ROLE OF PEACEFUL NUCLEAR TECHNOLOGY IN THE AGRICULTURE AND FOOD SECTOR OF PAKISTAN

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Abstract

The primary emphasis of the study is to evaluate that Pakistan is using peaceful nuclear technology to fulfil its domestic needs of agriculture and food. This study also evaluates that Pakistan has vast experience using peaceful nuclear technology. Pakistan can advance in food production and quality products if the international community opens its door to Pakistan. Pakistan believes sharing peaceful nuclear technology can overcome food shortages by improving the agricultural and industrial sectors. Four Nuclear Agriculture Institutes are working under the Pakistan Atomic Energy Commission (PAEC) umbrella. Pakistan is moving forward to introduce and modernise drone technology in the agriculture sector to save crops from insects and pesticides as a part of food security. PAEC is playing a vital role in transferring nuclear technology for peaceful purposes.

Keywords: Peaceful Nuclear Technology, Agriculture, Food Security, *Pakistan,*

Introduction

Agriculture is one of the essential areas for human survival, which helps to fulfil the fundamental needs of everyone. The agriculture sector plays a pivotal role in providing food to eat and raw materials for the industry to produce goods directly correlated to human life. Applying nuclear procedures in agriculture is a technique of peaceful nuclear technology.[1]

The role of PAEC is vivid to promote peaceful nuclear technology in multiple sectors of Pakistan like energy, medicine and agriculture. To develop new varieties, the PAEC is working on combining both mutation breeding and conventional method to enhance the crop's quality, stress tolerance, wider adaptability and high yield. The four institutes of PAEC use the technology of international standards to utilise the salt-affected land and educate the local farmers about the better utilisation of this type of land and improving saline areas. Water management is also a big challenge for farmers in the current time and a threat for the future, directly associated with increased output and food safety. Applying fertilisers is causing environmental risk, but using technologies has improved irrigation techniques and water management.[2] The prerequisite is to build more dams to secure water needs which is a fundamental necessity for the agricultural sector.

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Nuclear technology has brought a revolution in the agriculture and foods sector. Nuclear Technology is considered one of the most trusted and advanced techniques used in agriculture. The two main tools are isotopes and radiation techniques to encounter insect pests and diseases, increase agriculture and livestock production productivity, land management, water resource management and food protection and safety. There are many examples of improving the agriculture sector by using nuclear technology. Animal health and productivity have been improved by using nuclear technology. There is an increase in the production of milk and meat, and the income of the farmers raised, which has improved the standard of living of the farmers. Water management and improved soil conditions impact food security, enhancing the efficiency level by using nuclear technology.[3]

World Food Security

It is a big concern to consider and take remedial measures to save human life from hunger as around 821 million (almost 11% of the total world population) of humans on earth goes to bed hungry every night, while 3.1 million children die annually due to undernutrition. After harvesting, food production lost between 25-30% due to insects, bacteria and rodents, which must be minimised to counter the food deficiency and save the world's precious lives. Irradiation in the food does not make the food radioactive and looks like fresh and raw food. Food irradiation is used in the United States in school cafeterias, international flights, astronauts on space missions and meals for patients of open hearts in hospitals.[4]

Food irradiation has the same outcome, and it is useful when heated, frozen, refrigerated or in a chemical reaction without changing the temperature. IAEA is working with Food and Agriculture Organisation (FAO) to enhance the capacity of associated states through the safety and quality of the food by using radiation. These organisations are also working with International Plant Protection Convention (IPPC) and Codex Alimentarius Commission to equalise irradiation standards internationally.[5] Nuclear technology is used in agriculture to enhance food, insect control, neutronic sounding waves etc.[6]

Benefits of Nuclear Technology in Agriculture

Nuclear Technology is cheap, so it can be used in agriculture to reduce cost and time. As natural gas prices are increasing daily due to high demand and less production, nuclear energy can be used to produce nitrogen fertiliser. The mutation breeding has provided more than 3,000 crop varieties of 150 plants, including rice and barely in more than 100 countries.[7]

Radiation Technology is used to provide safer, healthier, longer and fresh food to improve our life with quality in diversified ways. This technology is also beneficial for the protection of the environment through saving water, increasing crop production, reducing environmental stress, keeping food safe, maximising crops, controlling pests and enhancing livestock productivity and health.[8] A joint programme of FAO and IAEA is to

use isotopes in food in agriculture so that food and plant diseases can be reduced and productivity can be increased in lucrative means. The use and purpose of nuclear technology in agriculture are to combat pests and diseases, increase crop production, protect land and resource and ensure food safety.[9]

Sterile Insect Technique Drones by IAEA

IAEA supports using drones to release sterile mosquitos from drones to overwhelm the insects that spread Zika and other diseases. The Sterile Insect Technique (SIT) technique is implemented jointly by the FAO and IAEA to sterile the male mosquitoes, which are spread and then gathered with remote females. This cost-effective method requires low time consumption as 20 hectares can be treated within 5 minutes. Furthermore, the drone's weight is less than 10 Kilograms; at 10,000 Euro per drone, that can carry 50,000 sterile mosquitoes, which is cheaper than ground labour. The IAEA and its partners are further working to decrease the drone's weight and raise the number of sterile mosquitoes to 150,000.[10]

The coalition of FAO and IAEA is to enhance the knowledge, skills and expertise in food and agriculture for over 50 years. Pakistan, Angola and Mozambique are examples of food safety and improvement in the traceability system. Pakistan food production and export organisations have benefited from this technology by improving their laboratory testing capabilities per international standards.[11]

IAEA and OPEC Fund for International Development (OFID) has performed an agreement of US$600,000 to improve food security and nutrition value and promote the agriculture sector in different Asian countries.[12] Food irradiation is a process to eliminate bacteria from meat, fruit and vegetables. This will not reduce the nutritional value or the taste of the eatables, and safe to use. It also improves the quality and production worldwide and is used for breeding new seeds with a higher return, enhancing and upgrading the nutritional value; insect control and elimination are also a function of irradiation.[13]

The proper safety measures in the research centres and laboratories of the PAEC institutes will be taken regarding waste management and radiological protection.[14] At the IAEA general conference 2012, the topic was related to "Food for the Future" due to its productivity, accessibility and safety measures threatened in the future. 70% more food will be required by 2050 to meet the fast-growing population's demand. The IAEA Director Yukiya Amano said that IAEA contributes to transferring nuclear technology to developing countries to ensure food production efficiency and to overcome animal and plant pest diseases. The food problem in the world cannot be solved individually by the IAEA, but the cooperation of the world is required.[15] He stated that around one billion people on earth do not have sufficient food to eat. I hope that those countries which are familiar with nuclear technology will be more benefited and other countries will also join us in using nuclear technology for food production and safety.[16] IAEA supports different technical cooperation projects with an annual expenditure of US $ 14 million and 30 research projects in over 400 various institutions of the member states.[17] Each year IAEA

receives requests from its more than 100 member states for technical training, equipment, services, expertise and assistance.[18]

Drone Technology in the Agricultural Sector of Pakistan

Drones Technology is also beneficial for the farmers in terms of a better picture and view of the agriculture farms and fields. There are two types of drones which are available to use in fields. The first type of drone has rotary wings, and the second one has fixed wings.[19] Turkey and China also manufacture global drones, a green signal for Pakistan to go ahead with domestic production with their support. Chinese drones are cost-effective compared to the USA, and the cost ratio is 1:4 respectively. Pakistan will import 48 drones from China, and the Chinese Chengdu Aircraft Industrial Group will support Pakistan Aeronautical Complex (PAC) for domestic production of drones.[20]

Pak-China friendship had also moved a step forward in a difficult time when 12 agriculture drones were handed over to Pakistani officials of National Food Security and Research. Pakistan has developed agriculture drones at the domestic level to fight locust swarms as Pakistan has declared emergency preparedness to tackle the global issue.[21] As per the statement of Minster for Science and Technology, Pakistan will announce its drone policy soon after dialogue with the concerned. In earlier times, drones were used for defence only, but now it has become the need of the hour to introduce drones for agriculture and police vigilance.[22]

Locust Control and National Food Security

FAO has cautioned about the locust attack as a significant threat to food security. The weight of a locust is about 2 grams, and a locust eats the same food as its weight. The size of a locust is between 10mm-70mm, which may vary with the growth cycle. Loss at the rate of 15% of wheat, gram and potato will reach $ 1.3B. The potential loss of 25% will be compared to Rs. 353B to Rabi and Rs. 464B to Kharif during the summer and winter seasons.[23]

In Pakistan, the Department of Plant Protection (DPP) at the Ministry of National Food Security & Research is responsible for countering locust attacks. Pakistan has declared an emergency through National Action Plan (NAP) and Inter-Provincial Coordination. Pakistan should have focused on its resources, i.e., human resources by the Pak Army, drones and equipment with the support of the Plant Protection Division instead of relying on China. The self-strategy of the department matters a lot to finding the experts and those with experience of surveillance of deserts.[24] Pak-India's border meeting has already been held to exchange information to overcome the issue of locusts across the border. Since 1995, Iran and Pakistan jointly undertake ground surveys every April at Baluchistan and southwest Iran for two weeks on each side.[25] Food security is compelling both countries to negotiate to counter the locust attack. In Pakistan, the farmers are adopting the traditional approach by beating drums and lifting the smoke in the air to stop the supply of oxygen to locusts. However, this isn't easy to manage accurately and efficiently.[26]

The World Bank has agreed to support Pakistan's 200 million USD to combat locusts, restore affected people of specific areas and support the country's food security. Out of this total amount, 125 million USD will be financed by International Development Association (IDA). Due to the COVID-19 pandemic, it has become a challenge for Pakistan to fight on both ends. 20% of the population is underweight, which reaches 40 million people, while 40% of the population is surrounding the poverty dimension, and 25% is living under the poverty line. It is a direct threat to national food security that should be controlled immediately.[27]

According to the Minister for Food and Security statement, Pakistan will spend Rs. 20 billion to overcome the issue of locusts. In the annual budget, it was proposed to allocate Rs. 9.7 billion by the federal government and Rs. 10.2 billion by the provincial government to tackle the menace of locusts. The resources were also provided to initiate ground operations over 8,500 hectares of land; as a result, over 500 hectares of land were sprayed with two helicopters.[28]

It has become difficult to overcome locusts during covid. Developing countries like Pakistan face a challenging time fighting and defending both ends. That is why international support is required to move forward for the survival of ordinary human beings. As per the prediction of the UN, the swarms could grow 400 times by mid-year. The lockdown due to the pandemic and locust attack may lead to disaster for third-world countries.[29] Scientists have claimed that nuclear technology in the agriculture and medicine sector has helped Pakistan achieve 12 national goals set by the United Nations. Nuclear technology has helped Pakistan earn $ 7.4 billion. Pakistan is also an honour to be part of 13 countries around the globe to share knowledge of peaceful nuclear technology.[30] The NDMA has worked a lot to control locust attacks and post effects. The NDMA has a covered area of 538,100 hectares, and 1,129 teams were engaged to participate in locust operations. The team has covered 7,600 hectares of Baluchistan, 600 hectares of Khyber Pakhtunkhwa and 500 hectares of Sindh.[31]

Advancement of Nuclear Technology in the Agriculture and Food Sector of Pakistan

According to FAO, from 2014-16 there were 795 million (1 out of every 9) suffered from chronic undernourishment. That is why the role of nuclear technology through radiation and radioisotopes in the agriculture sector is essential to reduce these figures and overcome food deficiencies. Therefore, an international standard was adopted jointly in 1983 by the three top international organisations, i.e. WHO, FAO and IAEA. The joint work of IAEA and FAO are also advancing the food techniques to use radiation in food by doing different tasks with the support of the International Plant Protection Convention (IPPC) and Codex Alimentarius Commission to make it a more effortless and accessible way.[32]

As per the Pakistan Bureau of Statistics (PBS), the agriculture sector shares almost 24% of the GDP as 50% of the country's labour power is attached to this sector,

and it is the country's most significant area of foreign exchange earnings.[33] Pakistan is an agricultural country that produces wheat, cotton, rice, vegetables, fruits and other agricultural products that are not only enough to consume, but the surplus is exported to gain foreign exchange.[34] The Pakistani economy is agriculturally based with semi-industrialised. It is the 26th largest in the world in terms of Purchasing Power and 45th in nominal Gross Domestic Product (GDP).[35] Today, 25% of land farmers owe less than 0.5 hectares, with the largest group.[36]

During the fiscal year 2014 to 2015, there was an increase of 2.9% in the agriculture sector and surprisingly the livestock sector rose by 4.1% and has recently contributed 11% to the GDP. Despite growth in this sector, the European Union has rejected 134 consignments of food due to contaminants, reflecting a significant concern for the country, exporters and farmers to bring safety control systems in their products. The joint division FAO/IAEA has supported Pakistani Institutes in developing efficient and effective ways to test for veterinary drug residues using nuclear technology. The division also keeps increasing the efficiency of its available resources instead of procuring new ones. The advice of the joint division has also worked for institutes and laboratories using International Standards Organization (ISO) certification and proficiency testing and authorised to provide eight analytical services to check for compliance. Due to this support, 45 public and private institutions export quality products after laboratory testing.[37] The agriculture sector of Pakistan contributes around 18.9% to the GDP and engages the labour force around 42.3%. During the fiscal year 2017-18, the growth rate surpassed the target of 3.5% to 3.81%, while the growth rate last year was 2.07%. The crop sector of Pakistan is also performing well at a growth rate of 3.83%.[38] Therefore, Pakistan must concentrate seriously on agriculture, contributing around 70% to the economy. PAEC is producing expert knowledge through an average of 40 courses and training on the latest techniques and technologies. In addition, the Pakistan Institute of Engineering and Applied Sciences (PIEAS) is providing quality education and awarding MPhil and PhD degrees to its affiliated institutes. Institutes working under PAEC are given in Table -1.

Table-1: Nuclear Agricultural Institutes Working Under PAEC

Name of Institute	**Established on**	**Location**
Nuclear Institute of Agriculture (NIA)	1963	Tando Jam, Sindh
Nuclear Institute for Agriculture and Biology (NIAB)	1972	Faisalabad
Nuclear Institute for Food and Agriculture (NIFA)	1982	Peshawar
National Institute for Biology and Genetic Engineering (NIBGE)	1994	Faisalabad

(**Source**: Pakistan Atomic Energy Commission)

Nuclear Institute of Agriculture (NIA)

The institute provides multiple facilities in Plant Breeding & Genetics, Plant Protection, Plant Physiology and Soil Sciences. It also has four laboratories: Bio Control Lab, Molecular Marker Lab, Marker Study Lab and Tissue Culture. Different types of 27 crops are produced by NIA, out of which wheat and rice cover 30% to 35% of the area in Sindh while the area of cotton and sugarcane is increasing progressively. The core function and responsibility of the NIA is to explore the potential use of isotopes for the betterment and advancement of the agriculture sector. The institute has to work on various crops through conventional means. Divisions and Laboratories of NIA are given in Table 2

Table-2: Divisions and Laboratories of NIA

S. No	Divisions	Laboratories
1.	Plant Breeding and Genetics Division	Bio Control Lab
2.	Plant Protection Division	Molecular Marker Lab
3.	Plant Physiology Division	Marker Study Lab
4.	Soil Science Division	Tissue Culture

(**Source**: https://nia.org.pk/main-thrust-of-division/)

Nuclear Institute for Agriculture and Biology (NIAB)

There are different facilities which are provided at and by NIAB. Ionising radiations and radioisotopes are the practical techniques that differentiate it from the conventional method used in agriculture and biological examination. NIAB has different equipment in the laboratories. A workshop for various works is also available for repair, maintenance, and other required functions at NIAB.[39] At the request of PAEC, the IAEA has launched a project of 2 years (2012-2014) in which a budgeted cost was € 208,321 in the area of Veterinary Drug Residues in Food Stuff.[40] Shandar is the rice covering 50% of the rice area in Sindh. The cotton variety covers almost 70% area of the cotton throughout the country.[41] Research divisions of NIAB are given in Table -3.

Table -3: Research Divisions of NIAB

S. No	Divisions
1.	Plant Breeding and Genetics Division
2.	Soil & Environmental Division
3.	Plant Protection Division
4.	Animal Sciences Division

(**Source**: http://www.niab.org.pk/)

Nuclear Institute for Food and Agriculture (NIFA)

The quality policy of NIFA demonstrates that food production should be sufficient, nutrient and environmental-friendly. The Plant Breeding and Genetics Division

of NIFA has produced 21 varieties of crops, including wheat, oil seed brassica, chickpea and mungbean, and these have become very popular among the farmers. NIFA also provides consultancy in termite control in buildings & crops and provides the service of oil quality analysis.[42]

Table -4: Divisions and Research Groups of NIFA

S.No.	Divisions	Research Groups
1.	Plant Breeding and Genetics Division	Wheat (Irrigated), Wheat (Rainfed), Oilseed (Brassica), Pulses and Horticulture
2.	Food and Nutrition Division	Food technology and nutrition and food & environmental protection
3.	Plant Protection Division	Agricultural entomology, medical entomology and plant pathology
4.	Soil and Environmental Sciences Division	Soil biology and biochemistry group and the other plant nutrition group

(**Source**: https://www.nifa.org.pk/)

National Institute for Biotechnology and Genetic Engineering (NIBGE)

It is the achievement of NIBGE to have Polymerase Chain Reaction (PCR) technology to test the different diseases. Improvement in the agricultural and industrial sectors directly correlates with national progression. NIBGE has an affiliation with PIEAS for MPhil and PhD degrees in biotechnology. The institute collaborates with International Center for Genetic Engineering and Biotechnology (ICGEB). NIBGE has also been declared and nominated as the regional centre of the United Nations Industrial Development Organization (UNIDO). The library of NIBGE has the National Library for Biological Sciences status, and it has also been awarded ISO 9001-2000 certification.[43]

Table-5: Divisions and Research Groups of NIBGE

S.No.	Divisions	Research Groups
1.	Agricultural Biotechnology Division	Gene isolation, gene transformation, molecular virology and gene silencing, plant genomics and molecular breeding, DNA markers and applied genomics, applied and molecular entomology and collaborative projects
2.	Health Biotechnology Division	Viral hepatitis, enteric pathogens, drug discovery and structural biology, human molecular genetics and metabolic disorders, tuberculosis, molecular haematology and oncology group and probiotic and food safety
3.	Industrial Biotechnology Division	Nanotechnology, industrial enzymes and biofuels, bioresource development for industry, bioprocessing of ores and fossil fuels and systems biology of prebiotic synthesis
4.	Environmental Biotechnology Division	environmental toxicology and molecular diagnosis, bioremediation and biodegradation, wastewater treatment and phytoremediation, microbial phytotechnology and environmental testing services
5.	Technical Services Division	Fermentation Technology, Workshop, IT Center, and CCML

(**Source**: http://www.nibge.org)

Detail of the institute working under PAEC is given in Table 6.

Table-6: Different Crops Varieties Produced by Institutes working under PAEC

S.No.	Crop	Institutes				Total
		NIA	NIAB	NIFA	NIBGE	
1.	**Brassica**	01	-	04	-	05
2.	**Castor Bean**	-	01	-	-	01
3.	**Chickpea**	-	06	04	-	10
4.	**Cotton**	05	14	-	09	28
5.	**Kinnow**	-	01	-	-	01
6.	**Lentil**	01	02	-	-	03
7.	**Mungbean**	01	12	03	-	16
8.	**Sesame**	-	02	-	-	02
9.	**Sugarcane**	04	-	-	-	04
10.	**Rice**	07	05	-	-	12
11.	**Wheat**	13	-	10	1	24
Total		32	43	21	10	106

(**Sources**: http://www.nibge.org)

Conclusion

There are 45 public and private institutions which are exporting quality products after laboratory testing. Institutes under PAEC have produced 106 varieties of quality crops through the continuous struggles of scientists. Pakistan is efficient in nuclear agriculture and the food sector to develop more types and produce quality products. Sterile Insect Technique should be introduced broadly in the agriculture sector. The role of nuclear technology through radiation and radioisotopes is essential to reduce food deficiencies worldwide. The SIT technique is also valuable for the agriculture sector to save the crop from insects as a significant portion went lost due to improper food safety. A joint programme of FAO and IAEA is to use isotopes in food in agriculture so that food and plant diseases can be reduced and productivity can be increased in lucrative means.
Pakistan should undertake diplomatic and political efforts to trade in civilian nuclear technology. In drone technology for the medicine and agriculture sector, Pakistan should make agreements with China and Turkey for the domestic production of drones. Drones technology should be acquired through China, Turkey, and Belarus, and the government should consider the services of the Pakistan Armed Forces. As Pakistan is also a member of IAEA, CERN and UICC, Pakistan should join worldwide organisations working on transferring nuclear technology for peaceful purposes. It is also required to increase human resources through international training and development programs and produce more researchers, scientists, doctors and experts to achieve the national goals.

New research centres should be established to promote peaceful nuclear technology by getting the services of nuclear experts, researchers and scientists to educate farmers**.** Energy and Food security should be included in the academic curriculum to transfer the knowledge at the grass root level to teach its understanding. The agriculture sector should also be promoted at a lower level by providing quality seeds tested by PAEC, reaching out to even more remote areas with the assistance of provincial governments. Cooperation with neighbouring countries, i.e. Iran, Afghanistan and India, is required to overcome the tension of locusts that travel inside and outside the borders. Transfer and use of peaceful nuclear technology are in a state's best interest to grow economically and politically. The cooperation between states strengthens the relationship to achieve national goals. Pakistan believes in the transfer of peaceful nuclear technology to meet domestic needs.

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