural minds together and bringing reality to the theoretical work done in the laboratories. That is something very lacking in most American universities, where theoretical concepts are explored, but not developed for the consumer.

The students of the college are incredibly motivated and incredibly bright. I attended the CAAS and WFP symposium along with Anne and Divindy. Attending that symposium were not the older Chinese scientists. The conference room was packed with the younger generation of scientists. Over a thousand college freshman, sophomores, juniors, seniors, and graduate students listened with rapt attention during Dr. Borlaug and Huber's lectures. Afterwards they posed for pictures as if Dr. Borlaug was a rock star. That says a lot for the future of agriculture in China, and for their food security.

My co-worker Mr. Wang is a good example of a dedicated student. He has connections with the farmers in the provinces of Hebei, Jiling, and Inner Mongolia. Many of the results of his experiments are brought right to the farmer. In the case of the Jiling farmers with the corn problem, he set aside his other experiments, researched the subject, and created a new experiment in order to help them. How many students in America would add another major research project to their workload halfway through their doctorate studies if a couple of farmers came to them with a problem? As long as there are people like Dr. Li, and Mr. Wang, China's people will never go hungry.