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National Responses to Food Insecurity in India

Home to the world's largest hungry population, India has a record on hunger that is worse than that of nearly twenty-five sub-Saharan African countries. India is ranked sixty-sixth among eighty-eight vulnerable countries in the Global Hunger Index prepared by the International Food Policy Research Institute. India is predominantly an agriculture-based country with 70% of its population living in a rural environment, as landowners or as landless labor. One reason for food insecurity in India is that the Green Revolution, which began in the late sixties, using modern agricultural techniques and high yielding varieties of seeds, has resulted in marked differences in regional concentration of food-grain output. But more importantly, in the mid-sixties North and North West India were deemed by public policy to become the granaries of India with states such as Kerala, Karnataka, Tamil Nadu, Assam and Andhra Pradesh thrust into the role of cash crop production with only a small amount of arable land being used for food-grain cultivation. Agriculture with a regional thrust such as this has meant that over time there has developed an inequitable pattern of food grain production, leading to the uncertainty of how much food can be grown at a certain time.

Typical of the problems created by these trends, fifty years old Chandrabhaga lives with her family that includes her husband Daneshwer Gaikward, their son, daughter-in-law, and their two grand children. The family's approximate income is 7-8 thousand Rupees per annum, barely enough to survive. Though very poor, their family owns 2.5 acres of land, on which they grow two cash crops. In the period from August to January, they grow vegetables in one acre of land and cotton in the rest 1.5 acres in the months June to March. The vegetables they grow are consumed for their personal use. The family took a loan to get a "well" constructed in their farm. The well had water during the rainy season, however the amount of water available drops significantly during times of drought. Toward the end of the periods of drought, the rains often come too late to save the harvests of Chandrabhaga and millions of Indian farmers like her, who watch the skies anxiously, waiting for the monsoon season. At other times, it rains too heavily, and many of the crops they have managed to grow are destroyed in the downpour. Early cotton balls are matted, soggy and unsellable though given time, they do work.

Over a period of time, there have been numerous scientific researches into crop biology and several agronomic technologies for improving yields, agricultural production, disease and drought resistance, and sustainable agricultural systems. One of the technologies adopted was the drip system. The drip irrigation, sometimes called trickle irrigation, works by applying water slowly, directly to the soil. The high efficiency of the drip irrigation results from two primary factors. The first is that the water soaks into the soil before it can evaporate or runoff. The second is that the water is only applied where it is needed (at the plants roots) rather than sprayed everywhere. Drip irrigation is easy to install, easy to design, can be very inexpensive, and can reduce disease problems associated with high levels of moisture on some plants.

Due to the lack of the modern drip system, and drought-resistant crops, Chandrabhaga and her family were living in sub-standard conditions, and were not able to improve their standard of living.

Chandrabhaga and her family presently cultivate two crops on the small land that they own. They use traditional farming methods and use water from their well to spray it on the crops they grow. During rainy season, the well has enough water. However, when there is a drought,

the family suffers since they have very little water for irrigation. As a result, Chandrabhaga, had to seek work employment as a wage laborer, which also was very inconsistent as it varied between two to six months in a year depending on the employment opportunities that were generated with the availability of water. In spite of the hard work, women suffered discrimination due to disparity in men and women wages. The women were paid almost half of what men got for the same work.

Trends in drought resistant agriculture have improved gradually. Farmers are growing some drought resistant crops, which help when there is a shortage of rain. They also are starting to use the Drip system method, which helps in producing crops. The situations of many farms in India are improving due to these measures. Of the many difficulties a farmer has to face, drought is a major factor that affects the farmer's life. A typical family like Chandrabhaga is making an average of 7-8 thousand rupees a year, but with the drip system, they are able to make an extra 7-8 thousand rupees a year, which is about 170 dollars. During drought, the income will go down slightly, but it increases during the rainy season to average out the income. The family is self-employed and is very successful as they grow their crops and vegetables for their personal needs. Chandrabhaga worked as a wage laborer and noticed that her employer used the Drip system to irrigate the farm. Soon she and her husband decided to buy a Drip system for their own farm. It cost them 1000 rupees for half an acre of land. Not only Chandrabhaga's rural family, but also almost every rural family started using the drip system due to its advancement in irrigating the farm. Using the drip system and the drought resistant crops has improved the rural family by increasing the income that they make.

There will be tremendous advances in the areas in the future, but these are more likely to address improving the efficiency in the use of fertilizers and crop protection agents, and in minimizing the side effects of these on the environment. The developments of combinatorial chemistry and the identification of new target sites from genomics research are likely to enhance the quality of agrochemicals at the farmer's disposal. Sophisticated systems to support decision-making, allied to machinery capable of implementing those decisions precisely, particularly in respect in the use of water, fertilizers and crop protection agents, will undoubtedly improve the quality of agriculture, but may not greatly enhance its output. Crops, unlike animals, stay in one place and are therefore at the mercy of the environment in which they find themselves. As a consequence, they have evolved complex genetic systems, which enable them to cope with, and adapt to, changes in the environment in order to complete their life cycle. Since the environment changes according to geography and season, a given variety will perform differently from place to place and season to season. That is to say the phenotype of a given crop genotype can vary markedly according to its interaction to the environment. Farmers are concerned with the yield of the crop phenotypes that they grow in their field. It is important not to forget the role of the environment in crop performance and that food comes from successful phenotypes.

Looking at Chandrabhaga's increased productivity, other farmers in the village were inspired and they adopted the same irrigational techniques adopted by Chandrabhaga and her family. Chandrabhaga feels that the drip system is very easy to operate and maintain and she can do it on her own. It considerably reduces the time and effort due to less weed growth. Chandrabhaga's family now grows vegetables from the water pumped from their well using the drip system, which lasts for half an hour irrigating one acre of land. The well is recharged the next day and regains its original level. In the last two years, the family has made an additional net income of 7-8 thousand rupees in addition to their income from cotton.

To improve the food security and incomes of impoverished family farmers, I recommend the following: (a) educating family farmers by providing farmers access to expert knowledge

about crops, markets, and farming, and water harvesting techniques, (b) providing technological and financial resources to farmers, (c) teaching effective water management processes, (d) implementation of internet technology to access expert knowledge, (e) improving infrastructure, and (f) price regulation to decrease the risk of high volatile prices.

Throughout history, people's concern has been producing enough food. In the developing world, food is both scarce and expensive. We need to double the food we need to grow to feed the world in 2050, but we can't double the amount of farmland. There just isn't that much arable land left, and we also want to preserve national habitats and biodiversities food production so that we can produce the food we need without taking up more land.

There are many ways we can improve yielding for crops. Although "biotechnology" and "genetic modification" (GM) commonly are used interchangeably, GM is a special set of technologies that alter the genetic makeup of organisms such as animals, plants, or bacteria. Combining genes from different organisms is known as recombinant DNA technology and the resulting organism is said to be "genetically modified", "genetically engineered" or "transgenic." GM products include medicines and vaccines, foods and food ingredients, feeds, and fibers. Locating genes for important traits-such as those conferring insect resistance or desired nutrients is one of the most limiting steps in the process.

The benefits of using GM products to produce crops could include reduced maturation time, increased nutrients, yields, greater stress tolerance, and resistance to disease, pests, and herbicides. Such products will benefit the environment by conserving soil, water, and energy providing better natural waste management, and more efficient processing. The benefit of GM products to the society is increased food security for growing population. Technologies for genetically modifying foods offer dramatic promise for meeting some of the 21st century's greatest challenges.

Another way we can improve the yielding for crops is by using molecular cloning as a tool. Molecular cloning is widely used as a method to transfer a particular trait to any variety of some or even completely unrelated species. It is also used to over express gene or a group of genes to change its property like yield or content etc. For example, we are interested in improving the salt tolerance of rice, cloning several genes to transform into popular varieties to improve their acceptability in salt affected areas. Targeted genes are cloned and transgenic plants are regenerated and are being characterized. Constitute expressions also causes yield penalty, and undesirable character for high yielding varieties.

We can improve crop yield by using the theory of natural selection. To reproduce, plants pollinate each other. In doing so, they exchange genes- the molecular instructions that produce different traits. The offspring has a different combination from either of their parents. Occasionally, genes undergo mutations during this mix. This mutation gave the plant an edge over others, so it passed its insect-resistance on to new generations.

Crop improvement using metabolic engineering has excellent potential to solve some of the greatest problems in both the U.S. and India.

Improving crop yield is beneficial not only to farmers who can make more money off their limited land, but to the environment as well. Transgenic crops are especially beneficial because many of them do not require as much pesticide as standard crops do, leading to less pollution of the water with agricultural runoff. Improved varieties of traditional crops will make it profitable for the farmers to economically plant crops high in micronutrients, thereby increasing the health and well being of India's rural population.

The slow progress in developing transgenic, results from problems that are both regional and global. At the regional level, the basic infrastructure for molecular work remains weak and there is a dearth of scientists experienced in the area of plant molecular biology and crop

biotechnology. Many Indian agricultural universities have strong breeding programs. Global problems exist which will continue to have a negative influence on the use of molecular biology tools for the advancement of agriculture in developing countries. Most DNA sequences are being patented. There is a general decrease in public spending on agricultural research in developed countries and emphasis on private sector research, especially by multinational corporations (MNCs). These MNCs are developing superior seeds to market globally as common ventures. In only a few cases do individual companies have all the resources to develop superior transgenic plants. Can the MNCs provide transgenic crops with superior performance to countries like India? Although almost every known crop is grown in India, the cultivars adopted to Indian agronomic conditions are very different from cultivars grown in developed countries. If transgenic must be supplied though MNCs, would Indian farmers with smallholdings be able to afford such seeds? Would MNCs invest resources in crops like sesame, safflower, pigeon pea, sorghum and millets, where genetic transformation techniques are not well established? With all their superior technologies, the MNCs will still have to draw upon the existing breeding programs to develop superior crops. The solution lies in strengthening national programs, both in basic molecular biology and in applied crop biotechnology. Meanwhile, Indian scientists need to show an impact of crop biotechnology in the farmer's field to instill confidence needed for national and state governments to invest more in both basic and applied molecular work. A fierce debate continues over the potential of GM crops to solve the problems of hunger in the developing world. At one extreme proponents argue that these new technologies will be the panacea needed to solve hunger, whereas the other extreme argues that the technologies are unsafe to both humans and the environment and are being promoted simply as a means to further the interest of the large multinational companies that market them. Most reasonable people understand that the truth lies between these extremes and, at best, GM crops are only one of the many approaches available to solve world hunger.

Bibliography:

1. Ainger, Katharine. "The Market and the Monsoon." *Sirs*. International Publications Ltd., Feb. 2003. Web. 30 Aug. 2009. http://sks.sirs.com/cgi-bin/hst-clean-copy?id=SCA0855-0-2099&type=ART&artno=0000166588

2. Unanimous. "Partnerships for rapid crop improvement." <http://www.icrisat.org/media/2003/media8.htm>.

3. Unanimous. "Shifting identities and enlarging roles for women." Ide India. Web. 1 Sept. 2009. <http://www.ide-india.org/ide/cs6-kbdrip.shtml>.

4. Unanimous. "Optimizing soil moisture for plant production." Natural Resources Management and Environment Department. Web. 18 Aug. 2009. <http://www.fao.org/DOCREP/006/Y4690E/y4690e06.htm>.

5. "Human Genome Project Information." U.S. Department of Energy Office of Science, Office of Biological and Environmental Research, Human Genome Program, 5 Nov. 2008. Web. 18 Aug. 2009. <http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml>.

6. Chakravarty, Sujoy. "Food Insecurity in India: Causes and Dimensions." Apr. 2005. Web. <http://www.iimahd.ernet.in/publications/data/2005-04-01sujoy.pdf>.

7. "The Science of Inoculation." INTX Microbials, LLC. Web. 18 Aug. 2009. <http://www.intxmicrobials.com/education.html>.