Meera Sury, Student Participant
Roseville Area High School
Roseville, Minnesota

India: Using Scientific Research to Decrease Yield Losses

Introduction

The Republic of India has always been a nation whose economy is largely focused on agriculture. Today, about 50% of India's population is employed in the agricultural industry, and this number is slowly decreasing because of higher paying and greater numbers of jobs in big cities, like Mumbai, Chennai, and New Delhi. India became self-sufficient and eliminated its need to import food after the Green Revolution, but today, new solutions are needed in order to stay this way. In order to produce the food necessary and keep small-scale farmers working, new technologies are necessary to decrease the large yield gaps from planting to yield potential.

First, a yield gap is defined as "the gap between the best experimental yields and those that farmers can achieve" (Chaudhary). India has the potential to increase agricultural production exponentially, but there are major problems in the way to actually do so. The two categories under which these problems fall are biological constraints and socio-economic constraints. Some of the socio-economic barriers include risk, lack of credit and lack of knowledge about fertilizers.

Increasing scientific research to provide farmers with more agronomic technologies is a key factor in bridging the yield gaps. Also, the seemingly unsolvable socio-economic problems can be solved, with this increase in research. The three areas in which scientific research can ameliorate yield losses are: first, to create varieties of crops which are constant in performance, second, to produce more efficient technologies for post-harvest use of rice, and finally, to work on eradication of weeds which are harmful to crops. Major reasons for the lack of consistency in performance are biological agents and climate changes.

Background

In India, the majority of farms are small, with sizes ranging across the nation, since there is such a variety in lifestyle with over a billion people. The majority of farms (over 50%) are less than one hectare, and only 4% of farms are over 10 hectare in size (Hertzman). Most farms are just large enough to feed a family, often not even able to do that. If there is additional yield, then families will sell it in order to make some money. On these farms, the most commonly grown crops are rice (India is second in production of rice in the world), cotton, grapes, maize, coconut, and sugar cane.

A major problem in India is education. Schools in rural areas, where 2/3 of the population lives, are often not teaching children basic math or proper reading skills. Another major issue is that only about half of the children between ages 6 and 14 actually attend school (Hertzman). The literacy rate currently rests at about 74% for men, and 52% for women ("India's Literacy Rate Increase Sluggish"). Increasing the level of education for women is necessary for implementation of new technologies on family farms, since women have "natural abilities and understanding" of farming, and these abilities could be utilized with higher education/literacy rates ("Poverty Alleviation and Women").

The major barriers to increasing yields and productivity on rural farms are water shortages, lack of technologies, and loans. Eighty percent of rainfall occurs during the monsoon seasons, meaning that Indian farmers are, currently, dependent on the monsoons to help their crops grow (Crutchfield). If crops are planted too soon, then they will not germinate, and if planted too late, the seeds do not grow because the ground is flooded with water. A byproduct of the water problem is an increase in the number of farmers committing suicide in India. In 2006, the last reported year, there were 17,060 farm suicides

(Sainath). These are largely caused by debts which farmers can no longer pay back, or years in which the harvest is not enough to feed the family or make enough money to support the family. Lack of technology is causing farmers to be fully dependent on monsoons. With more efficient water storing technologies and irrigation systems, farmers would be able to ration water throughout the growing season, which would allow a more reliable and stable harvest each season. Also, the dependence on monsoons and old technologies is feeding into the problem of yield losses, because farmers could produce far more with new ways to achieve their potential yields. Farmers depend on the old way of doing things because the cost of new technologies is simply too high, and the risk is too much. Finally, loans are becoming a larger problem as well. To plant crops, a farmer needs seeds, and to buy seeds, a farmer needs money, which he often doesn't have until after the growing season. A type of genetically modified cotton, known as Bt cotton, is resistant to bollworm infestation, which can radically reduce pesticide use, is becoming more popular in India (Sengupta). However, these seeds are far more expensive than normal seeds (usually about twice the price), so more farmers are taking out loans to pay for these seeds. However, moneylenders are then able to significantly overcharge farmers, and reduce the total profit going to farmers. This increase in debts also augments the number of suicides which occur.

Conducting Scientific Research

There is an interesting paradox among Indian farmers—as a whole, they spend $180 billion per year on pesticides, but are apprehensive about spending extra money on pest-resistant seeds, like the Bt cotton seeds (Dinham). However, research has shown that this apprehension may have been a good thing. The Bt cotton is actually not resistant to all pests, as it was originally marketed. What really needs to be done is scientific research to first, produce new species of crops which are truly pest resistant or drought resistant, and will therefore save farmers money. Second, new technologies need to be provided to farmers at low costs—it has been shown empirically that most Indian farmers are resistant to new tools if they cost too much (though some are willing to do so, at the additional price that moneylenders charge as well).

Presently, the lack of scientific research is causing major yield losses in rural Indian farms. The uneducated people who own farms need new ideas for planting and utilizing their crops, since historically, they have not done so themselves. The Green Revolution in India brought new ideas, but the times have changed, the needs are changing, and therefore, new technologies are necessary. The situation now is quite dire. Insects and weeds are the two major biological agents which are wreaking havoc on production.

Biological Reasons for Yield Losses

One mechanism for fighting insects which should be explored is the use of transgenic plants. By using recombinant DNA, combining DNA to produce different characteristics in an organism, scientists can produce plants which are able to fight off pests (Sharma). Bt and Bs cotton are examples of these genetically modified plants, but there is still more that needs to be done with these plants. In order to make these crops accessible and appealing to the rural Indian farm population, scientists need to work towards making more cost effective transgenic organisms. Currently, they are too expensive to be used on a large scale. Another problem with current transgenics is that they are not repellant to a broad spectrum of insects, rather to just a few (Sharma). Insects will continue to be a problem to crops, eating and degrading their quality. For the millions of farmers who grow pigeonpeas, India's most cultivated legume, a single insect can ruin a crop (Paarlberg). As well, the insect problem causes losses of $2.5 billion each year to Indian vegetable farmers, even though farmers spend an average of $100-200 annually per hectare on insecticides (Paarlberg). The environment is also being adversely affected, since the use of pesticides is extreme as well. DDT is by far the most widely used pesticide in India, and has been shown to be highly toxic to birds (it is recognized as the reason for the decline of the bald eagle; by stopping its use, the number of eagles has surged) as well as aquatic and human lives (Ray). In many parts of the world, India included, transgenic plants are opposed by the population since they often use genes

from animals. This causes a moral problem in India, where over 40% of the population is vegetarian. However, by using genes which come from bacterium, like Bt cotton or genes from different types of plants, this problem can be lessened. I believe that the people will be less resistant to transgenic crops as long as mammal or fish genes are not used, since those are foods which most vegetarians are unwilling to eat. Clearly, insect problem needs to be dealt with, as their effects are catastrophic, both economically and environmentally.

The other major biological agent, weeds, is also causing major problems when it comes to yield losses. Experiments conducted in Sweden show that there is a 31% yield loss of cereals due to the growth of weeds in crop areas. Some weeds were more detrimental than others, the worst being *Capsella bursa-pastoris*, *Matricaria perforate*, *Polygonum*, and *Galeopsis* (Hallgren). More research of this sort should be conducted with cereal growth in India, because it could be extremely helpful in creating treatments for soil to stop weeds from being able to grow, and therefore have a 31% increase in cereal harvest in India. Even when a rural farm family has planted enough of a crop to sustain their family and perhaps sell the extra in the market, the percentage ruined by weeds is enough to cause deficiency in a household.

These biological factors have immense effects within the general population of India. The July 2004 estimate of India's population, which is constantly increasing, is 1,147,995,904 people (CIA World Factbook). This number is the number of people that Indian agriculture needs to support, and these biological impediments are causing a major strain on crop production. The strain, in turn, causes malnutrition affecting a large sector of the population. In India, 2.7 million children die every year, with 60% dying because of malnutrition, or 1.6 million children dying per year due to malnutrition (Paarlberg). With an increase in scientific research to minimize yield gaps because of these major biological constraints, Indian agriculture would be able to sustain a greater number of people and help more farmers to come out of poverty, because of greater, more stable yields. With the continually increasing population, Indian agriculture needs to change its ways in order to maintain the number of persons living in the nation. Even if the biological problems remain at the same levels, their effects will be felt to a greater extent, since there will be more people to feel them.

Implementation of Scientific Research and New Agronomic Technologies

By enhancing and intensifying the amount of scientific research done to create new technologies, the problems I have presented would be greatly reduced. The use of better transgenic organisms can positively impact the economy of India, by adding at least another $2.5 billion in GDP, which would allow India to rise in the global economy (Paarlberg). The government could use additional profit to give loans to farmers who need it, without the high interest rates that some moneylenders now charge, in order to make a larger profit. Weed research could result in up to a 31% increase in cereal production, which is necessary because of the falling yields from the past few years (Sharma 2).

If small-scale and family farmers were able to increase productivity and yields on their own, there would still be a necessity for increased research. In order to create sustainable agricultural systems, farmers must be able to harvest and store crops without spoilage. This is another place where Indian farmers report yield losses. Since post-harvesting techniques have not yet been developed, up to 30% of tomatoes spoil, and cannot be used (Paarlberg). Also, if it rains at the time of harvest, crops are often ruined because of the damp environment (Chaudhary). Also, by using machines to harvest rice, for example, results are often much more profitable than the poor quality of rice which is hand-milled.

Recommendations and Suggestions

Once scientific research has been conducted to bring forth new technologies in order to eradicate biological agents and decrease yield losses, this technology needs to be used. In order to actually implement new ideas in order to make production and harvests more stable, the new ideas need to be: first, accessible to farmers, and second, relatively inexpensive. Many farmers do have problems with

access to local markets, since communication in rural areas is not of high quality. As well, with higher prices, rural farmers will likely opt out of using new technologies, since the loan situation is worsening in India. However, as the Green Revolution proved, India can be self-sufficient and use new approaches to agriculture.

With implementation of new approaches, Indian farmers would be able to provide a far more stable harvest and have production levels far closer to their ideal yields. The growing population of the nation needs to be supported by a consistently high agricultural yield. This can only be accomplished by having higher-resistance transgenic plants, and soil which doesn't allow for the growth of weeds. Improving post-harvest techniques is another way to ensure greater stability, since it can mean up to a 30% increase in the amount of crops which can actually be used.

My suggestion is to have universities in India conduct the research for new tactics towards agriculture, funded by the Indian government. While it would be an investment (a large one), the government needs to support the population working in the farming industry. The government is obligated to put in the money to ensure that the people of their country are able to make enough money to support themselves and their families. However, the government's support of research benefits more than just the people. When the people are benefited, and the overall income of farmers increases, the middle class of India will also increase. The economic effects of this are huge for India, since there will be more people participating in trade (when their farms actually produce enough to sell). Also, the students, professors, and researchers at universities in India are incredibly talented, and would have the skills and abilities to carry out this research.

Private companies could also participate in creating transgenic seeds or products which make the soil less hospitable to weeds. There are many companies, focused on highly specialized research, which are capable of working towards new types of seeds or soil. Companies could then sell their ideas or technologies to the government of India, who would then distribute and subsidize the cost of the technologies to rural farmers.

Conclusion

Since it became an independent nation in 1947, India has been reliant on agriculture to employ a huge sector of the population. The biological problems of today have caused an inability of the farmers of rural India to produce enough food for themselves, let alone the rest of the nation. Insects and weeds are these biological pathogens, while water dependence and irrigation is another issue which needs to be researched. By improving and increasing the amount of research done for new agricultural technologies, India will be able to self-sustain once again and begin selling agricultural goods in the world market again.

In the status quo, farmers do not have irrigation systems advanced enough to store the monsoon waters for the rest of the growing season, which causes major panic when the rains come late or are inadequate. Creating more efficient technologies for irrigation systems which are made to hold water from the monsoon rains is a necessity to having stable harvests, since farmers will no longer be completely dependent on the rains. The current transgenic plants, like the Bt cotton are excellent examples of what can be done with scientific research—recombinant DNA opens up many doors which can be utilized to go even further with the Bt cotton, which I recommend. Since the Bt cotton is not universally insect repellant, it is not very efficient or worth the amount of money for which it sells, but it provides a jumping-off point for research. Finally, by using scientific research to create appropriate storage technology to help Indian farmers prevent spoilage, yield can be increased.

By incorporating all of these technologies, yield can be increased 31% (yield lost to weeds) + 30% (yield lost to post-harvest spoilage) = 61% + $2.5 billion saved in insecticides. A 61% increase is so substantial that malnutrition and poverty levels would certainly go down. Improving the yield of crops

means that India will be able to sustain its growing population and reduce the number of fatalities through malnutrition. These three technologies could contribute to a, "Second Green Revolution".

Selected Bibliography

Chaudhary, C. "Strategies for Bridging the Yield Gap in Rice: A Regional Perspective." Participatory Rural Development Foundation. 9 August 2008 <http://www.fao.org/docrep/003/x6905e/x6905e0h.htm>.

Crutchfield, Jim. "India Monsoon: Rainfall Insufficient." Foreign Agriculture Services (FAS). 2008. United States Department of Agriculture (USDA). 12 August 2008 <http://www.fas.usda.gov/pecad2/highlights/2000/08/msn_week9.htm>.

Datt, Gaurav and Ravallion, Martin. "Farm Productivity and Rural Poverty in India." Fact Discussion Paper No. 42. 1998. International Food Policy Research Institute. 9 August 2008 <http://www.ifpri.org/divs/fcnd/dp/papers/dp42.pdf>.

Dinham, Barbara. "GM Cotton—farming by formula?" Biotechnology and Development Monitor 44/45 (2001): 7-9.

Hallgren, E and Milberg, P. "Yield loss due to weeds in cereals and its large scale variability in Sweden." Field Crops Research 2/3 (2004): 199-209.

Heitzman, James and Worden, Robert. India: A Country Study. Washington: GPO for the Library of Congress, 1995.

"India's literacy rate increase sluggish." India Info. 1 February 2008. News-India. 12 August 2008

<http://news.indiainfo.com/2008/02/01/0802010844_india_rate.html>.

Kader, Adel and Kitinoja, Lisa. "Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops." No 8E. July 2002. Post-harvest Horticulture Series. 9 August 2008 <http://www.fao.org/inpho/content/documents/vlibrary/ae075e/ae075e13.htm>.

"Major Crops." Agrimetindia. 2007. 9 August 2008 <http://www.agrimetindia.com/crops.html>.

Mishra, Sourav and Nayak, Debiprasad. "India cereal futures rise on lower rains." India. 18 July 2008. Reuters. 19 August 2008 <http://in.reuters.com/article/domesticNews/idINBOM27653720080718>.

Paarlberg, Robert. The Politics of Precaution: Genetically Modified Crops in Developing Countries. Johns Hopkins University Press: 2001.

"Poverty Alleviation and Women." The George Foundation. 2008. 14 August 2008 <http://www.tgfworld.org/AA-%20womens%20empoverment.htm>.

Ray, P.K, Prasad, A.K, and Nandan, R. "Pesticides—environmental problem." Science and Culture 57: 363-371.

Sainath, P. "17,060 farm suicides in one year." Front Page. 31 January 2008. The Hindu. 18 August 2008 <http://www.hinduonnet.com/2008/01/31/01hdline.htm>.

Sengupta, Somini. "On India's Farms, a Plague of Suicide." Asia Pacific. 19 September 2006. New

York Times. 18 August 2008 <http://www.nytimes.com/2006/09/19/world/asia/19india.html?_r=1&oref=slogin>.

Sengupta, Somini. "Warming threatens farms in India, UN official says." Africa and Middle East 7 August 2007. International Herald Tribune. 12 August 2008 <http://www.iht.com/articles/2007/08/08/africa/08floods.php>.

Sharma, Hari, Sharma Kiran, others. "Prospects for using transgenic resistance in crop improvement." Electronic Journal of Biotechnology. 2000. Universidad Catolica de Valparaiso—Chile. 21 August 2008 <http://www.scielo.cl/fbpe/img/ejb/v3n2/3/bip/>.