RADIATION AND CROP IMPROVEMENT

For many countries of the world today improvement of agriculture is one of the most significant contributions that atomic energy can make to immediate economic wellbeing. While some progress in this direction has already been made, the full potentialities are yet to be adequately explored.

Some of the agricultural applications of atomic energy are, of course, well established. For example, radioisotopes are being widely used in plant nutrition studies and research is being conducted for using radiation sources to preserve certain types of agricultural produce, such as potatoes. However, the most vital benefit that atomic energy can bring to agriculture is an increase in crop yields by producing new varieties of plants through radiation-induced genetic changes or by directly stimulating plant growth.

That ionizing radiation can bring about complex changes in the hereditary characteristics of living organisms is well known. What is not so clear is the exact mechanism by which these changes are effected. This is a fundamental problem of radiobiology and concerns not only plant life but also animals and humans. It is, however, easier to investigate the effects of radiation on plants because they are relatively simple organisms and can be subjected to extensive experiments. It is also fortunate that while the genetic changes, or mutations as they are called, are generally deleterious in the higher organisms like humans, the chances of favorable mutations are better in simpler forms of life such as plants.

Plant mutation experiments are being conducted in many countries and some promising results have already been obtained. An essential prerequisite for the success of these experiments is an adequate understanding of the effects of radiation on seeds - not only the end effects, but also the primary and intermediate processes through which they are reached.

The present state of this research was reviewed and its results analyzed at an international scientific Symposium on the Effects of Ionizing Radiations on Seeds and their Significance for Crop Improvement held at Karlsruhe, Federal Republic of Germany, from 8 - 12 August 1960. It was organized jointly by the International Atomic Energy Agency and the Food and Agriculture Organization of the United Nations, in co-operation with the German Kernreaktor Bau- und Betriebsgesellschaft. Approximately 100 scientists from 23 countries participated in the meeting and 53 papers were presented and discussed.

Seed Radiobiology

After listening to two general survey papers, the experts began a detailed examination of certain special aspects of the radiobiology of seeds. Some of the topics discussed related to the processes initiated in seeds as a result of irradiation. The influence of environmental factors, such as temperature, humidity and the presence or absence of oxygen, was also evaluated. Variations in the sensitivity to radiation were taken into consideration and ways of modifying the sensitivity were examined. For example, it was pointed out that extracts of resistant seeds can make sensitive seeds more resistant to radiation and vice versa. A scientist from the United Kingdom explained how the destructive properties of radiation could be employed to overcome the barriers to hybridization that exist between many closely related species of plants.

These discussions were followed by two sessions devoted to a study of radiation- and chemically-induced chromosome breakage and reunion. Chromosomes are the thread-like materials within a cell that carry the genes, i.e. the units of inherited material which determine the hereditary characteristics of an organism. The chromosomes exist in closely bound pairs, but they can break under the effect of ionizing radiations. The broken ends can, however, rejoin, but if the reunions are different from the original pattern and give rise to new chromosome configurations, a number of different abnormalities are created. It is not surprising that some of these abnormalities should find expression in changes in the structure of some of the genes affected, and if these genes are those of the germ cells, hereditary changes can be expected to follow.

The nature and mechanism of chromosome breakage and reunion are a subject of basic importance in all radiobiological studies and naturally constituted one of the main topics of discussion at the Karlsruhe symposium. Chromosome breakage, however, can be caused also under the influence of certain chemicals, and several participants in the symposium discussed the relative usefulness of these chemicals and ionizing radiations in inducing plant mutations.

After considering these basic scientific questions, the symposium turned to an examination of their relevance to crop improvement. Whether irradiation itself, without producing any hereditary changes, can stimulate crop yields is a matter of considerable interest. It has been found that in some cases the

effect is stimulative, while in others it is inhibitive. A number of experiments were described and an attempt was made to deduce certain principles from the results obtained.

New Plant Varieties

Perhaps the more promising line of approach is to breed new varieties of plants through genetic mutations - varieties that would give better or bigger yields. Experts from a number of countries reported significant successes in this direction. For example, scientists from Taiwan described an experiment in which 37 promising lines had been derived from certion varieties of rice by means of irradiation with x-rays, all the new strains being better than the mother varieties. One high yielding strain gave a 27.4 per cent higher yield than its mother variety. Encouraging results in respect of different crop plants were also reported by scientists from India, Italy, Japan, the Netherlands and Sweden. Discussing these positive results, an expert from FAO, however, pointed out that irradiation could not replace the classical breeding methods but merely constituted an additional means of increasing the possibilities of achieving variations.

Summing up the results of the meeting, one of the participants, Dr. Arnold H. Sparrow of the Brookhaven National Laboratory, USA, said that it marked "the end of an era - the end of the beginning, so to speak, and the beginning, we hope, of a new and better understanding and a new and better approach to the problems of cellular radiobiology". He thought that general agreement could now be reached on the fundamental role of chromosome breakage in radiation genetics and in plant radiation biology. An understanding of chromosome aberrations would eventually be of great value to the plant breeder, and further study was needed of chromosome breakage and of the nature of the aberrations at all levels. The study of chromosome breakage could make it possible to predict the radiosensitivity of organisms which had not been previously studied. This would be of considerable help to anyone starting work on new species.

Symposium in Karlsruhe, Federal Republic of Germany, on the effects of ionizing radiation on seeds and their significance for crop improvement

As regards chemical mutagens (i.e. agents causing mutations), Dr. Sparrow thought that they would supplement radiation as a tool in mutation research and mutation breeding, but would not, at least for some time to come, replace it.

Regarding the more restricted aspects of seed radiobiology, Dr. Sparrow pointed out that seeds were very versatile experimental subjects, particularly because of their tolerance to extremes of drying, freezing, heating, storing and pressures. Urging intensified research both in chemical mutagens and ionizing radiations, he suggested that a small group of experts should draw up a list of specifications to be followed in seed irradiation experiments. Radiation as a research tool, he said, had become a serious business and "it is no longer appropriate or profitable for amateurs to play with radiation".