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Commentary

Are Indian foods from genetically modified crops safe?

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Introduction

Agriculture is a base for Indian economy and rural development as 60% of the population is engaged, directly or indirectly, in various agricultural activities, and contributes about 60% to the national economy and 30% to the export. Therefore, improvement of farm produce in both quality and productivity and postharvest technologies have been a priority in research and development activities. Biotechnology through tissue culture, biopesticides, bioagents, biofertilizers etc. played an important role in agricultural development. Thus, in the late sixties, crop production has increased to at least 4-folds due to adoption of intensive cultivation practices. However, modern agriculture still loses 42% of crop production to the attack of pests, diseases and weeds. Crop productivity (e.g., production/ha) remains stagnant because of fragmented land holdings, non-availability of water resources, poor and infertile soils, biotic and abiotic stresses, and vagaries of weather.

Considering an increase of 2.1% per annum in human and animal population, food and fodder production has to be increased at least 5-10 million tons a year to feed about 155 crore people in 2020. Population below poverty line (BPL) is also increasing fast from its present level of 30%. Similarly, incidence of pests and diseases, pest resistance to synthetic pesticides, frequent crop failures due to natural calamities, the pollution hazards and environmental degradation are major problems that are to be solved urgently. Gene revolution through genetically modified crops (GMC) may be one of the solutions in near future, at least to enhance and stabilize the food production. GMC contain useful genes that have been obtained from beyond their normal sexually hybridising barriers and this technique includes identification and isolation of DNA, its purification, cloning vector construction, multriplication in stable host, transfer to target species, expression of target genes, and stabilization of gene products in GMC.

These crops are now grown in about 40 million hectares in 15 countries. In India, some multi-national companies (MNC), universities and public organizations have developed cultivars of GMC but debate is continuing amongst scientists, social activists, farmers and consumers. This situation may change in a few years due to World Trade Organization (WTO) policies of globalization, privatization and free market access to which India is one of the signatories.

At present, GMC are being commercialized worldwide for particular traits of herbicide tolerance, insect resistance and improvement in food quality. MNC are ready to supply different types of *cry* proteins. Likewise the National Plant Genome Centre, Delhi, has been able to map some of the major crops and technology is being developed for >10 crops by major public and private institutions to clone genes and promoters in food crops including oilseeds. According to the Confederation of Indian Industry and Department of Biotechnology (DBT), Government of India, foods from GMC are safe as food preparations caused no harm to human in the tests undertaken during the last five years. Therefore, Indian Government formulated several projects in biotechnology to ensure food security and super foodcrops are being developed.

Human Nutritional Aspects

The major components of human diet are fat, carbohydrates and proteins. Edible oils contain erucic acid which is harmful to human health. Therefore, the amount of this acid is being reduced in soybean and mustard. The products made of the GMC taste better and are less likely to trigger allergies. Plant proteins *per se* suffer from amino acid imbalances which are corrected in seed proteins of GMC. Starch content in potato is increased by heterologus expression of mutated ADP-glucose pyrophosphorylase gene from a bacterium, *Escherichia coli*. Transfer of genes encoding proteins rich in essential amino acids like lysine and methionine has been possible. Lysine content of storage proteins in maize could be elevated. Split grains of *Lathyrus sativus* (popularly known as *kesari dal*) is a common food for tribals but it contains neurotoxins (aflatoxin) and is not suitable for human consumption. If consumed, it causes lathyrism (a kind of paralysis). GMC without aflatoxin have been developed by gene mutation for toxin synthesis so as to inhibit production of the toxin or by harbouring antisense gene so as to stop toxin production. Phaseolin gene from Brazil nut expressed in transgenic tobacco produces methionin- rich phaseolin. The B-conglycin gene from soybean, patatin gene from potato and B-phaseolin gene from tobacco produce proteins on other transgenic plants and protein level is therefore augmented. Transgenic potato and tobacco can cure cholera and tuberculosis respectively. This potato can also prevent diabetes (a topmost anomaly). Tomato rich in carotenoids prevents heart diseases and cancer and proved to be beneficial for keeping good health.

In India, local maize hybrids have only 9-12% proteins and are deficient in lysine and tryptophan. Therefore, quality protein maize (QPM) containing opaque-2-mutant gene has been introduced but these genotypes were not popular because of low yields, lusterless kernel appearance and susceptibility to the attack of pests. Presently, the Indian Council of Agricultural Research entrusted the selected seed companies to multiply parent lines for QPM hybrids so that farmers would benefit. The deficiency in vitamin A is prevalent in India and about 10% people go blind. Therefore, tomato, wheat, soybean and other food crops are being developed to produce vitamin by controlling *psy* gene (phytogene synthase) and by isolating genetic sequences that help activate other genes. Augmentation of lysine content of storage proteins in wheat is done by employing several bacterial genes such as those for aspartokinase and dihydropicolinate which when incorporated into the plants, negate their feedback inhibition. This results in a better quality of bread. Iron-enriched rice is possible by integrating a ferratin gene with the endosperm-specific promoter or by incorporating a phytate gene or by adding metallothionein-like protein.

Trophic Interactions

Food toxicity (poisoning) and adulteration in food items has been frequently reported both in rural and urban areas. Similarly, genes or gene products can be toxic and therefore GMC with foreign genes would affect trophic level interactions through food chain as toxic effects may enter into body cells and wholesomeness of food may be destroyed. Rats fed on potatoes containing a bacterium, *Bacillus thuringiensis* (Bt) developed serious health problems. Nevertheless, incorporation of this bacterium is envisaged in brinjal, rice and other foodcrops to reduce the pest attack. National and international biosafety protocols should be available to public and food products from GMC should have certified labels as it is being observed in Europe and the USA for the organic vegetables. According to Research Foundation for Science, Technology and Ecology, Delhi, the golden rice cannot deliver vitamin A to all needy persons. Also, absorption of vitamin A by human body depends upon the overall nutritional status of a person which again varies as per food consumed. This rice will deliver 12% of required intake of vitamin A in children and <15% in adults whereas the present requirement is 25%, as stated by National Institute of Nutrition, Hyderabad. The Indian government should adopt the norms of the Codex Alimentarius Commission of Food & Agriculture Organization of the United Nations and should evolve a mechanism of regulatory code for all the foodcrops.

Patents are given for new discoveries but many crops grown in India are very well known since ancient times, for their medicinal and cooking properties. The new plant variety protection patents under WTO will work against the interest of Indian farmers. The Green Peace Organization strongly criticized the "golden rice" as there are cheap and proven solutions and technologies available to fight against vitamin A deficiency. Also, long-term effects on safety to human health should be established through research data which must be subject to judgement of scientific community. Besides this, consumers are to be told about health safety, freshness, flavour, nutritional value and general appearance of the farm produce.

Relationship with Food Industries

Since the production of ethylene is inhibited or polygalacturonase activity is decreased by antisense RNA technique, the storage period of vegetables, fruits and other fast-deteriorating commodities is prolonged, and over-ripening and rotting is stopped. The shelf life is thus extended by a few days which subsequently facilitates transport and marketing over a long period. For example, tomatoes rot due to plant hormone ethylene and dehydration of cell wall in a mature fruit. The transgenic tomato inhibits ethylene production, the gene responsible for making the tomato fruit soft is therefore cloned and backward copy of the gene is inserted into tomato. Some scientists developed a technique called "somaclonal variation" which does not involve DNA manipulation. Recently, the National Botanical Research Institute, Lucknow, has identified and cloned the antigens which can reverse the fruit ripening and cell wall decay in tomato.

The golden rice containing β-carotene (a building block of vitamin A) has been used to improve the Indian varieties, especially IR-64 and Pusa-1 because scientists were able to transfer β-carotene gene from daffodils to rice that contains three genes to make rice to produce enzymes (e.g., phytoene synthase, phytoene desaturase, lycopene cyclase) resulting up to 1.6 μg of β-carotene in gram of rice seeds.

According to the WTO rules, agricultural policies should be in concordance with the guidelines mentioned in the global economic regulations. To facilitate the adoption of above norms, the Indian Environment Act (1986), Hazardous Micro-organisms Rules (1989) and the Institutional Biosafety Committees have been set up. A Review Committee on Genetic Manipulation (RCGM) which is a statutory body under DBT, transmits the analysed results and certification to the Genetic Engineering Approval Committee to issue permission to the concerned company for large scale trials. Similarly, the DBT has issued in 1994 the revised guidelines for the field trials, handling and risk assessment of the GMC.

Ethnic Issue

India has a strong religious base and genetic manipulation is not less ethical than conventional breeding. For vegetarians, it would be difficult to distinguish a vegetarian tomato from the non-vegetarian one, a normal maize cob from another cob containing a gene of pig. If a person allergic to fish eats a tomato containing a fish gene, it may show same allergic reaction as eating fish.

Environmental and Economical Impacts

Human welfare is directly associated with environment. Protection of the environment should therefore be the priority of the government and also of citizens. The GMC are tested in fields but environmental impact including microbial life in the soils, particularly microbes of GMC resistant to nematodes, has not yet been experimented in India. The MNC are importing seeds from developed countries and creating big seed market. Farmers have to buy these special seeds every year, cannot multiply and therefore would be totally dependent on these companies. The monopoly in seed may extend to agricultural and animal products and livestock feeds too. Poor farmers may thus be exploited for financial gains to the maximum extent.

GMC are suitable for high value foods and may not be economical for dry land farming which is practised by small and marginal farmers or for sustainable agriculture that is already in jeopardy due to natural disasters. Research on the GMC has become less unequivocal due to national priorities and interests, e.g. bioethics, food safety and health hazards, environmental and socio-economic impacts, consumer choice and public awareness/information. At present, purity of GMC can only be maintained with utmost precautions for seed import, genetic heterogenity, phenotypic expressions and also the food values. Above this, GMC would transform farm-based food production and threaten the sustainable agriculture prevailing in India. When resource-based sustainable agriculture in small land holdings is practised with high doses of the external inputs and hybrids and improved varieties, introduction of GMC may be possible if it proved to be beneficial to small and marginal farmers. This extension work including monitoring of field experiments and assessing their impact on well being of rural families and regional ecology is proposed to be carried out at block level. It may assure the farming communities that profits go to them and not to seed companies. Urgent steps are needed for introducing integrated precautionary package, which would help the country to derive benefits from genomics and molecular breeding of crops without environmental, social and health risks. Participation of voluntary and non-government organizations would help increase awareness amongst farmers so that the livelihood of farmers should not be affected by WTO's liberalization and globalization policies. An interaction between government and private and public sectors, infrastructure for research on micro-organisms and special demonstrations are some of the valid steps to further integrate the GMC within an integrated national resources conservation and enhancement strategies to safeguard nature and develop acceptable standard and prevent unacceptable initiatives. By increasing national capacity in assessing known and unforeseen risks, it is possible to develop an unbiased calculation of risks and benefits. The biotechnology parks have been set up in some large cities where educated youths are being engaged for remunerative self-employment.