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Food Security and Rural India: Transgenic crops paving the road for a "Gene Revolution"

Introduction

Marked by a multiplicity of geographic features and varying climates, the country of India is home to 1.1 billion people, in which 72% live in rural areas [8]. Agriculture is the predominant sector of its economy, and is the means of livelihood for almost 2/3 of the work force [1].

During the Green Revolution, India enjoyed an agricultural production boom. The revolution empowered the country to achieve self-sufficiency in food grains and increased job opportunities in rural populations. Since then, India has been experiencing a slowdown in agricultural productivity due to the lack of recent technologies and sustainable systems of crop growth [10].

Poverty in India is predominantly a rural phenomenon. Some of the most poverty stricken areas in the country are rural farming communities. These communities do not have access to proper education and have been severely affected by the decreased agricultural productivity. The rural-urban income gap is also affected by this decline.

India is in a dire need of another agricultural revolution. The advancement in crop biology and agronomic technologies is a key factor in initiating this revolution. It can be achieved through genetically modifying crops to best fit their environment, and enriching crops through biofortification. Science has proved to be a great help in green revolution and will once again prevail as the answer to many, if not the majority, of our poverty and hunger problems.

Background

India is a land of small farms of peasants cultivating lands mainly by family labor. They are arranged into nucleated villages divided by caste. A typical family farm is around 1 hectare. Diets of these farmers vary from region to region but the typical meal consists of the staple grain-rice with stir fried vegetables, cooked lentils, and yogurt. The majority of the rural populations have little to no formal education. Most farmers use traditional agricultural techniques requiring manual labor, while irrigation is the same. Domesticated animals such as bullocks are used to till the land. The prosperity of rural farmers is being affected by poorly maintained irrigation systems. The main products of Indian farmers include, rice, wheat, oilseed, cotton, jute, tea, and sugarcane, while cotton and rice are the most widely produced. Most of these crops are sold to middlemen who may not provide the proper price for their product.

Many factors inhibit the agricultural productivity and income of a farmer. It is mainly due to the presence of biotic factors such as weeds, pests and disease which widely destroy crops. Social inequalities such as those implied from the caste system continue to plague farmers in attaining agricultural prosperity. The lack of roads in rural areas increases the difficulty to transport crops to the market. Water management is another limiting factor. Water is an integral part of farming, but many don't receive nearly as much as needed. Farms are very susceptible to drought and floods and proper modes of irrigation are yet to be developed.

Conducting scientific research into crop biology and agronomic technologies for improving yields, disease, drought resistance, and sustainable agricultural systems:

Introduction

Transgenic crops are presently the leading technological breakthrough in improving farm profitability. Although this field is being driven by the private sector and industrial countries, it has a great potential for applications in developing countries if proper regulations and funding are given. Moreover, transgenic crops will provide a viable source of nutrition for poor farm families. The first generation GM varieties focused on improving farm productivity through higher yields. Now scientists are focusing on "customizing" crops to the need of consumers. The following sections will address the benefits and controversies that come with transgenic crops.

Transgenics involves the direct manipulation of genetic material. This is done by inserting, altering, or removing genes in the desired crop[14]. India has been experimenting with genetically modified maize, mustard, sugarcane, sorghum, and many others. The cotton crop was modified to resist insects, and has proven to provide a higher yield. The transgenic plant tissue is toxic to three species of bollworm. It has been modified with incorporation of bacterium, *Bacillus thuringiensis* (Bt). This crop was tested in three of India's major cotton-producing states. There was an average improvement in yield from the BT cotton between 80 and 90%[6]. Known in India as the "poor man's vegetable", eggplant is one of the most widely consumed vegetables in the country. Farmers who cultivate this crop have to combat pests and diseases that decrease crop yield. A study conducted by the Asian Vegetable Research and Development Center (AVRDC) stated that about 54 to 70 % of yields get damaged by the fruit and shoot borer. New transgenic varieties of eggplant, resistant to fruit and shoot borer, are being tested in theses areas [14].

A study was conducted by Graham Brookes and Peter Barfoot, two UK-based economists. Their study quantified the cumulative economic and environmental impacts of biotech crops grown during the past decade (1996-2005) [9]. The economists said biotech crops have contributed to significant environmental benefits due to the overall reduction in pesticide usage. A greenhouse gas emission reduction from biotech crops was also noted. The authors found that the global "environmental impact" of pesticide use has been reduced by over 15 percent due to the planting of biotech crops. It noted that farmers in developing countries captured the majority of the extra farm income from biotech crops, mostly from insect resistant cotton and herbicide tolerant soybean

By creating "immunity" in the crops to detrimental factors such as drought, disease and insects, the use of pesticides, fertilizers and insecticides will be virtually eliminated. This is beneficial both for the farmer and the environment. By reducing pesticide use, increased water and soil conservation can be observed. The goal of the crop is to reduce input costs and provide higher yields for the farmer.

Besides increasing farmer profitability, transgenic crops have the potential to provide needed nutrition to India's rural poor through biofortification. Malnutrition in rural India is predominantly seen. Poverty and low status of women is to be blamed. Half of all children under four are malnourished, and 60% of women are anemic [7]. The lack of micronutrients in the diet is responsible for various health problems. These deficiencies are most likely due to low intake of fruits, vegetables, poor bioavailability of iron, and lack of universal use of iodized salt. Goiter due to iodine deficiency, blindness due to Vitamin A deficiency, and anemia due to iron and folate deficiency are some of theses health problems to name a few [5].

Biofortification is a cost-effective approach in enhancing the intake of micronutrients [5]. Biofortification is the process of increasing micronutrient levels in staple foods; breeding food crops that are rich in micronutrients, such as Vitamin A, Zinc, and Iron [15]. Through biofortification, scientists can provide farmers with crop varieties that provide essential micronutrients and could naturally reduce the major health problems listed above [5].

Previously, common foods such as oats, flour, and salt were fortified. With biofortification, you gain the ability to nutritionally enhance the food through gene modification. Public funding and government support are essential for the applications of biofortification in rural farmlands.

The technology itself is not the entire solution to food insecurity. With appropriate policies put into place by the government the technology will become a key factor in increasing food security.

There are many reasons for the slow progress in usage of transgenic crops. Due to multinational companies controlling and leading research for transgenic crops, public research is at a slow down. The costs of obtaining material transfer agreements and licenses from these companies are very high [13]. The environmental, safety, and social risks attributed to transgenic crops are being hotly contested and debated. This is mainly due to the public's lack of general knowledge of the crops. Some are concerned about gene flow to wild relatives between crop varieties. This will not occur if proper safeguards are applied.

Some of the technologies addressed in this paper may be too expensive for the farmer to purchase. This would result in the farmer using traditional ways of cultivation. The lack of science and technology would deplete the farmer's ability to produce a good crop. Without the transgenic crop resource, the cycle of low efficiency in agriculture would continue. Scientific research and development of agronomic technologies is greatly in the interest of the rural farmer.

There is always room for improvement in the field of science. New methods are on their way to increasing productivity and decreasing poverty. One of the limitations of transgenic crops and other biotechnologies are their high costs. If the government plays a role in lowering the costs of genetically modified products, the technology can be more widely used. The environment also benefits from the technology because of the reduction in pesticide usage and soil and water conservation.

Throughout India, women have an important role in society. They are to take care of the family, and in the case of farming, aid in the labor of her husband. With the help of biotechnologies, the work load of both men and women will decrease. This will have a positive impact on farm families all throughout rural India. Higher yielding crops will increase farm income, allowing the family, especially women and children, to consume a nutritious diet. Malnutrition is a major concern in present day India, and there is a positive outlook for transgenic crops alleviating this situation.

Through the improvement of agronomic technologies, rural populations will become less worrisome about the abiotic factors such as drought and soil erosion affecting crop growth. Presently, research has been going on and off because of governmental restrictions and politics that play a role in every nation. Overall, the path to applications of agronomic technologies is increasing and should be very helpful and useful for future subsistence farmers.

To improve food security in rural India, I believe that there are three aspects that need to be addressed (1) Implementation of transgenic crops in rural farming communities. (2) Improving education in rural farmers about agricultural protocols, marketing techniques, and know- how of biotechnology tools. 3) Government initiative through research and subsidies.

(1) For the improvement of food security in India, I believe that there needs to be a direct implementation of transgenic crops in rural farms. As the majority of the poor receive daily earnings from farming based jobs, the improved agricultural practices are directly related to improved food security.

(2) Due to a major concern for cross contamination of transgenic crop varieties and their wild relatives, educating the rural farmer is necessary to ensure biodiversity. Such precautionary measures as crop rotation, hybrid rotation and integrated pest management can be taught to the farmers. I believe that the government needs to provide extension programs whereby farmers have the opportunity to become more knowledgeable in these areas. Proper agricultural protocols should also be taught. These skills are necessary to preserve natural resources and conserve valuable farmlands.

(3) Lastly, In order to implement transgenic crops for rural farm use, I believe that the government needs to provide a cost effective regulatory system, specializing in management and usage of the technology. There needs to be some way in which government has enough control over the use of the technology so it is not misused. Currently, the transgenic crops are primarily being used by private sectors in commercial agriculture. I don't think that this is the right way to go for increasing food security in India and other developing counties. Rural farming will become more of a business rather than a practice and farmers will loose their independence. Rather than working for a higher authority, I think rural farmers should use the transgenic crops for the benefit of themselves. The government needs to make the transition from commercial use to a decentralized use by increasing research in public sectors.

The use of farming technologies such as GM crops are essential in increasing agricultural productivity, but the points listed above are essential precedents to this factor. Increased crop yield will keep food prices under control, allowing people to buy food and keeping nation food secure.

In order to implement these ideas I think that there should be a collaborative effort between government and international organizations such as the United Nations or the World Bank in educating farmers. I also think that the developed countries such as the US and England should provide financial aid for research and development for India and other developing counties. This will provide an overall state of prosperity for the entire world.

Conclusion

Advances in biotechnology and crop biology have proven to be very helpful in solving agricultural problems. From increased productivity to nutritional benefits, transgenic crops have the potential to significantly improve food security in rural India. Biotechnology can provide the possibilities to improved quality of life, but it is up to the people as to whether or not they are willing to create a solution out of the possibility. India should ultimately be able to make its own decisions on whether or not to implement the use of transgenic crops in rural India. In my opinion, I think it is worth the chance to implement transgenic crops in the name of farmers who have committed suicide due to "farm failure" and also for the children whose bellies need to be filled. I just think it is a chance worth taking.

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