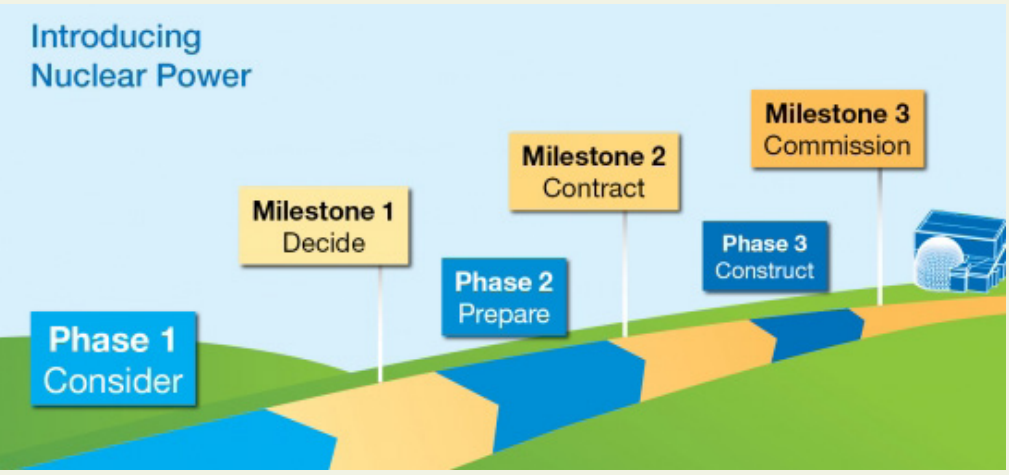

The Milestones approach for nuclear power is a phased, comprehensive method to assist countries that are considering or planning their first nuclear power plant.
(Image: IAEA)

potential sites are properly evaluated before being selected for a nuclear installation. The IAEA safety standards provide clear guidance in both areas, and we encourage all countries to apply them."

The workshop introduced the IAEA Milestones approach for the development of a new nuclear power programme. It lists 'site and supporting facilities' as one of 19 nuclear infrastructure topics that would require action during the development of a nuclear power programme.

In line with the Milestones approach, the IAEA provides integrated services, including on safety, security, legal and regulatory frameworks, human resource development, emergency planning and safeguards. These include peer reviews and advisory missions such as the Integrated Nuclear Infrastructure Review and the Site and External Events Design review service.

— By Ayhan Altinyollar

How nuclear techniques help feed China

The use of nuclear technologies is fully integrated into agricultural research at the China Academy of Agricultural Sciences. Here a technician is preparing samples for a food safety test. (Photo: M. Gaspar/IAEA)

With 19% of the world's population but only 7% of its arable land, China is in a bind: how to feed its growing and increasingly affluent population while protecting its natural resources. The country's agricultural scientists have made growing use of nuclear and isotopic techniques in crop production over the past decades. In cooperation with the IAEA and the Food and Agriculture Organization of the United Nations (FAO), they are now helping experts from Asia and beyond in the development of new crop varieties, using irradiation.

While in many countries, nuclear research in agriculture is carried out by nuclear agencies that work independently from the country's agricultural research establishment, in China the use of nuclear techniques in agriculture is integrated into the work of the Chinese Academy of Agricultural Sciences (CAAS) and provincial academies of agricultural sciences. This ensures that the findings are put to use immediately.

And indeed, the second most widely used wheat mutant variety in China, Luyuan 502, was developed by CAAS's Institute of Crop Sciences and the Shandong Academy of Agricultural Sciences, using space induced mutation breeding (see The Science box). It has a yield that is 11% higher than the traditional variety and is also more tolerant to drought and main diseases, said Luxiang Liu, Deputy Director General of the Institute. It has been planted on over 3.6 million hectares — almost as large an area as Switzerland. It is one of 11 wheat varieties developed for improved salt and drought tolerance, grain quality and yield, Liu said.

Through close cooperation with the IAEA and FAO, China has released over 1000 mutant crop varieties in the past 60 years, and varieties developed in China account for a quarter of mutants listed currently in the IAEA/FAO's database of mutant varieties produced worldwide, said Sobhana Sivasankar, Head of the Plant Breeding and Genetics Section at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

The new mutation induction and high-throughput mutant selection approaches established at the Institute serve as a model to researchers from around the world, she added.

The Institute uses heavy ion beam accelerators, cosmic rays and gamma rays along with chemicals to induce mutations in a wide variety of crops, including wheat, rice, maize, soybean and vegetables. "Nuclear techniques are at the heart of our work, fully integrated into the development of plant varieties for the improvement of food security," Liu said.

The Institute has also become a key contributor to the IAEA technical cooperation programme over the years: more than 150 plant breeders from over 30 countries have participated in training courses and benefited from fellowships at CAAS.

Indonesia's nuclear agency, BATAN, and CAAS are looking for ways to collaborate on plant mutation breeding and Indonesian researchers are looking for ways to learn from China's experience, said Totti Tjiptosumirat, Head of BATAN's Center for Isotopes and Radiation Application. "Active dissemination and promotion of China's activities in plant mutation breeding would benefit agricultural research across Asia," he said.

From food safety to authenticity

Several of CAAS' other institutes use nuclear-related and isotopic techniques in their research and development work and participate in several IAEA technical cooperation and coordinated research projects. The Institute of Quality Standards and Testing Technology for Agro-Products has developed a protocol to detect fake honey, using isotopic analysis. A large amount of what is sold in China as honey is estimated to be produced synthetically in labs rather than by bees in hives, so this has been an important tool in cracking down on fraudsters, said Chen Gang, who leads the research work using isotopic techniques at the Institute. A programme is also in place to trace the geographical origin of beef using stable isotopes, he added.

The Institute uses isotopic techniques to test the safety and to verify the authenticity of milk and dairy products — work that was the outcome of IAEA coordinated research and technical cooperation projects that lasted from 2013 to 2018. "After a few years of support, we are now fully self-sufficient," Gang said.

Chinese scientists are looking to use nuclear-related techniques to better trace the metabolism of cattle like these on a farm near Beijing and increase the amount of nitrogen cows use from fodder.

(Photo: M. Gaspar/IAEA)

Improving nutrition efficiency

Various CAAS institutes use stable isotopes to study the absorption, transfer and metabolism of nutrients in animals. The results are used to optimize feed composition and feeding schedules. Isotope tracing offers higher sensitivity than conventional analytical methods, and this is particularly advantageous when studying the absorption of micronutrients, vitamins, hormones and drugs, said Dengpan Bu, Professor at the Institute of Animal Science.

While China has perfected the use of many nuclear techniques, in several areas it is looking to the IAEA and the FAO for support: the country's dairy industry is dogged by the low protein absorption rate of dairy cows. Less than half of the protein in animal feed is used by the ruminants, the rest ends up in their manure and urine. "This is wasteful for the farmer and the high nitrogen content in the manure hurts the environment," Bu said. The use of isotopes to trace nitrogen as it travels from feed through the animal's body would help improve nitrogen efficiency by making the necessary adjustments to the composition of the feed. This will be particularly important as dairy consumption in China, currently at a third of the global average per person, continues to rise. "We are looking for international expertise, through the IAEA and the FAO, to help us tackle this problem."

— By Miklos Gaspar

THE SCIENCE

Space induced mutation breeding

Irradiation causes mutation, which generates random genetic variations, resulting in mutant plants with new and useful traits. Mutation breeding does not involve gene transformation, but rather uses a plant's own genetic components 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.

Space-induced mutation breeding, also called space mutagenesis, involves taking the seeds to space, where cosmic rays are stronger, and these rays are used to induce mutation. Satellites, space shuttles and high-altitude balloons are used to carry out the experiments. One advantage of this method is that the risk of damaging the plants are lower than when using gamma irradiation on earth.