Historical Introduction to the Use of Nuclear Techniques for Food and Agriculture

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It is a great honour for me to have been given the task of introducing the subject for this Scientific Afternoon, the application of isotopes and radiation to food and agriculture.

You will hear lectures this afternoon by world famous scientists who have been and are most actively engaged in this kind of research and development applied to their particular field of agricultural science. I am convinced they will all agree with me when I make the point that, in accordance with the normal development pattern, the basic research upon which today's application of nuclear techniques to food and agriculture is based was done several decades ago.

The history of research in nuclear sciences dates back to the last century and names like Roentgen, Becquerel and Curie are well known to all of us. Natural radioactive isotopes were identified and the nature of the penetrating ionizing radiation emitted from them was elucidated. Along with this development came the need for suitable detectors of nuclear radiation. Artificial radioactivity and particle accelerators were initiated in the early thirties of this century, paving the road for sciences applied to the use of these new tools. Two roads of application were early discernible: *the use of radioactive isotopes as tracers in studies of chemical and biological pathways and the interaction of the ionizing radiation with matter.* Both of these have been extensively applied in the fields of food and agriculture.

A pioneer in the first field is G.V. Hevesy who, after ten years of successful work in pure chemical systems, used a lead isotope as a tracer to study the uptake of lead by plant roots. This classic experiment was carried out in Copenhagen in 1923 and constituted the start of a widespread application of radioisotopes in the soil and plant sciences. Thus, the direct determination of the radioactivity present became an easy, sensitive and direct method for studying the amount and movement of water and nutrients in plants and animals.

For the first time it became possible to make a direct determination of the fate of a nutrient given to an animal through feeding, or to plants through fertilization as well as to quantify that fraction of the total amount present, which can be usefully metabolized by the organism. This type of research markedly increased after the war, when artificially produced radioisotopes of many important elements became available to a broad spectrum of agricultural sciences.

More recently, stable isotopes of agriculturally important elements such as hydrogen, oxygen, carbon, nitrogen or sulphur have become available at prices that are within the reach of the entire scientific community. The isotope tracer technique is now widely applied to economically important fields such as fertilizer efficiency, plant and animal nutrition and physiology, insect ecology and pest management systems, or chemical residues in the environment — just to mention a few.

The other field, the interaction of ionizing radiation with matter, also has old ancestors. Roentgen probably could not have foreseen the development of a new area of science which his discovery of X-rays in 1895 actually initiated. Efforts were early devoted to studies of the impact of ionizing radiation on living organisms in addition to the work done in pure chemical systems. That X-rays are capable of bringing about genetic changes was indicated as early as 1908, but the classic and conclusive demonstration of the artificial induction of mutations was provided by H.J. Müller in 1927 using the fruit fly *Drosophila melonogaster.* At about the same time, in 1928, L.J. Stadler had successfully induced mutations in barley and maize by means of X-rays. This was the beginning of plant mutagenesis.

In his paper on the "Artificial Transmutation of the Gene", Müller made the statement that "similarly, for the practical breeder, it is hoped that the method will prove useful". His hope has indeed come true. By the end of 1975, at least 197 crop cultivars had been developed worldwide, based upon mutated traits; 133 of these concerned agricultural crop plants, and a large portion of them, particularly cereals, have become economically important cultivars.

As an offshoot of Müller's work, E.F. Knipling as early as 1937 considered that with insects having a low population, it would be possible to rear, sterilize and release enough sterile males of the species to overwhelm the natural population and thus control or eradicate an infestation. The screwworm, a serious livestock pest in the United States, was the target of his work, and sterility was induced by exposure to gamma radiation. The successful eradication of this insect from a large area in Florida and the south-eastern states in the early sixties by this method — the Sterile Insect Technique — ranks as an outstanding entomological accomplishment, heralding a new era of use of modern biological methods for insect control.

The sterile insect technique is now used on a practical basis against other insect species of agricultural importance, such as the Mexican fruit fly, the Mediterranean fruit fly, the codling moth and the pink bollworm. The method is also being applied in large-scale field trials for the control of tsetse flies, mosquitoes, *Heliothis* spp., the melon fly, oriental fruit fly, onion fly and other important agricultural pests.

The first successful demonstration of lethal X-ray effects on pathogenic bacteria came in 1898 and on protozoa in 1899. One of the applications of these early findings is in the preservation of food and other agricultural products. Although the first scientific paper on the successful demonstration of the preservation of foods by ionizing radiation was only published in 1947, the first attempt was made in 1909 in the United States on the destruction of *Lasiderma* beetles in tobacco by means of X-rays.

Another point I wish to stress here is that, however useful and effective these nuclear techniques are when applied to food and agriculture, they do not normally stand alone but are complementary to and used in conjunction with other available methods.

Agricultural development can only prosper from their use if they become fully integrated in the overall research efforts to solve specific problems. I am sure the various speakers will record examples of this truism.

A third point I would like to make this afternoon relates to the desire to pool the efforts of atomic energy commissions and agricultural authorities in fostering the applications of isotopes and radiation in food and agriculture. Just as the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture is an international example of this pooling, it is indeed gratifying to see that in many countries the organization concerned with the peaceful use of atomic energy is engaged in a fruitful cooperation with institutions responsible for food production and protection. Work with isotopes and radiation does require highly specialized experience, skill and facilities that very frequently are not at hand in agricultural research centres. Proper waste management and radiological protection are imperative, and intensive training in specially equipped laboratories is only a start.

Once the nucleus of a well-trained staff and suitable facilities are available, the efforts must be fully integrated in ongoing agricultural training, research and extension if achieving the goal of increasing agricultural production is to be realized.

My last point will deal with the application of atomic energy to food and agriculture in developing countries, which is the main activity of the Joint FAO/IAEA Programme. As I already pointed out, isotope and radiation techniques are not entirely new, but their use to solve practical problems must be accomplished under the prevailing socio-economic and ecologic conditions. Studies on the response of a given animal diet or a fertilizer practice can only be done within the country itself in order to be practically applicable.

These techniques are neither esoteric nor so sophisticated that developing countries cannot apply them for the solution of practical problems. And they should apply them whenever it is more economic, faster or the only way to solve the problem. In this context, the Joint FAO/IAEA Division plays an important role in assisting the developing countries to determine if, when and how to embark on an isotope or radiation-aided project in agriculture. The Division also ensures co-ordination in about 24 research programmes in which scientists from the developing and the industrialized world participate in solving problems of immediate or impending practical importance in developing countries.

In conclusion, and viewed within the proper perspective, the use of isotopes and radiation serves as a very effective means of furthering mankind's demand for more and better food throughout the world.