IAEA FACTSHEET

Food and Agriculture

Mutation Breeding for Crop Improvement

The new cowpea variety — CBC5 — developed in Zimbabwe through mutation breeding using irradiation.
(Photo: Prince M. Matova/Crop Breeding Institute, Harare, Zimbabwe)

What should I know?

Sustainable food production will remain a preeminent challenge in the decades to come. Today, more than 800 million people do not have enough food to meet their daily needs. By 2050, the global population is expected to increase from seven billion people to 9.8 billion. To feed everyone, farmers will by then have to produce 50% more food.

Crop mutation breeding and the development of improved crop varieties using radiation and related technologies are important factors in meeting this impending demand. Nuclear technology is also helping scientists unmask the hidden potential in plants, allowing plant breeders to develop crop varieties that can withstand external stress, such as drought, often brought about by climate change.

The FAO/IAEA Mutant Variety Database currently lists more than 3200 officially released mutant varieties of crops.

What is plant mutation breeding?

Plant mutation breeding is the process of exposing plant seeds, cuttings or cell cultures to radiation, such as gamma rays, and then planting the seed or cultivating the irradiated material in a sterile medium that generates a plantlet. The mutated plants, after selection for improved agronomic traits over several generations, are then multiplied

New mutant plant varieties made using nuclear techniques in Bangladesh have helped farmer Mohammad Faridul Islam increase crop yields and improve his livelihood. (Photo: I. Khalil/Bangladesh Institute of Nuclear Agriculture)

and examined for their agronomic performance. Biotechnologies, including molecular- and *in vitro* techniques, are used to accelerate the breeding process.

Plant mutation breeding does not involve genetic transformation, but rather uses a plant's own genetic resources and mimics the natural process of spontaneous mutation, the motor of evolution. By using radiation, scientists can significantly shorten the time it takes to breed new and improved plant varieties.

This technique focuses on the use of radiation in combination with biotechnologies to develop favourable crop traits. New varieties of plants are bred to thrive in harsh conditions, or to improve their nutritional value, to resist diseases or pests, to grow in saline soils, or to use water and nutrients more efficiently.

Supporting countries to enhance crop improvement

The IAEA, in close cooperation with the Food and Agriculture Organization of the United Nations (FAO), assists Member States in developing and implementing technologies that — through the use of gamma irradiation, X-rays and other radiation source machines — can induce mutations in plants and thereby considerably speed up the breeding process. This can also involve the use of related biotechnologies to identify and select the desired mutations more quickly.

The Joint FAO/IAEA Division of Nuclear Applications for Food and Agriculture (Joint Division) supports applied research and development, specialized laboratory services, technology transfer, capacity building and information management to increase food security and food quality in member countries. Assistance is also processed through coordinated research projects and national and

regional technical cooperation projects to widen awareness of the global use of mutation breeding for crop improvement and of the implementation of nuclear technologies to increase food security and biodiversity.

The Joint Division assists in the application of radiation-induced mutation breeding technologies for the improvement of existing and local crop varieties. Through the development of resilient varieties with higher yields, improved quality or greater tolerance to environmental stresses — such as disease, drought and salinity — these varieties contribute considerably and sustainably to global food security and the enhancement of biodiversity.

Lab support

The Plant Breeding and Genetics Laboratory (PBGL) run by the Joint FAO/IAEA Division in Seibersdorf, Austria, focuses on radiation based technologies in plant mutation breeding. The research and development helps accelerate the development of new varieties with higher yield, better yield stability, improved food and feed qualities, improved resistance to pests and diseases, and tolerance to environmental stresses.

The PBGL conducts applied R&D to increase the efficiency of mutation breeding. This effort focuses on developing crop-specific mutation induction and trait selection procedures using advanced genomics or in vitro plant tissue culture techniques. Laboratory services include assistance in crop irradiation, both gamma and X-rays, to all Member States.

The laboratory disseminates knowledge and technologies in crop mutation breeding and provides training through group training or by hosting individual trainees, often supported through IAEA's technical cooperation projects.

Mutation breeding can provide a rapid response to crop improvement challenges faced by Member States, taking 5–7 years to develop a new variety. Mutant crop varieties have a long

Norazlina Noordin (Right), a plant breeder at the Malaysian Nuclear Agency assessing a Stevia plant, a natural sugar substitute. Researchers at the Malaysian Nuclear Agency have used irradiation to develop a variety suited for humid and damp conditions. (Photo: M. Gaspar/IAEA)

track record for food and feed, and their global adoption is expanding domestic and export markets. The increased revenues also contribute to socioeconomic development.

Snapshot of achievements

Mutation breeding has resulted in thousands of improved varieties with higher yields and improved tolerance to pests, diseases and environmental stresses.

The genetic diversity of crop plants is the foundation for the sustainable development of improved crop varieties for meeting present and future food security challenges. Induced mutations offer numerous benefits to crop improvement, especially when conventional breeding techniques fail for the lack of appropriate genetic variation.

Viet Nam officially released 18 mutant rice varieties over the past 10 years, including several varieties tolerant of the saline conditions of the Mekong Delta. Within only four years of its release to farmers, the most successful of these saline-tolerant rice varieties were grown by 4.5 million farmers on 30% of the rice production area in Viet Nam's Mekong Delta, generating an additional income of US $374 million/year. Viet Nam also has a highly successful soybean breeding programme, with mutant soybean varieties occupying about 50% of the dedicated soybean area.

In Peru, mutation breeding techniques have led to the development of improved barley and amaranth varieties that are adaptable to climatic conditions in high altitudes. The mutant barley variety, Centenario II, yields 3000 kg/ha, up from 800 kg/ ha, and is widely accepted by Peruvian farmers in the Andes. This variety contributes roughly US $32 million annually to the poor, high-altitude Andean farmers. The mutant amaranth variety, Centenario, which covers 47% of the dedicated area for this crop, is similarly successful.

In Bangladesh plant breeders developed 76 mutant varieties in 12 different crop species. Cultivation of the Binadhan-7 mutant variety, an early maturing variety with increased cropping intensity, has expanded so far to more than 300 000 ha of land as it enables three cropping seasons per year and hence helps combat the seasonal food shortage, known as 'monga' periods when food is scarce and the price of available foods are high.

Farmers in Northern Malaysia have also seen increased rice yields in the new mutant rice variety called NMR152.

The IAEA and FAO assist member countries in the implementation of modern and efficient plant breeding programmes with the overall aim to enhance food security through sustainable crop production using strategic, fundamental and applied crop science research and development, and the implementation of this advanced technology for agricultural benefits.

More information

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

www.iaea.org/about/plant-breeding-and-genetics-section

www.iaea.org/about/organizational-structure/department-of-nuclear-sciences-and-applications/joint-fao/iaea-division-of-nuclear-techniques-in-food-and-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