IAEA BULLETIN

INTERNATIONAL ATOMIC ENERGY AGENCY

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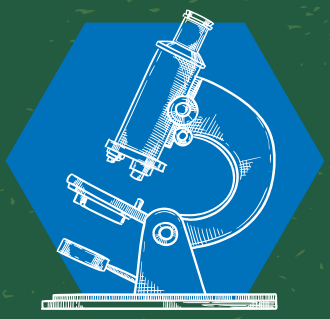
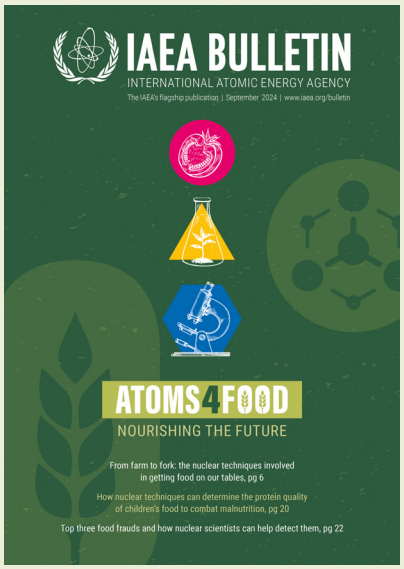


ATOMS4FOOD

NOURISHING THE FUTURE



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is produced by the
Office of Public Information and Communication
International Atomic Energy Agency
Vienna International Centre
PO Box 100, 1400 Vienna, Austria
Telephone: (43-1) 2600-0
iaeabulletin@iaea.org

Editor: Kirstie Gregorich Hansen
Managing Editor: Patricia Puhm
Design & Production: Ritu Kenn

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IAEA Atoms for Peace and Development

The mission of the **International Atomic Energy Agency** (IAEA) is to help prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water, industry and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists and criminals, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide the fundamental principles, requirements and recommendations to ensure nuclear safety and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre, Vienna, Austria. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

Fighting hunger with nuclear science

By Rafael Mariano Grossi, Director General, IAEA

We need to grow more food, and we need to do it better. We need food to be more nutritious, to grow in more difficult places, to be more resilient to weather extremes and to be safer for human consumption.

Millions of people are going to bed hungry, in every corner of the world. The number facing high levels of food insecurity has more than doubled since 2020. Climate extremes threaten to increase the number of crop failures, making it even more difficult to meet increasing global demand.

We have the tools to change that. Nuclear science is a tool that helps us to cultivate stronger, healthier, safer and more nutritious crops.

The IAEA and the Food and Agriculture Organization of the United Nations (FAO), through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, are developing these tools and helping those who need them most to learn how to apply them.

Our Atoms4Food initiative brings together knowledge gathered during our decades of experience helping countries get the best out of their soils, crops and coastlines to feed their growing populations.

Launched in 2023, Atoms4Food was created to help countries boost food security and tackle hunger. It provides countries with tailored solutions to enhance their agricultural productivity, reduce food loss, ensure food safety, improve nutrition and adapt to climate change.

At the heart of Atoms4Food is nuclear science. It brings a level of precision, accuracy and predictability rarely seen in the world of food production, where the large number of unpredictable variables — including seeds, weather and soil — can make it difficult to achieve reliable outcomes.

Nuclear irradiation is being used to induce natural mutations in plants to discover new varieties that can withstand irregular rainfall, saltier soil or more invasive insects. The IAEA and the FAO even sent seeds into space to help our scientists back on Earth learn more about plant mutation.

Isotope hydrology is being used to track the movement of water and fertilizer through the ground and into a plant, so as to discover the most effective way for a farmer to support growth in specific crops. Nuclear techniques such as polymerase chain reaction tests are used to monitor animal diseases, allowing us to spot outbreaks before they happen, and irradiation is used to eliminate insect pests such as the fruit fly without the need for chemicals. Methods such as the deuterium dilution analysis technique improve human health by revealing human nutrition levels, while radiotracers are used to check whether food is contaminated.

As the articles in this Bulletin lay out, many communities around the world already use these innovative approaches and many more want to use them. Countries send their scientists to us for training, and we send them back equipped with the knowledge and skills needed to apply the techniques locally and to pass them on to farmers and other food producers.

Farmers do not need a physics degree to apply these precise methods. The IAEA and the FAO, and our national partners around the world, are experienced at transferring these innovative technologies from the laboratory to the field to the dinner plate.

For decades, children in Kenya, Peru, Bangladesh and dozens of other countries have gone to school and to bed better nourished thanks to the innovation nuclear science has brought to the way their country produces food.

Together, through Atoms4Food, we can spread these innovations even further, giving policymakers, scientists and food producers across the world the best tools science has to offer to ensure the most fundamental necessity of life: enough reliable, nutritious and safe food.

"Our Atoms4Food initiative brings together knowledge gathered during our decades of experience helping countries get the best out of their soils, crops and coastlines to feed their growing populations."

— Rafael Mariano Grossi, Director General, IAEA

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IAEA UPDATES

State-of-the-art solutions for today's challenges

How atoms are helping to reduce hunger and poverty

By QU Dongyu, Director General, FAO

The Food and Agriculture Organization of the United Nations (FAO) and the IAEA have successfully collaborated on the development and application of nuclear technologies in food and agriculture for 60 years. Atoms4Food is a new joint initiative that scales up these ground-breaking research and development (R&D) efforts to help address hunger and poverty.

QU DONGYU
DIRECTOR GENERAL, FAO

Agrifood systems must feed growing populations amid ongoing global pressures such as environmental degradation, biodiversity loss, pollution and the climate crisis — all of which are driven by the systems themselves — and socioeconomic factors such as nutritional demand, persistent poverty levels and conflict. In 2023, between 713 and 755 million people went hungry. Billions more could not afford healthy diets.

To tackle today's complex challenges, the FAO and the IAEA are aiming high by scaling up their partnership to help countries adopt nuclear, isotopic and associated technologies to make agrifood systems more efficient, inclusive, resilient and sustainable. These innovative approaches can enhance agricultural and livestock productivity and the management of natural resources, reduce food loss and waste, ensure food security and safety, improve nutrition and help vulnerable food-producing communities adapt to the impacts of the climate crisis.

Increasing uptake

Since the establishment of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture in 1964, applications of nuclear techniques in agriculture have increased hugely, bringing benefits across the world.

Crop production is being increased through the use of isotopes to optimize plants' uptake of water and nutrients, and the use of radiation to produce crop varieties with higher yields, greater resilience and improved quality. Millions of hectares of crops are grown following mutation breeding, netting farmer billions of dollars every year while protecting their soils and environment.

Pests are being controlled through the release of sterilized insects to control and manage the population — an approach that has worked with fruit flies, moths, and the tsetse and screw worm flies. Areas free of fruit flies or that have low pest prevalence have been established from South America to the Middle East. This saves hundreds of millions of dollars in reduced production losses, and results in better quality food and increased exports, jobs and income.

The environment is being protected through the use of isotopes to minimize land degradation and water pollution and improve soil fertility. These techniques are used to determine critical factors, such as the optimal placement of fertilizer and the timing of its

The Atoms4Food initiative has laid out a comprehensive strategy, including country assessments and a robust action plan, to help countries propel themselves towards a better future through the FAO's 'four betters':

better production • better nutrition • a better environment • a better life

(Photo: Adobe Stock)

use. The economic benefit from fertilizer savings is at least $6 billion per year.

The list goes on: from increasing animal health and productivity through irradiated vaccines and molecular techniques that rapidly identify pathogens to improving food safety using food irradiation techniques to destroy bacteria, insects and other organisms, all these innovations translate into socioeconomic and environmental benefits for all — people, animals, plants and the entire ecosystem.

Accelerating change

The FAO/IAEA partnership has been instrumental in stimulating funding for and the implementation of initiatives. This unique R&D partnership — with proven scientific solutions — has had a positive impact on the transformation of agrifood systems. To respond to today's complex and overlapping challenges, however, we must accelerate collaborative actions. That is why the FAO and the IAEA launched the Atoms4Food initiative in October 2023. With the aim of giving countries ground-breaking solutions tailored to their specific needs, the initiative provides greater access to scientific evidence and capabilities to inform policy-making, enhance R&D, upscale application and standardization, improve technical and management capacity, and strengthen knowledge exchange and collaboration.

The partnership's guiding principles include equitable access to innovations for small-scale farmers and other underrepresented groups; gender equality; country ownership; alignment with the One Health approach; and sharing information on the risks and benefits of new technology. Innovations are only adopted once their added value has been confirmed and nuclear applications have proven beneficial, with high regional or global applicability.

The initiative has laid out a comprehensive strategy, including country assessments and a robust action plan, to help countries propel themselves towards a better future through the FAO's 'four betters': better production, better nutrition, a better environment and a better life, leaving no one behind.

FAO & IAEA

ATOMS4FOOD
GROWING FOOD SECURITY

Atoms4Food builds on nearly 60 years of experience developed jointly by the IAEA and the Food and Agriculture Organization of the United Nations (FAO) in supporting countries to use nuclear and isotope technology solutions. The Joint FAO/IAEA Centre advances and supports the safe and appropriate use of nuclear and related technologies in food and agriculture and provides the following services:

1. An Assessment Mission to map food security needs and develop a tailored plan to address food security challenges.
2. A Crop Variety Improvement Service to build crop improvement programmes using the nuclear method of plant mutation breeding to create more robust and nutritious crops.
3. A Soil and Water Management and Crop Nutrition Service to use the precision of nuclear and isotopic science to gather information on soil fertility; major crops and their average yield; and the availability of fertilizer and water irrigation systems.
4. An Animal Production and Health Service to provide a scientific assessment of the epidemiological situation of animal diseases; interventions for prevention, diagnosis and control; and laboratory and other veterinary service capacities.
5. An Insect Pest Control Service to tackle insect pests that affect agricultural production by using the nuclear-based sterile insect technique (SIT).
6. A Food Safety and Control Service to assess laboratory capabilities; the capacity to conduct surveillance of food hazards; and authenticity and irradiation applications.
7. A Public Health Nutrition Service to inform impactful nutrition programming using evidence on the nutritional value of foods and diet quality derived from the use of stable isotope techniques.

From farm to fork

The nuclear techniques involved in putting food on our tables

Did you know that nuclear techniques play a crucial role in putting food on our tables? From enhancing crop production to ensuring food safety, nuclear science is integral to sustainable agriculture.

This visual guide explores the nuclear techniques that protect our food supply and help make every bite safe and nutritious.

PLANT BREEDING

Using nuclear techniques, the IAEA, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre), builds national capacities in plant breeding to develop crops that are more resistant to diseases, pests and environmental stressors.

By inducing mutations with radiation, scientists create new plant varieties that improve product quality, have higher yields and yield stability and are more resilient to climate change and more tolerant to environmental stressors, contributing to a more robust and sustainable food supply.

The FAO/IAEA Mutant Variety Database is a repository for information on plant varieties developed using mutation breeding techniques.

It contains information on 3433 varieties from 75 countries, for more than 238 different crop types.

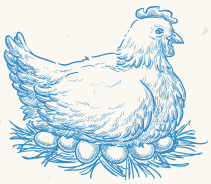
INSECT PEST CONTROL

The IAEA, through the Joint FAO/IAEA Centre, leads global efforts to implement and further develop the sterile insect technique (SIT), which uses radiation to sterilize male pests.

Sterilized males are released to mate with wild females, reducing pest populations. This eco-friendly method controls agricultural pests, reduces the need for chemical pesticides and protects crops and the environment.

Up to 40% of global crop production is lost to plant pests and diseases.

ANIMAL HEALTH



The IAEA, through the Joint FAO/IAEA Centre, utilizes nuclear and related techniques to monitor and control animal diseases, which in turn improves livestock health and productivity.

This allows countries to ensure a steady supply of safe and nutritious animal products, supports sustainable agricultural practices, and protects public health through early disease detection and vaccination programmes.

The Veterinary Diagnostic Laboratory Network (VETLAB Network), supported and coordinated by the IAEA, is a network of 46 veterinary laboratories in Africa and 19 in Asia.

Support is provided through the procurement of laboratory reagents and equipment and the provision of training courses to strengthen the proficiency of designated national veterinary laboratories in deploying diagnostic tests for transboundary animal and zoonotic diseases, and vaccine quality assurance.

CLIMATE-SMART AGRICULTURE

Climate-smart agriculture is a set of agricultural practices and technologies that can be used to sustainably increase agricultural productivity. The IAEA strengthens the capacities of countries in using nuclear and isotopic techniques to sustainably increase agricultural productivity, adapt and build the resilience of agricultural and food security systems to climate change, and reduce greenhouse gas emissions from agriculture.

146 countries work with the IAEA on **technical cooperation projects** that address climate change adaptation.

LAND AND WATER MANAGEMENT

Nuclear techniques contribute to optimized land and water management by tracing soil and water movement. The IAEA assists countries to develop and apply sustainable farming practices, improve water use efficiency and combat soil degradation, thus contributing to increased global agricultural production and food security while conserving natural resources.

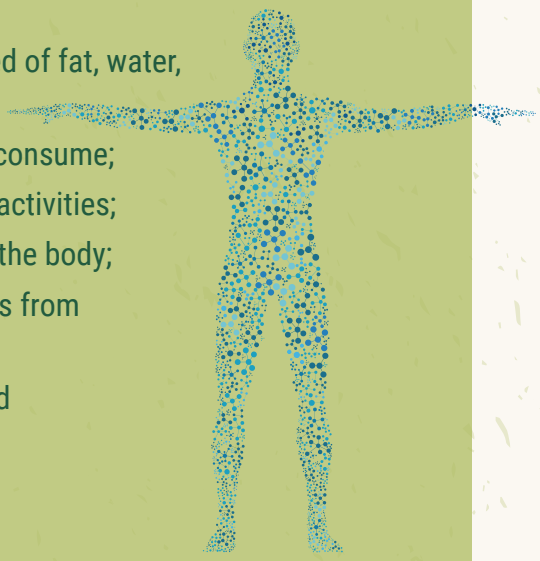
Agriculture consumes more than 70% of the world's water, mainly for irrigation, but water use efficiency is less than 40%.

NUTRITION

Proper nutrition is fundamental to health. The IAEA provides countries with the equipment and training necessary to use nuclear techniques to understand nutritional problems, so that nutrition and health professionals can develop and evaluate nutrition actions to combat all forms of malnutrition.

Nuclear techniques can assess:

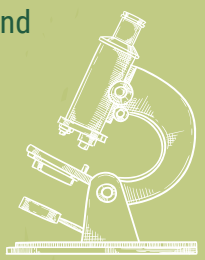
- how much of the body is composed of fat, water, muscle or bone;
- the amount of breast milk babies consume;
- the energy we expend in our daily activities;
- the amount of vitamin A stored in the body;
- how well the body utilizes nutrients from different foods;
- the true protein value of foods; and
- bone density and bone health.



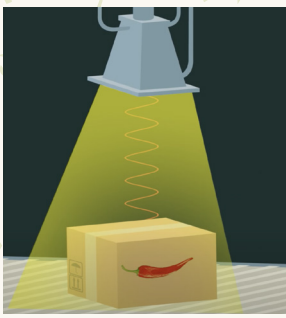
FOOD SAFETY

The IAEA, through the Joint FAO/IAEA Centre, assists countries in employing nuclear methods to detect contaminants and residues in food, verify the origins and authenticity of food, and meet international standards.

In 2023, 417 scientists from more than 43 countries were trained by the IAEA in these techniques and technologies.



Countries are also supported in the use of ionizing radiation. Techniques such as irradiation eliminate harmful bacteria and pests, extend shelf life and reduce food waste. These measures ensure that food is safe and nutritious and foster international trade.



(Photo: Adobe Stock)

Despite climate extremes, Bangladesh improves harvests to feed a growing population

By Melissa Evans and Sinead Harvey

Bangladesh — a country highly vulnerable to floods, cyclones, storms and drought due to the climate crisis — faces major challenges in its agricultural sector. Over one million hectares of land in coastal areas are unfit for cultivation, due to saline soil conditions and soil degradation.

With the goal of adapting food production to climate change, the IAEA has been collaborating with Bangladesh to develop high quality, high yield crop varieties resistant to extreme conditions.

Developing new rice varieties to adapt to climate change

Rice is a particularly important crop in Bangladesh, but extreme weather events or outbreaks of plant disease can ruin entire harvests. Farmers urgently need new crop varieties that can be grown despite extreme conditions.

Since 1971, the IAEA and the Food and Agriculture Organization of the United Nations (FAO), through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, have been working with Bangladesh to address agricultural challenges through training courses, fellowships, expert visits and the provision of equipment to enhance laboratory capabilities. In 2023, the IAEA and the FAO launched the Atoms4Food initiative to amplify their joint work on agriculture and help ensure food security.

In collaboration with the IAEA, the Bangladesh Institute of Nuclear Agriculture (BINA) has successfully produced 85 crop varieties. One of these is Binadhan-14, an improved rice variety developed using nuclear technology in just 4 years — less than half the time of a conventional plant breeding process, which typically takes 8–12 years.

The new rice variety can withstand higher temperatures and has a shorter growth period of 110–120 days instead of the usual 140–150 days. This creates an extended window for growing other crops and vegetables. The new variety produces nearly 7 tonnes of rice per hectare — nearly 75 per cent more than the global average yield.

BINA has also used plant mutation breeding to develop saline-tolerant rice varieties, providing hope for coastal farmers affected by saline soil conditions and soil degradation. Two saline-tolerant varieties are already available, and 40–50 per cent of previously fallow land can now be cultivated, improving food security and farmer income.

"The IAEA is working throughout Asia and the Pacific to support countries in applying nuclear based solutions to solve problems arising from changing climatic conditions. Through nuclear science and technology, the IAEA is able to support Bangladesh to improve its crop yields and help ensure food security," says Deng Ge, Director of the Division for Asia and the Pacific at the IAEA's Department of Technical Cooperation.

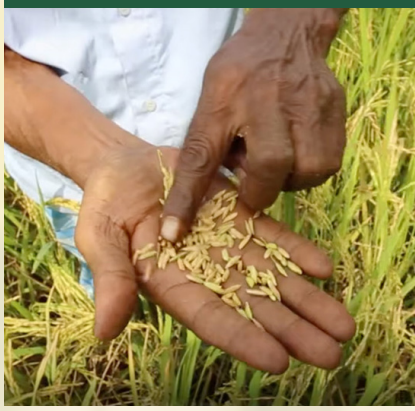
Plant mutation breeding is a nuclear technique in which plant seeds, cuttings or leaves are exposed to radiation such as gamma rays, speeding up the natural process of crop mutation. The irradiated material is then cultivated until it grows into a plantlet. The plants are multiplied and examined for favourable traits.

The new varieties help Bangladesh feed its 165 million people, almost a third of whom are food insecure. They have also enabled the country to maintain its status as the world's fourth largest producer and consumer of rice.

"Mutation breeding is a great hope for farmers in Bangladesh. These new pulse varieties ensure nutritional security, income and livelihood," says Abdus Salam, from Lalpure, Natore, in Bangladesh.

The IAEA promotes nuclear based solutions to protect and restore the environment in response to climate-related weather events and disasters. This includes reducing greenhouse gas emissions, adapting to climate change impacts and monitoring its adverse effects.

With the help of plant breeding, rice production in Bangladesh has tripled since the 1970s.



Photos: IAEA

How nuclear and climate-smart agriculture solutions can help mitigate climate change

By Emma Midgley

Global food security is under increasing strain due to climate change. Agrifood systems are facing huge challenges due to escalating drought and severe weather events, as well as human activities that are leading to land and soil degradation. Agriculture currently generates around a quarter of the world's greenhouse gas (GHG) emissions, and global demand for food is growing.

Nuclear science and related technologies play an important role in enabling farmers to adopt climate-smart agriculture — an integrated approach to managing agrifood systems through the adoption of agricultural practices and technology that can be used to sustainably develop agricultural productivity and incomes, adapt and build resilience to climate change, and reduce GHG emissions.

The IAEA, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, supports the advancement, transfer and application of nuclear science and techniques in global agrifood systems to promote animal nutrition and animal health; enhance crop productivity and on-farm ecosystem services through plant nutrition and nutrient cycling; minimize soil erosion and land degradation; improve soil health; increase biodiversity and crop production; maximize water use efficiency; and trace agricultural and industrial pollutants and assess the threat they pose to crop production and environmental sustainability.

"To reduce hunger and malnutrition, the IAEA provides countries with research and data from climate-smart field tests and creates models to generate recommendations for farming systems adapted to various affected regions," says Mohammad Zaman, soil and water management and crop nutrition expert at the IAEA.

By boosting crop yields on farmland, farmers can feed more people while avoiding deforestation, increased GHG emissions and depletion of the natural resources of soil and water. One solution is to use a stable isotope technique of nitrogen-15 to measure how plants take up nitrogen — one of the primary nutrients for optimal growth. This enables farmers to use smaller amounts of nitrogen fertilizer in a more targeted and efficient way, thereby reducing GHG emissions and increasing crop yields.

In a recent IAEA project, farmers in Burundi, the Central African Republic, Ghana, Nigeria, Rwanda, Zimbabwe and the Lao People's Democratic Republic were able to double and triple their cassava yields by applying climate-smart agricultural practices.

"Everyone who visits my farm and sees the way I am farming and producing cassava — they get excited," says Theogene Ntakarutimana, a farmer in Burundi who has been using methods enhanced with nuclear science and related techniques since 2016. "I used to have a low yield, about 11 tonnes per hectare, but thanks to the enhanced practices, production has increased to 30 tonnes per hectare, sometimes 33 tonnes."

Through this project, farmers were trained in the use of nitrogen-15, a stable isotope of nitrogen, to measure cassava plant uptake of added nitrogen fertilizer and track the amount of nitrogen absorbed. They also received training in isotopic techniques to precisely determine the water required for cassava, and in pest management and soil improvement techniques.

Climate-smart agriculture involves monitoring soil moisture and offers solutions to address this challenge. Moisture sensors provide crucial information to farmers and help them to better manage their water consumption. In a recent project in Ethiopia, cosmic ray neutron sensors were used to measure soil moisture. The sensors collect incoming cosmic rays and provide data that can be used by farmers. In Namibia the IAEA has been able to help farmers apply precise drip irrigation techniques, increasing their water use efficiency by 80 per cent while continuing to increase crop yields.

GRAIN YIELDS

The potential impact of better agricultural practices is evident from a comparison of grain yields per hectare between regions:

Africa (1.5 tonnes per hectare)

Latin America and South Asia (3 tonnes per hectare)

China (5 tonnes per hectare)

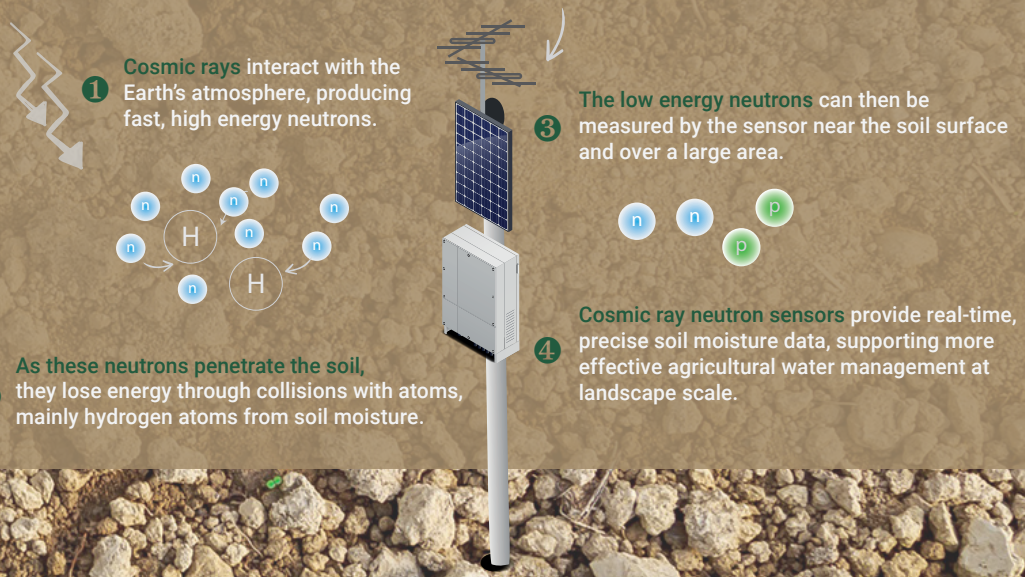
North America, Europe and Japan (>10 tonnes per hectare)

IAEA technical cooperation projects are helping 146 countries address climate change adaptation through the application of nuclear techniques for plant breeding, animal production, food safety, health and insect pest control.

(Photo: Adobe Stock)

THE SCIENCE

How do cosmic ray neutron sensors work?



IAEA's successful field trial

A promising breakthrough in combating Fusarium wilt in bananas

By Wolfgang Picot

Fusarium wilt caused by the fungus *Fusarium oxysporum* poses a major threat to banana cultivation worldwide. The pathogen is detrimental to bananas. As banana cultivation plays a crucial role in global food security, addressing this challenge is imperative. In a noteworthy development, the IAEA has completed a field trial with promising results, marking a critical step forward in the fight against this devastating disease.

Bananas are among the most produced, traded and consumed fruits globally. With over 1000 varieties, they provide vital nutrients to populations in producing and importing countries. The most traded variety is the Cavendish banana, which accounts for just under half of global production and has an estimated annual production volume of 50 million tonnes. Bananas are of particular significance in some of the least developed countries and in low-income food-deficit countries where, as a cash crop, they contribute not only to household food security but to income generation.

The threat of Fusarium wilt

Fusarium wilt is not a new problem. The Gros Michel banana variety, which once dominated the global market, was decimated by the disease in the mid-twentieth century. In response, the Cavendish variety, which was resistant to the original strain of Fusarium wilt, was developed. However, the pathogen has evolved and the new tropical race 4 (TR4) — the latest variant of the fungus *Fusarium oxysporum* — now threatens the Cavendish variety.

Pooja Mathur, a leading researcher at the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre), explains the seriousness of the situation: "The spread of TR4 is currently confirmed in 21 banana-producing countries and could have devastating effects on banana production and, consequently, on food security."

Once a piece of farmland becomes contaminated with TR4, managing the disease is challenging and costly in all reported cases. This highlights the urgency of developing resistant banana varieties to safeguard the industry.

While Cavendish is widely known as a 'table banana' consumed as a dessert or fruit, many other banana varieties are staple foods, particularly in developing countries. These 'cooking bananas' are integral to the everyday diet of millions of people. For example, the Mchare banana, an East African diploid variety, is a popular cooking banana favoured in Tanzania and Uganda. These cooking bananas are also at risk of Fusarium wilt, posing a serious threat to food security in these regions.

A promising breakthrough

The IAEA, in collaboration with the International Institute of Tropical Agriculture, Stellenbosch University recently completed an 18-month field trial that has yielded highly promising results under Belgium supported Peaceful use initiative (PUI) project on "Enhancing climate change adaptation and disease resilience in banana-coffee cropping systems in East Africa." Conducted in a region of Tanzania known to be a *Fusarium oxysporum f.sp. cubense* (Foc) race 1 pathogen hotspot and with high prevalence of the disease, the trial tested Mchare type cooking bananas, which were developed through the nuclear technique of mutation breeding.

"For us, the primary objective is to generate Fusarium wilt disease-resistant bananas in Africa, which are vital for food security and income generation for millions. This research is crucial because the disease poses a significant threat to banana crops, especially in regions where bananas are a staple food and a major source of income," said Altus Viljoen, an expert on Fusarium wilt from Stellenbosch University. Mchare is one of the parents of Cavendish and improving its genetics hold tremendous potential for banana improvement.

Fusarium wilt caused by the fungus *Fusarium oxysporum* poses a major threat to banana cultivation worldwide.

After 18 months, the trial results were clear: a significant proportion of Mchare bananas showed complete resistance to Fusarium wilt.

(Photos: H. Mduma/IAEA)

Research and innovation at the Joint FAO/IAEA Centre

For several decades, the Joint FAO/IAEA Centre has been at the forefront of combating Fusarium wilt. It has developed tools and technologies for mutation breeding with the aim of enhance banana resistance. Initially focused on race 1 of Fusarium wilt, research has now expanded to address TR4. The field trial involved planting the 3000 individual Mchare banana mutant varieties in a Tanzanian hotspot with a high incidence of Fusarium wilt (Foc1). By continuously introducing the Fusarium fungus to the field, the IAEA ensured that disease pressure remained consistently high. To accurately assess resistance, the mutant lines were planted alongside wild-type controls and susceptible varieties.

After 18 months, the trial results were clear: a significant proportion of Mchare bananas showed complete resistance to Fusarium wilt, while the susceptible controls were severely affected.

"This research is critical for both food security and the future of banana cultivation," says Pooja Mathur. "Improving the resistance of parental lines like Mchare is a significant step towards developing robust Cavendish bananas capable of withstanding TR4."

The next phase involves further evaluation of the resistant lines in multi-location hotspot regions for Foc1 as well as Foc, tropical race 4 (Foc TR4), in Mozambique. These steps will ensure the durability and effectiveness of the resistant lines in a range of environmental conditions.

The path ahead

The successful field trial marks a significant breakthrough in the fight against Fusarium wilt. By focusing on parental improvement through mutation breeding, the Joint FAO/IAEA Centre is developing a sustainable and durable solution to the Fusarium wilt threat to help safeguard banana cultivation across the globe.

Enhancing mung bean and chickpea cultivation in Pakistan through nuclear techniques

By Bernadette Hogg

Pulses such as chickpeas, mung beans and lentils are staples of Pakistani cuisine. While many countries are reliant on imports, Pakistan has achieved self-sufficiency in mung bean production thanks to nuclear science, and some farmers have doubled their yield.

Mung beans are high in protein and help to combat malnutrition. Most of the mung bean varieties grown by Pakistani farmers are developed by Pakistan's Nuclear Institute for Agriculture and Biology (NIAB) in collaboration with the Joint Food and Agriculture Organization (FAO)/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre). These new varieties have improved crops' yield performance, resistance to disease and nutritional profile. The two varieties released in 2021 — NIAB Mung 2021 (NM-2021) and Abbas Mung — were grown on around 70 per cent of Pakistan's mung bean acreage that year, contributing significantly to the country's food security and economy.

While Abbas Mung is a medium sized seed variety known for its cooking quality, NM-2021 is a bold sized seed variety with increased nutritional quality. Hakim Ishfaq Mohy ud Din Chisti, a farmer from the Punjab province, praises NM-2021: "The yield of my crop was high. NIAB must continue its efforts to develop such varieties in future." As NIAB mung bean varieties produce more than twice the yield per hectare than previous varieties, they could effectively double mung bean production, helping to address Pakistan's food and nutritional needs.

Nuclear mutation breeding techniques, which have been applied since the 1930s to accelerate the process of developing and selecting valuable agronomic traits, use plants' own genetic make-up to mimic the natural process of spontaneous mutation. The mutation process generates random genetic variations, resulting in mutant plants with new and useful traits.

In 2022, intense and deadly floods swamped two million acres of agricultural land, severely affecting the mung bean crop in Punjab and causing a shortfall. But Muhammad Jawad Asghar, principal scientist in the mung bean group within NIAB's Plant Breeding and Genetics Division, is hopeful for the future of the mung bean crop in Pakistan: "This is not the end. This is an opportunity to do two things: remain self-sufficient and produce a surplus."

(Photo: M. Imran/NIAB)

Increasing chickpea yield and pest resistance

In addition to mung beans, chickpeas are a major ingredient in many Pakistani recipes. In 2021, Pakistan ranked as the world's seventh largest producer of chickpeas by volume, but the country's farmers had a low yield relative to the area cultivated.

NIAB's chickpea group has been working on both Desi and Kabuli types. Desi types are typically flavourful and preferred by farmers, while Kabuli types are larger, lighter in colour and preferred by the younger generation, with many using them as a breakfast ingredient. Two-year evaluation studies have been completed on two new chickpea varieties that will soon be released for cultivation by the Punjab Seed Council.

NIAB is part of an ongoing IAEA coordinated research project (CRP) that aims to improve the tolerance of pulse crops to biotic stressors such as disease and insect pests using mutation breeding, a nuclear technique that speeds up plants' natural evolution. Azeem Asad, principal scientist in NIAB's chickpea group, says the CRP provides "valuable inputs and experiences in developing chickpea varieties tolerant to a pod borer, which were made possible through insightful collaborations with the Joint FAO/IAEA Centre and participants from around the world." The pod borer in question — the cotton bollworm *Helicoverpa armigera* (Hübner) — is chickpea pest that causes severe damage by boring into growing pods.

Anupama J. Hingane, a plant breeder and geneticist at the Joint FAO/IAEA Centre's Plant Breeding and Genetics Laboratory, says: "The results of the ongoing CRP open up the prospect of enhancing insect resistance in pulse crops using nuclear techniques. This breakthrough promises a sustainable solution to combat pests and protect pulse crop yields, which presents an opportunity that could revolutionize pulse crop cultivation."

Continuing cooperation and improvement

In March 2023, the Punjab Seed Council approved PRI-NIAB Mung — a novel, versatile mung bean variety that matures more quickly — for commercial cultivation. In the future, NIAB hopes to increase mung bean tolerance to herbicides and insects. Within NIAB's chickpea group, the focus has shifted to improving heat tolerance. With temperatures in February 2023 rivalling those of the summer months, developing heat-tolerant varieties has become increasingly important. A seed track-and-trace system was deployed in 2023, so the real impact of NIAB's work will be more visible in years to come.

Pakistan is continuously strengthening and enhancing its capabilities for developing climate-smart crops and improving animal productivity and the management of soil, water and nutrient resources using nuclear and related techniques. Since 2022, the IAEA has planned and organized over 50 activities to support the country's objectives.

THE SCIENCE

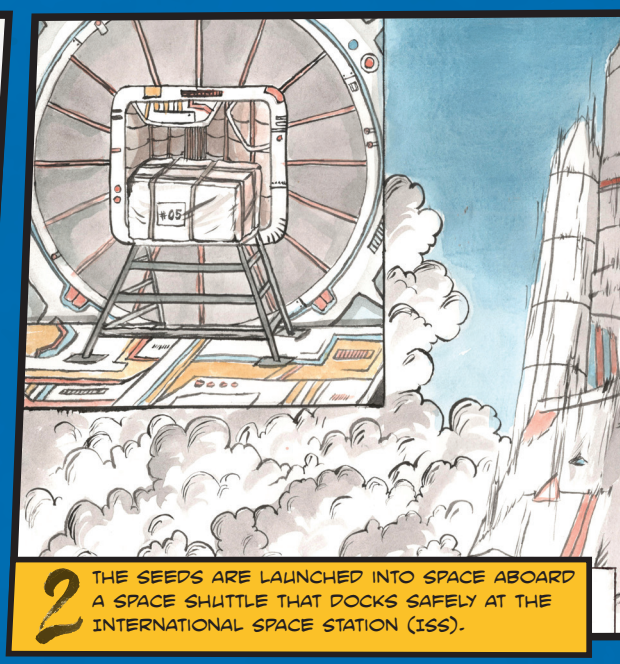
Irradiating plant material

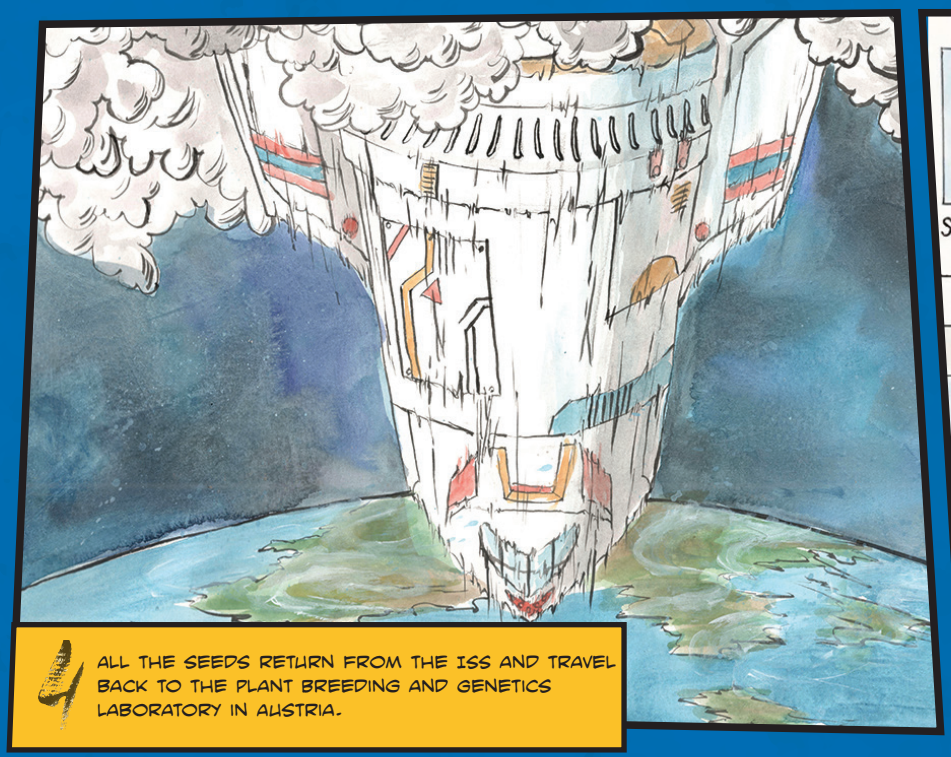
Used since the 1930s, plant breeding (also called evolution breeding) is the process of exposing plant seeds, cuttings or other planting material to radiation, such as X rays or gamma rays to create genetic diversity/variation. Induced irradiation causes changes in the DNA, mimicking the natural process of spontaneous genetic adaptation of plants to their changing environments. The individual plants exhibiting the desired traits are cultivated and multiplied so they can be distributed to farmers.

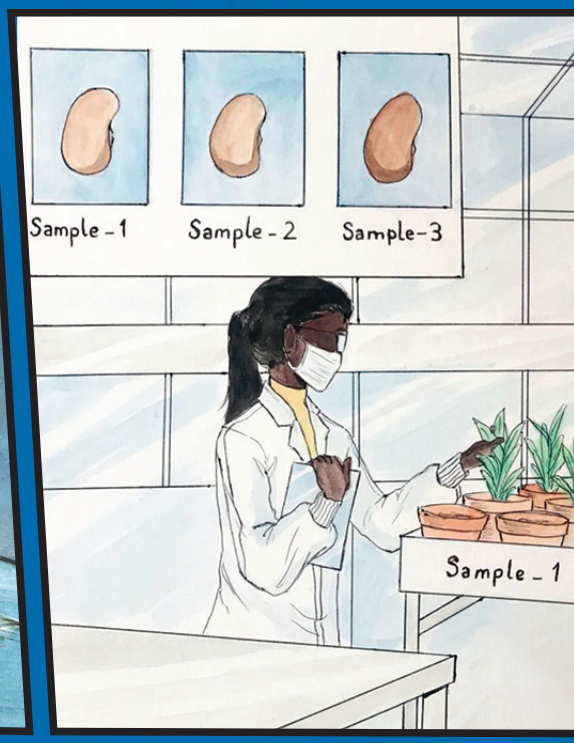
So far, over 3400 new varieties of more than 230 plant species have been developed using radiation-induced genetic variation and mutation breeding — including numerous food crops, ornamentals and trees used by farmers — in 75 countries.

Seeds in Space

For 60 years, the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint Centre), based in Austria, has been speeding up the natural genetic adaptation of plants by using gamma radiation in laboratories to develop more resilient crop varieties and support global food security.





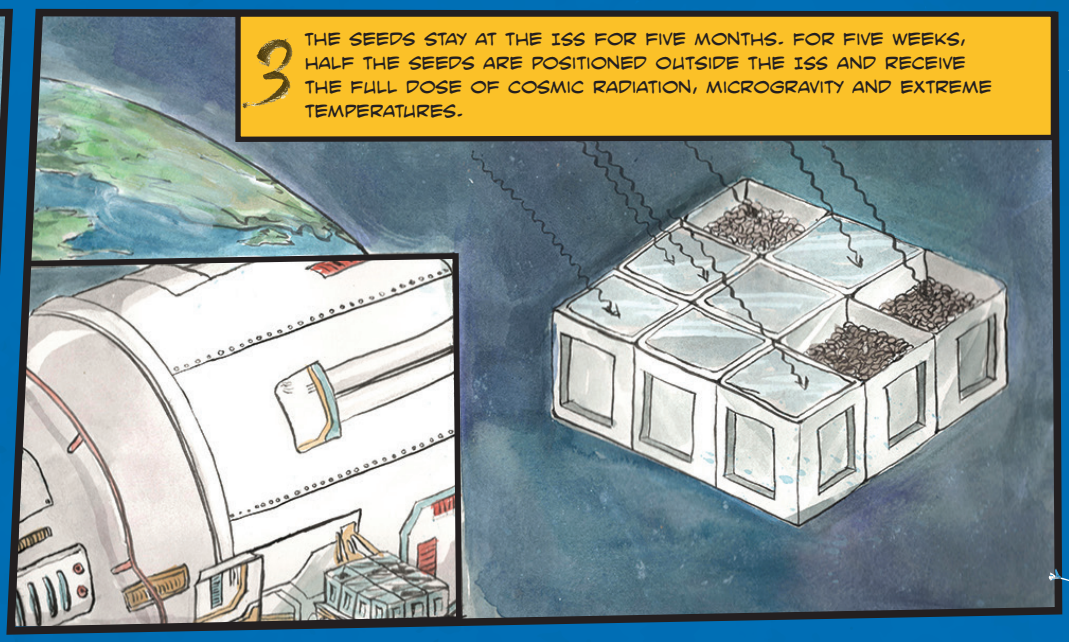


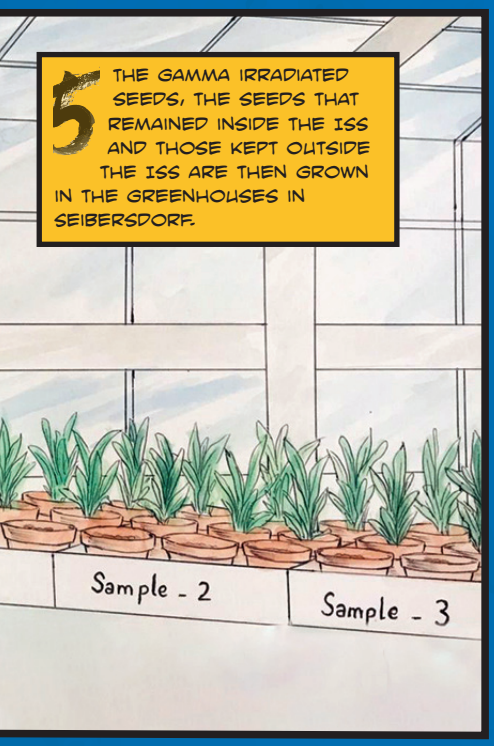
ARTWORK BY
SEEMAB FATIMA

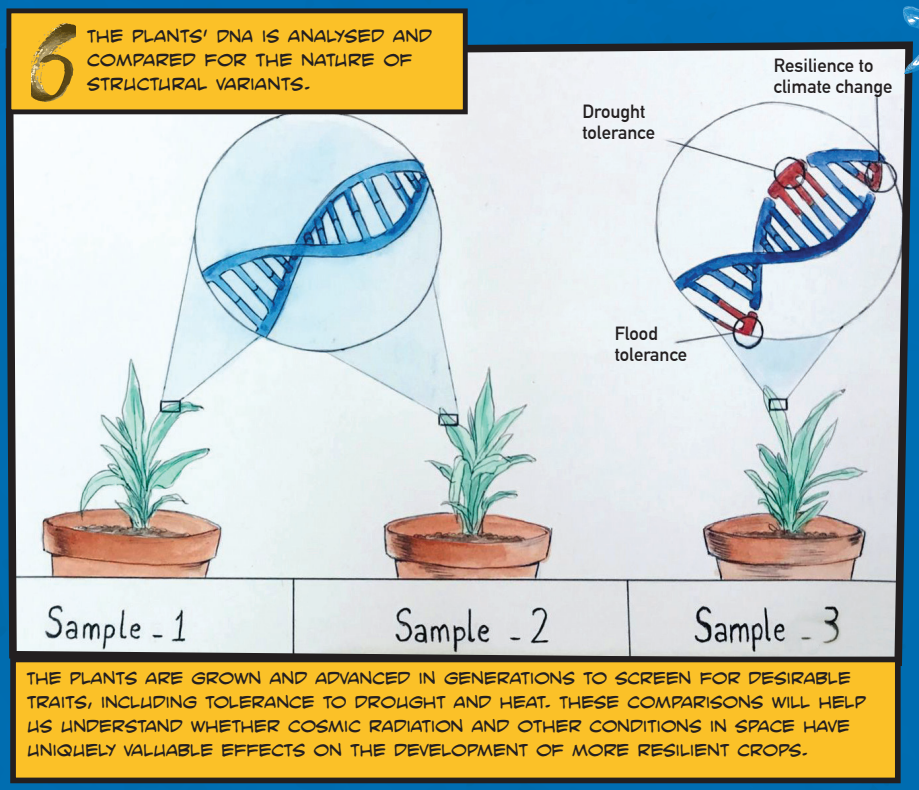
In 2023, more than 70 young artists around the world submi
the Food and Agriculture Organization of the United Nations
and technology. The winner was Seemab Fatima from Pakis
showing how cosmic radiation and the harsh conditions in s

Amid the ravages of climate change, farmers increasingly struggle to produce enough food and the need for these crop varieties has become increasingly urgent. In 2022, scientists at the Joint Centre started exploring new avenues of research that could potentially speed up crop breeding even more.

One of the methods they considered was to send seeds up into space…







tted designs for the Seeds in Space Comic Book Contest, held by the IAEA and (FAO) with the aim of inspiring the next generation of experts in nuclear science tan, whose ink and watercolour artwork will be the inspiration for a comic book space could help develop better crops and contribute to food security on Earth.

LEARN MORE ABOUT
SEEDS IN SPACE

How nuclear techniques can determine the protein quality of children's food to combat malnutrition

By Victor Owino

Global agrifood systems are changing rapidly, driven by factors such as climate change. These changes can have adverse ramifications in terms of both access to and the availability of nutritious foods. Low concentrations of essential nutrients, such as protein in major food crops, is one way climate change undermines nutrition security, especially among the world's most vulnerable populations, such as infants and young children.

India continues to bear the brunt of the double burden of malnutrition. According to the 2022 Global Nutrition Report, 35 per cent of all children below 5 years of age are stunted, meaning they are too short for their age, while 17 per cent are wasted, meaning they are too thin for their height.

The World Health Organization and the United Nations Children's Fund recommend that babies should be exclusively breastfed until they are six months old, without any additional foods or fluids other than prescribed medicines.

Children aged between 6–23 months are the most affected by foods deficient in essential nutrients, as this period coincides with the introduction of complementary foods in addition to breast milk. In about 80 per cent of cases in India, these foods consist of grains (cereal and legumes), while less than 20 per cent are from animal sources such as meat, fish, poultry and eggs. These plant-based foods seldom supply the right balance of nutrients, especially essential amino acids needed for rapid growth and development.

By building capacity to accurately measure the protein quality of food for infants and young children, it is possible to tackle malnutrition with evidence based data and improved dietary recommendations on protein intake. Determining the protein quality of plant-based foods is especially relevant given the environmental consequences related to consumption of animal-source food.

Protein quality is defined as the proportion of protein or amino acids ingested that is absorbed and utilized by the body. There are limited options for measuring protein quality in humans, as the standard method involves the invasive procedure of intestinal intubation to collect a sample of the ingested food as it undergoes digestion in the intestine. The sample is analysed to determine the concentration of free amino acids after a period following a meal. In 2014, an Expert Consultation convened by the Food and Agricultural Organization of the United Nations (FAO) recommended new methods, including stable isotope-based approaches to measure protein quality based on a newly recommended index: the digestible

By building capacity to accurately measure the protein quality of food for infants and young children, it is possible to tackle malnutrition with evidence based data and improved dietary recommendations on protein intake.

indispensable amino acid score (DIAAS). One of the methods recommended was the dual isotope tracer technique (DSIT), which was developed, tested and optimized in the context of an IAEA-supported coordinated research project in seven countries.

A research team from the St John's National Academy of Health Sciences in Bangalore, India, deployed the DSIT to measure protein and essential amino acid digestion from commonly used infant foods such as rice, finger millet and mung beans. These were compared to chicken egg, which contains a very easily digestible protein that is often used as a reference protein.

Crops were first 'watered' with deuterium oxide, which is similar physically and chemically to ordinary water but is slightly denser. Once harvested, the crops were used to prepare culturally appropriate test meals to which a carbon-13 labelled standard amino acid was added. The test meals containing two isotopes (deuterium and carbon-13) were fed to children aged 6–24 months.

"Protein quality is very relevant for child growth and development," says Nirupama Shivakumar, lead researcher and author at St John's National Academy of Health Sciences.

"The dual isotope method is the best approach in children as it is minimally invasive. We found eggs to have the best protein digestibility compared to other protein sources, which is no surprise, and re-emphasises the quality of animal proteins. Considering the slow rate of improvement in children's nutritional indicators, the incorporation of animal source protein in a child's daily diet, particularly in food insecure populations, may benefit growth and development."

Isotope concentration was measured in both blood and breath with an isotope ratio mass spectrometer. The digestibility of each of the essential amino acids was calculated as the ratio of isotopic enrichment in blood/breath to that in the test meal. Results showed that the digestibility of essential amino acids — methionine, phenylalanine, threonine, lysine, leucine, isoleucine and valine — was significantly lower in rice, finger millet and mung bean compared to egg. Further, it was shown that the lower the DIAAS, the higher the risk of stunting.

"These findings are very relevant in shaping guidelines on dietary protein intake in India and beyond," says Cornelia Loechl, Head of the IAEA's Nutritional and Health-Related Environmental Studies Section.

The results of the IAEA-supported research have been used in India to inform new complementary food formulations to achieve a good balance of essential amino acids.

Child development schemes have now been integrated into government policies in many states in India, thereby ensuring that milk and eggs are provided to toddlers and school-age children in preschool settings and government-run schools.

Additionally, this data will be included in a future joint FAO–IAEA database on the protein digestibility of human foods to inform future discussions on protein requirements across age and physiological groups. The new database is currently under development.

(Photo: Adobe Stock)

Top three food frauds and how nuclear scientists can help detect them

By Monika Shifotoka

Did you know that the food in your kitchen may not be what it seems and may not correspond to the information on the label?

1

Olive oil can be adulterated with cheaper alternatives.

Fraudsters have surreptitiously entered the lucrative global food market and have developed methods to scam food consumers for profit. These include producing counterfeit foodstuffs that imitate certain recipes or brands; adding undeclared materials to food; diluting or substituting high value ingredients with lower value ones; concealing poor quality ingredients; and mislabelling. Food fraud not only impacts consumers' wallets and harms international trade but can also jeopardize public health and safety.

Food fraud can be defined as any action taken with the intention of deceiving customers about the identity, quality and composition of food products for financial gain. The exact cost of this type of fraud to the global food industry is difficult to calculate given its clandestine nature, but it is estimated to cost producers $40 billion annually.

The IAEA, through its research and technical cooperation programmes and joint efforts with the Food and Agriculture Organization of the United Nations (FAO), supports countries to use nuclear and related techniques to tackle food fraud by tracing the origin of food, verifying its authenticity and testing for adulterants. Food authenticity and traceability methods, such as stable isotope analysis, can help identify and prevent food fraud and protect public health.

How can nuclear scientists help detect food fraud?

Each of the elements has a chemical identity defined by its atomic composition, which consists of neutrons, protons and electrons. Atoms that have the same number of protons but different numbers of neutrons are called isotopes. Stable isotopes are non-radioactive forms of atoms, and their unique properties mean that they can be used in a wide range of applications, including food forensics and the detection of food fraud.

By comparing stable isotope ratios, scientists can distinguish between authentic and adulterated foods and identify mislabelling of

(Photo: AdobeStock)

a food's geographical origin and false claims about the production process. Stable isotopes are measured using isotope ratio mass spectrometry, and very small differences in the ratios of the heavy and light forms of isotopes can be detected. These ratios are like nature's 'fingerprints', or signatures, on food. This hidden evidence can be used to determine whether the foods we buy contain the ingredients listed on the label, or whether they have been falsified.

Selvarani Elahi, Deputy Government Chemist for the Government of the United Kingdom and Executive Director of the Food Authenticity Network (FAN), emphasizes the network's collaborative effort to prevent food fraud: "By leveraging the free information, training and tools available through this global network, countries can enhance their capabilities to detect food fraud and mitigate their vulnerability to it." FAN facilitates collaboration between scientists, the food industry, government bodies and academia.

Olive oil, honey and seafood: the targets of fraudsters

Among the food products most affected by food fraud are olive oil (valued for its beneficial effects on the heart); seafood (sought after for its omega-3 essential fatty acids); and honey (prized for its natural sweetness and health-enhancing properties).

Olive oil can be adulterated with cheaper alternatives such as sunflower, rapeseed or even hazelnut oil, posing health risks to individuals allergic to the substitute oils. This practice has implications for food safety, as the adulterated oil may contain other compounds that are potentially toxic or harmful.

Using stable isotope analysis, scientists can effectively trace the geographical origin of a food item, differentiate between organic and conventionally produced foods, and detect adulteration by identifying inconsistencies in the expected isotopic signatures.

Rapid screening approaches are another method used to detect fraud and verify the authenticity and provenance of food.

Using near infrared spectroscopy, scientists at the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre) were able to distinguish between extra-virgin olive oil from Slovenia and other countries with 94 per cent sensitivity and 86 per cent specificity.

"Infrared spectroscopy and other techniques such as headspace gas chromatography–ion mobility spectroscopy can be used to analyse samples in the laboratory or directly in the field. They offer high sample throughput and low operational costs as they require little or no sample preparation, and there is no need for chemicals or specialized laboratory facilities," says Christina Vlachou, Head of the Food Safety and Control Laboratory of the Joint FAO/IAEA Centre.

Honey fraud is similarly prevalent, with cheaper sweeteners such as high-fructose corn syrup being added to natural honey. Stable isotope analysis and rapid screening tools can help to detect honey adulteration, verify claims about floral or geographical origin, and differentiate authentic manuka honey — which commands a high price — from fake versions.

In the case of seafood, scams often take the form of mislabelling, whereby a cheaper species of fish or seafood is sold as a more expensive variety — a practice that not only deceives consumers but undermines conservation efforts aimed at preventing overfishing of endangered populations. Stable isotope analysis allows scientists to verify whether products are correctly labelled, and can even be used to distinguish between farmed and wild-caught fish.

The IAEA supports food safety and quality globally and forges partnerships to fight food fraud under Atoms4Food, a new flagship initiative launched last year.

Honey fraud is prevalent, with cheaper sweeteners such as high-fructose corn syrup being added to natural honey.

2

3

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Enhancing export success

Costa Rica's commitment to food safety

By Sinead Harvey

At Alberto José Salas Jiménez's expansive farm in Costa Rica's Alajuela region west of the capital San José, cattle are reared in the country's lush natural landscape. Taking advantage of Costa Rica's fertile volcanic soil and tropical climate, Salas Jiménez rears cattle destined for international markets.

The range of local produce exported to foreign markets has expanded in recent years, but as it travels from farm to fork, it must go on a journey to ensure its safety. This includes rigorous testing for contaminants in meat products to ensure that they are safe for local consumption or foreign export.

Farmers like Salas Jiménez are allowed to use vaccines and veterinary drugs to manage animal diseases, as well as pesticides for weed control in fields where livestock graze. Residues from these chemicals can persist in meat and potentially enter the human food chain, necessitating robust food safety surveillance to protect public health.

Costa Rica's National Service for Animal Health (SENASA), which is part of the Ministry of Agriculture and Livestock, is responsible for ensuring that animal products meet national and international standards to protect public health and facilitate export markets. Previously, to meet global food safety standards, SENASA had to send food samples abroad for testing, with the costs borne by the producers. This process led to increased expenditure and delays in export approvals.

Since 2014, the IAEA, through the technical cooperation programme and the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, has supported SENASA in upgrading its National Laboratory for Veterinary Services (LANASEVE) with specialized equipment for testing food safety

through nuclear techniques, and through the provision of training. LANASEVE now uses isotopic techniques to detect and quantify trace amounts of harmful contaminants such as pesticides, veterinary drug residues, chemicals and heavy metals, thus ensuring that meat is safe for consumption.

"Producers no longer need to send samples abroad, saving both time and money," SENASA Director General Luis Matamoros explains. "This collaboration has strengthened SENASA's operational capacity, ensuring food safety for consumers and improving the competitiveness of our producers by opening up new market opportunities without added costs for testing."

Yajaira Salazar Chacón, head of food safety at LANASEVE, says that the laboratory can test for 410 compounds in 2024, compared to 54 in 2014. "Our laboratory now performs nearly 98 per cent of the required tests internally, with only about 2 per cent going to external laboratories. As SENASA no longer charges producers for food testing, this has eliminated a significant financial burden, making it easier for producers to meet export requirements."

LANASEVE is now internationally recognized as a regional leader in food safety and provides training to other laboratories in the region. "This advancement enables us to assist other regional laboratories with food safety analysis, bolstering overall quality and safety standards," adds Salazar Chacón.

Enhancing LANASEVE's comprehensive laboratory testing services has significantly bolstered Costa Rica's export strength. These efforts have kept international markets open for Costa Rican livestock products and have facilitated entry into new markets.

"In just five years, China has become Costa Rica's most crucial market for animal product exports," adds Matamoros.

The growth in meat exports has enabled producers like Salas Jiménez to sustain and expand their livelihoods.

"I am confident that our products from Costa Rica are not only safe for consumption but also meet high safety standards, both within and beyond our borders," says Salas Jiménez.

Though IAEA's support, LANASEVE now uses isotopic techniques to detect and quantify trace amounts of harmful contaminants such as pesticides, veterinary drug residues, chemicals and heavy metals, thus ensuring that meat is safe for consumption.

(Photos: S. Harvey/IAEA)

(Photo: Stock media provided by BlackBoxGuild / Pond5)

Climate smart agriculture in Kenya feeds more people

By Katy Laffan

Scientists in Kenya are using nuclear science to help farmers modernize their planting practices amid changing climate patterns.

"Kenya, like many African countries, is struggling to grow the crops it needs in the face of climate change. There is no one perfect solution," explains Shaukat Abdulrazak, Director for the Division for Africa at the IAEA's Department of Technical Cooperation. "But nuclear techniques are helping to give Kenyan scientists and farmers the precise information and tools needed to squeeze every drop of water and every inch of growth out of this beautiful land."

The work begins in the laboratory, where scientists — many of them trained or supported by the IAEA and the Food and Agriculture Organization (FAO) — strive to identify the best planting and watering techniques that can be adopted by farmers in water-scarce conditions.

Using nuclear and isotopic techniques, the scientists can track carbon, water and nutrients as they move through soil and crops to test the success of different approaches.

"Nuclear science helps farmers adapt to climate change. The IAEA and the FAO are working with scientists in Kenya and around the world to increase crop yields, protect water sources and feed more people," says Najat Mokhtar, Head of the IAEA Department of Nuclear Sciences and Applications.

A better understanding of crops

For example, at the Kenya Agricultural and Livestock Research Organisation (KALRO) in Nairobi, soil and water scientists run a laboratory that has its own prototype farm, with training and equipment support provided by the IAEA.

Jane Akoth, a PhD candidate at KALRO, is one of the next generation of scientists learning nuclear skills for farming. "We are using nuclear techniques to evaluate different plant technologies that can be adopted by different farmers," she explains.

To investigate how different plants respond to different watering and fertilizing conditions, the scientists test the success of techniques such as drip irrigation, which uses considerably less water than traditional irrigation techniques.

From lab to farm

Once the scientists have determined the best approaches for each crop, they share that information directly with farming communities. This leads to a shift in the management of agricultural resources that results in a more productive and resilient agriculture.

KALRO's Dr Kizito Kwena works closely with hundreds of 'farmer field schools' around the region, where cooperatives of small scale farmers come together to cultivate shared pieces of land and learn these climate-smart techniques that they can take back to their own plots.

"Despite poor soil fertility and water scarcity, these techniques have already helped thousands of farmers in Kenya increase their crop yields by 20 per cent and save 20 per cent in fertilizer costs," says Dr Kwena.

"The use of moisture metres is very important, because they tell farmers when to irrigate and when not to, helping them to manage the little water that they have very well," he added.

Eunice Francis, a farmer who attends a field school in Machakos, said the novel approaches had already helped her to grow more food to feed her family. "Since I started farming with these technologies, I have improved crop yields and the water use is much better."

The IAEA and the FAO work together to strengthen countries' capacities to use nuclear and isotopic techniques to improve agricultural resilience and adapt to climate change.

Agriculturalists across Kenya, such as this Maasai banana farmer from Rombo, are benefitting from nuclear and isotopic techniques to improve the management of water and other resources.

"Despite poor soil fertility and water scarcity, these techniques have already helped thousands of farmers in Kenya increase their crop yields by 20 per cent and save 20 per cent in fertilizer costs."

(Photos: K. Laffan/IAEA)

Viet Nam improves food safety and increases agricultural productivity and sustainability with nuclear science

By Melissa Evans and Sinead Harvey

As the climate changes, the range of insect pests is increasing as territories become newly habitable for species that would never previously have been able to support breeding populations there. Invasive pests can damage environments and ravage agricultural production. Strict controls prevent them from spreading, including restrictions on trade in fresh fruit and vegetables.

Facilitating trade with other countries while preventing the spread of pests is important for countries such as Viet Nam, where agriculture accounts for a quarter of gross domestic product and provides a livelihood for 60 per cent of the population.

The intensifying heat makes food-borne infections and toxins more common and promotes the spread of fungal growth and spoilage. With the support of the IAEA, through its technical cooperation programme, Viet Nam is using nuclear technology to improve food safety and increase agricultural productivity and sustainability.

By irradiating food with electron beams (e-beams), X rays or gamma rays, Viet Nam can ensure that its imports and exports of fresh fruit and vegetables are free from insect pests, enhance food safety by preventing food-borne illnesses, and extend the shelf life of food products that would otherwise be spoiled by the growth of bacteria and fungi.

What is food irradiation?

Food irradiation is the exposure of food to beams or rays that have enough energy to break chemical bonds (also known as 'ionizing radiation'). By using beams to efficiently transfer energy without significantly increasing temperature, irradiation can be used on pre-packaged food to prevent insect breeding, kill spoilage organisms and destroy microbes responsible for food poisoning, while also slowing down ripening.

Depending on the dose delivered, food irradiation ensures that fruit and root vegetables do not sprout or ripen prematurely; parasites are killed and spices decontaminated; food poisoning organisms such as salmonella are destroyed; fungi that could spoil meat, poultry and seafood are eliminated; and food shipments meet the international trade regulations necessary to prevent the spread of pests and diseases harmful to plants and the environment.

The IAEA helps Viet Nam to enhance food safety and trade

The IAEA has been supporting Viet Nam with food irradiation since 1999, supplying both a gamma irradiator and an e-beam irradiator and providing training in their use. Recently, the IAEA supported staff training at the Viet Nam Atomic Energy Institute's Research and Development Center for Radiation Technology, which is responsible for irradiation treatment.

"Different types of foods can be irradiated, either using gamma rays from radioactive cobalt-60 or caesium-137 or, increasingly, with electron beams generated in machines, and X rays. There are many health, quality and economic benefits of irradiation treatment capabilities that several other Member States can take advantage of while learning from experienced countries such as Viet Nam," says James Sasanya, Acting Head of the Food Safety and Control Section at the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture.

Food products have been irradiated in Viet Nam for more than 50 years. Initially only lucrative products such as spices were irradiated, but now the market for other irradiated food products is flourishing. Viet Nam now irradiates more than 120,000 tonnes of food each year, ensuring that it is safe for consumption.

THE SCIENCE

Food irradiation is the exposure of food to beams or rays that have enough energy to break chemical bonds.

This nuclear technique can be used on pre-packaged food to prevent insect breeding, kill spoilage organisms and destroy microbes responsible for food poisoning, while also slowing down ripening.

It does not affect the quality of food, as it does not increase its temperature, cause it to become radioactive, or leave chemical residues.

Market in Ho Chi Minh City, Viet Nam. (Pond5)

Tropical fruits from Viet Nam, such as dragon fruits and mangoes, are a particularly popular export. The value of the country's fruit and vegetable trade increased by 350 per cent between 2012 and 2019, with growing demand from the United States of America, the European Union and China, according to the Asian Development Bank.

"I am proud to highlight the transformative role that nuclear science plays in enhancing food safety and agricultural productivity. Through technical cooperation projects at national, regional and interregional levels, the IAEA has empowered us to harness these advanced technologies. This collaboration fosters sustainable agricultural practices and contributes to the overall health and wellbeing of our nation," says Tran Bich Ngoc, Director General, Department of Atomic Energy of the Ministry of Science and Technology.

How nuclear techniques help 'blue food' security

By Ellie McDonald, Marc Metian and Jana Friedrich

Since human beings came into existence, they have relied on the ocean as a source of sustenance. Today, more than three billion people depend on seafood and ocean products, also known as 'blue food'. To ensure food security, these people need a supply of seafood that is healthy and safe to eat. However, the safety and sustainability of ocean-based food products are contingent on a healthy ocean and sustainable ocean management.

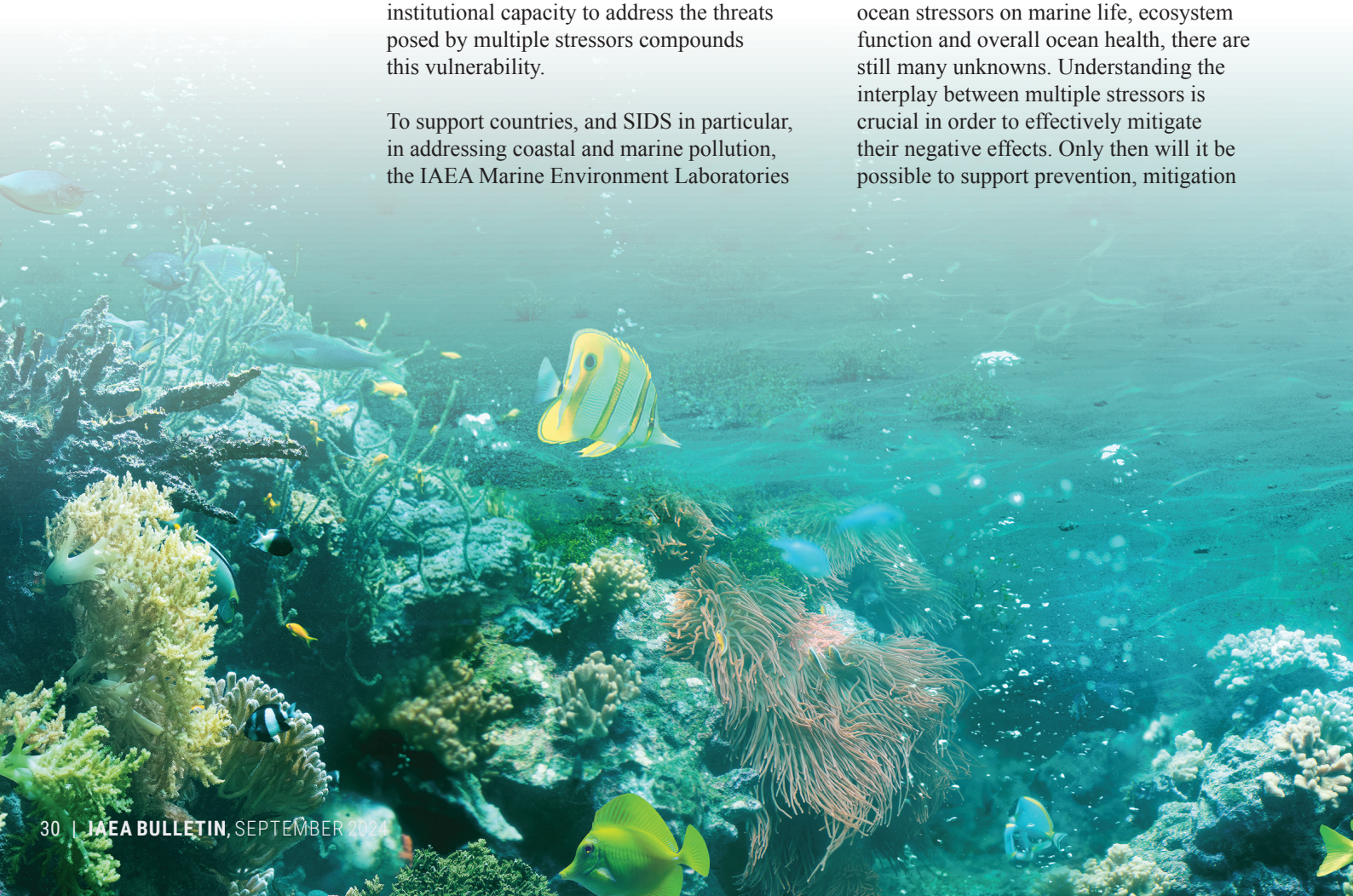
The ocean is heavily affected by climate change, pollution and biodiversity loss. Pollutants released from industrial and agricultural activities, ocean acidification resulting from excess carbon emissions, ocean warming and microplastic pollution place marine ecosystems under huge strain. Each of these stressors will have negative impacts on seafood safety and security; in combination, they can wreak havoc. Small island developing States (SIDS) are particularly at risk, as their economies are heavily dependent on the ocean for food security and employment. Furthermore, the ocean is fundamental to their cultures and way of life. The lack of resources and institutional capacity to address the threats posed by multiple stressors compounds this vulnerability.

To support countries, and SIDS in particular, in addressing coastal and marine pollution, the IAEA Marine Environment Laboratories in Monaco apply cutting-edge nuclear and isotopic techniques that allow countries to accurately monitor pollution, minimize the impact of polluting incidents and mitigate the effect of climate change on local populations. Using these techniques, the IAEA provides data on the potential impacts on ocean and human health and disseminates the knowledge necessary for the development of mitigation methods. The IAEA's NUTEC Plastics initiative addresses the global challenge of plastic pollution on two fronts: at the point of source, by introducing new technologies to improve plastic recycling; and by identifying, tracing and monitoring plastics in the ocean, where the bulk of plastic waste ends up.

Nuclear technology complements conventional scientific techniques by assessing multiple stressors simultaneously — a key advantage for countries with reduced scientific capacity.

Understanding ocean stressors

When it comes to the impact of multiple ocean stressors on marine life, ecosystem function and overall ocean health, there are still many unknowns. Understanding the interplay between multiple stressors is crucial in order to effectively mitigate their negative effects. Only then will it be possible to support prevention, mitigation



and adaptation strategies that can counteract them effectively.

Through its Ocean Acidification International Coordination Centre (OA-ICC), the IAEA coordinates collaborative research on ocean acidification and additional stressors. The OA-ICC enables the training of early career scientists entering the multiple stressor field to help them better understand key concepts and supports research in SIDS through various channels. "The OA-ICC and the IAEA are key in providing scientists in SIDS with the resources and capacity they need to study multiple stressors and the impacts they may have on their respective marine environments," says Sam Dupont, a researcher at the University of Gothenburg in Sweden.

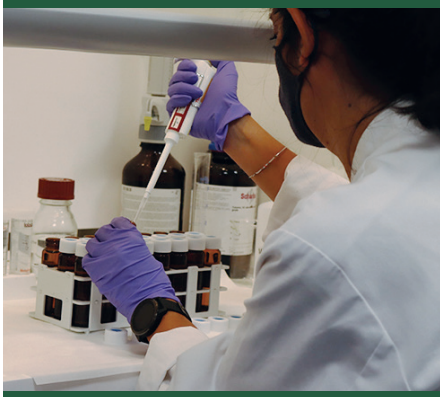
Additionally, the IAEA provides expertise on the pathways of potentially toxic chemicals. This enables scientists to study where heavy metals or radioisotopes from industrial, agricultural and municipal runoff end up, for example when they are released into rivers and groundwater and then into the ocean. In some instances, these toxins make their way to the sea floor, where they are ingested by bottom-feeding organisms such as clams and flat fish. IAEA scientists study how these toxins cycle through the marine food chain.

The IAEA conducts research on the biological impact of chemicals on certain species, and on how substances in organisms appear in increasing concentrations at the top of the food chain — a process called biomagnification.

"SIDS are particularly vulnerable to ocean changes and require greater attention and support to effectively address and mitigate the impacts of human activities," says Florence Descroix-Comanducci, Director of the IAEA Marine Environment Laboratories. "Using nuclear isotopic tools and techniques, the IAEA Marine Environment Laboratories are providing critical support to study past ocean changes and the tools needed to address future impacts."

More recently, the IAEA has developed laboratory approaches to focus on the impact of multiple stressors on blue food and provides support to scientists who lack access to nuclear and isotopic technologies in their countries. In this way, they can assess the impacts of multiple stressors on their national marine environment using nuclear technology, with the help of IAEA experts. For example, the IAEA Marine Environment Laboratories trains scientists in analytical methods including the use of radioligand receptor binding assays, a specific analytical procedure for identifying harmful algal blooms.

The IAEA hosts fellows from institutions around the world to enhance individual capacity and support the transfer of knowledge to home institutions.



"The OA-ICC and the IAEA are key in providing scientists in SIDS with the resources and capacity they need to study multiple stressors and the impacts they may have on their respective marine environments."

(Photos: IAEA)

(Photo: AdobeStock)

Managing the New World screw worm using the sterile insect technique in Latin America

By Rosalia Fraga Pazos

A reinfestation of New World screw worm is emerging in Central America and the parasite is already endemic in South America. New World screw worm *Cochliomyia hominivorax* is a parasitic fly larva that feeds on the flesh of warm-blooded animals, including humans. Myiasis, an infection caused when the fly larva hatch in animal tissue, is endemic in some Caribbean islands and in most South American countries. It has a devastating effect on livestock production, resulting in higher mortality rates and decreased milk and meat yields. Until Costa Rica reported the first cases in cattle in July 2023, the entire Central American region, including Costa Rica, had been free of the disease.

A total of 14 countries in Latin America are being supported by the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture (Joint FAO/IAEA Centre) to protect livestock and farmers' livelihoods through the application of the sterile insect technique (SIT), an environmentally friendly pest control method that has been used successfully for over 60 years to tackle pests that harm livestock.

The SIT involves sterilizing millions of male insects using ionizing radiation before releasing them into the wild to mate with wild females. As no offspring can be produced, the SIT leads to a drastic reduction in the wild population of the disease carrier while minimizing the use of pesticides.

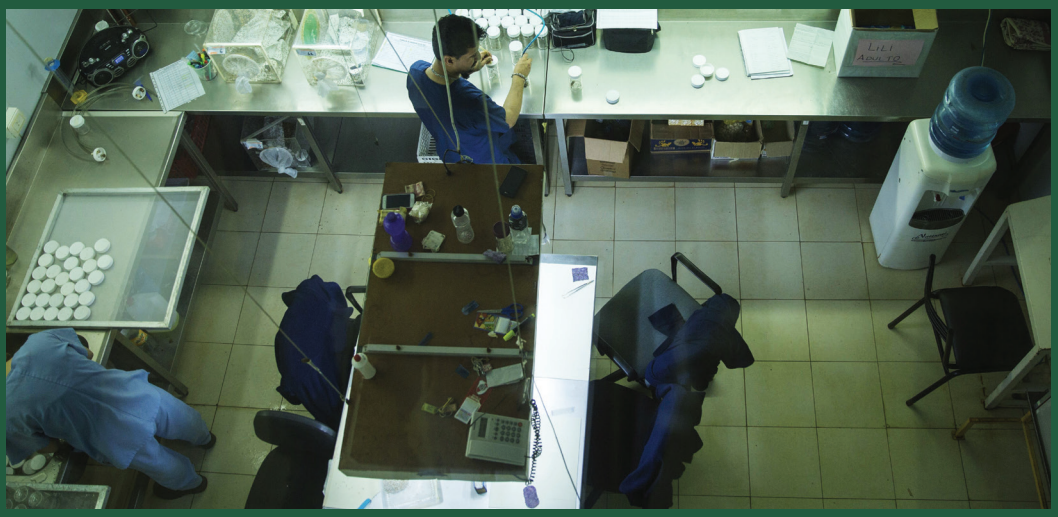
As part of this approach, the IAEA is providing specialized training in the SIT, in addition to knowledge transfer and training, and a regional IAEA technical cooperation project is supporting the procurement of technical equipment and supplies.

Following the re-emergence of the New World screw worm, which threatens the region's livestock and food security, Costa Rica declared a sanitary emergency on 7 February 2024 in an attempt to control the spread of the parasite.

"The main objective of this decree is to have the necessary inputs to prevent the spread of this disease in the national territory," says Luis Matamoros, Director General of Costa Rica's National Animal Health Service (SENASA), which is part of the Ministry of Agriculture. "The IAEA's support for the transfer of nuclear technology to apply the SIT is essential to prevent, control and eradicate the disease."

In March 2024, the IAEA organized a regional emergency response workshop in Costa Rica in collaboration with SENASA, the Food and Agriculture Organization of the United Nations, the Inter-American Institute for Cooperation on Agriculture, the Regional International Organization for Plant Protection and Animal Health, and the USA-Panama Commission for the Eradication and Prevention of the New World Screwworm.

(Photo: AdobeStock)



(Photos: L. Gil/IAEA)

(Photos: F. Chaverri/SENASA)

A total of 14 countries in Latin America are being supported by the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture to protect livestock and farmers' livelihoods through the application of the sterile insect technique.

Participants at a regional workshop on emergency response to a New World screw worm outbreak, held in Costa Rica in March 2024.

"This workshop was absolutely crucial," says Walther Enkerlin, an entomologist at the Joint FAO/IAEA Centre. "Participants from national animal health services from across the region shared knowledge, strategies and resources. The goal was to develop a robust system for early detection, treatment methods and rapid response to control the New World screw worm infestation and promote its eradication using the SIT."

"Thanks to the training sessions supported by the IAEA's technical cooperation programme, I now feel confident in diagnosing New World screw worm at both the adult and larvae stages and in applying effective eradication methods," says Maria Gabriela Mejia, a participant from Honduras.

The IAEA continues to work closely with national animal health services across Latin America to facilitate the implementation of the SIT. It is sharing expertise on the comprehensive management of the pest and providing laboratory equipment and supplies. Moreover, the IAEA is assisting in the development of technical documents which will help to inform decision making by national authorities on applying the SIT as part of an area-wide integrated pest management approach.

Sterile insect technique used to supress mosquito disease vectors in Florida

Sterile *Aedes aegypti* males inside a bucket, ready for release on Captiva Island in Lee County, Florida. (Photo: LCMCD, USA).

Sterile mosquitoes are being used to suppress mosquitoes that have become resistant to insecticide in Fort Myers, Florida, United States of America (USA). The pilot project is being carried out with the support of experts from the IAEA and the Food and Agriculture Organization of the United Nations (FAO) and aims to suppress populations of *Aedes aegypti*, a disease vector species prevalent in Florida.

Aedes aegypti mosquitoes are particularly difficult to manage using traditional insect control techniques as they are diurnal and have cryptic breeding habitats, making it difficult to find and remove their larvae. Moreover, these mosquitoes are becoming increasingly resistant to insecticides. The Lee County Mosquito Control District (LCMCD) in south-west Florida has been working to mitigate the public health threat posed by these mosquitoes since its inception in 1958. A combination of increasing urbanization and resistance to insecticides has resulted in *Aedes aegypti* becoming almost ubiquitous in the county, creating a need for the LCMCD to identify alternative ways of combating this challenging species.

A new pilot project involving the sterile insect technique (SIT) is being used to suppress populations of disease vector mosquitoes in Fort Myers. The SIT is an environmentally friendly pest control method that involves sterilizing male insects using radiation before releasing them to mate with wild females, which then produce fewer or no offspring. The SIT pilot project benefits from extrabudgetary funding contributions from the IAEA's Peaceful Uses Initiative (PUI).

Rui Cardoso Pereira, Head of the Insect Pest Control Section at the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, says: "The extrabudgetary PUI funds contributed by the USA have been instrumental for research and development-based improvement of the SIT package for Aedes mosquitoes and its further transfer to pilot projects in our Member States." *Aedes aegypti* mosquitoes can spread diseases such as chikungunya, dengue, yellow fever and Zika fever, making them a significant threat to public health, and the project contributes to the attainment of Sustainable Development Goal 3 (good health and well-being).

The methods of the SIT pilot project, initiated in the coastal city of Fort Myers, has already been trialled around 30 miles away on Captiva Island, Florida, as part of another successful pilot project conducted between 2020 and 2022. Male mosquitoes were mass reared and sterilized before being released to mate with wild females. At the peak of the releases, approximately 400 000 sterile males were released on Captiva Island per week. The releases led to a significant reduction of the *Aedes aegypti* population in the project's first year (2020), and complete suppression was achieved in 2021 and 2022. Scientists were able to compare the ecological indices of Sanibel Island (the control area) and Captiva Island. "It was remarkable to see the impacts that our sterile male releases had on the population of *Aedes aegypti* on Captiva," says Rachel Morreale, Manager of the Applied Science and Technologies Department at LCMCD.

Hurricane Ian devastated Captiva and Sanibel islands in September 2022, making it impossible to access them by car and putting an end to the pilot project. The damage caused was so severe that LCMCD determined that the best course of action would be to move the release programme to a new area on the mainland. Drawing on lessons learned from the pilot project on Captiva Island, LCMCD collected baseline data to better inform their releases of sterile male *Aedes Aegypti* in Fort Myers, which began in February 2024. While the move to this new area happened sooner than initially planned, the pilot project on Captiva Island allowed LCMCD to validate the SIT as a component of an integrated mosquito management operation for the county. Using the knowledge gained from mass rearing, releases and fieldwork, LCMCD is hoping for similarly successful outcomes in Fort Myers, providing relief and protection to local residents.

David Hoel, Executive Director of LCMCD, says: "The unique attributes of this programme and the technical expertise provided to us by the IAEA is enabling LCMCD to gain a foothold in the suppression of this mosquito, which at best is difficult to control by conventional mosquito control techniques and shows great promise for the future prevention of mosquito-borne disease in Lee County, Florida."

— By Emma Midgley

Releases of sterile mosquitoes on Captiva Island. (Photo: LCMCD)

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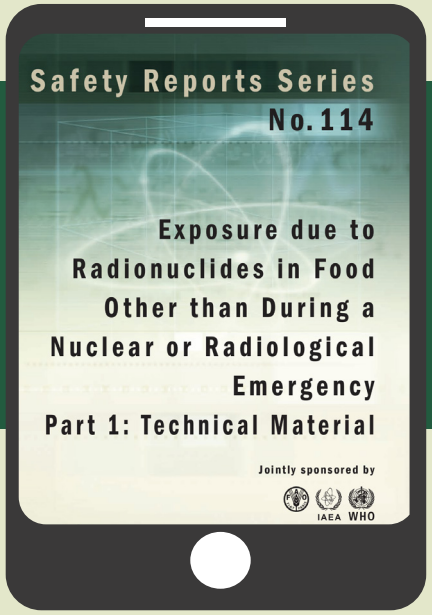

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