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GROWING GREENER: HARNESSING THE POWER OF NUCLEAR TECHNOLOGY FOR SUSTAINABLE CROP DEVELOPMENT

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Nuclear technology has a wide range of agricultural uses. To boost agricultural yield, radioisotopes were employed to produce high-yielding crop seeds. Radioisotopes were also employed to investigate the function of fertilisers in various plants. Certain radioisotopes' radiation was also employed to destroy insects that harmed agricultural grains. By carefully exposing cereals, fruits, vegetables, and canned foods to radiation, they can be stored for longer periods of time. Applications of radioisotopes and radiation are assisting us in solving difficulties in much less time. The use of radioisotopes in agriculture has expanded due to the generation of radioisotopes by nuclear reactors and other atomic installations. India is the world's leading producer of radioisotopes, and our nuclear scientists are working on various technologies for the beneficial use of radioisotopes.

Nuclear technology has multiple applications that are fundamental to our daily life. The best-known applications are medicine and electricity production, but there are others in such diverse fields as agriculture, industry and art. These applications have a large presence in our day-to-day life, and in the future, they will be even more relevant as research is increasing their possibilities of application and justifying their use. Radioisotope and radiation techniques are used in agriculture to increase food quality by inducing mutations in plants and seeds to achieve desired crop types without having to wait for the long process of spontaneous mutation. Certain radioisotopes' radiation was also employed to destroy insects that harmed agricultural grains. By carefully exposing cereals, fruits, vegetables, and canned foods to radiation, they can be stored for longer periods of time.

Crop Improvement

Ionizing radiations can be used to induce mutation in agricultural crops. Mutation breeding also called mutagenesis is a crop improvement process in which heritable changes occur in the genetic material that sometimes is repaired in the DNA repair process (Ahloowalia and Maluszynski, 2001). The widespread use of mutation techniques in plant breeding programmes throughout the world has generated thousands of novel crop varieties in hundreds of crop species and billions of dollars in additional revenue. For the purpose of improving crops, plant breeding needs genetic variety of beneficial features. It is possible to use several radiation types to create desired mutations, such as disease resistance, improved quality, the ability to ripen fruit early, and increased yield. The "miracle" rice, which has significantly boosted the pace of rice production, is one well-known example of a productive crop.

Controlling Pests and Diseases

The usage of harmful chemicals and other pesticides can be reduced thanks to the widespread use of radioisotope techniques in pest management. The sterile insect technique (SIT), which uses gamma radiation to sterilise male, lab-raised insects, is the most popular method. Following their reintroduction into the wild, these sterilised insects' mate but do not create progeny, which over time decreases the insect population and finally stops it from growing.

Improving Water Use Efficiency

Nuclear and in particular isotopic technologies play a significant part in enhancing the water use efficiency in agricultural contexts. In particular, isotopic techniques can:

1) Optimize irrigation scheduling by accurately monitoring soil in order to minimize water losses,

2) Optimize crop's water absorption rate from rainfall or irrigation, and

3) Assist in selecting crop with higher tolerance to drought and higher crop water productivity. Stable isotopes can be used to measure the abundance of oxygen, carbon, nitrogen and hydrogen in soil, water and plant in order to help with identifying sources of nutrient fluxes, and more evenly spread water and different nutrients throughout the soil(Iaeaorg. 2017).

Fertilisers

Fertilisers cost a lot of money, and improper application can harm the ecosystem. It's crucial that as little spent fertiliser as possible escapes into the environment and gets "fixed" in plant matter. It is possible to determine how much fertiliser has been absorbed by the plants by "labelling" fertilisers with a specific isotope (for example, nitrogen-15), which enables better management of fertiliser use.

Postharvest Applications

The appropriate use of radiation can extend shelf life, reduces the requirement of chemicals for preservation and pest control, produces sterilized products that can be stored without refrigeration, delays the ripening of fruits and vegetables and limits the deterioration of quality of stored tuber and bulb crops by preventing postharvest

Direct irradiation of food is a technique accepted and recommended by the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA). Nuclear technology improves the quality of food and extends its period of conservation.

Use of Nuclear Energy in Indian Agriculture

Using radiation induced mutagenesis technology, DAE has developed 42 varieties in oilseeds (groundnut, mustard, soybean and sunflower), pulses (urdbean, mungbean, Pigeonpea, cowpea), rice and jute, which have been released and notified for commercial cultivation across the country.

The Government of India (Department of Atomic Energy) has established two radiation technology demonstration units, one in Vashi, Navi Mumbai, for high-dose irradiation and another in Lasalgaon, near Nashik, for low-dose irradiation, namely the Krushi Utpadan Sanrakshan Kendra (KRUSHAK) facility. The Board of Radiation and Isotope Technology (BRIT) operates the facilities. Two plants are also set up one each by Maharashtra government and Gujarat government. Currently, 15 irradiation plants including those in Private Sector are functional in the country carrying out radiation processing of agricultural/food products. Presently fruits like Mango and Pomegranate and vegetable like onions and garlic are being irradiated for shelf-life extension.

In so far as Agriculture sector is concerned, Ministry of Food Processing Industries (MOFPI) grants subsidy to gamma radiation processing plants under SAMPADA (Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters) which are installed for gamma radiation processing of food products(Press Information Bureau Government of India Department of Atomic Energy, 2018).

Disadvantages of Nuclear Energy

Nuclear Radiation Accidents

Both mankind and Mother Nature are seriously endangered by the radioactive waste that results from nuclear power facilities. The disastrous impacts of the Chernobyl tragedy continue to haunt us, and the serious effects on humans are still evident.

Demands substantial start-up capital expenses.

Requires High Initial Capital Costs

The fact that it costs a lot of money to build up a nuclear power plant is another practical drawback of employing nuclear energy. It costs a lot of money to build a nuclear power plant.

Eutrophication Causes Aquatic Organisms to Perish

Eutrophication, which is primarily caused by runoff from the land, is the significant enriching of the lake and other water bodies by nutrients. This process results in dense plant growth, which ultimately causes aquatic life to perish from a lack of oxygen. This issue may be brought on by radioactive waste. It takes around 10,000 years for radioactive waste to decay.

Nuclear Waste

Nuclear waste is generated by nuclear reactors and must be disposed of or kept safely and easily since it poses a serious risk of radiation leakage if improperly disposed of.

It is Not a Renewable Source of Energy

Uranium is the primary component used in the production of nuclear energy. Since uranium is mined, not many nations have access to it. It is a limited resource as well.

Conclusion

We live in a world where food security can be greatly impacted by harvest failures and the consequential rising of food prices. The use of nuclear technologies is a potential solution to these problems, and many of these solutions are currently being widely used in different agricultural contexts. Genetic modification, pest control using sterilization and water usage control are three main areas of nuclear application in agriculture. Unfortunately, the application of nuclear energy in agriculture is a highly debated, highly politicized issue due to potential contaminations and nuclear waste management, so it is imperative that we work toward a greener nuclear age, where these powerful technologies can be implemented to its full without their challenges and threats.

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