A Summer in Mexico

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Borlaug Ruan International Internship

CIMMYT in El Batán, Mexico

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Introduction

I am Elizabeth Roche, a graduate of Metro Early College High School in Columbus, Ohio. I have grown up in Westerville, a suburb of Columbus, OH and outside of a family garden, had no agriculture experience before attending high school. I attended Metro, a STEM high school (science, technology, engineering and math), which has an advanced curriculum. The goal of Metro is to finish high school classes in your first two years. In the third year students finish any additional coursework and are required to do an internship and research project. In the fourth year students can take coursework at The Ohio State University (OSU). I never had an interest in agriculture until high school. Being a city/suburb child, I thought that people who worked in agriculture fed cows and picked corn. I know now that I was very wrong.

For my high school third year research project, I signed up to study in the botany/agriculture area. There were three project options offered: medicine, robots, or plants. I knew I never wanted to be a doctor, and I didn't like building robots, so I chose plants. Little did I know that decision would change a lot about my life. During classes I learned about food production and agriculture. The classes took place at the Mid Ohio Food Bank, and I had a mix of different perspectives on food production and agriculture. I started to really enjoy it and I was assigned to do my research project with the OSU plant pathology department. From my research project I learned about wheat stem rust, Ug99, Norman Borlaug's work, and other plant diseases. Everything was a learning experience for me; I realized there was much to learn about agriculture, plant pathology, and global food production. I was excited when my OSU mentor told me I could stay on for the summer and work in the rice lab. While working in the lab I learned about a fungus that attacks rice in Asia called Rice Blast. I got to view different experiments, take care of the rice plants, inoculate the leaves, and collect the results. That summer I also was a Manager at the Metro High School farmer's market. I had a lot of fun working in the field growing different vegetables and understanding how a farm worked. I helped to teach other students about agriculture, and I learned the business aspects of running a farmer's market. Both of these experiences were very beneficial to me, and something I never imagined myself doing as a child. I found that I enjoyed agriculture and learning about plant disease, and that I still had a curiosity to learn more about agriculture.

My teacher, Mr. Bluel, told me that I should consider looking into the World Food Prize option of applying to go to Iowa in the autumn. I then wrote a paper about wheat stem rust and its effects in Uganda. I submitted my paper to OSU and went through a presentation and interview process. I was very happy when I found out that I was chosen as one of the six students from Ohio that would attend the World Food Prize in October 2010. When I told my family and friends, they congratulated me but all questioned what exactly the World Food Prize was as they had not heard of it.

Going to the World Food Prize was an experience in itself. I met many amazing global researchers, farmers, scientists, and organization leaders. The students attending got to attend seminars and see Jo Luck and David Beckman receive the World Food Prize. I realized how much I had to learn after attending the World Food Prize. Even talking with the other students there let me know how different and how much of a “city girl” I was considered. I was slightly embarrassed to admit that I was never in FFA or 4H, and didn’t have a fancy blue jacket. I was simply a student with an interest in agriculture who wanted to learn more. When the students were handed an applications for an opportunity at an international internship, I was sold. I knew that was what I wanted to do the summer before college. I knew that I loved traveling and being abroad and the World Food Prize Internship sounded like an excellent opportunity! I could learn about global food security, agriculture, and more for two months in another country. While some of my friends thought I was crazy to consider leaving for the whole summer because I would miss out on graduation parties, a summer job, and spending time with my friends, none of those seemed as great to me as the internship opportunity. So I sent in my application, and waited. When Lisa called with the good news I was so ecstatic! I would be spending my summer at CIMMYT in Mexico.

CIMMYT Research Center

El Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) is based in Mexico. CIMMYT works with public research and extension organizations, private companies, advanced research institutes, NGOs, and farmer associations in countries worldwide, working to fight hunger and poverty.

CIMMYT was formed in 1943 from a sponsorship from the Mexican Government and the Rockefeller Foundation. Norman Borlaug, founder of CIMMYT, developed wheat that was resistant to wheat stem rust, adaptable to latitude, and produced more grain. Wheat stem rust was a major problem between 1900 and the 1950s. Stem rust usually caused about 30% to 40% yield loss to the wheat crop. Dr Borlaug used a shuttle breeding technique that allowed for his resistant wheat to be grown almost anywhere. He developed diseased resistant varieties of wheat that were grown across America, India, China, Africa and other areas and is now a staple crop is those areas. He saved millions of lives from hunger and famine with his work. He won a Noble Peace Prize in 1970, but that did not stop his continuing the fight against hunger. Today, wheat stem rust has reemerged, and there are current projects and research being conducted on stem rust at CIMMYT. CIMMYT was established in 1963 in El Batan, Mexico and has continually developed new wheat varieties and improvements in crop management practices that have revolutionized wheat production in Mexico, and around the world.

CIMMYT's work in agriculture is very important and has global impact. Seventy percent of the world's poorest people live in the countryside, with many dependent on farming for food and income, especially farmers of maize and wheat. According to the Food and Agriculture Organization FAO, maize and wheat account for about 40% of the world's food and 25% of calories consumed in developing countries. Today, developing countries need to produce about 700 million tons of maize and wheat. With population increases, shrinking plow-able land, and environmental changes, it is predicted that by 2020 the world will need to produce 368 million additional tons of maize and wheat. CIMMYT works continuously on the goal of ending global hunger and improving global agriculture. Wheat varieties bred at CIMMYT have helped prevent famine and hunger in South Asia and elsewhere in the world during the second half of the 20th century. Norman Borlaug's research at CIMMYT helped launch the Green Revolution. According to Hazell, the Green Revolution refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s that increased agriculture production around the world, beginning most markedly in the late 1960s. The benefits of this Green Revolution were recognized through the 1970 Nobel Peace Prize given to Norman Borlaug. Nutritious maize varieties developed by CIMMYT won recognition through the 2000 World Food Prize. There are also current projects to further improve nutrition quality, such as a variety of corn with additional vitamin A for undernourished children in Africa and Asia.

Wheat varieties developed by CIMMYT and its partners are planted on more than 64 million hectares in developing countries, representing more than 75% of the area dedicated to modern wheat varieties in those countries.   As reported in Science (Vol. 300: pp758-62), in the absence of Consultative Group on International Agricultural Research (CGIAR) Centers such as CIMMYT, and their many partners in the developing world, crop yields in developing countries would have been 19.5-23.5% lower. In addition, prices for food crops would have been 35-66% higher; imports would be 27-30% higher; calorie intake would have been 13.3-14.4% lower; and 32-42 million more children would have been malnourished. The area planted with crops would be 4% higher for wheat and 2% for maize.   CIMMYT not only makes agriculture and global hunger improvements, but also makes food more affordable with environmental improvements. Lower food prices extend the benefits of agricultural research to poor consumers in urban areas and landless people in rural areas, and to the industrialized world. Most of the world's poor rely on agriculture for income and sustenance. Globally, there is enough food for everyone, but locally, hundreds of millions of people lack the resources to grow or buy enough food. Food is unequally divided between the poor and the wealthy.

Maize and wheat research at CIMMYT is very important because maize and wheat are imperative to nutrition, health, income, and environmental sustainability in low-income countries. Improved maize and wheat seed can produce plants that naturally resist diseases and pests, tolerate drought or flooding, overcome poor soil quality, survive excessive temperature, offer more nutrition, and yield more grain for food or sale. Better cropping practices save water, land, and other natural resources, aside from raising yields, which is also one of CIMMYT's missions.

CIMMYT teaches farm households and rural communities to use new farming practices and produce seed. CIMMYT provides technical information and support that helps researchers, policymakers, and development workers globally, and advocate appropriate policies to foster food and income security. CIMMYT also works with government agencies, relief organizations, and health organizations to help advise them about appropriate seed and cropping practices to help farm households recover from famine, drought, floods, war, and other disasters. CIMMYT also helps nations restore agricultural research material and infrastructure. This reduces the threat of continuing food shortages and long-term dependence on food aid.

CIMMYT achieves its mission with a global staff of approximately 100 specialized research staff and 500 support personnel. The staff represents 40 countries. The Center is funded by international and regional development agencies, national governments, private foundations, and the private sector. Major supporters include the World Bank, the USA, Switzerland, Japan, the European Commission, the Mexican Government, the Rockefeller Foundation, and other countries that host CIMMYT staff.

Internship Experience

During my internship at CIMMYT, I worked in wheat pathology in the Global Wheat Department. Plant pathology is crucial to the world's food supply, as every year it is diminished by many different plant diseases. Plant disease affects millions of farmers each year, resulting in yield loss and loss of food. The estimated of the number of people who will suffer chronic hunger this year is 925 million (Food and Agriculture Organization of the UN). About one in four children under the age of five is underweight in the developing world, and the economic crisis is expected to push an estimated 64 million more people into extreme poverty. World hunger is affecting our world, causing malnutrition, increasing gender disparity, violence, and can even cause political unrest. CIMMYT is working to improve the conservation and utilization of maize and wheat genetic resources, develop and promote improved maize and wheat varieties, test and share sustainable farming systems, analyze the impact of its work and researching ways for further improvement. CIMMYT partners with national agriculture research institutions across the globe to help improve food security. One of the ways CIMMYT does this is work for resistance to plant pathogens such as *Septoria tritici*, *Septoria nodorum*, *Fusarium spp* and *Bipolaris sorokiniana*.

In the Global Wheat Department laboratory where I was assigned, the work was specific to fungus. I worked with *Septoria tritici*, and *Septoria nodorum*. Throughout my stay, there were multiple projects taking place in the lab in which I was able to help. I worked with evaluating *Septoria tritici* resistance in Morocco wheat populations. I also evaluated detached leaves in an experiment to determine resistance to *Septoria tritici*. My personal project was a germination test of seeds inoculated with *Septoria nodorum*.

Septoria nodorum is a disease that affects wheat plants worldwide. *Septoria nodorum* blotch lesions are often lens-shaped with a yellow-green border surrounding a dead tissue area. Pycnidia may appear within the center of the lesion, but are more common on nodes, stems, leaf sheaths and glumes. Pycnidium distribution is random and does not follow a distribution pattern like *Septoria tritici* blotch. When nodes are infected, it may cause distortion and bending of the straw with a possibility of lodging and breakage of the straw. This breakage leads to subsequent losses in yield, about 30% yield loss.

The mycelium of *Septoria nodorum* can also be seed-borne and can cause seedling infection. Brown lesions occur on coleoptiles of wheat seedlings grown from infected seed (Machacek, 1945). Infected seed poses a major problem for wheat farmers as wheat grown from infected seed causes a significant rate of disease and yield loss.

Wheat Seed Germination Test

For my experiment I conducted the Wheat Seed Germination Test for transmission of infection from seed to seedling against two different isolates of the *Septoria nodorum* fungus (SN1 and SN4). For this experiment I used 100 seeds each of five types of seeds: Sonalika, Ciano 79, GB-662, GB-365, and Erick. Ciano 79 and Sonalika are susceptible varieties to infection of *Septoria nodorum,* GB365 and GB662 are moderately resistant varieties, and Erick is a resistant variety. I cleaned the seeds by soaking them in Chloro to disinfect and clean the seeds from any previous ailment. I soaked the seeds in the inoculum of conidia of *Septoria nodorum* 1 (SN1) and *Septoria nordorum* 4 (SN4). The *Septoria nodorums* were taken from different locations in Mexico last year. I then placed 100 seeds of each seed variety on a sheet of filter paper with the embryo facing up. It is important that the embryo faces upwards so that when the seeds germinated they do not turn and tangle, making it more difficult to evaluate. Then I folded and rolled the paper to completely cover the seeds. I placed the rolls in open bags.   I made four repetitions of 100 seeds each for each of the five varieties of seed. Each seed type had its own bag to prevent contamination. The bags were incubated at 20 degrees Celsius for eight days. I then evaluated the seeds for infected, abnormal, and un-germinated seedlings. After collecting the initial data, I recorded the severity of the infection for each seed type, using a scale of 0 to 5.

Hypothesis

My hypothesis was that the Erick seeds would show the most resistance, Ciano 79 and Sonalika would show the least resistance, and GB-662 and GB-365 would show moderate resistance to *Septoria nodorum*. The experiment was to determine the amount of infection from the seeds that would be transmitted to the seedlings. Seed to seedling transmissions of nearly 100% have been recorded in field plots sown with seed infected by *Septroia nodorum*. (G.C. Bergstrom 1995).

Results

My experiment shows that seedlings infected with *Septoria nodorum* will produce seedlings infected with *Septoria nodorum.* All of the seed types tested showed infection with both types of *Septoria nodorum.* For SN1 (*Septoria nodorum* 1), Sonalika had the highest infection rate. For SN4 (*Septoria nodorum* 4), Sonalika also had the highest infection rate. GB-365 had the lowest infection rate for both SN1 and SN4. However, the GB-365 seeds developed contamination from another fungus. Therefore the results of the GB-365 seeds are not completely accurate. The contamination skewed the results of the GB-

365 seeds. This was taken into consideration when I drew conclusions from the data.

I checked for infection on the roots, stem and seeds. I checked for discoloration on the stem, roots, and seed, shortened roots, damage to the stem, and fungi growing on the seed. I also looked at the height and overall health of the seedling, in order to determine the severity of infection. See tables 1 and 2.

In figure 1, you can clearly see the difference in the severity of infection between Sonalika and Erick infected with *Septoria nodorum* 1. The roots on Sonalika show discoloration, one sign of infection. Also, the stem had more discoloration on the Sonalika seeds. The Erick seedlings were taller and overall healthier looking.

Figure 2 shows a close up picture of Erick seeds infected with SN1. The infection is not severe, however is still present. Compared to figure 3, the infection is not strong as the infection is only visible on the stem. The figure below shows Sonalika infected with SN1. The infection is more severe then Erick. You can see the infection on the seed, roots, and stem. The roots are stunted and discolored. The seeds are heavily discolored, as well as the stems. The stems show more infection then the Erick seedlings.

The data also shows that GB-662 has a high rate of infection. However, similar to Erick, the seedling did not have as severe of an infection as Erick. The GB-662 seedlings had infection severity that was between Erick and Sonalika. Therefore I created a scale to differentiate the severity of infection. (The scale is shown below) This scale shows the severity of infection from lowest to highest.

0 has the lowest, or no infection, and 5 has the most severe infection. All of the seeds were ranked using this scale. See figure 4.

For each of the different seed types, SN1 and SN4, tables 3 and 4 show the severity of infection. The data below allows one to see the difference between seed severity, rather than just the amount of infected seed.

Seed borne infection is a major agricultural problem. This experiment shows that planting infected seed, will likely result in infected plants and high yield loss. This helps to define which seeds are most resistant to *Septoria nodorum* will eventually help farmers to plant varieties of wheat that will be resistant to infection and lower yield loss to help to feed more people.

Evaluation of Resistance in Morocco Wheat Population

Aside from the seed germination project, I also helped with many other projects being researched in the laboratory. One of the projects was an evaluation of a Morocco wheat population for resistance against *Septoria tritici.* For this project, I participated in the inoculation of four repetitions of 200 offspring of Morocco and Nasma wheat varieties. The inoculum was a mixture of *Septoria Tritic* with distilled water and Tween. We then counted the pycnidia in the mixture under the microscope to achieve the correct concentration. We then inoculated the plants three times each at fifteen minutes apart. After the inoculations, the plants would spend three days in a mist chamber at 40 degrees Celsius. The plants were then removed from the mist chamber and left in the greenhouse and watered every other day. Each repetition was evaluated four times. Each plant was evaluated by recording the percentage of the leaf infected with *Septoria tritici.* *Septoria tritici* lesions begin to appear as small yellow flecks on lower leaves closest to the soil. Flecks can expand into red-brown lesions. As the plant develops, yellow to reddish-brown or grayish-white to brown spots or blotches begin to form on upper leaves and other parts of the plant as well. Leaves infected at the base of the plants are often killed. The pycnidia of *S. tritici* are dark black and circular. *Septoria tritici* can result in yield loss of 25 to 50%, with the seed being shriveled and unsuitable for milling.

Detached Leaf Evaluation

Another project I helped with was the detached leaf evaluation. This experiment was to determine resistance of different wheat varieties. Young plants were inoculated with *Septoria tritici.* The second leaf was detached of 10 different varieties. The leaves were put into petri dishes with the agar cut out of the middle, so that the leaf laid flat across the middle of the dish. The leaves were sorted randomly into the dishes. The leaves were incubated for seven days at 25 degrees Celsius. The leaves were then evaluated four times, four days apart. The leaves were evaluated by calculating the percentage of pycnidia on the leaf using Eyal and Brown’s Septoria pycnidia scale. The pycnidia were then counted under the microscope, and the percentages recorded according to the scale.

Field Inoculation

Another project I helped with was inoculating the fields at the CIMMYT Toluca and Boximo stations. We prepared an inoculum of *Septoria tritici* collected from different locations in Mexico. We inoculated the fields once a week for three weeks total. The fields in Toluca and Boximo had different varieties of wheat planted. This experiment is to test for resistant varieties to *Septoria tritici.*

Learning from My Peers

The people I worked with at CIMMYT were so kind and helpful. I worked with a student intern from Serbia named Tijana. She was very nice and patent to teach me about all of the projects going on in the lab. I helped her with her projects, including the evaluation of Morocco plants and the detached leaf experiments. Tijana also really helped me if I needed help translating Spanish throughout my time here. She left me in charge of her projects for a week when she visited her home country. She taught me the ways of the lab.

Nerida, Monica, and Mari are the three lovely ladies that work in the wheat pathology lab. They are all very kind and patient, and only speak Spanish. They really helped me improve my Spanish. They each have been working at CIMMYT for over fifteen years.

Jo is a Korean student intern who arrived a month after I did. She is also very kind, and was very helpful when Tijana was away for a week. I helped Jo with her Spanish and English; when she arrived she spoke no Spanish and little English.

Javier and Fransico are the two in charge of the field for our lab. They taught me about inoculation and let me observe their projects. They also helped me with my Spanish.

Everyone at CIMMYT was so kind, friendly and helpful. I became good friends with everyone in my lab. Figure 5 shows my last day at CIMMYT with Jo and Erick, two of my good friends. I will miss everyone here at CIMMYT and would be fortunate to work with any of them again in the future.

Cultural Experience

I loved every minute I was in Mexico! When I went to orientation in May, I was shown a chart of how I would be homesick, as well as the ups and downs of travel. I never fell from the initial "I love this place" stage. Mexico was a great experience for me, and I didn't let anything stop me from enjoying it. Even when I was sick for a week, I still went to work and to the field, because I loved being there. I tried to take advantage of every opportunity while in Mexico. Everyone at CIMMYT asked me when I was coming back. They said CIMMYT is like a magnet, and draws you back in. I really hope in the future I can return, whether for studies, research, travel, or a job!

One of the things I found most interesting in Mexico was the cultural differences. I learned so much about Mexican culture and the Spanish language, and I loved being immersed in it. One of my favorite aspects was the friendliness. Everyone greets each other as they walk past one another. If you don't know the person, you would introduce yourself. I got numerous "buenos dias", which made me feel very welcomed. Everyone at CIMMYT was so kind and helpful. Even for the first few weeks when there was a bit of a language barrier, everyone was so patient and kind. Also when greeting someone, it is customary to shake the other's hand and kiss their cheek. It was something a little strange at first, but I came to appreciate the gesture. I soon realized that the people of Mexico are so welcoming and kind that they aren't afraid to show a small sign of affection to a stranger. Another part of Mexican culture was "mi casa es tu casa", which means, "my house is your house." Very often I was invited to dinner, and was shown generous hospitality. I tried to reciprocate the hospitality every chance I could. I offered to cook for others, and to help out in every way I could. One example of this is when Sarah, Rodrigo, and I took a Saturday afternoon to help Gemma move into her new apartment in the city. Afterwards she thanked us profusely and said to me "mi casa es to casa" and welcomed me to her home always. Hospitality and kindness are key parts of Mexican culture, and Mexicans definitely know how to make you feel welcome!

Another aspect of Mexican culture I absolutely loved was the food! It was different then my expectations, but was amazing! When I first came I figured I would have lots of tacos and quesadillas. And while they have tacos and quesadillas here, there was so much more! When I arrived I had the mentality that I would try everything here, and I am so glad I did. I had some interesting dishes, but overall I had great meals. One of my favorites was Pastel Azteca, which literally means Aztec cake. It is similar to lasagna, but instead of pasta it's tortillas and instead of spaghetti sauce it is made with salsa verde. It is filled with vegetables native to Mexico, such as flore de calabaza (squash flower). I also loved the fresh tropical fruits! I think I ate the equivalent of 3 papaya trees during my stay in Mexico. Not all of my experiences with trying everything turned out for the best. I ate many dishes which I still don't know what was in them. Also when I was sick and working in the field, we took a lunch break. I told Javier, my supervisor, that I was sick and couldn't eat any meat or anything spicy. He said he knew the perfect thing for me. A little bit later, a foil package was placed in front of me. When I open the mysterious package, I saw a fish staring back at me. Javier ordered me a fish. What I didn't realize was that in Mexico, you cut your own fish. I was very shocked at first to see my meal looking back at me, but I quickly had to get over it, and I tried it. The fish turned out to be fine and it didn't make me sick, but it just wasn't what I was expecting with an upset stomach!

One of the other things I had to get used to was to eat slowly. I ate very quickly when I first got to Mexico, and soon realized that when you eat too fast, people assume you are hungry and put more food on your plate. In Mexico it is rude to not finish your plate. So for the first few days I was very full, until I learned to adjust. Mexicans also wait for everyone at the table to finish before you leave. I think this was really nice as it provided conversation time. It made me realize how much I didn't talk during dinner in the US. At home I would eat quickly and leave when I finished. This aspect of Mexican culture forced you to make conversation, and talk with others at your table. This really helped me to meet people and get to know them better. Every meal seemed like a family dinner in Mexico, and I would like to bring this bit of culture back with me to my home for family dinners. While in Mexico, I also learned the importance of tortillas, limes, and chilies. Everything (yes, I believe I mean everything) in Mexico is covered in lime juice and chilies. This includes fruits, candies, and ice creams! Tortillas were not only a staple food and present at every meal, but they are also an important piece of silverware. One day at lunch with my lab, Javier asked for more cucharas (spoons). When the waitress came back, she didn't have spoons in her hand, she had tortillas. Mexicans really do use tortillas as spoons, to scoop up meat, rice, beans, sauce, or whatever else is on their plate.

Having cultural experiences in another country is equally as important as learning the language. When you learn about culture, you are learning a part of the people, their history, and traditions. Not only is Mexican culture very interesting, learning about it helped me better to understand the people. My experiences at CIMMYT also helped me appreciate how fortunate I am. I come from a privileged family in the United States, and have never had to face hunger. Working here at CIMMYT helped develop my desire to learn more about the global food supply and the effects that plant disease have on our food supply. My internship in Mexico helped me contribute a small amount to global research to help stop food insecurity and feed more people. As I in continue my education and career, I want to continue to research, study and contribute to help expand the global food supply and prevent hunger.

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Table 1

Seed/Fungi Type	Repetition	Uninfected	Infected	Ungerminated	Total Germinatec	% Infected	Average % Infe	% Uninfected
Sonalika SN4	R1	5	89	6	94	0.94680851	0.981651107	0.01834889
	R2	1	97	2	98	0.98979592		
	R3	1	99	0	100	0.99		
	R4	0	100	0	100	1		
Ciano 79 SN4	R1	11	85	4	96	0.88541667	0.922462348	0.07753765
	R2	3	93	4	96	0.96875		
	R3	6	92	2	98	0.93877551		
	R4	10	87	3	97	0.89690722		
GB-365 SN4	R1	77	7	16	84	0.08333333	0.096865622	0.90313438
*contamination	R2	77	8	15	85	0.09411765		
	R3	84	4	12	88	0.04545455		
	R4	66	13	21	79	0.16455696		
GB-662 SN4	R1	3	96	1	99	0.96969697	0.96083483	0.03916517
	R2	3	90	7	93	0.96774194		
	R3	5	92	3	97	0.94845361		
	R4	4	90	6	94	0.95744681		
Erick SN4	R1	4	96	0	100	0.96	0.969432381	0.03056762
	R2	3	94	3	97	0.96907216		
	R3	1	94	5	95	0.98947368		
	R4	4	94	2	98	0.95918367		

Table 2

Seed/Fungi Type	Repetition	Uninfected	Infected	Ungerminated	Total Germinatec	% Infected	Average % Infe	% Uninfected
Sonalika SN1	R1	5	91	4	96	0.94791667	0.961878157	0.03812184
	R2	3	97	0	100	0.97		
	R3	4	95	1	99	0.95959596		
	R4	3	97	0	100	0.97		
Ciano 79 SN1	R1	15	81	4	96	0.84375	0.868837774	0.13116223
	R2	12	86	2	98	0.87755102		
	R3	10	87	3	97	0.89690722		
	R4	14	84	2	98	0.85714286		
GB-365 SN1	R1	69	10	21	79	0.12658228	0.262936599	0.7370634
*contamination	R2	49	26	25	75	0.34666667		
	R3	61	18	21	79	0.2278481		
	R4	50	27	23	77	0.35064935		
GB-662 SN1	R1	6	93	1	99	0.93939394	0.93265569	0.06734431
	R2	9	87	4	96	0.90625		
	R3	5	94	1	99	0.94949495		
	R4	6	87	7	93	0.93548387		
Erick SN1	R1	3	91	0	100	0.91	0.960678793	0.03932121
	R2	1	97	8	92	1.05434783		
	R3	4	96	0	100	0.96		
	R4	8	90	2	98	0.91836735		

Figure 1

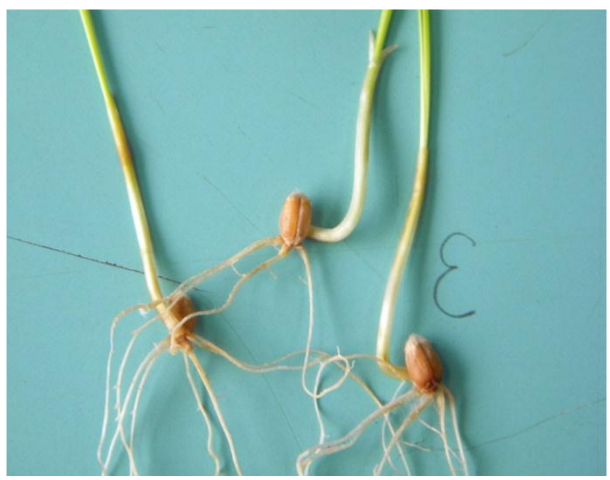

Figure 2

Figure 3

Figure 4

Table 3

	0	1	2	3	4	5	Ungerminated
Ciano79 SN1							
R1	6	21	12	19	31	5	6
R2	2	13	10	12	41	6	16
R3	3	8	14	22	42	6	5
R4	10	10	20	24	33	2	1
Average	5.25	13	14	19.25	36.75	4.75	7
Sonalika SN1							
R1	0	4	7	36	46	5	2
R2	0	6	10	30	49	5	0
R3	2	3	8	18	58	5	6
R4	2	2	10	28	53	2	3
Average	1	3.75	8.75	28	51.5	4.25	2.75
GB662 SN1							
R1	6	11	28	18	27	8	2
R2	7	12	21	23	25	3	9
R3	0	16	25	21	29	2	7
R4	2	16	25	21	29	2	5
Average	3.75	13.75	24.75	20.75	27.5	3.75	5.75
Erick SN1							
R1	3	3	35	40	17	0	2
R2	1	3	26	34	24	1	11
R3	0	5	30	50	15	0	0
R4	7	6	34	32	17	0	4
Average	2.75	4.25	31.25	39	18.25	0.25	4.25
GB365 SN1**							
R1	45	12	3	9	10	1	20
R2	37	13	3	9	10	1	27
R3	55	9	2	7	9	0	18
R4	38	9	6	6	18	1	22
Average	43.75	10.75	3.5	7.75	11.75	0.75	21.75

Table 4

	0	1	2	3	4	5	Ungerminated
Ciano79 SN4							
R1	11	12	5	15	36	17	4
R2	2	3	12	15	49	19	0
R3	7	7	11	12	42	19	2
R4	11	2	10	14	37	23	3
Average	7.75	6	9.5	14	41	19.5	2.25
Sonalika SN4							
R1	0	3	6	14	58	6	13
R2	0	1	7	13	60	15	4
R3	1	3	2	12	69	11	2
R4	2	0	8	17	63	8	2
Average	0.75	1.75	5.75	14	62.5	10	5.25
GB662 SN4							
R1	17	34	23	10	6	2	8
R2	7	35	24	15	9	3	7
R3	16	32	19	12	12	5	4
R4	13	38	19	12	12	5	1
Average	13.25	34.75	21.25	12.25	9.75	3.75	5
Erick SN4							
R1	2	5	32	42	12	0	7
R2	3	14	16	44	15	3	5
R3	1	12	29	45	8	0	5
R4	2	18	33	41	6	0	0
Average	2	12.25	27.5	43	10.25	0.75	4.25
GB365 SN4**							
R1	71	8	2	1	3	0	15
R2	58	14	6	3	5	0	14
R3	74	9	4	0	0	0	13
R4	63	17	2	1	0	0	17
Average	66.5	12	3.5	1.25	2	0	14.75

Figure 5