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Ensuring Food security in India through Scientific Research in Crop Biology and Agronomic Techniques

My interest in food security in India arises from my family's history of farming in India. Through discussions with my grandfather, a farmer in India, I have learned that maintaining food security in India is an issue of great concern. Before the agricultural breakthroughs of the Indian Green Revolution, India produced 6.6million tons of wheat in 1947 and 51.4 million tons of rice in 1961 (http://dacnet.nic.in/dwd/wheat_prod1/history.htm; http://www.irri.org/science/ricestat/data/may2008/WRS2008-Table07.pdf). In 1998, India produced 66.4 million tons of wheat and 129.1 million tons of rice (http://www.fao.org/es/ess/toptrade/trade.aspa; http://www.fas.usda.gov/remote/india/wheat2000/wht_map/wht_map.html). Although India has multipled its grain production in recent years, malnutrition and population growth continue to rise (Prakash and Conko, 2004). Before the Green Revolution, India was dependent on food aid to alleviate poverty and the threat of starvation, but soon after dwarf disease resistant wheat cultivars were introduced in India, the country became self sufficient. The Indian population is better fed than ever before, even though the region's population has increased (Prakash and Conko, 2004). However, the Green Revolution's success can only be maintained with a stable population, and the Indian population has been steadily rising. (http://www.indiadaily.com/editorial/1710.asp). India's population was 863.3 million between the years 1990 to 1992 and had increased to 1065.4 million by 2002 (http://www.fao.org/faostat/foodsecurity/MDG/EN/India_e.pdf). The UN has predicted that by the year 2030 the population growth of India will exceed that of China. By 2025 India's population will reach 1,395 million, and by 2050 it will reach to 1,593 million (http://www.indiadaily.com/editorial/1710.asp). This increase in population and the development of new pathogens and insects, drought threats, decreasing water tables, increasing salinity, strict regulation of genetically modified organisms (GMO), and failing economy may offset the improvements created by the Green Revolution. The extent of the problems currently facing India is evident. For example, in 2000 28.6% of the total Indian population was living below the national poverty line. In the years 2001 and 2003, 20% of the population was classified as malnourished (http://faostat.fao.org/). New technological advancements in crop production and biological breakthroughs must be accepted and distributed throughout India in order to address food security. Currently there is little chance of acceptance of these advancements because of wide spread fear of GMOs and lack of funding for technology replacements. There are many technologies and crop improvements that would sustain the environment, provide drought and disease tolerance, and improve yields. Advancements such as bed planting, conservation tillage, drainage systems, transgenic crops and nutrient fortified crops would succeed in supporting a growing global population while targeting malnutrition and starvation in India. Consequentially, biotechnology policy and funding will need to be modified for technology to become accepted and the shift from a Green Revolution to a Gene Revolution must be realized. Therefore, an increase in agricultural productivity and improved food security in India can be implemented by conducting research into crop biology and agricultural technology to improve yields, disease, and drought tolerance, to protect the environment and economy.

My paternal grandfather has experienced the life of a subsistence farmer in India and related this information about his first hand experience. The need to concentrate on the rural poor arises from the malnutrition and starvation that occur daily from low crop production. A farming family in India normally consists of five to six people, two adults and three to four children. The children go to school until the fifth grade, and normally drop out to work on the family farm. The few that do go into junior high school rarely continue into college due to the shortage of colleges in the area and too much work to be done on the family farm. Subsistence farmers grow rice in the South of India and wheat in the North. The family may also cultivate a small vegetable garden near the house, and rely on this for food when there is no surplus of crop to sell or trade for vegetables. The Southern diet is mainly composed of rice and vegetables such as: squash, eggplants, and okra, and more recently tomatoes, garlic, cabbage, cauliflower, ginger, and onion. The Northern diet is composed of wheat and many of the same vegetables grown in the South. The average diet consists of 428g of cereals per day, indicating the need to diversify the diet of farmers. Subsistence farmers also grow ground nuts, spices, coconuts, and sugarcane to eat and to sell. The average farm size is two to three acres, and an excess of five acres is rare. With the use of primitive technology, the farmers carry their surplus crop to the closest markets and sell to whole-sale buyers. Although this may not suit the traditional definition of subsistence farming, this is the condition in many parts of India. The average income per day is about 80 rupees (two dollars) for men, and 60 rupees (one and a half dollars) for women. This shows the disadvantage of the women because they bring in less money than men (Krishnamurthy, personal communication).

Some recent agricultural practices have caused determental health and environmental effects. Before the introduction of fertilizers and pesticides, many farmers fertilized their crops with cow dung and leaves. Currently many farmers use commercial fertilizer and use pesticides without proper protective equipment, harming themselves and polluting the environment. For example, in China about 400 to 500 cotton farmers die every year from acute pesticide poisoning, a figure that probably relates to Indian statistics (Prakash and Conko, 2004). The reason for the use of additional chemicals is because of the development of new strains of pathogens and insects. In the North, the threat of locusts is ever present, and in both the North and South the threat of shoot borers and bollworms exists. A large portion of a farmer's cost input goes into buying pesticides to combat the bollworm. However, the creation of Bollguard, a transgenic cotton plant, resistant to bollworm saves farmers an average of 1,600 rupees for every acre due to reduced need for pesticide (Damodaran, 2000, http://www.financialexpress.com/fe_full_story.php?content_id=169723). In the South, rice normally needs spraying two to three times during its growing season, and sugarcane also needs to be sprayed. Aside from spraying, the farmers use ground water and water storage tanks to water their plants. Although the electricity to pump their water from the ground is free, the electricity is rarely working. Additionally, the government hinders the production of rice and wheat by restricting the use of genetically modified plants that would decrease the use of fertilizers and pesticides (Prakash and Conko, 2004). Another barrier is the insecurity of banks to provide loans to poor farmers to buy cattle and seed. Any large loans to buy farm equipment, such as tractors, are not possible. Therefore, farmers resort to loan sharks, who charge 36 to 48 percent of the original price, and the farmer will be paying the loan for most of his life. New career opportunities for farmers, such as construction are more appealing because they pay more. Farmers lose farmhands and hire replacement farmhands at higher wages. Additionally, the land is divided in such a way that a farmer may have multiple, scattered small farms in different parts of the village. He may rely on other farmers to water his crops, and this requires the farmer to pay a part of the final produce. All of these debts leave the farmer with very little to spend on buying new seed, improving his farm, and diet.

Presently, lack of biological research lowers income and food because it lowers the amount of produce. For example, 40 percent of all crop productivity in Africa and Asia, including India, is lost to biotic stresses, such as pests, weeds, and plant diseases (Prakash and Conko, 2003). However, biological research discoveries can reduce losses by providing resistance to biotic stresses. Unfortunately, the Indian government also does not provide transportation or information to encourage farmers to use these new cultivars of seed. Additionally, the Indian government does not support the production or distribution of genetically modified organisms (Potrykus, 2004). There have been cases of Indian farmers illegally planting seed cultivars that were still under government review (Prakash and Conko, 2003). The use of genetically improved plants could save millions of acres of sensitive wildlife habitat from being converted into farmland (Prakash and Conko, 2003). The Green Revolution shows that the same amount of land can support larger populations (even after a 50 percent increase) in population, because of the proper application of new technologies (Prakash and Conko, 2004).

The introduction of new technologies, such as GMO’s, marker assisted selection, etc. will be necessary to supplement the yield improvements gained through the Green Revolution and conventional crop improvement technologies.. However, the system is so congested with fear that many are against the use of these relatively risk-free GMO seeds (Borlaug, 2000). The fear that additional DNA from other species inserted into plants is unnatural and can potentially cause antibiotic resistance or present new allergens because of the introduction of bacterial genes has no scientific backing(Doyle, 1999). Specific BT toxins target certain insects and should have no effect on non-target species (Doyle, 1999). The introduction of BT cotton came about because it does not directly affect the human diet; however, cows feed on the byproducts of the cotton fodder. Therefore, this GMO product will be consumed by humans through dairy products, yet there have been no negative effects on human life to the present date. (Gupta personal interview). The scientists that are able and willing to produce these transgenic seeds are discouraged by the hurdles needed to be passed in order to manufacture and distribute the seed (Potrykus, 2004). However, transgenic cultivars are now grown on 58.7 million hectares in developing and advanced countries, and nearly one quarter of this is farmed by five million resource- poor farmers in under developed countries (Prakash and Conko, 2003). Progress in biological research can be measured in the number of GMO crops released versus the number of cultivars developed, the number of scientists available to apply the science of GMOs to India, and the growth in yield production. The acceptance of transgenic cultivars is slow, but figures show that the new seeds are slowly being absorbed by society. For example BT cultivars are popular among farmers because they reduce pesticide spraying, water absorption, work hours and deliver a profit increase (Prakash and Conko, 2004). There has been an increase in the acceptance of GMO crops throughout the world, but India is needlessly shutting down research and utilization of GMOs, with the exception of BT cotton. (Borlaug, 2000). If there is an increase in biological research in India, the families will be better fed, nourished, and have higher incomes. However, Indian farmers currently have restricted access to GMO’s due to the strict regulation of most GMO crops. This leaves farmers with little options except resorting to illegal smuggling of crop seeds or reusing previous seeds and receiving a low harvest. The deregulation of anti-GMO rules is advised so that the poor farmers do not suffer. For example, the success of BT cotton in India can serve as an example of the positive impact of GMO crops. With the acceptance of BT cotton in India came the additional gain of fewer 10-hour work days, fewer watering sessions, and a 30-40 percent profit increase (Prakash and Conko, 2003; Prakash and Conko, 2004). Use of BT cotton cultivars resulted in a yield increase of 50% over the conventional, non-BT cotton cultivars. In addition, BT cotton farmers also earned 7,039 Rupees per acre in excess of what would typically be earned growing non-BT cultivars. Furthermore, the reduction in pesticide costs resulted in an additional savings of 1,600 Rupees per acre for BT cotton farmers (http://www.financialexpress.com/fe_full_story.php?content_id=169723). With GMO crops, a farm family can receive a profit and harvest increase, and a decrease in pesticide cost, water cost, and work hours (Prakash and Conko 2003; Prakash and Conko, 2004).

Although there is an increase in genetically modified crop usage in many parts of the world, this trend is not as prominent in developing countries (Borlaug, 2000). Unfortunately, the developing countries do not realize that they add to the economic pressure for cereal products when doing so, and allow more of their people to starve (Borlaug, 2000). However, the governments continue to have stringent regulation on GMOs that would benefit the thousands of people facing starvation and malnutrition. Opponents of GMO crops may claim they are unnatural; however, for thousands of years humans have been genetically altering crops through traditional plant breeding and selection methods (Potrykus, 2004). The reason why developing governments feel unsafe with the GMOs is because they are less experienced with the regulation and production of the products. The richer and more advanced societies can afford to grow organic because the society can afford to pay for organic produce, but developing countries cannot follow the same pathway (Borlaug, 2000).

The main transgenic product that should be implemented in developing countries that rely on rice is Golden Rice. However, the production of Golden Rice, with the use of two daffodil and one bacterial gene, caused unnecessary safety concerns and caused the Indian government to postpone its usage indefinitely (Conway, 2001). The rice is formulated to provide 10-20 percent of the dietary Vitamin A requirements of a child (Conway, 2001), and reduces the amount of children that go blind from Vitamin A deficiency (VAD). Globally, over one-hundred million children are affected by VAD each year, two million will die, and 500,000 will go blind (Conway, 2001). Greenpeace labels golden rice as “fools' gold” and a quick fix, but changing people's farming patterns and lifestyles takes time (Conway, 2001). The best sources of vitamin A are animal products, such as butter, eggs, cheese, and liver, but these items are often out of the reach of the poor. The new Syngenta strain of Golden Rice produces up to twenty times more vitamin A than the previous strains (Black, 2005). Additionally, Syngenta is willing to donate the rice free of charge to farmers who make less than $10,000 dollars, and the World Food Program also accepts food donations that meet the safety standard of the donor country, but governments must first accept the transgenic crops (http://www.goldenrice.org/). Scientists from the Swiss Federal Institute of Technology and the International Rice Research Institute have further increased the amount of vitamin A, iron, and other micronutrients (Borlaug, 2000). In 2000, after the crop was invented, it was announced that the plant would be released in two to three years, but overregulation delayed the release (Enserink, 2008). Eight years later, field tests have just begun because humanitarian corporations did not have the money to satisfy the required regulatory testing. The current predicted release date of Golden Rice is 2011, but most likely the release time will be further delayed (Enserink, 2008). Reducing strict regulation is key to making Golden Rice available to help combat malnutrition and VAD in India.

The implementation of improved agricultural technologies is also needed to support crop improvement advances. The combination of conservation tillage, bed planting, and improved drainage systems will save water, money, and increase productivity (Borlaug and Dowswell, 2000). In research projects carried out in Mexico, scientists tested to see which method of agriculture would be most effective: conventional tilling beds and incorporating residues of previous plantings, creating permanent beds and burning the residues, creating permanent beds and removing the residues, or creating permanent beds and incorporating the residues (Ortega et. al., 2000). Farmers normally use bed planting systems, in which plants are sowed on ridges to better manage water, fertilizer, and weeds with less crop lodging, or by planting and burning the wheat (Ortega et. al., 2000; http://www.css.cornell.edu/faculty/hobbs/File%20posters/posterBP1.pdf). The research showed that planting and rotating in permanent beds with retained residue resulted in more stable and higher wheat yields (http://www.css.cornell.edu/faculty/hobbs/File%20posters/posterBP1.pdf). This is most likely the practice in present day India and the results should be implemented. The bed planting system combined with conservation tillage, which is the practice of leaving plant and stubble residues on top of the soil, improves the physical, chemical, and biological components of the soil (http://www.css.cornell.edu/faculty/hobbs/File%20posters/posterBP1.pdf). Reduced tillage also lowers production costs, increases nitrogen uptake, and decreases water consumption. Additionally, the government should rethink and redirect their use of drainage funds. The Indian government should follow suggestions for developing countries and begin to channel the drainage funds to provide longterm irrigation systems that maintain water tables through proper water drainage and removal systems, which decrease the threat of salinization or flooding (Borlaug and Cowswell, 2000). With the implementation of these technologies, the poor farmers will have a broad profit increase resulting from a decrease in water usage and harvest increases.

If all these suggestions are implemented, then Indian farm life will inmrove positively. Indian farmers will become economically prosperous, and as people become more prosperous they become independent and will improve the quality of their diets (Doyle, 1999). The diversification in a farmer's diet allows India to become a self-reliant country that can provide the necessary dietary vitamins and minerals for its population. For example, the acceptance of BT cotton has reduced the amount of Rupees spent on pesticides, and increased yield and income. (http://www.financialexpress.com/fe_full_story.php?content_id=169723). The farmers can use the increased cash flow to buy health care, eat better foods, invest in better seeds, etc. The other GMOs that are waiting to be released, such as BT eggplant, BT tomatoes, and Golden Rice, will likely have the same results as the BT cotton. An increase in crop biology and agricultural technologies will be a positive change in the lives of the subsistence farmers in India. Fewer people will die from malnutrition and starvation, and the introduction of new technologies will entice future and present farmers to continue farming.

The implementation of the new technological advancements should be made in stages. Instead of over regulating genetically modified crops, the government should establish regulatory frameworks to guide testing (Borlaug, 2000). Secondly, they should provide improved roads for easy transportation and enhanced educational systems so that future generations can receive an improved education. Next, governments should educate the farmers about opportunities to receive seed free of charge from organizations. Government support is needed to educate farmers about crop advancements and new agronomic practices to best fit the needs of the region. The Indian government should also encourage the establishment of banks in the rural towns so that farmers have easy access to money, instead of falling prey to loan sharks, and can offer the increased income they receive from agricultural improvements as security for loans. Corporations, such as Syngenta, are already fulfilling their potential, but they should work with the government and the subsistence farmers, so that an increased awareness of the problems of farmers and the government can be provided and targeted. For example, the acceptance of transgenic corn from the U.S. in Zambia to save 2.3 million starving people shows the potential of agricultural advancements (http://www.ens-newswire.com/ens/jul2002/2002-07-29-01.asp). Other corporations should also follow the lead of Syngenta and provide aid to developing nations.

My grandfather's experiences made me aware of the challenges facing food security in India. I believe that the acceptance of improved crops and advanced technologies will increase agricultural productivity and food security in India. This increase in agricultural productivity and improved food security can be implemented by conducting research into crop biology and agricultural production technologies to improve yields, disease and drought tolerance, and to protect the environment and economy. Golden Rice represents the first bio-fortified product through genetic engineering and should be distributed to India and other developing countries. GMOs, such as BT crops, reduce pesticide cost and increase yield (Potrykus, 2004). Additionally, there are no specific risks associated with the technology of GMOs that would not be present in traditional plant breeding (Potrykus, 2004). GMO crops also have the potential to support and complement traditional methods of breeding, so a complete replacement is not necessary (Potrykus, 2004). Studies have found that bioengineered crops are as safe to consume as conventional crops, and may even detoxify some risky Indian foods, such as kesar dal and tapioca (Prakash and Conko, 2004; Harish Damodaran, 2000). Unless the scientific breakthroughs are accepted and properly regulated by the government, the lifestyle of many farmers may remain inadequate and challenging, encouraging many farmers to leave the farming community for jobs elsewhere. By the year 2020 most Asian countries will have more people living in urban areas rather than rural areas (Borlaug and Dowswell, 2000). Although there are many technologies and crop improvements that would sustain the environment, provide drought and disease tolerance, and improve yields, the implementation of these technologies needs a carefully planned step by step schedule. Advancements such as bed planting, conservation tillage, drainage systems, transgenic crops, and nutrient fortified crops would succeed in supporting a growing global population and economy, while targeting malnutrition and starvation present in India. By the year 2025, the world will need to double its current food production, and with the stringent regulations present on GMOs this prospect sounds daunting, especially combined with the knowledge that India's population will be the largest in the world (Borlaug, 2000; http://www.indiadaily.com/editorial/1710.asp). The government needs to overcome strict regulations and adopt crop and agronomic improvements in order to maintain food security in India. In the words of Dr. Norman Borlaug “Nowhere is it more important for knowledge to confront fear born of ignorance than in the production of food, still the basic human activity” (Borlaug, 2000).

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