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A Study on Its Impact on Economic Reforms in Indian Agricultural Sector – An Assessment

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Abstract

A change in this sector's structure is likely to have a negative influence on social justice in rural areas. To achieve sustainable agriculture production requires a combination of natural resources such as soil and water as well as genetically modified plants, fisheries, and forests, as well as appropriate technical management within the current socio-economic infrastructure. Resources, infrastructural, institutional, technology, and government-imposed limits are all highlighted in numerous research and policy initiatives. Natural and capital resources, as well as institutional and human capital, are required for sustainable agriculture. Information Technology is a crucial enabler of rapid economic growth and social change in emerging countries. As runners of globalization, information technology and biotechnology will bring new hazards of exclusion and vulnerability to the Indian agricultural industry. An agricultural resource information system employing Geometrics Technology should be built in districts with public support, according to this article, to eliminate marginalization and vulnerability. Additionally, the Open IS concept and the development of metadata are both advocated to maximize agricultural resource use.

Key Words: Information Technology, Economic development, Capital Equipment, Agricultural Resource Utilization, Globalization, Socio-economic Infrastructure and Liberalization process

Introduction

The existence or absence of favourable natural resources can have a positive or negative effect on economic development. In the words of Professor W.A. Lewis: "Natural resources dictate the course of development and present challenges that the human mind may not be equipped to accept". Developing countries often start with and focus on the development of locally available natural resources in order to enhance local living standards and purchasing power, obtain foreign exchange to purchase capital equipment, and begin the development process. Food grain production and other agricultural commodities have been prioritized since independence, with an emphasis on boosting productivity and maximizing the use of resources in agriculture. Soil and water conservation and appropriate technical management are essential for a sustainable agricultural production in today's socio-economic environment. The FAO's idea of sustainable development includes agriculture, forestry, and fisheries. Sustainably developing societies require management and conservation of natural resources and technological and institutional change in order to meet the human needs of present and future generations. Conservation of land, water, and plant and animal genetic resources is a hallmark of environmentally sound, technically possible, and socially acceptable agricultural, forestry, and fishery growth.

Economic Reforms Process

As part of the Liberalization process, certain economic reforms were implemented, including the increase of production capacity, the de-servicing of production zones, the abolition of government industrial licensing, and the freedom to import.

- Other terms for liberalization internal and external.
- Extension of privatization.
- Allocating scarce public resources to sectors where private participation is unlikely to occur
- The globalization of the economy.
- Due in significant part to a consistent growth in agricultural production, this macroeconomic adjustment programme has had a reasonably pleasant transition when compared to similar

programmes abroad. Global commerce in agriculture will fundamentally shift as a result of the 1995 GATT agreement.

Agricultural Sector Impact of Economic Reforms in India

In rural India, privileges and deprivations are centered on the agricultural sector, and any changes to its structure are likely to affect the existing pattern of social equality. Agriculture is essential to the success of any economic reform strategy.

A number of typical structural adjustment measures were included in the New Economic Policy of 1991, including a depreciation of the rupee and an increase in interest rates. **Living Standards Improvement, Poverty Reduction and Food Security, Industry and Service Expansion, and Substantial Contribution to National Economic Growth.**

Developing countries' economies are heavily dependent on agriculture, which is the primary source of food, money and employment for rural populations. Despite this, agriculture continues to spread into marginal and fragile soils in many poorer nations with low productivity rates and expanding populations. It established a new industrial policy to liberalize the economy, enhance employment and productivity, make Central Public Sector units more competitive, and welcome foreign investment. The industrial sector had been extensively deregulated as a result of the programme.

Agricultural Development in India

As a result of the development of high-yield seed varieties and greater fertilizer usage, India has made considerable strides in agricultural production in recent decades. Agricultural practices in different sections of the country varied dramatically in terms of topography, slope, temperature, rainfall, soil qualities, holding sizes, technology, and the availability of irrigation, labour and infrastructure.

Farmers' income, productivity, and yield per hectare all contribute to the definition of agricultural development, as does a steady increase in the overall production of agricultural products. Indian agriculture began in the north-west of the country around 9000 BCE as a result of early plant cultivation and domestication. After settling down, agricultural implements and practices began to be developed. Two monsoons in one year resulted in two harvests.

Poverty Alleviation Programmes (PAP): doubling food production, increasing employment and incomes, distributing food grains to those living below the poverty line (BPL), observing land, water, and biological resources; developing rural infrastructure; and developing rainfed agriculture.

In India, agriculture is planned and developed

An overview of Indian agriculture the expansion of India's economy, which is still mostly rural, relies heavily on planning. The Planning Commission's only goal in terms of agriculture planning in India is to increase total agricultural output and support the country's economic growth. Agro-climatic environments. In addition to the agro-ecological regions (20) and 60 sub-regions, there are also agro-Edephic regions, terrain mapping sub-units, and natural resource endowments geology and geomorphology, human resources population density, rural infrastructure investment levels, and technology adoption levels.

System for the Management of Agricultural Resources

Farmer management online application, Agriculture Management System, assists farmers in providing best-practice farming procedures. Improves the productivity and profitability of farmers. It allows farmers to sell their products online and to buy tools and seeds directly from the supplier, allowing them to maximize their profits.

Agriculture systems can be classified in a number of ways. Agri-system refers to any system that produces livestock and crops food, feed, fibre, or energy as well as the social, political, or economic components of that system for purposes of this guide.

Natural resources soil, water, cattle, genetics, fisheries, forests, climate, rainfall, and topography must be handled with suitable technologies within the current socio-economic infrastructure in order for agriculture to be sustainable. Agricultural development on a long-term basis requires a combination of economic, institutional, and human resources. Agricultural Resources consists of the following components. There are a variety of resources available to you, including animal resources, capital resources, climate resources and environmental information. Institutional resources of the institution Landowners' information; Soil and Water Resources, Socio-Economic and Infrastructure information. Increased micro-level output requires inventories of currently used and potentially available resources, as well an assessment of their number and quality. An agricultural resources information system, such as the ones listed below, must be designed and implemented in order to support effective agricultural planning and development.

Resources in the Natural Environment

As a result, land, water, biodiversity, and forest resources need to be conserved and used appropriately in order for agriculture to remain profitable and for rural communities to retain their livelihoods and social well-being. Natural resource utilization in agriculture has been addressed through several programmes.

Natural resources include oil, coal, natural gas, metals, stone, and sand. Air, sunlight, soil, and water are other natural resources. Also included in the definition of natural resources are animals, fish and plants. It is necessary to use natural resources so that we can produce food, fuel, and raw materials for the manufacture of products. Land, air, and water are examples of resources that humans require and cherish. As a result, resources are classified as either renewable or nonrenewable. Maps depicting differences in physical land characteristics, meteorological, climatologically, hydrological, geological, and geomorphologic conditions; population densities, types of land tenure systems used.

Resources in the form of capital

Institutional and non-institutional sources are the two major forms of financing in agriculture. In addition to government and cooperative groups, commercial banks such as the Regional Bank and Lead Bank are sources of information from an institutional perspective.

Agricultural production depends on capital, and the accumulation of capital is essential to agricultural growth and development. Sadly, cross-country data sets on agricultural fixed capital are rare and difficult to come across. Agri-investments include: Agricultural inputs buildings, water systems, irrigation works, and drainage systems. Agricultural implements and machinery seeds, fertilizers, pesticides & insecticides, and credit.

Conclusion

Agriculture is the primary source of income for the vast majority of Indians, whether directly or indirectly. Some people work in agriculture, while others work in businesses that deal with these commodities. Food grains can be grown in India, which can have a huge impact on the Indian economy. To achieve the government's goal, both small and large farmers must be given support in the form of land, bank loans, and other machinery. We can expect some development in the Indian economy as a result of this.

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Irradiation Practices Over Fresh and Fresh-Cut Fruits and Vegetables

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Abstract

The ultimate aspiration of all post harvest research and marketing is to minimize the quality deterioration and present the fruits and vegetables to the consumer in as close to freshly picked conditions as possible. Irradiation is a strategy which keeps the fruits and vegetables in a fresh state. Irradiation is the process in which an object (fruits, vegetables, both food and non-food products) is exposed to radiation. Radiation sources such as gamma rays, X-rays, man-made nucleotides such as Cobalt-60 and Cesium 137 are useful in after harvest management of fruits and vegetables. Irradiation facilities are very safe and convenient to operate and are also eco-friendly. Irradiation is effective for post-harvest handling that reduces bacterial infectivity, slows spoilage and maintains the food value. It helps in preventing early mature sprouting and ripening as a phyto-sanitary treatment to regulate pests in fruits and vegetables. It also helps in achieving smaller amounts of pesticides and additives needed to keep the produce fresh for longer. The method of radiolysis of water which produces free radicals and they attack other components like DNA in micro-organisms is the basic working mechanism when different products are exposed to irradiation. The low-dose irradiation helps in killing human pathogens without causing deterioration to product quality. Currently, irradiation technology is practiced in 60+ countries. The chapter gives detailed information on the aspects of irradiation over fresh and fresh-cut fruits and vegetables.

Keywords: Eco-friendly, fruits, irradiation, shelf life, vegetables

Introduction

Irradiation process is the restricted application of the ionizing radiations of γ-rays and X-rays machines of 5MeV and accelerated energy of electrons from electron accelerators having maximum energy of 10 MeV to food and edible commodities, in order to maintain quality, protection and extend storage life. It plays a major role in maintaining the freshness of fresh fruits and vegetables. Horticultural commodities are in perishable status within a short period after getting harvested. Irradiation helps in maintaining the quality of the produce, disinfestations of pests and insects, encourages international trade, reduction in sprouting of tubers and bulb crops and many advantages reserved in it (Shah *et al.*,2021).

Foundation to Irradiation

Few years back quite a lot of steps were in use by the joint FAO/IAEA division, collaboration with WHO, to encourage international recognition of irradiated food. The dose up to10kGy has no toxicological hazard which was concluded by 1980 expert committees setup by FAO, WHO.

Labeling of Irradiated Products

The foods which get irradiated cannot be familiar by vision, aroma or feel. The countries which are following the rules of the Codex Alimentarius Commission must tag all the foods which are irradiated or foods that any of its components have irradiated before assimilating into the final product. The 'Radura' symbol indicates that the product underwent an irradiation process.

Factors Influencing Response

Several factors which can influence the effectiveness of ionizing energy treatments on fruits and vegetables are summarized in Table 1. There may also be pre-harvest factors like climatic conditions and cultural practices that might affect composition and quality of the commodities.

Table 1- Factors influencing the effectiveness of ionizing energy treatments actions on fruits and vegetables

COMMODITY FACTORS	IRRADIATION FACTORS
Kind of commodity and cultivar used	Dose
Manufacture area and season to be considered	Dose rate
Maturity at harvest to be undertaken	Environmental conditions during irradiation
Original quality must be concerned	Temperature
Postharvest handling procedures are learned	Atmospheric composition

Energy Sources for Irradiation

Radiation process involves the function of a minimum amount of energy from ionizing radiation like gamma rays, electrons, and X-rays. The available γ-radiation sources used for food processing are radioisotopes like cobalt-60 and cesium-137, electron beam of 10 Mev range and X-rays range of 5 Mev. The X-rays and electron beams are generated by using electricity. The units for measuring radiation are mentioned in Table 2. Dose refers to the product. The dose rate is defined as the amount of energy engrossed by the food when it is open to the elements of the radiation field. One gray is equal to 100 rad. Irradiation dose is measured by an instrument called Dosimeter.

Table 2.Units for measuring radiation.

	ENGROSSED DOSE	RADIOACTIVITY
UNIT	Gray (Gy)	Becquerel (Bq)
EXPLANATION	1Gy = 1J/kg	1Bq = 1disintegration/sec
FORMER UNIT	Rad	Curie(Ci)

Division of Irradiation Dose Rate

Low dose <1kGy-radicidation

- ✓ This range of dose helps in controlling the insects in grains and fruits (Hallman, *et al.*,2013).
- ✓ Low dose range helps in reducing the sprouting of tubers (Arvanitoyannis, *et al.*, 2009).
- ✓ Radicidation also delays the ripening of fruits/vegetables (Arvanitoyannis, *et al.*, 2009).

Medium dose 1-10kGy-radurization

- ✓ It controls *Salmonella*, *Shigella*, *Yersinia*, *Listeria* and *E.coli* (Farkas, J. 2004).
- ✓ The range of 1-10kGy helps in reducing the mold growth on strawberries and other fruits (Mahajan, *et al.*, 2014).

High dose > 10kGy-radapperization

- ✓ High doses effectively kill the micro-organisms and insects in spices (Mostafavi, *et al.*, 2012).

Radiation Processing Facility

The radiation process is performed in an irradiation chamber that is protected by concrete walls having 1.5 to 1.8 m thickness. The produce to be irradiated can be in bulk or already packed in suitable containers that get passed into the irradiation chamber with the assistance of an mechanical conveyor that goes through a concrete wall.This helps to prevent the radiation from attaining the work area and worker room. The radiation sources like Cobalt-60 or Cesium-137 get stored underground deep water of 6m when the radiation process is not performed. The utilization of a water shield is that it does not permit the radiation to run away into the irradiation chamber. It helps in free admittance for workers to take out the repairs work.

When the irradiation process takes place, the safety devices get activated and restriction of human entry is announced and then the source is brought to the required position above the water level. The products are sent inside with the help of carriers automatically and placed just about the source rack and then get fixed on their individual axis, so that the products are irradiated on equal sides to get the dose equality depending on the dose division in the product.

The dose that gets absorbed by the product is checked by using the dosimeters and gets placed at different places in a carrier.

Irradiation Physiology

The cells get injured when high-energy electrons fall on the molecules, also the radiolysis of water produces high reactive radicals which spoil DNA and other cellular components. Bacterial DNA is more sensitive to break from radicals at the time of active replication or transcription. Pathogenic bacteria like *Yersinia enterocolitica,* which bring plasmid-encoded virulence genes, possess a condensed virulence after irradiation. The dried and frozen products have very little free water, thus it can produce only a smaller amount of hydroxyl and oxygen hydroxyl thereby their action is reduced. The non-stop breakage of DNA becomes the major means of radiation damage. Human pathogenic viruses are an exception in case of irradiation when compared to bacteria.

Irradiation applications In After Harvest Handling of Fruits And Vegetables

➢ INHIBITION OF SPROUTING IN VEGETABLES

Treatment with ionizing energy at 0.05-0.15kGy is effective in inhibiting the sprouts of potato, yam, Jerusalem artichoke, sweet potato, ginger, sugar beet, turnip, carrot, onion and garlic. Irradiation doses below 0.15kGy have minor effects. But above 0.15kGy induce side effects such as decreased tissue darkening, wound healing ability, increased sugar content in pathogens, decreased vitamin content, susceptibility to pathogens.

➢ INHIBITION OF POST-HARVEST GROWTH OF ASPARAGUS

The asparagus spears when subjected to ionizing energy at range between 0.05-0.15kGy, it inhibits the elongation and curvature of spears, but on the other hand higher doses are detrimental to its quality and storage life. If additional treatment is needed for long distance transportation, modified atmospheres (10-15% carbon-di-oxide added to air) can be used to maintain asparagus quality.

➢ Insect Disinfestation

Many insects were present inside the fresh fruits and vegetables. Mostly, the fresh produce is found with tephritidae family insects. Irradiation below 1kGy is effective against insects, moths and so on. Insects get killed at 0.05-0.75kGy.Moy *et al*., (1983)reported the minimum mortality dose on mature med fly eggs on peaches to be 0.4kGy, while 0.45-0.50kGy on nectarines.

➢ Alteration of Ripening And Senescence

Banana ripening is inhibited at the radiation dose of 0.25-0.35kGy, and irradiated fruits can be ripened in later to good quality by the treatment with ethylene. The same kinds of results were also reported in mango, papaya, guava (Thomas and Moy, 1986). The sensitivity of more fruits to the ripening action of ethylene was reduced by the higher doses (Maxie and Abdel-Kader, 1966). The physiological disorders in fresh fruits and vegetables were found when doses given above 1kGy (Bramlage and Couey, 1965).

➢ Control of Postharvest Disease

The postharvest fungi can be inhibited by a minimum dose of 1.75kGy. Sommer and Fortlage(1966) revealed that the maximum tolerable dosage to fresh commodities is at 2.25kGy.

➢ Effects on Fresh-Cut Fruits

MANGO

Vieites *et al*. (2004) worked on the result of low down doses of gamma irradiation between 0.1 to 0.5kGy and chosen packages were also considered on mango fruits. The fruits were physically slice into cubes of 3×3 cm and kept at 5˚C with 85% RH for 10 days of storage.Doses of 0.4 & 0.5kGy with package of polyethylene terephthalate neoform transparent plastic glass with cover exhibit smallest bacterial rates. But Non-irradiated mango became in appropriate for utilization from 5th day of storage.

STRAWBERRY

The strawberries are picturised by having a very less after harvest life because of its physiological and pathological processes, a dose range of 3kGy radiation was given by 19 countries for strawberry (Breitfellner *et al*., 2003).The dose of 3kGy was found to achieve the addition in the shelf life of strawberries. The colour intensity decreased with differences in fruit texture observed when strawberries were subjected to higher doses (d'Amour *et al*.,1993; Yu *et al*., 1996).

GUAVA

Campos, *et al*. (2011) worked on the result of gamma irradiation collective with modified atmosphere in cold storage on minimally processed guavas cultivar 'Pedro Sato'. The guavas are allowed in cold storage of 10˚C with 90%-95%RH for 12days.They were slash into slices of 0.5cm broad, after get irradiated with doses of 0.2,0.6, 1.0kGy. Package of polystyrene &low density polyethylene was used. They stated the result with lower dose (0.2kGy) along with MAP promotes positive effects.

APPLE

Fabbri *et al*., (2011) evaluated the value of minimallyprocessed gala apples exposed to irradiation at doses range of 0.25, 0.5, 0.75, 1, 2 kGy for 10 days. Results found that appleswere effective at ranges of 0.25, 0.5, 1kGy. A 2kGy resulted in softening of texture. The correct doses maintain the good texture of apples which can be recommended for fruit salads.

BLUEBERRIES

Trigo *et al*. (2004) studied the consequence ofirradiation on blueberries that were packed in a preserved polymeric Cryovacfilm bags. They found with that the speed of fruit respiration gets reduced at a dose range of 0.5-2kGy. The higher doses of 2.5 and 3kGy resulted in fruit damage.

Effects on Fresh Vegetables

TOMATO

Schmidt *et al*.(2005) studied the outcome of low dose electron beam irradiation on value and protection of fresh cut tomatoes were also analyzed via cutting the tomatoes keen on cubes and unraveling from stem scars. After cutting into cubes the tomatoes are inoculated with *Salmonella enterica* and irradiation at a range of 0.7 and 0.95kGy were given. Result obtained was that both doses reduced the count of *Salmonella* population during 15 days of storage. The short dose irradiation of 0.7kGy was helpful in dropping the pathogens from fresh cut tomatoes.

BRINJAL

Hussain *et al*. (2014) studied that exposure of minimally processed eggplants to gamma irradiation at range between 0.25-1.0kGy were taken and they were undergone mixture of gamma irradiation at 0.5-2kGy with ascorbic acid dip (2% w/v). The polyphenol oxidase action along with the outside browning was getting reduced with 2% ascorbic acid and irradiation at 1kGy. It also helps in maintaining the white colour of the egg plant during storage.

CUCUMBER

Khattak *et al*.(2005) studied the result of irradiation on the shelf life extension of cleanly processed cucumbers. They revealed that the reduction in firmness when increased irradiation dose were given at 0-3 kGy. After 14 days of storage, the texture of cucumbers was under acceptable limit upto irradiation dose range of 2.5 kGy.

LETTUCE & SPINACH

The endorsement was set by the US FDAin 2008, that the application of radiation dose not 4kGy on clean lettuce, iceberg and spinach to enhance microbial protection and expand their shelf life. Fan *et al*., (2012) revealed that the microbial security of lettuce and spinach is acceptable at 1 and 2kGy.

THE PACKAGING MATERIALS APPROVED BY FDA

TYPES OF MATERIAL USED	MAXIMUM DOSE GIVEN AT kGy)
KRAFT PAPER	0.5kGy
GLASSINE PAPER	10kGy
PAPERBOARD WITH WAX-COATED	10kGy
CELLOPHANE WITH COATED	10 kGy
POLY OLEFIN FILM	10kGy
POLY STYRENE FILM	10kGy
RUBBER HCI FILM	10kGy
VEGETABLE PARCHMENT	60kGy
POLYETHYLENE TEREPHTHALATE FILM	60kGy

Advantages of Irradiation

- It helps in minimizing food losses.
- It also improves public health.
- It promotes international trade.
- It acts as a substitute for food fumigation.
- Physical, non-additive, efficient one time process.
- Non-polluting, eco-friendly with no residual harmful toxic residues in the product.
- Extremely reliable cold process and helps in preserving the food in natural form.

Disadvantages of Irradiation

- It lacks in harmonization of regulations among the countries.
- Irradiation process is slow acceptance by consumers.

- It needs high capital costs at initial stages.
- Limitation in packaging material.

Consumer's Reaction

People are enthusiastic in purchasing a clearly labeled product of irradiated food. The price may reach higher than the normally available one but it is not much important when compared to safety. They found the benefit of eliminating harmful bacteria and extending shelf life. The price hike is the major drawback among consumers to buy irradiated products. The attitude studies mention that more than half of the people were willing to buy the irradiated food for hygiene and prevention from food-borne illness (Bruhn, 1995).

Conclusion

People all around the world are aware of the benefits of food irradiation and its potential to reduce the risk of food-borne disease. There are also some other developing technologies for reducing human pathogens. Need of increase the shelf life is achievable in irradiation techniques. Thus, irradiation will achieve its place in upcoming years.

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Transgenics in Vegetable Crops and its Impact on the Environment

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Abstract

Vegetables are major sources of vitamins, minerals, phytochemicals and dietary fiber in human nutrition. Fruit and vegetable consumption is expanding over the world and we need to enhance the food production by using modern breeding techniques to feed the ever growing population. Horticultural crops suffer alarmingly by various stresses factors which warrant the use of huge plant protection chemicals. Transgenic crops, also known as genetically modified (GM) crops, allow plant breeders to introduce gene of interest into commercial cultivars, significantly increasing their nutritional value, shelf life, taste, color, flavor, as well as providing unique opportunities for controlling biotic factors affecting crops. Modern gene transfer based on recombinant DNA technology is a rapidly growing area of research and offers wide opportunities in breeding vegetable crops, but the commercialization of GM food is still a big deal. Additional research in both scientific and policy areas is needed to expand opportunities for horticultural biotechnology. Many present vegetable breeding efforts remain disorganized. A more targeted, coordinated strategy is urgently needed to properly use money, exchange ideas, and maintain advancement in horticultural GM technology and breeding. Transgenic vegetable breeding can help the poor to avoid food scarcity and hunger in the twenty-first century, but only if sufficient investments are made to improve and support vegetable crop breeding and productivity.

Keywords:Agrobacterium-mediated transformation, GMO crops,Impact, Transgenics, Vegetable crops.

Introduction

The current horticultural crop production in India is 326.58 million tonnes, estimated to be 3.12% higher than the previous year. With the rapidly increasing populations and major climatic changes, supplying food to the increasing population is a major challenge.Vegetables are crucial in the human diet because they provide not only energy but also important protective nutrients such as vitamins and minerals, as well as a rich source of flavor compounds, antioxidants, and bioflavonoids. Hence, the vegetable and fruits consumption is increasing year by year. Even though many scientific studies with improved agricultural techniques and more recent applications of scientific evidence exists, still there is a problem in some areas of research like the need for breeding crops with high shelf life, biotic and abiotic resistance, pest disease and nematode resistance, enhanced nutritive value, color, taste, and flavor. Conventional plant breeding techniques involve natural selection which tends to produce offspring as a result of a particular combination of genes inherited from the two parents. We have been using this conventional breeding approach for thousands of years and came up with our modern crop varieties with high yielding and more nutritious than the wild ones, but they compete poorly in the wild. Nowadays many genes contribute to the improvement of sustainable food production, in some cases, conventional breeding approaches are found to be the best way to transfer them and in others, Genetic Modification might be the easier and the only way the gene of interest can be transferred to get the plants with good quality traits. Globally, sufficient food is produced to feed the present population. However, by 2050, it is expected that the global population would have risen to almost 9.1 billion people (https:/esa.un.org/unpd/wpp/). The world's population is increasing at a rate of 1.05 percent each year, implying that the food supply will need to be doubled. Furthermore, climate change is already a major constraint that is affecting the crop yield potential in several crop production areas. Hence to feed the growing population, using modern biotechnology tools such as transgenic technology is the best alternative to overcome all these constraints and to breed plants having the desired traits.

Transgenics

Transgenic crop technique has the potential to improve global food production in the future and feed the world's rising population. In genetic manipulation technology, the gene of interest is taken from one plant and inserted into another organism via transformation to get the plant with desired trait or character. This transformation is done employing some techniques like biolistics (gene gun), electroporation, direct uptake in protoplasts, and microinjection which are all the direct gene transfer techniques while Agrobacterium-mediated transformation is an indirect gene transfer technique. In the above-mentioned techniques, later found to be used commonly in which Ti plasmid produced from plant pathogenic bacterium *Agrobacterium tumefaciens* is employed as a vector into the host plant chromosomes in Agrobacterium-mediated transformation. In transgenic breeding, there are three generations.

- First-generation crops are those that have been bred for resistance to biotic stresses with entended storage life The second generation focuses on excellent nutritional value, amino acid content, and high quality.
- Vaccines, antibodies, and pharmaceutical items are made from the third generation of modified plants.

Transgenic Vegetables With Improved Storage Life

Perishability is a major concern in most fruits and vegetables which causes food losses. In India, the postharvest losses were found to be 50% of the total horticultural production which affects consumer preferences. Such post-harvest losses are efficiently eliminated by using a successful technique that delays the ripening of produce by manipulating the genes through genetic engineering. The ripening takes place by an increased respiration rate which shows a rapid increase in ethylene synthesis. The enzyme polygalacturonase (PG), which digests the cell wall, is involved in the ripening and softening of tomatoes. Traditional tomatoes are harvested at unripe stage and are artificially ripen with ethylene gas, a plant hormone that increases shelf life but with reduced flavor. To reduce the enzyme expression that causes tomato softening, tomato plants were genetically engineered with antisense RNA and the shelf life of these transgenic tomatoes is not affected by allowing them to ripen on the vine. By using antisense RNA technology, the gene encoding PG has been isolated and transferred to a vector bacteria for cDNA molecules production, and they are inserted into a tomato plant. with the help of the RNaseH enzyme antisense RNA will break the target mRNA sequences and it will block the protein synthesis from mRNA to produce transgenic Flavrsavr tomato. Calgene released flavrsavr tomato as the first transgenic food for human consumption, which was well received by the public. Degradation of cell walls by enzyme hydrolases results in fruit softening (Fisher and Bennet, 1991; Brummell and Harpster, 2001). Chourasia *et al*.(2006) determined that the enzyme pectate lyase aids in altered fruit softness in many fruit crops like grapes, mango, banana, and strawberry. Lu Yang *et al*.(2017) identified 22 pectase lyase genes in tomatoes and one is SIPL (Solyc03g111690) pectase lyase gene which showed the dominant expression in fruit maturity. Hence, silencing of the SIPL gene showed an increased firmness in fruits. Thakur *et al*.(1996) indicated that Pectin methylesterase antisense gene expression in transgenic tomatoes reduced PME activity, resulting in enhanced fruit attributes such as greater juice viscosity, higher total solids, and decreased pectin hydrolysis.

Transgenic Vegetables With Enhanced Taste, Flavour and Aroma

In fruits and vegetables, breeding for biotic stress resistance, abiotic stress resistance, firmness, and improved shelf life is common during the past few years. Breeding for flavor, aroma, and quality is needed to fulfill consumer preferences as well as to improve the quality of the produce. The carotenoid gene (crt1) of the bacteria *Erwinia uredovora* encodes the phytoene desaturase enzyme, which converts phytoene to lycopene and resulting in a 45 percent increase in -carotene in tomato fruits. (Susanne Romer *et al*., 2000). Specific expression of ySAMdc yeast gene shows a 300% increased lycopene, enhanced polyamine, and shelf life of tomatoes in transgenic tomato line 579HO (Roshini *et al*., 2002). According to Sheng *et al*.(2007), Delila (Del) and Rosea1 (Ros1) genes of *Antirrhinum majus* (Snapdragon) are expressed in transgenic tomatoes which shows a high anthocyanin content by utilizing the proper target specificity of selected transcription factors. Overexpression of the ANT1 gene showed enhanced anthocyanin production and overexpression of Lc and C1 genes resulted in high flavanol content in transgenic tomato fruits (Butelli *et al*., 2008). Expression of MT-1 gene from mouse results in high levels of zinc content, superoxide dismutase activityand superoxide-free radical scavenging activity. Zinc content was found to be was 32.7 mg/100 g in transgenic tomatoes.

The production of the geraniol synthase enzyme produced from the Ocimum plant, which exhibited an increased level of volatile chemicals in matured tomatoes, improves the flavor and aroma of tomatoes. There were low concentrations of monoterpenes such as limonene, myrcene, cis-b-and trans-b-ocimene, geranial, geraniol, geranyl acetate, citronellal, and citronellol comparing to nontransgenic tomatoes (Rikanati *et al*., 2007). Monoterpene levels in ripened tomatoes are raised by genetic engineering of the terpenoid pathway. The expression of the gene S– Linalool synthase(LIS) in transgenic tomatoes enhances the amounts of S-Linalool and 8-hydroxylinalool molecules. (Lewinsohn, 2001).

Expression of geranyldiphosphate synthase from snapdragon with geraniol synthase (GES) gene from *Ocimum basilicum* showed the monoterpenes synthesis such as neral, geranial, geraniol, citronellal, and citronellol, but also found decreased carotenoid levels(Gutensohn *et al*., 2013). According to Rikanati *et al*. (2008), in tomato, the accumulation of mono and sesquiterpene compounds by overexpression of a sesquiterpene synthase gene, α -Zingiberene synthase (ZIS) from lemon basil shows the high level of α -zingiberene and some other sesquiterpene compounds. Monoterpenes such as α-thujene, α-pinene, β-phellandrene, and γ-terpinene compounds were also produced by transgenic tomato fruits. The introduction of the thaumatin gene from the African plant katemfe (*Thaumatococcus daniellii*), which is a low-calorie protein sweetener, changes the taste of tomato fruits. In tomatoes, the expression of this gene results in improved fruit taste and flavor (Bartoszewski, 2003).

RNA Interference Silencing Technology

RNA silencing technology involves the sequential selection of a particular protein-coding mRNA strand and cleaving the target which blocks protein formation. Asparagine is involved in nitrogen uptake and storage in potatoes, and during heat processing, acrylamide is formed by the reaction of amide amino acids with reducing sugars using the Maillard reaction. Acrylamide is found in processed food products like potato fries and French fries which may cause health effects in humans. According to JECFA (Joint Expert Committee on Food Additives),the average daily acrylamide intake

is 0.3-0.7 µg/kg/day (Dybing *et al*., 2005). Hence the committee recommended reducing the acrylamide level in processed potato food products. By using RNAi silencing technology, Sts1 and Sts 2 genes are silenced which reduces the free asparagine by 95% in transgenic potatoes. Even though asparagine in potatoes is highly beneficial in nitrogen assimilation and storage, this metabolic engineering does not affect the quality and yield parameters of potatoes (Rommens *et al*.,2008). Imai *et al*. (2002) studied that,Lachrymatory factor synthase is responsible for the changing of 1-propenyl sulfenic acid to lachrymatory factor. RNAi silencing technique is used to silence the lachrymatory factor synthase gene, resulting in tearless onions with upto 1,544 times reducedamount of Lachrymatory factor synthase (Edy, 2008).

Transgenic Vegetables With Improved Nutrition Value

Many studies indicated that plant carotenoid compounds such as β-carotene and lycopene play a key role in preventing the occurrence of many diseases like Coronary heart disease (Ignarro *et al*., 2007) and certain cancer types (Block *et al*. 1992), as they possess good health effects and antioxidants. Consuming the tomato products enriched with lycopene shows less incidence of lung, stomach, and prostate cancers (Giovannucci, 1999). Hence to overcome these problems, there exists a need to breed for crops with increased β-carotene and lycopene in fruits to elevate the nutritional value of the plant produce. Fraser *et al*., (2001), in their studies, resulted in transgenic tomatoes with an increased level of carotenoid compounds up to 2-4 times comparing to the non-transgenic tomatoes. These transgenic tomatoes are produced by overexpression of phytoene synthase gene from *Erwinia uredovora* bacterium into the tomato plants which showed anelevated level of β-carotene, lycopene, and lutein in fruits.

Chung-chima is a lettuce cultivar with high tocopherol content by transgenic expression of γ-tocopherol methyl-transferase gene from thale cress plant (*Arabidopsis thaliana*). Silencing *Lycopersicum* Invertase5 (LIN5), which encodes the enzyme cell wall invertase, regulates the total soluble solid content of tomatoes. Genetic changes in transgenic tomatoes is confined to sugar metabolism and it controls the TSS content in fruits(Zanor *et al*., 2009). Hemavathi *et al*.(2009) studied that transgenic expression of GaUIR gene(Strawberry D- Galactouronic acid reductase) shows a high level of ascorbic acid content up to 1.6 to 2-fold in genetically transformed potato (Table 1). These potatoes were also shownto have a high abiotic stress tolerance by retaining more chlorophyll in those potatoes. Biofortification is enriching the nutriet content of foods to keep the malnutrion at bay.In vegetable crops, mineral nutrition concentrations are enhanced by fortifying the food crops. Cassava is a major crop in most developing countries, hence this crop is fortified with iron and zinc to elevate the micronutrient content of the cassava. In orange sweet potato, provitamin A content is enhanced and the first variety was released in 2002. Fe rich potatoes are developed by CIP (International Center for Potato) and released in 2017. High iron-rich peas varieties Pant lobia-1,2, 3 and 4 were developed in Brazil. Biofortification is used to improve the iron content of beans so that they meet 60% of the Estimated Average Requirement and pumpkin was biofortified with carotenoids and provitamin A and first released in 2015(Jena *et al*., 2018).

Table 1: Transgenic potatoes for quality improvement

SI.No.	Quality trait	Gene	Source
1	Amino acid-rich storage protein	AmA1 tar1(tarin) Boxla, Boxlla, BoxlaIIa 2	*Amaranthus hypochondriacus* *Colocasia esculenta* *Bertholletia excels* (Brazil nut)
2	High amylose starch	SBE I antisense	Potato
3	Carbohydrate engineering	SUSI(Sucrose synthase)	Potato
4	High tuber galactose	stUGE45 stUGE51	Potato
5	High tuber fructose	Xy1A(glucose isomerase)	*Thermus thermophiles*

PEST RESISTANCE

In Chinese cabbage, a two-spotted spider mite (*Tetrany chusurticae*) causes leaf yellowing by piercing the leaves and sucking the leaf sap out. According to the studies of Yun Hee Shin *et al*. (2020), transgenic Chinese cabbage lines resistant to mites were developed using an RNA interference technique. In brinjal, FSB causes fruit losses up to 37-63 %. Bt-brinjal plant was introduced by the MAHYCO Company (https://mahyco.com/) against fruit and shoot borer by incorporating the cry1Ac gene (Insecticidal protein) in brinjal plant which confers resistance against FSB (Fig.1). After ingestion,theinsecticidal protein binds to the specific receptors on the midgut of the insect and it collapses the gut integrity causing septicemia which kills the insects (Hoffmann *et al*., 1998).

Fig. 1: Left- Btbrinjal fruits; Right: Non- Btbrinjal fruits

Source- https://mahyco.com/

Colorado potato beetle is an important pest of potato at the global level. Breeding of potato plants showing resistance to Colorado potato beetle (*Leptinotarsa decemlineata*), by inserting the Cry3A toxin in potato plants, improves the plants to resist insect damage (Fig.2). Currently only one GM potato variety "Amflora" is commercially grown and approved for using it as animal feed and industrial purpose. Petek*et al*. (2020) designed

dsRNA to silence the potato beetle's mesh gene (MESH) and results showed that insertion of dsMESH gene impaired larval growth and decreased larval survival. Finally, it is found that dsMESH controls the Colorado potato beetle larvae effectively.

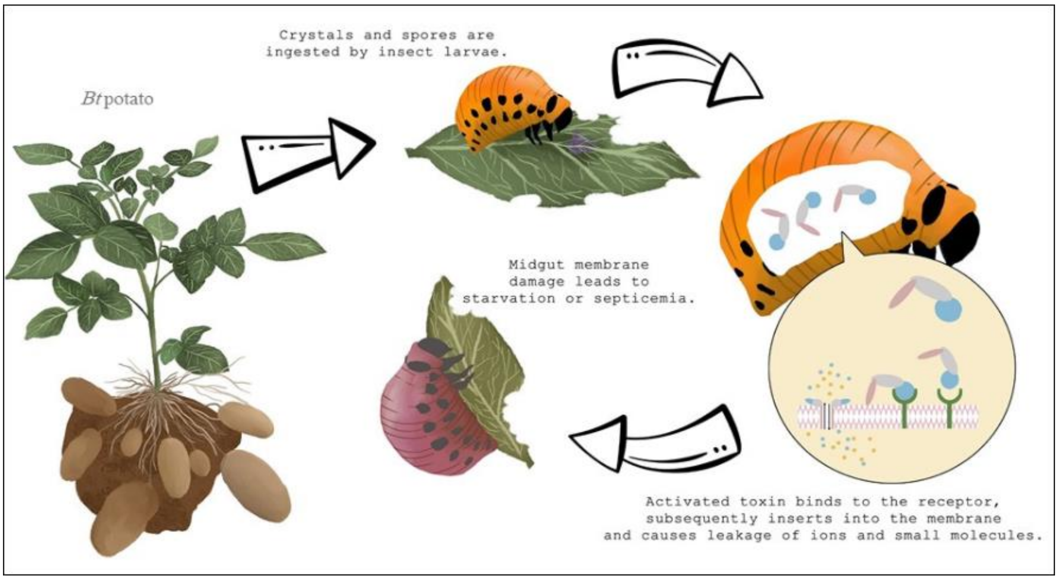

Fig.2: ***Bacillus thuringiensis*** **(Bt) toxin affects Colorado potato beetle larvae.**

The Cry 1A(b) gene expressed in transgenic cabbage plantsthrough genetic transformation shows specific insecticidal activity against the Diamond black moth larvae (Bhattacharya *et al*.,2002). Experimental studies of Narendran *et al*. (2013), show that the Cry1 Ac gene is expressed in okra plants and this shows resistance against fruit and shoot borer causing 100% larval mortality.

Disease Resistance

Plant diseases are a major threat to crops and losses are estimated to be 11-30% (Oerke and Dehne, 2004; Savary *et al*., 2019). Hence integrated disease management approaches need to be adopted to tackle all those problems. Adoption of conventional techniques along with modern breeding approaches like genetic modification of crop plants for pathogen resistance provides a good solution to protect the crop plants from plant pathogens. To prevent fungal infection in plants, they develop an innate immune response system for recognizing the pathogen presence and start effective defense response by producing the protein defensins (Van Loon, 1997). Defensins have a prominent role in the innate immunity development in plants by preventing the growth of microorganisms and insects causing pathogenicity in plants. Expression of defensins in potatoes prevents the fungal pathogen *Verticillium dahliae* from causing verticillium wilt (Gao *et al*., 2000). In potato, the expression of *Galanthus nivalis* agglutinin (*GNA*) gene shows a harmful effect on potato-peach aphid development by reducing fertility and delaying the reproductive cycle, thereby decreasing the aphid population (Gatehouse *et al*., 1996). Expression of peptide-T4 lysozyme gene under CaMV 35S promoter control shows resistance to *Erwinia caratovora* in transgenic potato plants (During, 1993). Wild species such as *C. lundelliana*, and *C. okeechobeensis* contain fungal resistance genes which are transferred into *Cucurbita moschata* for bringing resistance against *Phytophthora capsici* (Phytopyhora crown rot). Through Agrobacterium-mediated transfer, Coat protein (CP) genes are genetically engineered to develop a variety 'Freedom", the first commercially available transgenic squash variety showing resistance against Zucchini yellow mosaic virus (Tricoli *et al*., 2008). In transgenic melon, over expression of the CMV-CP shows resistance against Cucumber mosaic virus under protected cultivation ((Yoshioka *et al*.,1993). Another transgenic melon line BU21/3 was obtained by over expression of At1 and At2 genes which are enzymatic resistance (eR) genes,expressedby enhanced glyoxylate aminotransferases activity, shows resistance against Downey mildew (*Pseudo peronosporacubensis)* (Taler *et al*., 2004).

Abiotic Stress Resistance

As the global temperature rises, many crops are experiencing a negative influence on various develeopmental processes. Developing a heat-tolerant genotypes solves these challenges. Osmolytes in plants play a major role in the production of reactive oxygen species that shows tolerance against oxidative stresses.Hence, by transfer of genes showing osmolyte synthesis to the crops results in the development of heat-tolerant varieties. In the chloroplast of potato plants, the genes for Cu and Zn superoxide dismutase and ascorbate peroxidase are overexpressed, indicating that they are temperature tolerant to 42 °C. Both antioxidants operate as scavengers of reactive oxygen species and aid in the quenching of free radicals that lead to plant heat tolerance (Tang *et al*., 2006). Many research studies reveal that proline and glycine betaine are two compatible osmolytes synthesized in crops under stress conditions which confers tolerance against salt and drought. Hence overexpression of P5CS pyrroline-5-carboxylate synthetase gene from *Arabidopsis thaliana* in potato plants resulted in enhanced proline production and these GM potatoes also showed drought and salinity tolerance as well as increased tuber weight and yield of potatoes.(Hmida-Sayari *et al*., 2005). Mercury contamination in food and the environment is hazardous to both soil and human health.Transgenic expression of merA and merB genes removes the mercury accumulation in soil (Li *et al*., 2020). In recent days, one of the most critical plant traits for sustainable food production has been the creation of transgenic crops with better thermotolerance (Zhang *et al*., 2019). Transgenic Chinese cabbage plants expressing the nucleolar DEAD-Box RNA helicase OsTOGR1 gene are more resistant to heat stress. Heat shock proteins are important in combating plant heat stress (Yarra and Xue, 2020). Hence, Plants' heat stress transcription factors and heat shock proteins are genetically engineered to create heat tolerance genotypes. Heat tolerance is achieved in transgenic tomato plants by inserting the HSP24.4 gene from wild banana into the PKM 1 variety, which protects against heat-induced damage and controls the protein metabolic activities. Under high-temperature conditions, these transgenic tomato plants show improved seed germination, vegetative development, and fruit and seed set (Mahesh *et al*., 2013). Also by overexpression of MT-sHSPs (Mitochondrial heat shock proteins) in tomato plants, shows high-temperature resistance (Nautiya *et al*., 2005). Zhu *et al*. (2018) found that the BcHsfA1 heat stress transcription factor is expressed in Chinese cabbage and it has thermo tolerance potential in plants. Heat resistance is achieved in transgenic potato plants by introducing the temperature-dependent heat shock cognate 70 (HSc 70 gene) (Trapero-Mozos *et al*., 2018).

Herbicide Tolerance

Weeds are major competent to the main crop and cause yield losses up to 76% and to control weeds, herbicides are used by farmers which is more expensive and many cultivars are also sensitive to these herbicides. EPSP synthase gene from Petunia is inserted into a tomatoplant to make glyphosate-resistant plants.Goodwin *et al*.(1996) showed that transgenic potatoes developedutilizing gene silencing technology and by transferring non-translatable DNA sequences have lead to the synthesis of virus-resistant transgenic plants. In potato, the EPSP synthetase gene has been for making the herbicide resistance plants. The gene obtained from the soil bacterium *Klebsiella ozaenaeis* inserted into potato plants, the gene contains deactivating principle which deactivates the herbicides and offers resistance to Bromoxynil.

Edible Vaccines

Vaccines are immune boosters that protect humans from various diseases by improving the immune system of our body. Edible vaccines are plant-based which involves the insertion of the gene of interest into plants and these transformed plants are aided to produce the encoded proteins. Wild plants are used to treat many diseases over the past few years. The production of vaccines using GM technology is a very interesting topic nowadays. The first vaccine was produced against hepatitis B by toxin production in transgenic banana plants. These vaccines are produced by extracting the tissues or organs of plants in which it accumulates, which maybe leaves, roots, or seeds of the plant. Ying Ma *et al*.(2001), studied that hepatitis E virus (HEV) open reading frame 2 partial gene is overexpressed in tomato plants, which develops the immunoactivity and a new vaccine developed is called HEV oral vaccine. Transgenic expression of carrot plant parts results in the development of many edible vaccines against infectious human diseases like hepatitis B virus, cholera, tuberculosis, Rabies, and porcine cysticercosis (Fig. 3).

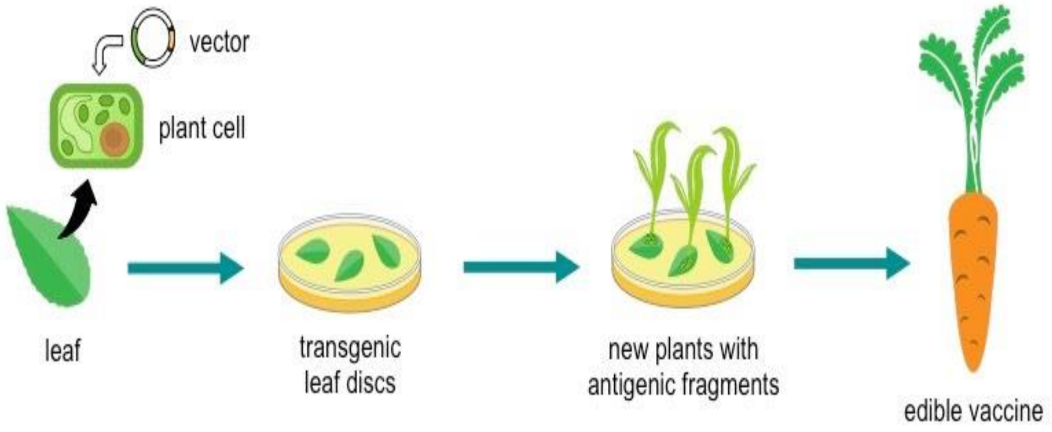

Fig. 3: Edible vaccine production

Controversies

Some of the case studies reveal that genetically modified potatoes expressing agglutinin gene from *Galanthus nivalis* plant when fed to rats, show toxicity effect on rat's gastrointestinal tract and results in stunted growth.Critics further claimed that this transgenic technology has bad effects on human health, the environment, non-target organisms,and also its use will boost private-sector profits and it will leave the small farmers farming in difficulties. There is a concern that horizontal gene transfer may occur between transgenic plants and animals. But the studies have proven that no residues were found in the analyzed animal tissue samples. Some other risks in utilizing these genetically modified crops include horizontal gene transfer, crop diversity loss, allergenicity, and antibiotic resistance.Prolonged exposure of insects to Bt proteins results in the development of resistance against the insect. Such insect resistance can be overcome by growing non-transgenic crops adjacent to Bt crops expressing insect-resistant proteins and also by co-expression of different cry genes in similar types of plants.

Impact on Environment

Transgenic crops have a positive environmental impact since they aid in poverty alleviation, economical improvement in agriculture by boosting crop yield and reducing crop losses due to insects, pathogens, and weeds. According to committees of the National Research Council and European Commissions, safety considerations on GM crops adoption is not different from conventional breeding in cases of disagreeable arguments putforth by critics, related to environment and human health associated risk factors. In soybeans, the use of herbicide-tolerant crops has reduced the conventional usage of selective herbicides. There is a method to determine the impact of every individual selective herbicide on the environment, known as the Environment Impact Quotient(EIQ). This factor helps us to understand the effect of these herbicides on the environment and make us use the alternative method like the use of herbicide-resistant crops to combat these uncertainties. In cotton also, more amount of pesticides were used to get rid of bollworm insects, which resulted in high usage of chemicals in the environment. By the introduction of bollworm-resistant cotton, many countries have shown the great impact of Bt-cotton against the targeted pest. There is also a concern that toxic insecticidal proteins that are released in the soil after plant growth shows a toxic effect on the beneficial soil microorganisms. But this fact is scientifically proven wrong by conducting the experiments, in which insect-resistant cotton plants (which encodes for cry 1Ac protein in plants to kill the targeted insects) were grown and these plants were incorporated in the soil after tillage practices. Then these soil samples were taken from the field, analyzed, and tested for the presence of insecticidal protein in the soil samples. But the results have shown that there was no detectable limit of Cry 1Ac protein was found in the analyzed soil samples. Transgenic crops have no negative impact on non-target organisms. Some of the studies found that these insecticidal proteins have changed the behavioral pattern in worker bees after intake of these proteins. Hence, in such a case, proper analysis and focused research studies need to be undertaken to ensure the resistance of Bt proteins against non-target species. Proper funding and policy adoption is a major concern that needs to be more focused on to extend the research studies in horticultural biotechnology.Transgenic vegetable breeding will result in ensured food security, overcomes malnutrition problems, mitigate climate change, conserve species diversity, better plant and disease management. Proper biosafety regulations and policies have to be strictly regulated to manage the biosafety issues related to GM crops to ensure future development in vegetable breeding.

Risk Assessment

Safety assessment is a part of risk assessment and it is used to identify whether any bad impacts exist in the genetically modified crops. Hazards in the produce are identified and that information is collected and evaluated to determine their severity. The foremost step in the risk assessment process is to identify and characterize potential concerns related to nutritional aspects and to determine the allergenicity and toxicity. Then the next step is to monitor the level of human exposure to the targeted gene expression on the plants and to access the hazards. The safety risks of GM crops are accessed by comparing the genetically modified plants with conventional breeding crops and focusing on existing differences and similarities. According to US Environmental Protection Agency (EPA), risks are managed by assessing the risks associated with GM crops, and also the pre and post-marketing operations of these crops have to be monitored and evaluatedto identify the hazards and totake the necessary actions. Many scientific studies after various risk assessments have also concluded that there found to be reduced risks resulted from the improved nutrition value, mycotoxins, and plant toxins. All the uncertaintiesrelated to human health and the environment can be overcome by identifying those risks and proper measures have to be undertaken to minimize the undesirable environmental impacts.

Risk assessment procedures listed down by National Research Council(NRC) in 1983 are listed below:

- The population that is exposed to stressors, as well as the size, duration, and spatial extent of the exposure, should be documented in the exposure assessment.
- Identifying detrimental impacts (e.g., cancer, short-term health effects) that may arise as a result of exposure to environmental stressors should be the first step in hazard identification. Dose-response assessment should be done by determining the toxicity or potency of stressors
- The toxic effects of stressors are evaluated through dose-response studies.
- Risk characterization should be done by assessing and reporting the consequences of human or ecological exposure to stressors using the data acquired in the first three steps.

Conclusion

If people anxieties about genetically engineered crops are eliminated, the transgenic breeding methodology would provide a better solution to tackle the problems encountered by the horticulture farming community in food production. GMO crops do not appear to have any detrimental effects on human health or the environment, and this has been scientifically validated in several studies. China and India have a 40% global population and nearly 60% of vegetables are grown and consumed by them. China and India have already accepted and cultivating Bt cotton and Bt rice. If these countries embrace other advantageous transgenic crops, farmers in other parts of the world will be encouraged to do so as well.The European Union is now following stringent restrictions in the entry of transgenic crops to the market place and targeted gene delivery in the crops is closely monitored. Many risk assessment and impact studies have resulted in better and significant benefits in crop production economically, with less pesticide usage and enhanced crop yield performances. Climate change is a major matter of concern for farmers, since it poses significant production risks, leading to reduced nutritious quality and yield measures. As a result, advanced biotechnology methodology has been widely used to mitigate all such biotic and abiotic stresses. If paired with conventional agricultural expertise, transgenic breeding will be a miracle cure in reaching all of these objectives. To ensure the trustworthiness of GMO crops in the future, both concerns and benefits are thoroughly monitored and analyzed for every transgenic crop.

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