Rice and the People of the Philippines:

Experiments for Simple Happiness

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Tolling in the field until high noon,
Beads of sweat roll to the ground.
Who knows how rice is grown?
Each grain is hard work and suffering.

As part of my mother's endeavors to ensure that I do not forget Chinese, she and I would sit down and read simple Chinese poems. At the time, I saw most of the poems as simply scores of erratic characters arranged in lines that I must memorize. The meaning of each poem usually escaped me as I absentmindedly copied each word into my workbook. However, there was one particular poem that my mother made an extra effort to explain. It was the poem printed above—one about rice farmers. My mother's insistence on my absorbing its full meaning made the short selection quite memorable to me—so memorable that it resounded in my head, a decade later, as I rooted myself for a summer among the rice paddies of the Philippines.

My mom colorfully described the beaded sweat on rice farmers' backs as they bend and labor arduously in the field. During meals, she taught me that every single grain of rice in my bowl was matched with one of those beads of sweat, beads symbolizing diligence, hard work, and sacrifice. Rice has always been part of my way of life. For as long as I can remember, large, generous scoops of it have been dug out of the seemingly bottomless rice cooker and set before me at nearly every meal. However, before this summer, I've never thought twice about the enormous 50-pound bags of rice that I would help lug home from the grocery store. This summer, my rice poem came to life.

It was personified in what I found out about more than half of the world's population, who eat rice as their staple food. For these people, many of whom live in Asia, rice is central to their lives. More and more people are relying on their daily bowls of rice; people are deriving a growing proportion of their energy intake from the rice they eat. In the 1960's, a rice crisis of sorts was coming to the forefront of the world's concerns. There was simply not going to be enough rice to feed the world; yields were too low to meet the demand of a population that was burgeoning at a frightful rate. The International Rice Research Institute (IRRI) in the Philippines, along with the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, were centers created to meet the challenge. They have tackled the issue from all different fronts, fusing studies in conservation, genetics, and the social sciences.

Since 1970, IRRI has had the upper hand in almost doubling rice production in Asian. A new variety of rice, IR8, was created and distributed. IR8, the first semi-dwarf line of rice, used energy more efficiently and was more resistance to diseases. Rice production and yields were close to catching up at last.

However, a similar food shortage crisis is approaching in the near future. Population growth has been the factor putting the most pressure on the impending situation. More than 80 million additional people need to be fed each year, forcing farmers to use less labor and water on smaller areas of land. In addition, the quality and quantity of the nutrients that can be taken in from rice are becoming crucial, as they may be among the only ones that many impoverished people consume. Given the circumstances, rice research must be persistently pursued to improve the nutrient content of rice and to make more of it to feed the world.

Some of the poorest must spend 20 to 40% of their income on rice. These people are some of the world's poorest consumers; highly enumerated among them are rice farmers and landless farm laborers who have to buy their daily rice. Because of this, not many private interests are willing to invest in rice research, as the beneficiaries are so poor. It's easy for large companies and private interests to justify investment in computers and other technology, as these are seen as having a good potential of increasing practicality and profit. However, the International Rice Research Institute recognizes a different potential—the potential of using rice science to feed the world. Unlike many private companies, IRRI's motivations lie not with profit, but with the goal of helping rice farmers contribute to the bowls of some of the poorest families. Institutions like the IRRI are vital to the future development and improvement of rice varieties that are easier to grow, varieties that have the potential to keep on feeding the world. The International Rice Research Institute serves as an investor in rice genetics and rice technology, an investor that exists to make a real and crucial difference for the people of the world.

To rice farmers, IRRI serves a triple role: researcher, advisor, and friend. IRRI has traditionally guided poor rice farmers in their rice growing ways—advising them to use methods that rely on less water, labor, and chemicals. IRRI has come a long way in the pursuit of the goal of improving rice and rice-consuming communities. Not only does IRRI develop new rice growing technologies and seed varieties, it makes an extra effort to encourage the flow of its discoveries to the people who can make the most use of it. Since its founding in 1960, IRRI has developed a working rice seed collection of over 100,000 varieties. These are generously stored and shared free-of-cost in IRRI's Gene Bank. Scientists and farmers from all around the globe can easily request certain varieties to plant or use in experiments. IRRI also extends its extensive rice knowledge and expertise to small-community farmers, many of whom come from all around the world to participate in IRRI-run training programs. These programs teach special field management and irrigation techniques among other topics, encouraging farmers to become exposed to and apply effective growing practices. These resources, along with many other features of IRRI, have helped the institution develop a reputation for improving the lives of rice farmers around the world.

IRRI's research agenda clearly indicates its priority in all of its work: alleviating poverty. Research designs in IRRI departments tend to vary because rice is grown in four different environments: irrigated and rainfed (which includes rainfed lowland, flood-prone, and upland). Although rice farming overall is generally associated with low incomes and poverty, the rice farmers in the three different rainfed areas have by far shown the most need. These farmers and their families are the people with the least access to other arable lands; they are forced to confront the ever-rising problems of high run-off, drought, erosion, severe infestations of plant diseases, and the corresponding paltry yields. The irrigated areas are comparably more favorable for rice cultivation. Thus, only 25% of total rice production occurs in the non-irrigated, rainfed areas. However, according to IRRI's Director of Plant Breeding, Genetics and Biochemistry Department (PBGB), Dr. David Mackill, and as evidence of IRRI's strong commitment to end poverty, the Institute's research efforts are divided evenly between the rainfed and irrigated rice-growing environments.

The rapidly increasing world population demands the consumption of more water and rainfall for crops. As this water supply continues to vary greatly with unpredictable seasons, the water needed to grow enough rice to feed more than half of the world's people becomes increasingly unstable and scarce. Paddy rice in particular, which is grown in a constantly water-submerged environment, has extremely high water demands. The setup of the rice paddy is analogous in appearance to an attempt to maintain the depth of a shallow pool of water with an expansive surface area during the hot summer months. The heightened ability for rice crops to withstand periodic water shortages would be very valuable in the impending situation. However, drought resistance is one of the most important aspects of rice plants that is not yet fully understood.

In fact, at IRRI, drought resistance is seen as one of the most complicated rice plant traits. Dr. Mackill, who is more focused on minimizing the harmful effects of flooding on rice and the development of varieties that can withstand floods, admits that submergence is a lot easier than drought in terms of genetics. Dr. Mackill attributes this to the likeliness that the ways that rice responds to drought are dictated by a complicated interaction of genes. Coupled with the lack of a quantitative measure of drought, it has been relatively difficult to study. As Dr. John Bennett, a senior scientist in the PBGB Division puts it, "We can't just administer one mole of drought and see what happens."

My two advisors, Dr. Bennett and Dr. Lafitte, are among the most inspiring and self-directed people I have ever met. They were both able to see past the more specific and surface details of the members of their research teams in their fields, greenhouses, and labs. Dr. Bennett happily overlooks the daily spectacle of busy students donned in lab coats, darting around the lab, doing front-line research. However, he also deems of great importance the development of every one of his students as a person and as a research leader. He briefed me on his "list of achievements" that all his students must master, including those of learning: English, how to manage time, how to manage people, how to design an experiment, how to design a research program, to know one's plants, to learn techniques, to write research papers, and to understand the philosophy of science. He stood true to these objectives and engaged me in meetings that checked on my progress on *all* of these fronts.

In my second week, I was warmly welcomed into the Bennett Lab. It was beneficial to immediately start observing and practicing the procedures that I planned to repeatedly perform for my own experiment later on. I was glad to seem reminisces of equipment and protocols that I had encountered in my two previous internships at Iowa State University labs. We named the PCR machines in our Iowa State Animal Science lab, and I was happy that see that versions of both "Bugs" and "Tweetie" followed me to the Bennett Lab. It was very interesting to see variations upon the same essential lab techniques and to be able to offer my own input on what I had done in a lab on the other side of the world.

In the lab, I first met and observed Xin Ai. Xin Ai is a student from China—an eager worker who insisted that I have the very abilities needed to help her enhance her English. Right when I walked into the lab, Xin Ai greeted me with a pair of lab gloves and we started peeling away at long rice leaves. We extracted rice panicles and performed a series including RNA extraction, *in-situ* hybridization, and RT-PCR. All three steps allowed us to learn something about a particular gene and where it was expressed in the rice plants that Xin Ai was working with. The RNA extraction and RT-PCR's were the first steps in isolating and analyzing the presence of RNA in the rice tissue. The *in-situ* hybridization is a procedure that highlighted the exact cells that expressed a certain gene within a cross-section of tissue. With Xin Ai's lab efficiency, we covered most of such common procedures used within the lab within a span of two days.

Amidst such diligent scientists and students, I was able begin my own project of rice experiment work. Before I started my experiment, Dr. Bennett gave me the first part of many of his invaluable and seasoned-scientist words of advice. He reaffirmed the belief that if, "something's worth doing, it's worth doing well." But, less obviously, he asserted that if, "something's worth doing, it's worth doing badly." In other words, he wisely assured me that all experiments do not have to be complicated and perfect when one first plans them out. Sometimes, it's beneficial to not have everything figured out from past experimental precedents. The details could be worked out later. With such reassurance, I began to plan what would become my own rice project.

Both Dr. Lafitte and Dr. Bennett are interested in drought-resistance in plants, but they have two different approaches. Accordingly, my project had two parts. Both parts were experimental attempts to clarify the nebulous details of drought-resistance mentioned earlier. First, plants that differ in their abilities to tolerate water stress were compared in their reactions to different plant hormone treatments.

The balance of plant hormones in rice changes naturally with all different conditions and forms of stress. The hormones that I focused on have already been strongly linked to several plant growth behaviors. Abscisic acid (ABA) is thought to have a generally inhibitory effect. Of all the plant hormones, it has been studied the most in relation with drought stress tolerance. ABA's function of stimulating the closure of plant stomata, the little openings in plant leaves that allow water loss, has sparked most of this interest. In essence, the hormone serves as the gateman of the plant's doors; it allows gases and water to pass in and out of the rice plant by regulating the stomata. ABA also inhibits shoot growth and is logically produced mainly in plant leaves themselves. Most of the time, the effects of gibberellic acid (GA) are thought to directly counteract the effects of abscisic acid. The concentrations of ABA and GA during drought illustrate this antagonism; when concentrations of GA decrease during drought, concentrations of ABA steadily rise. In general, gibberellic acid stimulates cell division and elongation, thus stem elongation as well. Finally, ethylene gas, an odorless and colorless hormone, stimulates the abscission of leaves and fruits. It also affects shoot and root growth and cell differentiation. Its effects are commonly known as the triple response: stunting of growth, twisting of plants, and thickening of stems.

The more drought-tolerant plant varieties studied were selected from a collection of over 40,000 mutant rice plants that has already been developed at IRRI. These mutant varieties of IR64 were produced by irradiation that altered small portions of their chromosomes. IR64 seeds were bombarded with gamma rays and fast neutrons, effectively changing the seeds at the genetic level. These new "mutant" seeds can then be tested to see if they are different in any useful ways. Usually, mutant plants are thought to be weak or deficient in some way, perhaps refusing to germinate when sown or growing with big stunting problems. However, after a screening of many thousands of mutant plants, a few have demonstrated enhanced function or growth. Such plants that are genetically changed by a deletion of a portion of their genes are termed "gain-of-function deletion mutants".

In the Lafitte lab, this type of testing manifested as a long screening of more than 5,000 mutant varieties during the dry season. Mutant strains were grown and compared with the wild type to search for more water stress-tolerant rice plants. Based on field tests, several of the mutant strains have shown improved resistance to drought conditions when compared with the wild type IR64. The mutants that showed a substantial improvement in dealing with drought were automatically of particular interest, and the first part of my project aimed to compare the differences in effects of three plant hormones on one of these mutants with the normal wild type.

I performed an analysis to find the differences morphologically, or physically, between one of the more resilient mutants, 547-2R, and the wild type IR64 while subjecting them to the different hormones. The mutant and wild type rice plants were grown in hydroponics, or in water environments with added nutritional media. Usually, the Lafitte lab conducts its experiments in the field, but I arrived during the wet season, not the most appropriate time to conduct drought research outdoors. I used two different setups: a plating setup and a floating setup. For the plating setup (see Appendix 3), I lined up rice seeds and sandwiched them in between filter paper adhered to plates and a thin sheet of tissue paper. These plates were arranged vertically in a rectangular tub. The nutrient solution was poured directly into the tub and while traveling up the filter paper, kept the seeds constantly moist. This moisture kept the paper and the adhered plants wet enough for germination and growth. For the floating setup, the rice seeds were literally floating on top of the solution. They were wrapped in bits of sponge and fit snuggly into Styrofoam boards with small holes. The sponge soaked up the water, and the rice seedlings grew up out of the board.

To make the nutrient solution, or Yoshita solution, distilled water was mixed with the solutions of many other chemical substances that plants need for uptake and growth, including magnesium, potassium, and sodium. Hormone treatments of abscisic acid [0.375µM], gibberellic acid [50µM], abscisic acid with gibberellic acid (ABA [0.375µM] and GA [50µM]), and Etherphon (a chemical that induces the production of ethylene gas [1mM]) were applied daily to both the mutant and wild type during development. The pH of the water needed to be monitored daily and kept at a constant optimal pH of 5.5. After seven days, the plants were ready to be harvested. I measured the root and shoot lengths of all of the rice plants and compared the differences in growth between 547-2R and IR64 (see Appendix 1). In general, the mutant plant 547-2R was not affected as much in growth by the hormones as was the wild type IR64.

IRRI resourcefulness was in full swing in everything I did; a large wooden stake that I discovered in the corner of the greenhouse served as the long stirring stick for the nutrient solution. The project fused much raw creativity and makeshift substitution with standard techniques. In this way, much of what I did in the lab and greenhouse required keen improvisation skills. I proudly figured out how to use a pipet tip as a spatula, a paper clip as a "micro-spatula", and several rectangular washtubs for growth containers. As Jill Cairns explains, part of the reason why we use such pragmatically simple methods is because part of the grant money is supposed to go towards developing such techniques for research use in laboratories in developing countries. Many developing-country research institutes are not very well-funded, and use of simple, around-the-house materials in research is crucial to them.

In the second part of my project, I looked at just the wild type IR64 and compared an aspect of its genetic responses to the different hormone treatments. One group of plant enzymes, called invertases, have been of particular interest to a few people in the Bennett Lab, one of them being Xuemei Ji. Xuemei may very well be the world's expert on invertases and their genes.

She works with invertases all day and has made significant progress in the classification of the enzymes, how they work, and what they may be affected by. Invertases are enzymes that catalyze the breakdown of sucrose into fructose and glucose. They are very important in directing the flow and use of plant energy. Since plants cannot use sucrose in processes that release the energy needed for critical functions, if the sucrose is not broken down by invertase in a particular spot, that part of the plant doesn't have energy to spend. One aspect of invertases that really drew my attention was its hypothesized function in the rice peduncle.

The rice peduncle is the uppermost part of the rice stem directly beneath the rice panicles, the reproductive parts of rice that produce seed. The panicles themselves are developing grains with long stems. The invertase enzymes provide energy from sugar breakdown for the elongation of the peduncle, which pushes the reproductive panicles up out of the rice sheath for further development. This displacement of the panicles is crucial for proper grain development and high rice yields. Activity of the invertases in the peduncle releases the sugar energy needed for elongation. As already mentioned, the sucrose would flow right on past the peduncle if the invertase enzyme did not convert it to usable forms. Without the enzyme, all of the sucrose would flow to the panicles themselves and would contribute to the growth of the seeds. However, without the peduncle elongation to push the panicles out into open air, grain development is not complete. The focus of my project was on cell wall invertases, of which there are 9 types. Eight of those are functional while one is truncated and not expressed in rice.

The functions of gibberellic acid are also tied closely to the invertase enzymes. Since gibberellins stimulate cell division and elongation, there may be an interaction between the presence of GA and the sugar breakdown mediated by invertases. The sucrose needs to be broken down into usable energy for the cell division and growth to occur. The types and strength of invertase expression may be different in rice plants with differing capacities for tolerating drought; finding this difference holds important implications for the use of invertases to promote high rice yields and good plant development even after periods of water deficiency.

For the second part of my project, I used the floating hydroponics set-up and grew my plants in 10L of nutrient solution. The pH was again monitored daily, and the plants were harvested 14 days after germination. The tissue from the rice plants was immediately separated into root and shoot portions and stored in liquid nitrogen. The technical lab work came in here.

After I practiced RNA extraction and RT-PCR with random rice shoot samples, I was ready to perform the two procedures on my hormone-treated IR64 plants.

RT-PCR, or real time PCR, is designed specifically for the amplification of strands of RNA. RNA is extremely sensitive, and degrades quickly in room temperature. I had much previous experience performing PCR on DNA, but handling RNA required special care. I was careful to store the rice samples in the -80°C refrigerator and crushed them in a mortar that was constantly filled with liquid nitrogen. Contamination of the samples, such as with RNA and DNA from our skin cells, would have been very easy, so I wore gloves at all times.

The strengths of expressions of the eight cell wall invertases were compared in the IR64 rice grown in three different hormone environments. This was to determine whether growing the rice plants in hormone additions of ABA, GA, and Ethephon would impact the expression of the invertase genes. This can then be applied to the bigger picture: uncovering the relationship between the expression of each invertase and improved drought resistance. Perhaps the hormonal changes of a rice plant during drought influences which invertase enzymes are present, which in turn may impact the development of rice grains.

The gels of the RT-PCR product turned out nicely (see Appendix B), and they gave me good information about the expression of the eight cell wall invertases (CINs) in young shoot and root rice tissue. Furthermore, I was able to compare the impact of the three different hormone treatments on the expression of the cell wall invertases. By comparing the brightness of the bands that corresponds with each invertase primer, it was evident which invertase genes were down and up-regulated in young tissue. There were clear differences among the invertase gene expression of IR64 grown in the ABA, GA, Ethephon, and control environments (Appendix B, Table 1). This suggests that there is a relationship between the hormone concentrations in rice plants and the invertases that are active in shoots and roots. This, in turn, may suggest that the hormone levels that change with drought are linked with crop and grain yield through differing invertase expression in tissues like the peduncle. Of course, more work is needed to clarify the details of this relationship. Dr. Bennett informed me that the findings will be followed up after I leave with either more replicates and *in-situ* hybridization to find out where exactly the enzymes are being expressed in the growing rice tissue.

If there was one thing of most importance that I learned at the 2003 World Food Prize Youth Institute, it was that world hunger and poverty is about much more than just crop production and productivity. It's about population control. It's about internal infrastructure. It's about politics. It's about social roles and responsibility. Knowing this, I was determined to infuse the scientific aspect of my internship experience with as many social exposures, lessons, and experiences as possible from the very beginning.

I was ever curious about the life that poorer Filipino families lead—the life that was only visible outside of IRRI gates. I was also determined to get more than a superficial exposure to real poverty—the poverty that IRRI is working hard to eliminate. Through a rigorous follow-up of an IRRI employee named Tom Clemeno from a nearby Rotary Club, I was able to arrange for a visit into one of the shantytowns right outside of the IRRI gates. I was introduced to a community leader, Lucia, who was more than happy to help me learn about the people in the community. After I wrote up a simple questionnaire (see Appendix 2) and had it translated into Tagalog, Lucia and the village captain helped me arrange a day when the heads of the families in the village would gather in a central location, take the survey, and speak with me.

I conducted the survey in one of the most impoverished villages, barangay Paciano Rizal, that was located right behind IRRI experimental fields. This was my effort to correlate specific details of the village members' lives such as income, educational resources, and medical care access with the severity and variety of their most common day-to-day problems and ambitions. I analyzed the data that I collected and found many general, yet extremely interesting trends. I tried to make my own conclusions in an effort to better understand the lives of some of the poorest Filipinos and how their life situations can best be helped and improved.

Paciano Rizal is comprised of a long line of concrete shanty houses along a rusting government-owned railroad. The residents purchase a one-time license from the government for the right to set up a shanty in the tiny area between the railroad and the dirt road. Venturing past these shanties, a few more established houses mark the slightly more well off of families. The people that live in the shanties are mostly migrant workers, many of whom moved to the village to work as contract field workers at IRRI. These people have dreams that to the rest of the world, may appear to be quite fundamental and small. A woman at the age of 60 still wrote in her survey that her dream is to own a house. Almost all of the people who took the survey said in way or another that they would like to give their families a better life, to make just a little more so that their children could go to school or to do a little better financially than to merely break even.

On a Saturday morning, I gave the surveys on a voluntary basis. We set up the survey area right in front of the village medical building, right next to the open village square. I had the surveys translated into and printed in Tagalog, the Filipino language used on the island of Luzon. Two native Tagalog speakers, a well-established, older member of the village community named Lucia and Dennis Gavino from the IRRI Training Center served as my translators and helped transcribe oral responses for the survey participants that hadn't had much writing practice. The survey was given from 8 to 10am, and a light snack was provided for the participants.

I was able to learn so much about the lifestyle of Filipinos that were not so well off. Two rather open-ended prompts on my survey gave me answers that were particularly revealing and surprising. When I asked the question, "What is one thing that you would change about your life?" an overwhelming number of people echoed the same basic desires. The majority wanted a permanent job, to own a house, to own some land or a combination of the three. When asked, "Is there anything else you would like to tell me about your life?" a 49-year-old woman proudly responded, "We can eat three meals a day." Life is undoubtedly tough in Paciano Rizal. A man that was just 40 years old says, "I want to share the hardship of one who has no regular job and has reached old age." One 44-year-old woman wants to "improve my lifestyle and escape poverty" and another wants "a little more income so I can help my sick father and buy him medicine". Medical care access was also a difficulty; 28 of the 31 participants said that they could not always get medical care when they needed it.

Several factors were linked strongly with a higher income. The level of education of the villagers was highly positively correlated with monthly income. One fact that seems like improvement: all of the participants said that their children are currently in school. Paciano Rizal actually has a government-funded free elementary school right in the middle of it. This has clearly had a positive influence on the ability of families to begin educating their children. However, many said that they can barely afford to pay high school fees and one father voiced his need for "free education beyond elementary school" so he can afford to send his children there. Most farmers and contract workers earned the minimum income on the survey, less than 2500 pesos or ~$45 a month. Having the extra skills or technical school training really paid off; farmers that doubled as carpenters or owned a small business earned a much higher income and were noticeably better off.

In the Philippines, my tendency to be quick to engage myself in other similar endeavors that simply appear worthwhile really paid off. I was able to infuse my intense interest in community work and medicine with the science of my rice project. During an orientation my first week, I discovered a building partially hidden in the parking lot behind my dorm. After reading the banner draped across the small white building and curious as to what the "IRRI Safety Services Team" does, I wandered in and walked out a few minutes later having signed up for my first IRRI Outreach Medical Mission. Going on the missions resulted in days that were among the most rewarding and productive of my life. Due to the desperate need of health help, I, without a day of medical training backing me up, was put to work taking blood glucose and cholesterol readings. After I earned my rite of passage, I was hustled to the *backroom* and put in charge of the ECG machine. I conducted the checkup step right before the patients would proceed to visit with the only doctor.

The most amazing thing was how much trust the patients put in me. Most of the patients were elderly and absolutely melted with complete trust when I gave them a warm smile and reassured them with a firm, but gentle touch. They put all of their faith into me, waiting patiently as I cleaned off their chests and arranged the sensory electrodes on their chest, arms, and legs. The ECG machine was slightly dilapidated; it was still hand operated. However, it did the job and a long sheet of paper twirled out with all of the different heart beat patterns and waves etched out in thin ink. There are several emotions that I saw that day untainted—which are sometimes hard to find in mainstream American culture. Simple need, trust, and gratitude made me treasure my day's work all the more deeply, driving me to sign up for the next mission as soon as I returned from the first.

A medical representative that I met during the mission signed me up for a Physician's Cardiology Conference that would take place on the coming weekend. The theme being "Preventative Cardiology", I had the pleasure of sitting through an entire day of useful lectures on hypertension, congestive heart failure, and heart attacks. Many of the doctors that made presentations came right from the Los Baños and Laguna areas; they described how they sometimes must take common recommendations for cardiology care and modify them for the impoverished Filipino communities. In my eyes, the health care professionals that I met that day were truly heroic. They acknowledged the destitute financial conditions of many of their patients, yet were so determined in finding a way to give them health care that they could afford—be it prescribing lesser-known brand name of drugs to suggesting alternative medicine.

One thing led to another and before I knew it, Pam Cantrell offered to take me to a nearby Children's Feeding Center. This was started by SUHAY, a group of IRRI spouses and two Filipina ladies that provide the financial and administrative support to run two preschool centers. The children are between the ages of 3 and 6, and they come to the school to get their first exposure to colors, shapes, numbers, and the alphabet. Just as importantly, they are given a quality lunch, complete with a spoonful of vitamins. Mrs. Cantrell told me that these children were from the poorest of the poor financial backgrounds. Most of their parents are just "tricycle" drivers, the motorcycle sidecars that one can ride for a small fee. Even though they come from such indigent backgrounds, it is evident that Filipinos love their children. They were relatively strong children, more than eager to shout out the letters of the alphabet that the schoolteacher, Betty, traced out on the board. Dr. Cantrell arranged for me to come every Friday until the day I left; one of the most amazing experiences. Only at SUHAY have I felt so loved for my ability to belt out the Hokey Pokey, fold paper fans, and organize side games of *London Bridge Is Falling Down*.

One of my favorite parts of the internship was how I would often find myself in the simultaneous company of people from six of the seven continents. This meant that I could lend an ear to the descriptions of the intricacies of the Iranian educational system, the details of Indian arranged marriages, and the frustrations with the results of the European Soccer Cup all in one night. When every other person sitting at a particular cafeteria table hails from a different continent, it makes for some interesting conversation. It was fascinating to bring up a topics ranging from the Kyoto Protocol to presidential politics to countries' problems with drug abuse and to hear a raging Australian perspective of the need for drug decriminalization following a Dutch assessment of the negative externalities of the situation in the Netherlands.

Before and even during my daily immersion in exploring the science side of rice research in the lab and greenhouse, I was able to take advantage of the Filipino delights that the diversity and natural beauty of the country had to offer. After arriving at the IRRI dorm from the Manila airport closer to the hour of sunrise than sunset, my instinct to get out and explore the new environment was heightened to an extremely suggestive degree. This all culminated in my jumping on the first morning bus to metro Manila; the trip was chartered by the IRRI society of scholars, termed AFSTRI. In Manila, the city bustled me into quick introductions to jackfruit, traditional Filipino dress, shantytowns, and the art of waiting through the long, Filipino line. I was so glad to have been on that trip; I made friends that supported me with their humor and cultural explanations for the rest of my internship.

I was also pleasantly exposed to one of the aspects of the Filipino spirit—this being its natural gift of being able to achieve the perfect balance among so many different international cultures. The Filipino people acquired the invaluable technique to do so through much historical practice. After colonization by the Spanish, the Japanese, and the Americans within closely fitted time spans, Filipinos quickly and gracefully make additions to their ways of life. They do this so well because they know how to ground themselves in the strength that acceptance, caring, and amity offers. I have found that the people of the Philippines, with this loving spirit, are willing foster parents to all of their visitors. All people passing through the country seem to catch the contagious friendliness, which enhances their own spirits of camaraderie and thoughtfulness as they come through, leaving a bit of themselves and their own culture.

The natural beauty of the country matches with the beauty of the attitude of its people. One of the post-docs that I met on my first trip to Manila, Sarah Johnson, herself only a one-month resident of the area, took me on a welcome drive through the back weaves of Mount Makiling. An extinct volcano which rises right outside of IRRI gates, the mountain commands astounding view of deep valleys and gorges lush with palm and other towering trees. Everything in the forest was bold and lush—no petty little flowers with skinny stems. Bold splashes of color on thick, juicy petals constituted the typical flower. There was a perfect view of a distant lake, lined with fish-breeding boundaries. A dark mountain rose up in the background, peeking through the mist. This would be a series of natural surprises that attested to the variety of experiences that I had throughout my two-month stay.

The nearby mountains and surrounding ocean made for a fascinating facet of my internship experience in itself. Adventurous instincts soon led us to hike up Makiling, and our 9-member team grew incredibly close as we spent a day hopped among flat rocks arranged around gentle waterfalls, pushing each other up steep, muddy paths, and stopped for mutual leech-swiping sessions. I realized how lucky I was every time I gazed out car windows and my eyes met the constant landscape of towering coconut trees and glittering ocean silhouetted by a quiet sunset.

From all of my experiences in the Philippines, I noticed that Filipinos don't wait for good things to happen to them; they create their simple joys themselves. Everyone in the Philippines loved to sing and dance—such a pleasant and consistent cultural motif. Be it listening to the humming of the contract workers, or participating in the sing-along that was led by two doctors in the group of Cardiologists at the medical conference, music was everywhere. The Filipino people have a very strong sense of community and mutual caring. During my time at IRRI, a group of employees put on a night called *Songs for Francis*. IRRI staff and their families packed into the IRRI club to support contestants—mainly enthusiastic employees and their willing family members—in a heart-warming attempt to raise money for a co-worker's accumulated medical bills since a recent battle with cancer. They beautifully used their love of song to sing in unanimous support for a friend in need.

As is evident through all my Filipino experiences, both in and out of the lab, the people of the Philippines are truly a remarkable group. Many of them don't have very much in monetary terms, but are still able to find it worthwhile to work hard to help their worse-off friends and to infuse their children with love.

During the months of my internship, I not only became fascinated with rice genetics and exciting laboratory work. I would like to think that in addition to exploring the social, scientific, and personal aspects of my mother's Chinese rice poem about the dedicated life of a farmer, I became a little more Filipina. What could be more Filipina than two months of being surrounded by truly internationally minded people, letting my curiosity run wild, exploring my passions in medicine and community service, being doused in rich encounters with nature, and loving fresh buko pie? These two months have given me the chance to witness ongoing experiments for simple happiness—both in the Filipino people and in the grains of rice.

Acknowledgements

I am truly honored that the World Food Prize Foundation has given me the opportunity to engage in such an incredible internship experience. In particular, I would like to express my gratitude to Dr. Norman Borlaug, Mr. John Ruan, Ambassador Kenneth Quinn, and Lisa Fleming.

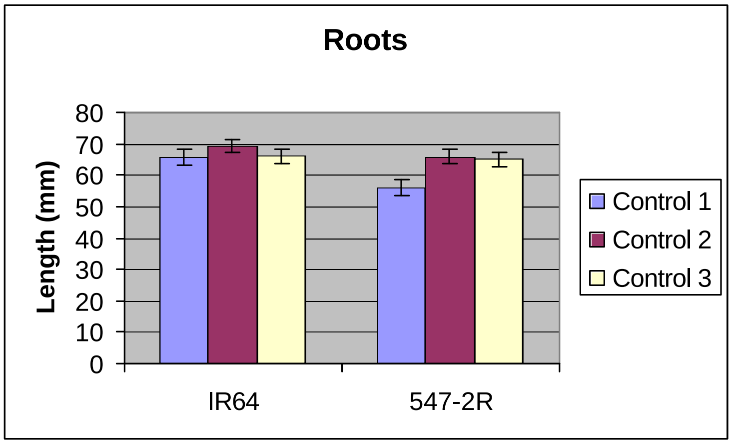
I also thank the International Rice Research Institute, especially Drs. Lafitte and Bennett, who both warmly welcomed me into their research groups. Thanks to the graduate students and scientists that gave me such invaluable advice and help, particularly Jill Cairns, Xin Ai Zhao, Lakshmi Manavalan, Xuemei Ji, and Nards.

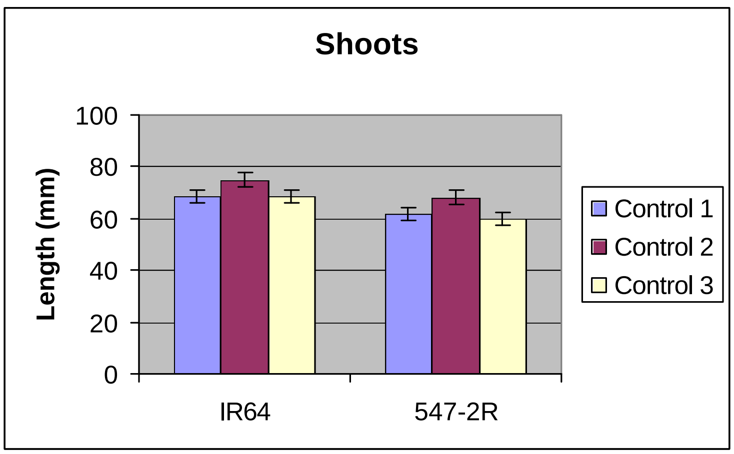
A huge thank you again to Lisa Fleming for looking out for me and making me feel well cared for. Thank you, Sarah Johnson, for being such a great Los Baños friend. Thanks always to my family for their constant encouragement and support.

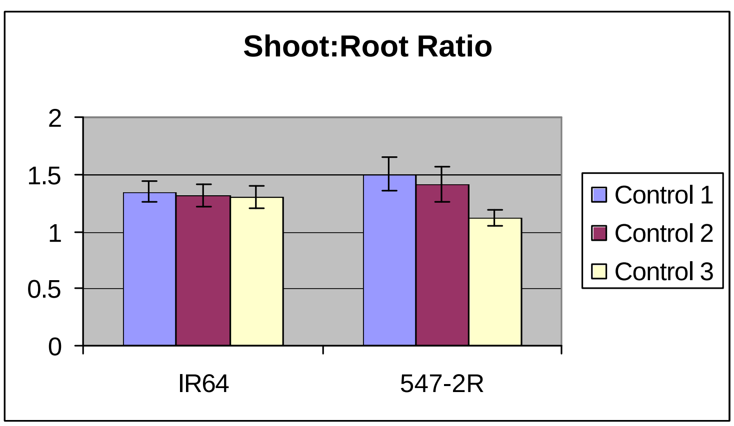
APPENDIX ONE

Plating Experiment Graphs and Conclusions

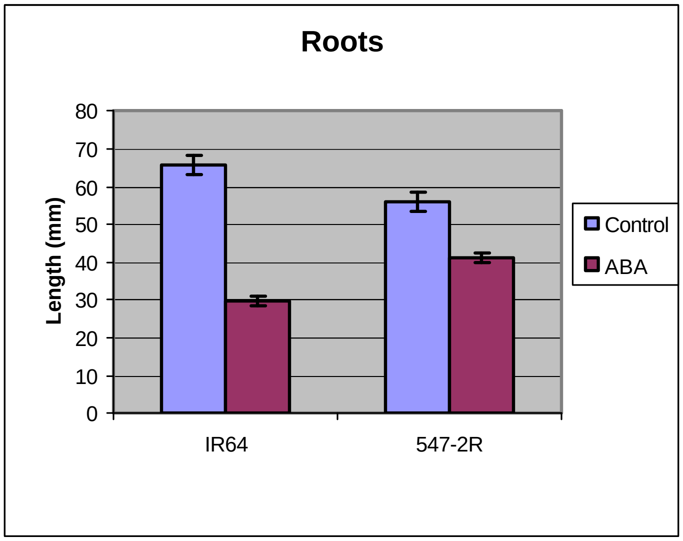
IR64 v. 547-2R: Replication 1 Comparing Controls



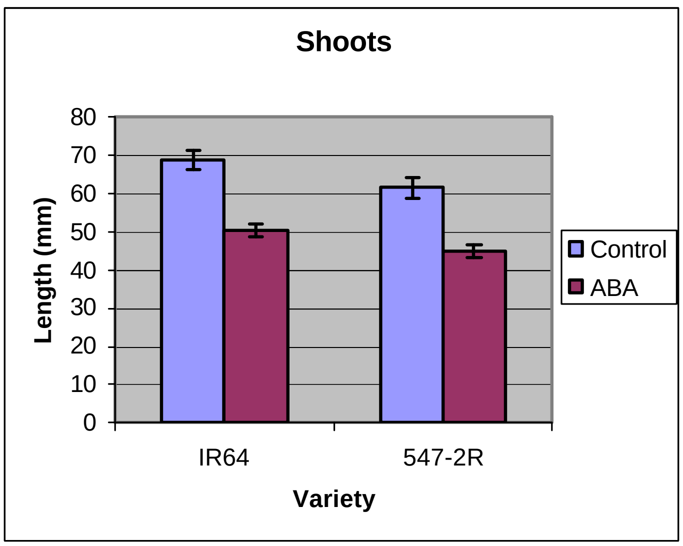




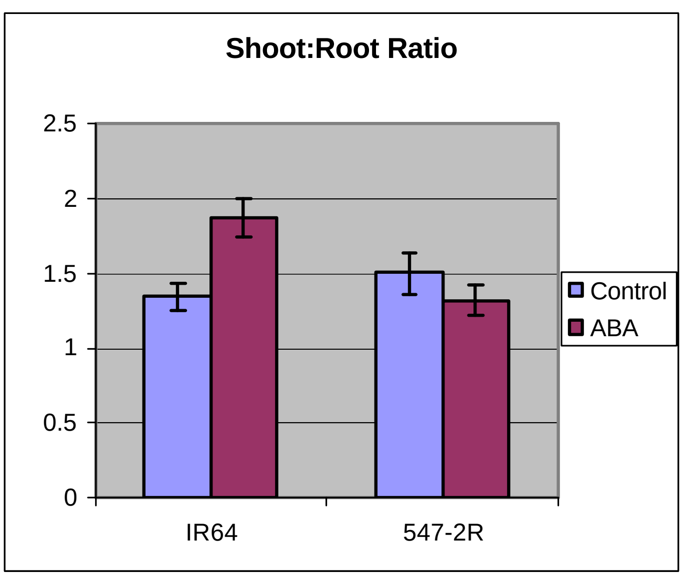
IR64 v. 547-2R: Replication 1 ABA Addition



An ABA concentration of 0.375µM had a general inhibitory effect on root growth. The root length of 547-2R was shortened much less than that of IR64. ABA did not have as pronounced of an effect on the root growth of 547-2R as it does on those of IR64.

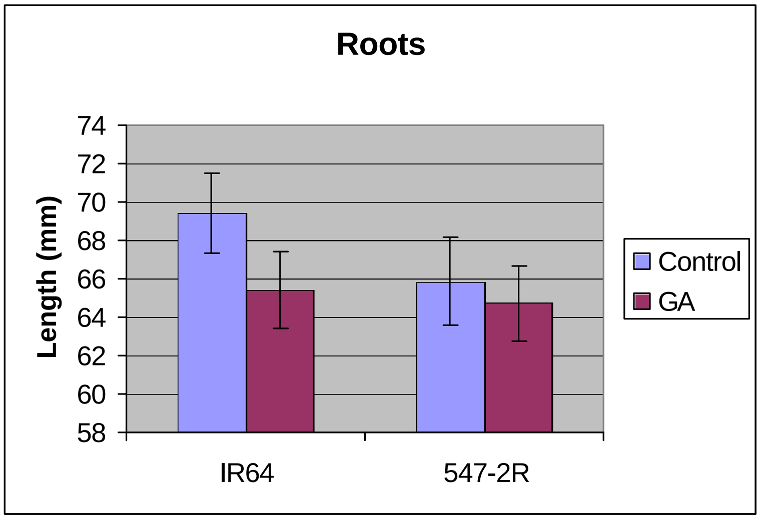


ABA [0.375µM] had an inhibitory effect on the growth of plant shoots of both IR64 and 547-2R. The effects on both varieties were of similar magnitude.

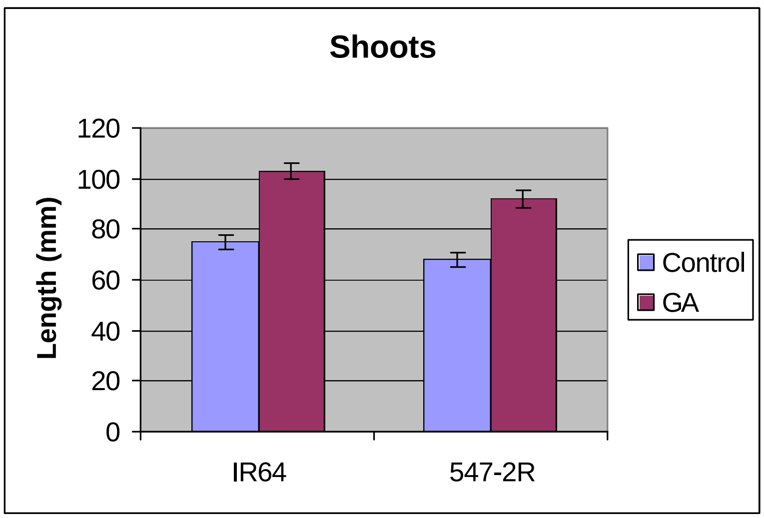


ABA [0.375µM] did not have a noticeable effect on the shoot to root ratio of 547-2R. However, it increased the shoot/root ratio in IR64.

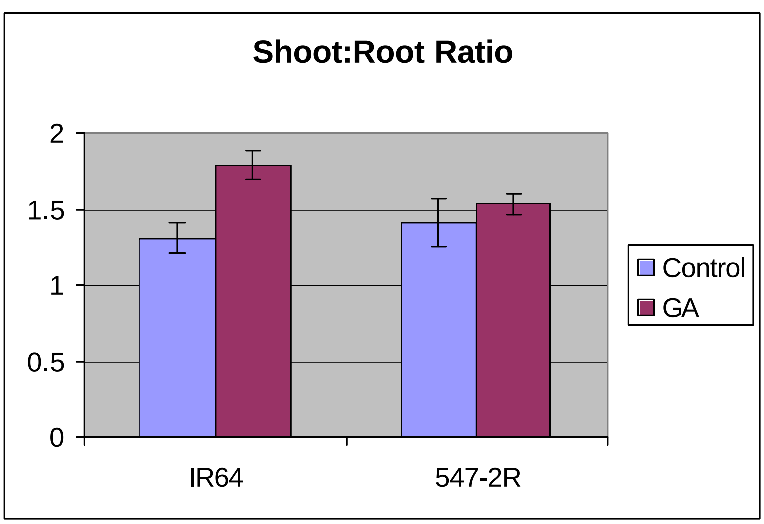
IR64 v. 547-2R: Replication 1 GA Addition



GA [50µM] may have had an inhibitory effect on the root growth of IR64. The error bars of 547-2R overlap, but the effect may also be inhibitory.

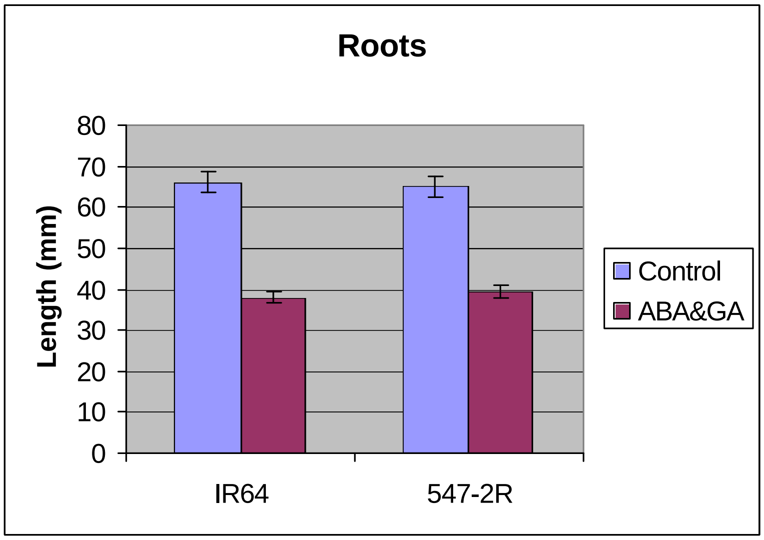


GA [50µM] stimulated shoot growth in both IR64 and 547-2R. The shoot lengths of the two varieties increased with similar magnitude.

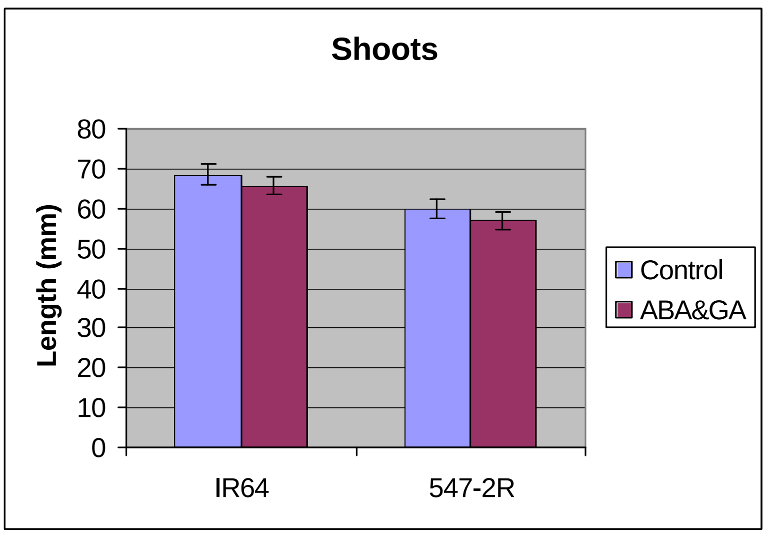


GA [50µM] increased the shoot to root ratio of IR64. There was an apparent increase in shoot/root ratio in 547-2R, but there was overlap of the error bars.

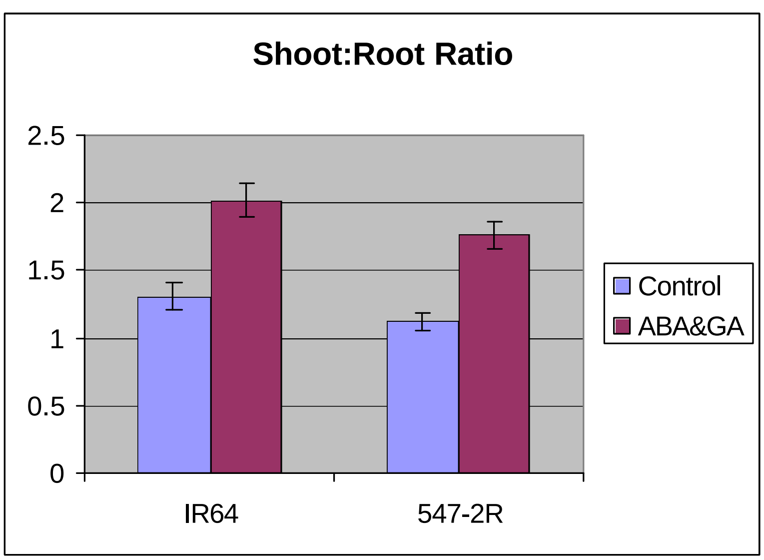
IR64 v. 547-2R: Replication 1 ABA&GA Addition



A concentration of 50µM GA and 0.375µM ABA resulted in a general inhibitory effect on the root lengths of both IR64 and 547-2R of similar magnitude.

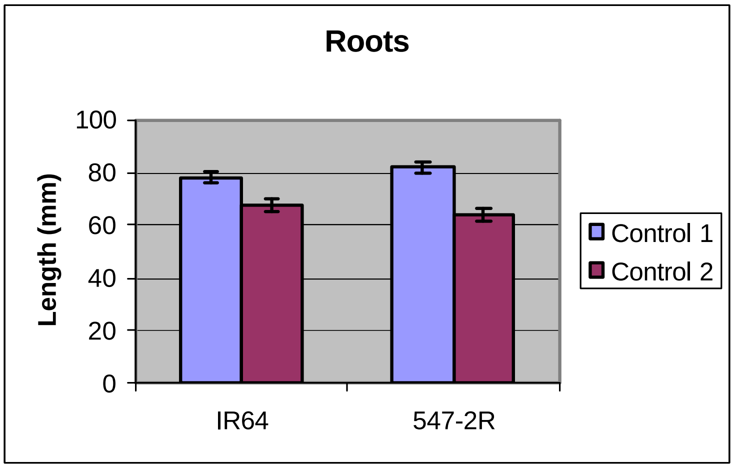


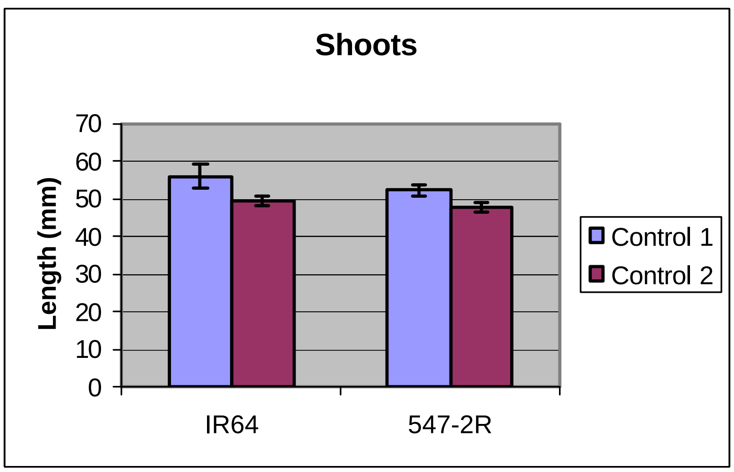
Only a slight inhibitory change in shoot growth was seen with GA [50µM] and ABA [0.375µM].

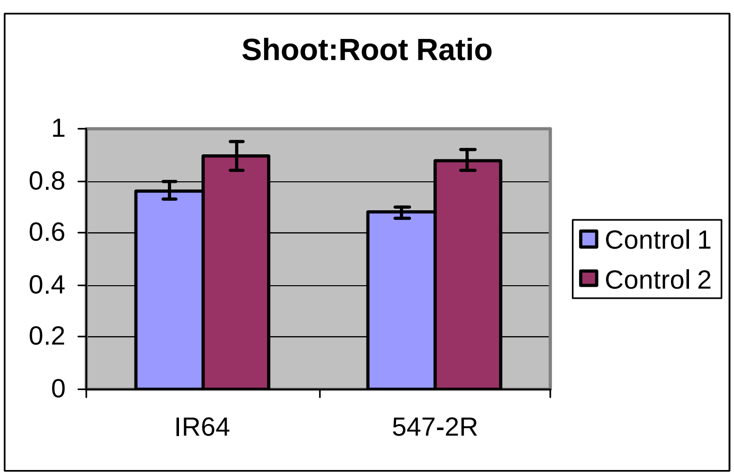


GA [50µM] and ABA [0.375µM] greatly increased the shoot to root ratio of both IR64 and 547-2R varieties with a similar magnitude.

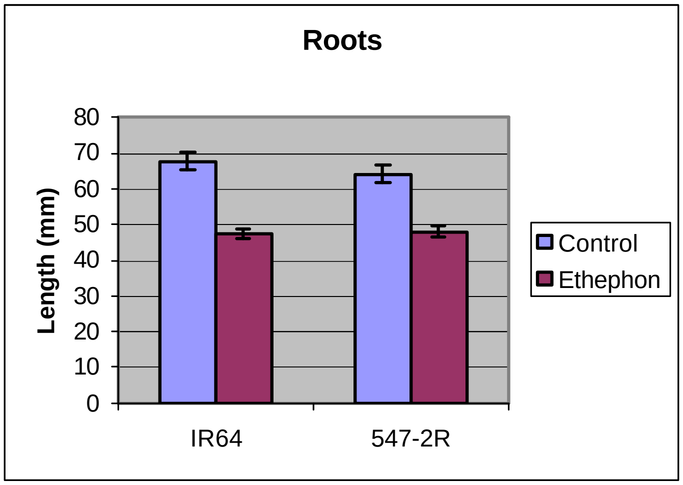
IR64 v. 547-2R: Replication 2 Comparing Controls



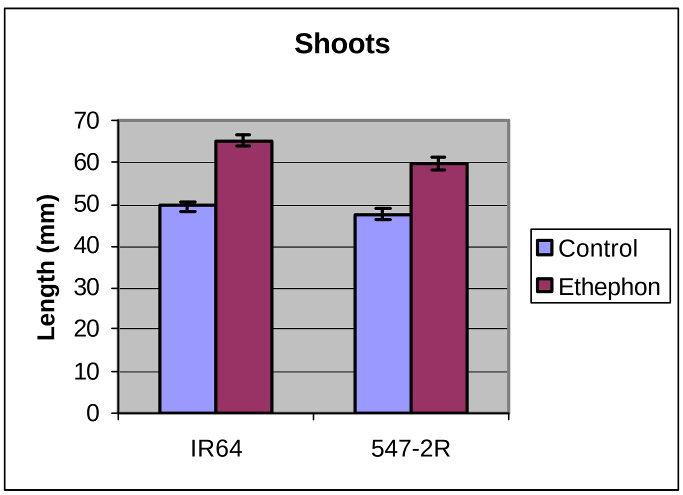




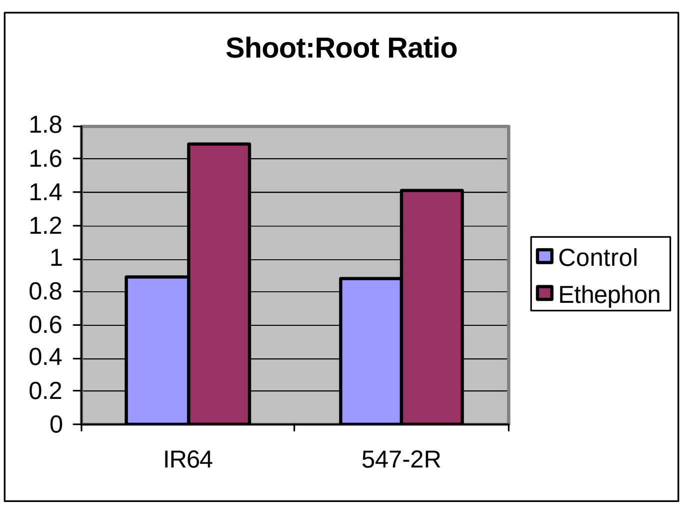
IR64 v. 547-2R: Replication 2 Ethephon Addition



An Ethephon concentration of 1mM had a general inhibitory effect on root growth. Ethephon shortened the root lengths of IR64 and 547-2R with the same magnitude.

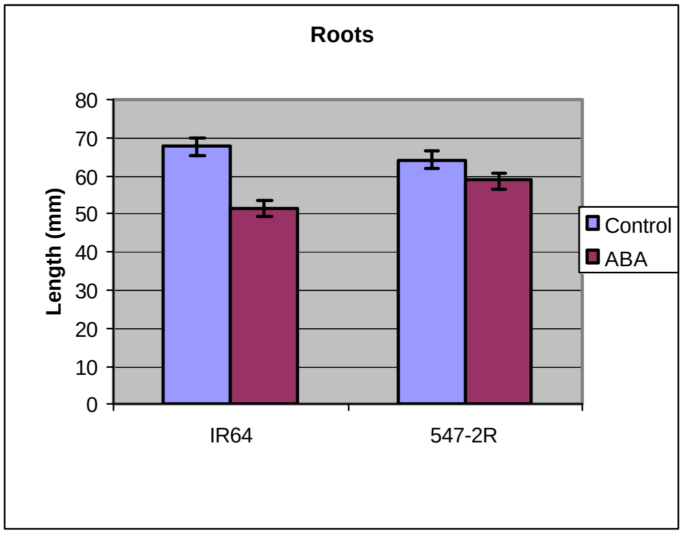


Ethephon [1mM] had an elongation effect on the growth of plant shoots of both IR64 and 547-2R. The effects were slightly more pronounced in IR64 than 547-2R.

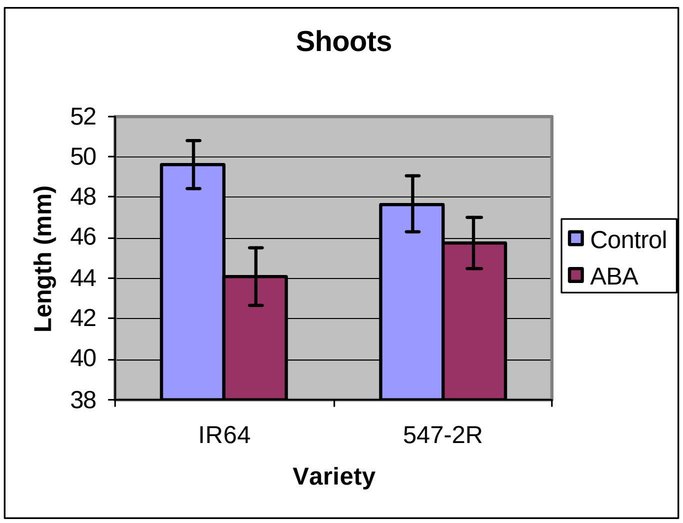


Ethephon [1mM] increased the shoot: root ratio of both IR64 and 547-2R. There was a more pronounced increase in IR64.

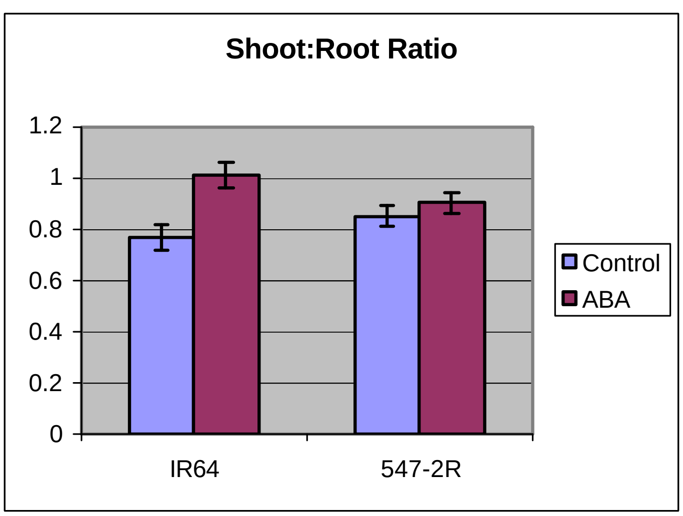
IR64 v. 547-2R: Replication 2 ABA Addition



An ABA concentration of 0.375µM had a general inhibitory effect on root growth. The root length of 547-2R was shortened much less than that of IR64. ABA did not have as pronounced of an effect on the root growth of 547-2R as it does on those of IR64.

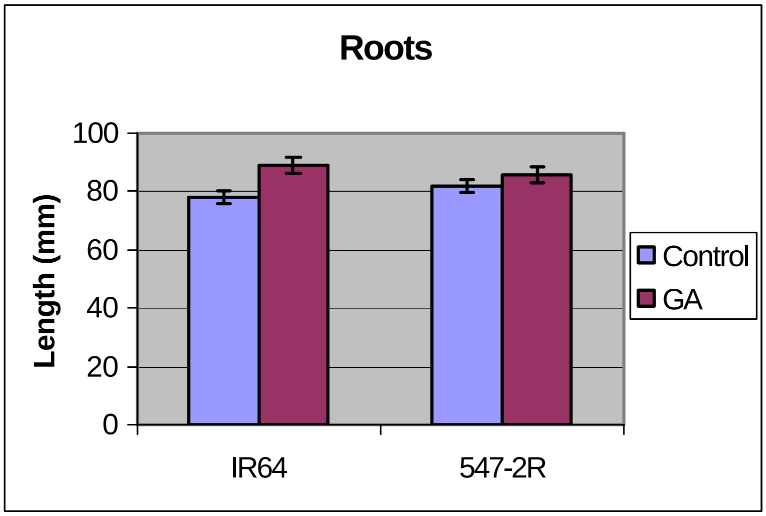


ABA [0.375µM] had an inhibitory effect on the growth of plant shoots of both IR64 and 547-2R. The effect was more pronounced with IR64 than with 547-2R.

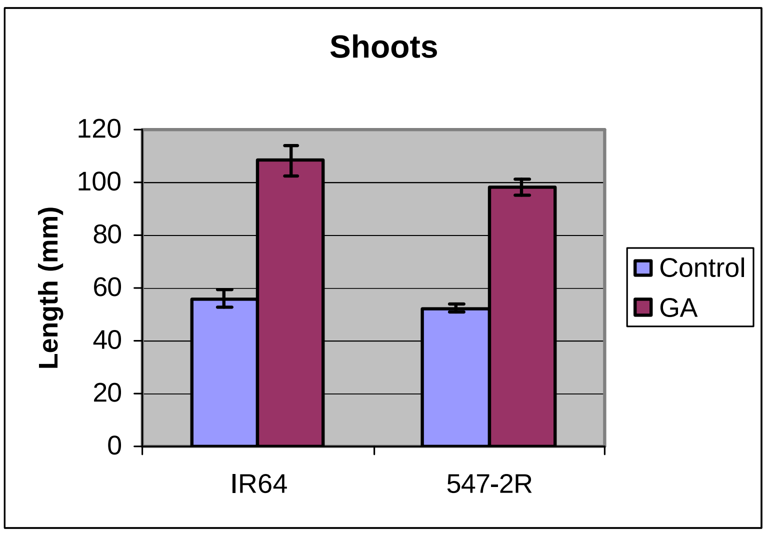


ABA [0.375µM] had an increasing effect on the shoot to root ratio of both IR64 and 547-2R.

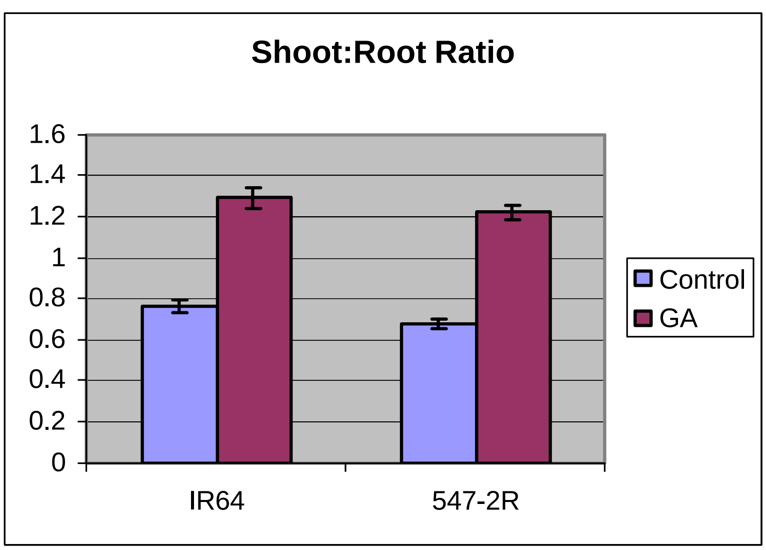
IR64 v. 547-2R: Replication 2 GA Addition



GA [50µM] may have had a stimulatory effect on the root growth of both IR64 and 547-2R. The error bars of 547-2R overlap, but the effect still seems stimulatory.

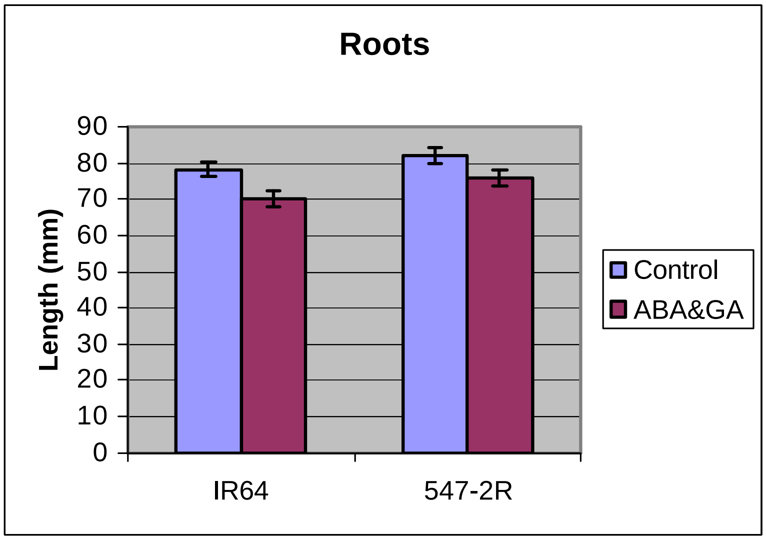


GA [50µM] stimulated shoot growth in both IR64 and 547-2R. The shoot lengths of the two varieties increased with similar magnitude.

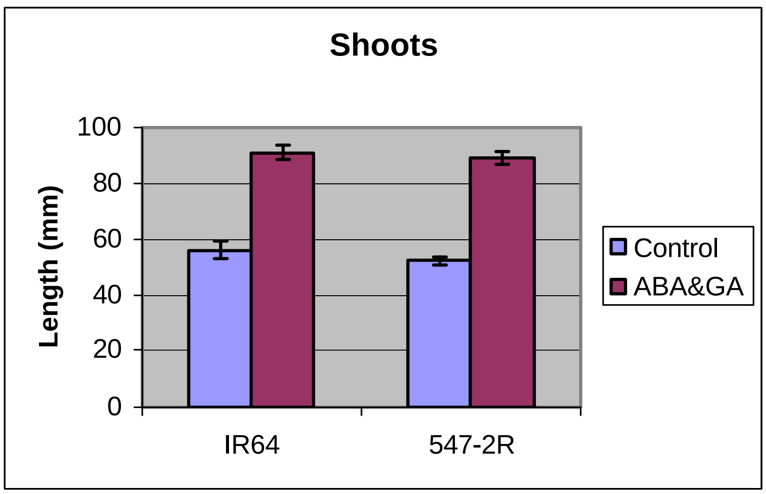


GA [50µM] increased the shoot to root ratio of IR64 and 547-2R with approximately the same magnitude.

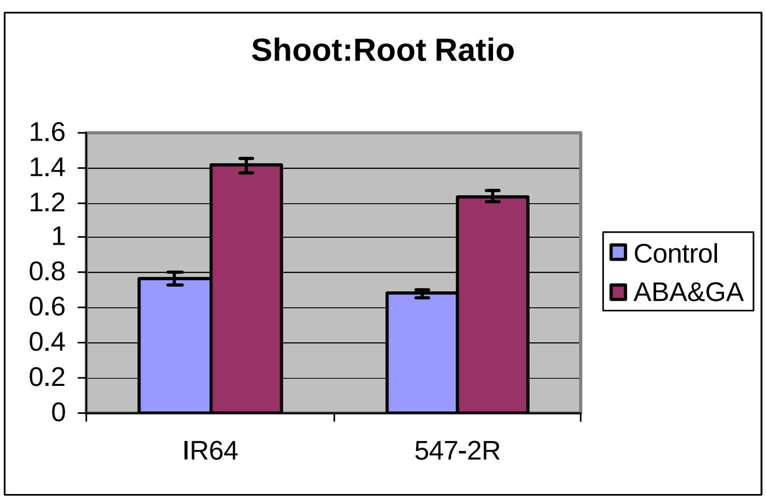
IR64 v. 547-2R: Replication 2 ABA&GA Addition



A concentration of 50µM GA and 0.375µM ABA resulted in a general inhibitory effect on the root lengths of both IR64 and 547-2R of similar magnitude.



A pronounced elongation effect on shoot growth was seen with both IR64 and 547-2R with GA [50µM] and ABA [0.375µM]. The conditions come close to doubling the shoot length.



GA [50µM] and ABA [0.375µM] greatly increased the shoot to root ratio of both IR64 and 547-2R varieties with a similar magnitude.