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**India: Biological Innovation to Increase Crop Size and Nutrition**

India is the second largest country in the world by population, totaling 1.2 billion people. However, the proportion of the country's land to its people is relatively small (Davis). India has a large divide between rich and poor and urban and rural. Although 70% of the people in India make their living through agriculture, the country as a whole struggles to feed itself. Poverty is evident all over the country- in fact, at least 237.7 million people (close to twenty percent of the population) in India are undernourished (FAO). In 2006, the United Nations Standing Committee on Nutrition stated that "undernutrition is the main threat to health and well-being not only in middle- and low-income countries but also globally," verifying one of the threats that prevent India from reaching the Millennium Development Goal of improved child and maternal health (2010 Global Hunger Index). Undernutrition is one of the largest problems in India, partially due to the low income of rural families and the lack of roadway infrastructure in many rural areas, and the cycle of undernourishment must be broken in order for the rural people of India to flourish. The use and availability of biotechnology in India's agriculture is needed to increase the yield of crops so that all people can be fed, and to improve the nutrition content of the food that Indians eat.

India is its own subcontinent, cut off from Asia by the Himalaya Mountains, which contribute greatly to the soil, climate, and isolation of India. India is also split within itself, divided by religion, race, and state boundaries. Farming is vital to the Indian economy, involving "a wide range of stakeholders," with the largest group being the small holder farmers. Food shortages are emerging, and when coupled with rising food prices could be disastrous for the people and the economy. However, India actually produces a lot of food, with high rice, wheat, fruit, and vegetable yields in some of the states. According to Ben Doherty,

No nation produces more fresh fruit, pulses or milk than India, and only China grows more wheat and rice. Fifty-two per cent of India's workforce is directly involved in growing food. But one-quarter of the world's hungry, more than 250 million people without enough to eat each day, live in India. More than 40 per cent of India's children under five are malnourished (Hidden Hunger).

The typical subsistence farm family's diet fluctuates depending on which crops have succeeded, and if the roads are clear and passable so that they can travel to other farms and towns to purchase food as well as to sell their crops. India's tropical environment contains lush soil suitable for growing rice, wheat, oilseed, cotton, jute, tea, sugarcane, lentils, onions, and potatoes. Other farms produce dairy products, keep sheep, goats, or poultry or fish to earn a living (CIA). India's farmland is mostly divided into small subplots, with farms usually less than 2 hectares, or 20,000 miles$^2$ (Neale). India's farms have yet to be consolidated, as "large-scale involuntary unemployment leads to persistence of small scale family farms" (Small Scale Family Farms). Although it is growing quickly in population and in technology, around 100 million small farmers work with an ox and plow (India's Mr. Big).

One of the main problems contributing to hunger in India is that around sixty percent of agriculture is dependent on the amount of water it receives, causing crops to fail if not enough or too much rain soaks the crops (Kumar, et. al). Each year, the monsoons are critical in determining if the harvest will be plentiful, average, or meager, which in turn affects the amount of food available for small landowners, their families, and the urban areas (India Agriculture). This is an especially fragile situation in Southern India, where monsoons douse the Brahmaputra Valley with rain (Davis). Flooding produces less than desirable crop yields, as extra water will kill some plants (India Agriculture). Droughts are equally as

hazardous for crop yields, as they lead to crop failure and drinking water shortages, putting unwarranted hardships on the community (India Agriculture).

As previously stated, rainfall and monsoons play an important role in agricultural yield in India. As India's small scale farmers tend to be some of the least wealthy in the population, a lack of quality education persists throughout the countryside. Farmers use precious time working to support their families instead of worrying about learning. Agricultural production has also been impacted by the number of suicides taking place in the group of rural farmers. Suicides commonly ensue among small landowners in exchange for life insurance claims, money for suffering families. Suicides are also "becoming political acts by which despondent agriculturists seek to highlight and protest their degraded conditions." Limited options in the face of "large debts, loss of crops and loss of face" have prompted this irrational behavior, highlighting serious problems in the world of agriculture (Vasavi). Farmers resorting to suicide to help their families and to relieve themselves from the stressful area of small-scale food production in India further emphasize the need for change in Indian agriculture.

Another problem for productivity is poor infrastructure and scarce resources for the small farmers. In rural areas, roads are scarce, and if they become flooded or impassible, "it's estimated between 30 and 40 per cent… of food grown in India goes rotten each year because it simply can't get where it needs to be." As stated by India's finance minister Pranab Mukherjee, "an estimated 40 per cent of the fruit and vegetable production in India goes to waste due to lack of storage, cold chain and transport infrastructure." Since farmers often cannot take their crops to market, they do not have access to other food as well. Even when they are able to make it to the market, failing transport inflates the cost of food, as the small supply ensures that the price of food has elevated enormously. Rural families unable to afford the rising price of food "are going without necessities, even ingredients as fundamental as onion." When farmer's crops fail and they have no income, they also have no resources to obtain other food. To combat food going to waste and money loss, many farmers have stopped growing vegetables and other perishable items, and instead have starting growing grains with longer storage capacities. These farmers then "lack the nutrients found in vegetables," and have begun to suffer from malnutrition, "a phenomenon known as 'hidden hunger." In a particular Indian village, all of the farmers used to grow vegetables, whereas "now fewer than a third do, and those on only a tiny fraction of their land." The government has promised intervention, but little has been done to combat this growing problem (Hidden Hunger).

As India is a large country, its climate differs depending on the location in relation to the Indian and Pacific oceans and the Himalayan Mountains. Biotechnology used in India would need to be specifically altered to the weather conditions in each community. For areas that do not receive large amounts of rain, conventional plant breeding or genetically engineering crops to be drought- resistant would benefit the farmers by producing larger yields. Although little work has been to address drought-resistance in plants compared to that of other resistances, large strides have been made to increase drought- resistance in plants. Through conventional plant breeding, scientists would mark genes that show drought resistance in different crops and breed those that are favorable for the gene, producing more drought- resistant crops with each new generation. Wheat, a food staple in India commonly affected by drought, has been bred in many different facilities all over the world, inducing drought- resistance and therefore increasing the crop yields of wheat in dry regions (Ashraf). The same can be done by inserting drought- resistant genes into any crop (Campbell, et. al.).

Genetic engineering would also be helpful in bringing other traits to crops to improve yields. Herbicide tolerance and pest and disease resistance are commonly found in genetically modified crops, remedying problems with insects or diseases wiping out entire fields and helping crops survive while weeds are sprayed with herbicides (Campbell, et. al.). In fact, Indian scientists have used genetic engineering to insert a salinity resistance gene in some rice varieties to allow the rice to grow in water up to three times as salty as seawater (Campbell, et. al.).

In communities with malnutrition, biofortification would also be advantageous. Malnourishment is defined as the extended absence of one of more essential nutrients from the diet, and can lead to deformities, disease, or even death (Campbell, et. al.). Many people in India, especially children, suffer from vitamin A deficiency, which "leads to a host of health problems, including blindness in extreme cases, and increases children's risk of dying from other conditions, such as diarrhea and malaria" (2010 Global Hunger Index). However, thanks to researchers at the Swiss Federal Institute of Technology Institute for Plant Sciences, there is an easy way to receive vitamin A through food. They have genetically engineered rice to contain a high amount of beta-carotene (vitamin A), coining the term "golden rice." Researchers are also working to develop crops that contain vaccines, such as tomatoes and potatoes, which would be extremely helpful for doctors in rural communities. Medicine and vaccines can be very costly and require specific storage, and vaccine crops would readily address and improve these problems (Whitman).

Child and maternal health would also be greatly improved through the use of biotechnology in crops. Undernourishment is a massive problem in India. Undernutrition, otherwise known as undernourishment, occurs when a person's diet does not supply enough chemical energy for the body to function. When undernourishment occurs, the body uses up its supply of stored fat and carbohydrates, and turns to breaking down its own proteins for fuel, decreasing the size of muscles and potentially causing protein-deficiency in the brain (Campbell, et. al.). Undernourishment in children generally leads to "lifelong damage, poor health, and even early death", and is very prevalent in India, as "in 2005–06, about 44 percent of Indian children under age five were underweight and 48 percent were stunted." This means "that India is home to 42 percent of the world's underweight children and 31 percent of its stunted children." Many mothers have poor nutrition before and during pregnancy in India, producing small babies that blossom into small, undernourished children, and when these children have children, the second generation is even smaller. Many children do not survive due to undernourishment, but those who do only continue the cycle, passing on poor health to their children. Research shows "that it is more effective to prevent child undernutrition than to treat it," and improved crop varieties can have better nutritional value, and therefore will be helping in feeding mothers nutritious food, making babies and children healthier (2010 Global Hunger Index).

India has bred and used many genetically modified foods in the past; however, the GM business there is monopolized by certain companies, and is not being used to help the hungry. Many small farmers in India are actually opposed to the use genetically modified foods (GMOS) because the only benefactors consist of large corporations. The problem of hunger cannot be solved by the use of GMOS alone; instead, agricultural biotechnology must become affordable and available to all small farmers. The hungry cannot afford to pay for any food, let alone expensive biotechnology seeds (Chopra and Kamma). If agricultural biotechnology is not made readily available to farmers, many rural people of India will continue to starve while the top percent waste the full potential agricultural biotechnology has to offer the world. Groups such as the Genetic Engineering Approval Committee of India and the Indian Council for Agricultural Research need to make genetically modified seeds available to small rural farmers through grants, in turn benefitting not only the farmers, but the research facilities as well. Exchanges between researchers and farmers in India would not only boost the economy, but it would pave the way for a long-standing relationship between the two.

Many people have voiced concerns over the sustainability and nutritional content of genetically altered crops. Some believe that producing crops resistant to insects or weeds might lead to "superbugs" or "superweeds" that are resistant to pest and weed control. However, no evidence has proved this statement to be true. In fact, measures have been put in place to guarantee that something like that would not happen, "including crop rotation, hybrid rotation and integrated pest management." Environmental groups are also concerned that using agricultural biotechnology will hurt the environment, while in reality biotechnology is sustainable and beneficial for the environment. It contributes to the use of fewer

pesticides, the conservation of water and soil, and enhanced safety for workers and the ecosystem. Some people also believe that genetically modified foods are harmful for our bodies and less nutritious. Scientists have agreed that the dangers of consuming genetically altered crops are basically the same compared to foods produced without scientific interference (Chopra and Kamma).

Biotechnology use in India would help solve many of the Millennium Development Goals for India. Using biotechnology in India would not only benefit farmers, it would also benefit the overall economy by pumping money into research institutes and into small farms. Genetically modified foods are known to produce larger yields of crops, which would in turn promote food security in India, as farmers would have surpluses of their crops. If small urban farmers were given access to grow improved plant varieties, they would no longer have to worry about food security and money scarcity, as their surplus crops could be sold, giving the farmers more money to support their families, buy land, or buy improved machinery to increase efficiency in growing their food.

In conclusion, although India has the second largest population in the world, it is lacking in the resources to feed its people. Poverty is evident throughout the country, with "237.7 million people in India… undernourished- almost twenty percent of the population" (FAO). The cycle of undernourishment is continued from generation to generation in poor communities, producing sickly children that are never able to defeat their battle with hunger. However, selective breeding and genetically engineering foods would solve many of India's problems. The world's population is expected to double in the next fifty years, and we do not possess the amount of arable land required to sustain a population so large (Chopra and Kamma). Through research, scientists are able to improve plants to withstand droughts, flooding, to be resistant to pests, or to enhance the nutritional content of the food grown. India has problems with pests, droughts, and flooding, and "biotechnology could well help to prevent these maladies and others by producing more healthful, nutritious crops" (Prakash). This, in turn, will increase crop yields and hopefully provide enough food for the world. However, agricultural biotechnology alone cannot beat hunger. Measures need to be put in place to provide small rural farmers with biotechnology, benefitting researchers and farmers alike. The problem of hunger can only be effectively addressed when the solution benefits everyone, not exclusively the elite.

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