IAEA FACTSHEET

Food and Agriculture

Climate-Smart Agriculture
How Nuclear and Isotope Techniques Help

What should I know?

By 2050, the world population is projected to reach 9.6 billion, and many of these people will live in developing countries that are already confronted by food crises. To feed that population, agricultural production will have to increase by some 50%. That is a demanding challenge, especially as the effects of climate change are expected to worsen, bringing more frequent and more intense droughts, floods, heatwaves and destructive weather events that make agricultural production more unpredictable.

The impacts of climate change are expected to worsen farming conditions, especially in developing countries that will need to produce more from limited land resources while using less efficient technologies. Food producers face climate change threats to their fields that are exacerbated by water shortages. It is therefore important to enhance land productivity and soil resilience against the impacts of climate change and the associated variability in soil erosion, salinization and degradation, which contribute to a decline in the land's production capacity and its ability to retain water.

The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), supports Member States in their efforts to implement climate-smart agriculture that targets national and local specificities and priorities.

Climate change: what needs to be done?

Climate change has both direct and indirect effects on agricultural productivity, including through changing rainfall patterns; drought; flooding; geographical expansion and the redistribution of animal and plant pests and diseases; and adaptability challenges for animals and plants in harsh environments. Making global agricultural systems resilient to these changes is critical to efforts to achieve global food security.

To help developing countries address declining food production caused by climate change, one species of edible grain-like crop, quinoa, has benefitted from the use of induced mutation using nuclear techniques. New and improved varieties of quinoa are now available to farmers in Bolivia and Peru.

(Photo: L. Gomez-Pando/National Agrarian University of La Molina, Peru)

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (Joint Division) assists Member States, particularly the developing countries most vulnerable to climate change. It facilitates an integrated approach to climate change using nuclear and related technologies centred on climate-smart agriculture along two major lines:

- **measuring and monitoring** to better understand the impact of climate change on agriculture and

food production processes and the impact of agricultural practices on climate change;

- **adaptation and mitigation** to enhance existing and developing new technologies to counter the impacts of climate change and establish resilient climate-smart agricultural practices.

Through its multidisciplinary activities in crop and livestock production; control of transboundary animal and plant pests and diseases; food safety and quality; land and water management; and plant mutation breeding, nuclear and related techniques are used to measure, monitor, mitigate and adapt to the impacts of climate change in food and agricultural production.

What nuclear technologies can do

Nuclear and isotopic techniques can help to develop climate-smart processes and methodologies covering a broad range of areas:

1. Soil conservation and the efficient use of water are very important in countries affected by climate change. Each year, an estimated 36 billion tonnes of fertile topsoil are lost through human activity and changes in land use, and this is further aggravated by climate change. The use of fallout radionuclides, such as caesium-137, lead-210 and beryllium-7, can simplify the measurement process and minimize the timespan required to accurately assess soil erosion.

2. Isotopic techniques, using carbon-13, oxygen-18 and nitrogen-15 signatures, are used to assess soil carbon sequestration and trace water and nutrient sources and pathways. In this way, isotopic techniques can contribute to more efficient water and fertilizer use. Cosmic ray neutron sensors are also used to measure near ground neutrons ("the sensor technique") in order to establish the soil water content of a wide area, information that also helps improve water use.

3. Integrated analytical approaches, using nuclear, isotopic and physico-chemical techniques, biomonitoring and bioassays, along with risk assessment tools, are being developed and applied to monitor agricultural inputs and the transfer of these chemicals to the environment and the food supply.

4. Compound specific stable isotope techniques are used to estimate the intake and diet selection of livestock grazing in heterogeneous pasture to better manage pasture and prevent its degradation.

5. Nuclear and nuclear-derived immunological and molecular techniques for the early and confirmed detection, diagnosis, control and prevention of livestock diseases, and the irradiation of pathogens for the development of animal vaccines.

6. Stable isotope techniques trace and monitor the spread of animal diseases and their carriers to better manage and prevent pasture degradation. Techniques such as radioimmunoassay and nuclear-derived immunoassay are used to analyse hormone profiles in animals for the application of assisted reproductive techniques, such as artificial insemination and embryo transfer, and the development of breeding strategies.

7. Sterile insect technique (SIT), an environment-friendly insect pest control method, uses irradiation to sterilize mass-reared insects so that, while they remain sexually competitive, they cannot produce offspring. It helps to control insect pests that impact agriculture, livestock and the environment. SIT has become an important tool to contain and eradicate outbreaks of invasive high-profile pests, for which the risk of introduction has been exacerbated by increased global travel and trade, as well as more favourable environmental conditions for pest establishment due to climate change.

8. Irradiation can be used to induce mutations in plants with the goal of developing varieties with improved quality, higher yields and yield stability, greater resilience to climate change and better tolerance of environmental stresses.

9. Nuclear and related techniques are used to ensure the safety and quality of food and agricultural commodities and to facilitate international trade. They can also be used to prevent the spread of invasive species (phytosanitary irradiation) affecting trade in fresh food products.

(Right to left) Farmer Moufaq Bashtawi explains to Setan Al-serhan, Head of the Pest Control Division in the Jordanian Ministry of Agriculture, on how his fruit production has benefitted from the sterile insect technique method that reduced damage to fruit crops from the medfly, increasing his fruit yield and economic revenue.
(Photo: D. Calma/IAEA)

Looking ahead

Changing climatic conditions facilitate the spread of diseases to new destinations and intensify their impact. Outbreaks and expansions can cause huge crop and livestock losses, threatening the livelihoods of farmers and the food security of millions of people. Enhancing existing and developing new technologies for adaptation to climate change is key to ensuring food security through climate-smart agriculture, such as:

1. Developing innovative land and water management technology packages for more crop per drop and increased soil health and resilience to degradation under different climate change scenarios. The use of oxygen-18, hydrogen-2 (deuterium) and nitrogen-15 is an integral part of climate-smart agricultural water management, since they allow water-saving (more crop per drop) technology packages to be developed, help determine sources of pollution, and track water movement and pathways within agricultural landscapes influenced by different cropping systems and farming practices.

2. Enhancing and enriching crop biodiversity through mutation breeding. There is a need to increase genetic diversity in order to find potential responses to climate change related stresses and other improvements required to boost the efficiency of crop cultivation or increase nutritional value. The induction of mutations is one of the most effective approaches to increasing the genetic biodiversity of crops.

3. Identifying and determining the nutritional value of non-traditional animal feeds to improve livestock productivity, and identifying genetic markers of economic traits for the selection of breeding animals resistant to major diseases and harsh climatic conditions.

4. Enhancing disease diagnostic techniques for the early and rapid detection and control/eradication of plant and animal pests and diseases, and the rapid detection of animal disease pathogens.

Supporting capacity building

The Joint Division supports capacity building in Member States through applied research and development activities performed both at its own specialized FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf, Austria, and at over 400 research institutions and experimental stations in Member States through coordinated research projects and through the IAEA's technical

Nuclear and nuclear derived techniques are important tools in practically all fields of animal science when the objective is to advance the productivity and health of economically vital domestic animals. (Photo: M. G. Podesta /IAEA).

cooperation projects. This support includes expert services, training of scientists, guidance on analytical quality controls and assurance, technical and policy advice, and the dissemination of knowledge through conferences, symposia, seminars and advisory panels on the safe and efficient application of nuclear and related technologies as part of efforts to implement climate-smart food and agricultural practices to ensure food security.

Global partnerships

To boost programme delivery, partnerships are maintained with organizations and international instruments that facilitate agricultural development and international trade; they include, among others:

- Codex Alimentarius
- Arab Organization for Agricultural Development
- African Union Pan African Tsetse and Trypanosomiasis Eradication Campaign
- Inter-American Institute for Cooperation on Agriculture
- International Plant Protection Convention
- Regional plant protection organizations
- Convention on Biological Diversity

The IAEA, in partnership with the FAO, plays a vital role in supporting global efforts to measure, monitor, mitigate and adapt to the impacts of climate change and hence to improve the sustainability of climate-smart food and agricultural production in Member States, attain food security and protect the environment.

More Information

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
www.iaea.org/about/organizational-structure/department-of-nuclear-sciences-and-applications/joint-fao/iaea-division-of-nuclear-techniques-in-food-and-agriculture

Climate-smart agriculture
www.iaea.org/topics/climate-smart-agriculture

IAEA Factsheets are produced by the Office of Public Information and Communication
Editor: Aabha Dixit • Design and Layout: Ritu Kenn

For more information on the IAEA and its work, visit www.iaea.org
or follow us on

or read the IAEA's flagship publication, the IAEA Bulletin, at www.iaea.org/bulletin

IAEA, Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Email: info@iaea.org • Telephone: +43 (1) 2600-0 • Facsimile +43 (1) 2600-7