Climate change adaptation: boosting quinoa production using nuclear techniques

By Aabha Dixit

Field with quinoa mutant lines.
(Photo: L. Gomez-Pando/ National Agrarian University of La Molina, Peru)

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In the battle to help developing countries overcome threats from declining food production caused by climate change, one species of edible grain-like crop has caught international attention because of its unique nutritional value. New and improved varieties of quinoa, historically grown in the highlands of South America, will be made available to farmers in mutations adapted to challenging environments in Bolivia and Peru.

Increased genetic diversity is the result of the use of nuclear techniques (see box) in collaboration with the IAEA and the Food and Agriculture Organization of the United Nations (FAO), said L. Gomez-Pando, Principal Professor and Head of the Cereals and Native Grains Research programme at the National Agrarian University of La Molina in Peru. "There are 64 mutant lines of quinoa selected by yield potential and quality for the market," he said. "These mutant lines will be further evaluated and the best lines will be released as new varieties in 2015–2016."

The use of new and high-yielding quinoa varieties will allow farmers to improve their income and increase their own protein intake, Gomez-Pando explained. The new varieties will provide seeds at affordable prices to people in danger of malnutrition, especially children below five years of age.

"Due to its high nutritional, agronomic and economic value, quinoa is set to be a major food for future generations and an important alternative crop, considering the challenges caused by climate change," said Qu Liang, Director of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. Quinoa is now considered to be essential in efforts to tackle hunger, malnutrition and poverty.

Protecting and enhancing quinoa production using nuclear techniques

The Joint Division used advanced nuclear techniques to enable farmers in Latin America and elsewhere to further boost quinoa production. This was achieved through induced mutation and the detection of improved quinoa genotypes, which has resulted in the breeding of new quinoa varieties.

Quinoa has exceptional nutritional composition, with higher protein content than brown rice, barley and millet. Besides being gluten free, quinoa is an excellent source of dietary fibre and has elevated levels of

phosphorus, magnesium, iron and calcium. It is also rich in vitamins.

Global interest in quinoa farming

Quinoa is cultivated in the Andean region, from Colombia in the north, to Argentina and Chile in the south. It is planted mainly at elevations of between 3000 and 4000 metres, where hostile climatic conditions thwart the growth of other crops. The key producing nations are Bolivia, Peru and Ecuador. Farmers in the United States of America, France, England, Sweden, Denmark, Holland and Italy, as well as Morocco, Egypt, Kenya and the northern regions of India, have also begun cultivating the crop, with increasing success.

The recognition of the value of quinoa has transformed it from a neglected crop to one in high international demand. Various quinoa varieties have been developed to be tolerant to salt, drought or frost and these attributes have created wider global interest in its cultivation. There are valuable genetic resources that can be obtained by using mutation breeding techniques to improve the productivity and quality of quinoa. "By using nuclear techniques the impact from negative traits can be reduced," said Ljupcho Jankuloski a geneticist at the Joint FAO/IAEA Division. Scientists have now developed varieties that are shorter, so easier to harvest, have a shorter growth cycle, and contain a lower amount of saponin, a naturally occurring detergent that gives the grain a bitter taste. The new varieties set to be released later this year will contribute to increased quinoa production and improved livelihoods of farmers, he said.

New mutant quinoa plants in Peru.

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

In recognition of the ancestral practices of the Andean people, who have through the centuries preserved quinoa in its natural state, as food for today and for generations to come, the United Nations General Assembly declared 2013 as the "International Year of Quinoa".

THE SCIENCE

Plant mutation breeding

Plant mutation breeding is the process of exposing plant seeds, cuttings or shredded plant leaves to radiation, such as gamma rays or X-rays, and then planting the seeds or cultivating the irradiated material in a sterile rooting medium, which generates a plantlet. The individual plants are then multiplied and examined for their traits. Molecular marker-assisted breeding, often referred to as marker-assisted selection (MAS), is used to accelerate the selection of plants carrying genes of interest (desired traits). MAS involves the use of molecular markers for the selection of plants carrying certain genes that express desired traits. Those exhibiting the desired traits continue to be cultivated.

Plant mutation breeding does not involve gene modification, but rather uses a plant's own genetic material and mimics the natural process of spontaneous mutation, the motor of evolution and a process that otherwise takes millions of years. By using radiation, scientists can significantly shorten the time it takes to see beneficial variations to as little as a year. Screening techniques target certain traits to address key needs, such as tolerance to high salt levels in soil or resistance to certain diseases and pests. This makes it possible to validate a new variety for use in record time.