Cultivating better crops for sustainable agriculture

A project of the Regional Cooperative Agreement for Research, Development and Training in Nuclear Science and Technology in Asia and the Pacific (RCA)

The RCA is helping countries in Asia and the Pacific acquire nuclear technologies to breed new varieties of crops with higher yield rates, greater resistance to drought, salinity, disease and pests, and improved quality for consumption. This much-needed boost to agriculture is a timely response to the region's rising demand for food. It will also increase the production of high-value crops such as biofuels for domestic and export markets, and it could make a difference to thousands of smallholder farmers seeking a more sustainable livelihood.

In many parts of Asia and the Pacific, agriculture is beset with difficulties. Rapidly-changing weather patterns over recent years have frequently precipitated floods and droughts. Inappropriate farming practices, deforestation and poor water management blight the earth by eroding top soils and increasing salinity. Yield levels of many traditional crops have reached their limit. And for the region's innumerable subsistence farmers with small landholdings, a bad season doesn't just mean loss of income, it threatens their very existence. Add to these factors the effects of global warming, which are predicted to encourage the spread of pests and disease to new areas, and the outlook for agriculture is challenging to say the least.

Young scientists on an RCA field trip to the sorghum mutant trail in Beijing, China. Sorghum mutants with good tolerance to drought and salinity were developed using nuclear radiation mutation techniques in China and Indonesia. Sorghum mutant germplasms were also exchanged through the Mutant Germplasm Network.

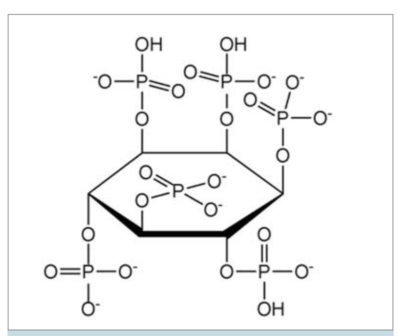
In response to these challenges, the RCA established a project to transfer advanced nuclear, chemical and biotechnological techniques to Member States to assist them in breeding improved food, pulse and oil crops quickly and efficiently. Importantly, an agricultural 'gene bank' - the Mutant Germplasm Network - has also been established in the region. Germplasms (or genotypes) of promising new crop varieties are deposited into this gene bank and preserved. Subsequently they can be drawn on by any country in the network.

Collaboration has been instrumental to the success of this RCA project. As well as establishing a common pool of genetic material through the germplasm network, participating countries have been exchanging research results and sharing insights into how to improve plant breeding techniques. They have also been assisting each other in field-testing crop mutant varieties outside those varieties' countries of origin. For example, a variety of soybean native to Vietnam has proved suitable for growing in Thailand, where it consistently outperforms local varieties. These trials have shown that non-native crop varieties with superior characteristics may retain those characteristics despite being transposed to different environmental conditions. Several of these non-native varieties have been identified for commercial release.

Soybean crinkle leaf disease is a major problem in Thailand, where no native varieties of soybean are resistant to it. Scientists have succeeded in irradiating soybean germplasm with gamma rays to develop several new varieties which are not only resistant to the disease but also high yielding.

Experimenting with plant breeding is nothing new. People have been cross-breeding plants to produce better-performing varieties for many years. In fact, most major crop varieties grown today have at some point in their history been crossbred. But traditional cross-breeding is a slow process, taking several (plant) generations to achieve the desired results. Much quicker results are produced by induced mutaion techniques.

Mutation-breeding by irradiation works, in essence, by accelerating the natural processes of evolution. When living organisms reproduce, they do so imperfectly. Genetic code, as it passes from one generation to the next, mutates slightly - and randomly - in a process known as mutagenesis. This introduces greater diversity into the gene pool, increasing a species' chances of survival. Some mutations are 'successful', surviving to establish themselves over many generations as new varieties (or even new species) - according to Darwin's principle of 'natural selection'.



Phytic acid, found in many cereals, soybean and other legumes, can form anti-nutritional compounds that make these foods indigestible. Research has shown that the presence of two genes significantly reduces phytic acid content. Two new crop varieties containing these genes have now been developed and yield tested. The germplasm can be used to greatly improve the nutritional quality of several crops.

Ionizing radiation (such as gamma rays) increases the rate at which genes mutate. Irradiate a thousand seeds of wheat, for example, and you generate many different mutations-you diversify the gene pool. Some of these mutations may be found to be more resistant to a particular disease, or more tolerant of drought or salinity, or have a higher yield potential. Careful screening and selection of the best performing mutations leads to the development of new plant varieties. This process should not be confused with the production of GM crops, which have been manipulated with foreign genes from other species to enable the crops to acquire specific characteristics. Mutation breeding, in contrast, only accelerates natural changes of its own genes and does not involve cross-species transport of genes.

Through regional training courses, expert missions, group technical visits, and open lecture sessions involving extensive interaction with leading researchers from institutes around the world, countries participating in this RCA project have acquired the skills and technology to conduct their own mutation-breeding programmes. Several high-performance varieties of soybean, groundnut, mungbean, wheat and sesame - some of the region's most important crops - have already been released onto market, and a number of other

Salinity is a serious problem in South-east Asian countries in crop production; and groundnut, an important oil crop in the region, is highly susceptible to it. Dozens of groundnut mutant lines which consistently show improved tolerance have been developed and field tested.

new crop varieties are being field-tested prior to commercial release. China and Indonesia, for example, have developed drought-tolerant wheat and sorghum; India and Sri Lanka have developed high-yielding and early-maturing groundnut; Korea has produced no-shattering sesame and easy-cooking soybean; and Pakistan virus-resistant mungbean.

Together, participating countries are now steadily improving the efficiency of radiation-induced mutations, chemical mutagens and new mutagens, as well as the efficiency of mutant selection processes. The importance and potential of the technology is well illustrated by the fact that today, roughly 10% of all agricultural land in China is cultivated with new varieties of rice, wheat, corn, and cotton that were developed through radiation mutation techniques.

By 'cross fertilising' ideas as well as genotypes, this RCA project has sown the seeds of an agricultural breakthrough that is increasing biodiversity and reducing the time and effort usually required to improve yields and crop quality. Above all, it will help the region develop a sustainable response to the ongoing challenges of population growth, declining land and water resources, drought and salinity, and global warming and climate change.

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