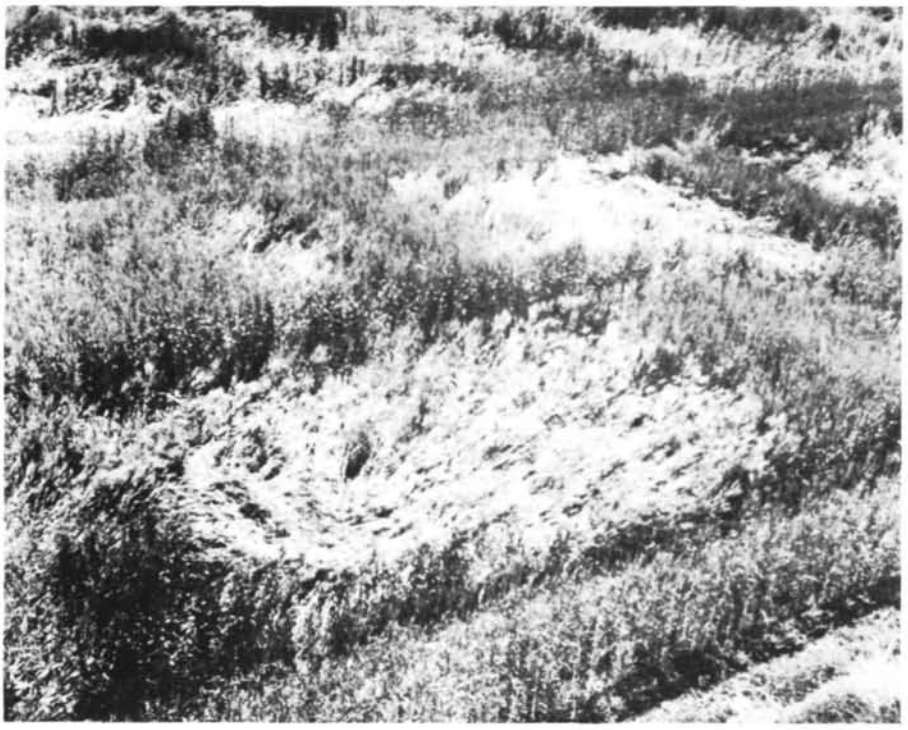
ADVANCES IN BREEDING FOR BETTER CROPS

Mutations are changes in the hereditary nature of living things. In nature they are ultimately the source of evolution. Scientific methods, mainly the use of radiation, can increase by a hundred thousand times the likelihood of beneficial changes in plants grown for man's use, and provide a tool to break through present limitations in variability. Already there are examples of better crops of wheat, barley, rice, oats, peanuts, soybean and other plants.

A lecture by Dr. Björn Sigurbjörnsson, of the Joint FAO/IAEA Division of Atomic Energy in Agriculture in Stockholm this year explained methods of inducing mutations and dealt with misunderstandings, even by agricultural experts, of the subject.

Two tasks facing mankind, he said, take priority over everything else; control of population growth and increase of food production. We know how to reduce the rate of population growth and also that it is possible to multiply food production. But the problem is so enormous that all available means, even if only in the short term, must be applied to the food question. Breeding of crop plants capable of high yield in response to fertilizers and of resisting diseases and pests was one of the most promising means. Artificially induced mutations provided a tool to break through the limitations of variability in plants known at present and to introduce specific improvements into crop varieties without losing their better attributes.

In 1965, as a result of gamma radiation treatment of rice seeds by a participant in an international programme conducted by the Joint FAO/IAEA Division, a new rice variety, Reimes, which resists lodging better than other strains in response to increased fertilizer application was officially introduced in Japan. Induced mutation has produced several lines of rice which mature 40 to 50 days earlier than the mother strain without losing the desirable characteristics such as cooking quality and yield. Varieties of soybean and oil rape which matured early with high yield had been developed in the same country. Promising mutant lines of rice had been reported in Formosa and India. The new Luther winter barley had been released for commercial use following treatment with a chemical used for inducing mutations. Indian research had produced strains of wheat with branched ears and a fifty per cent increase in protein content. The same workers had succeeded, by using radiation, in synthesizing all species of wheat from one variety of bread wheat.



A heavy rainstorm at the Casaccia Nuclear Research Centre provided a remarkable demonstration of the effects of scientifically induced mutations. In this field of wheat the plants left standing were grown from mutant seeds chosen for ability to withstand bad weather. The others, all beaten down, were from the best commercial durum wheat varieties available.

Despite the remarkable results which were being achieved, however, it is true that induced mutations have been and still are being used haphazardly by plant breeders who use the "look for something" method. This is perhaps more true in developing countries where breeders using induced mutations are working in relative isolation and often lack facilities like libraries to keep up with new developments. It is thus one of the primary activities of the FAO and IAEA to render assistance and guidance and to bring about co-operation and co-ordination. Equally important is to guard against inappropriate and untimely use of the methods.

MULTIPLYING THE POSSIBILITIES

Spontaneously occuring mutations have been of great value to plant breeders and have been used in the development of superior varieties of cereals. vegetables, forage crops, fruit trees and ornamental plants. The limitation on making much greater use and selection of them is the extreme rarity of their occurrence. In a cereal field one may expect to find one plant out of every 10 000 to 100 000 containing a newly arisen mutation. Unfortunately only one of these out of a thousand or more turns out to be beneficial.

An extra crop each year becomes possible with the rice plant shown on the right. The seeds were irradiated at the National Institute of Radiation Breeding, Japan and tests are in an advanced stage. The plant reaches maturity up to 50 days earlier than the mother variety.

On the other hand when one applies ionizing radiations or chemical agents it is possible to increase the rate of mutation so that every plant in a treated population will contain at least one mutation. The rate can be increased from 10 000 to 100 000 times the rate of spontaneous mutations.

One of the important advantages is that induced mutations enable breeders to introduce specific improvements without affecting the existing good attributes of crop varieties, as demonstrated in examples already mentioned. In comparison a new rice variety known as IR-8 produced last year by the International Rice Research Institute, despite a dramatic increase in yield had also inherited a disadvantage in grain quality. Two participants in the FAO/IAEA rice programme in Asia have been asked to apply the induced mutation technique in an attempt to correct the defect. One of them, Dr. Swaminathan of India, has already reported success in correcting a similar defect in a related variety.

It is not surprising that the enormous potential usefulness of induced mutations for plant breeding has stirred the imaginations of geneticists from the turn of the century. Through better understanding of the mutation process this potential is now being realized.

CO-OPERATION IN MANY COUNTRIES

International co-operation in this subject was given an important stimulus when in 1964 the FAO and the IAEA formed a Joint Division of Atomic Energy in Agriculture. This Division is active in every aspect of agricultural research and training and has a Section on Plant Breeding and Genetics with the objectives of promotion and co-ordination of research leading to the development of more efficient methods of inducing and utilizing mutations; fostering co-operation between and rendering assistance to mutation workers engaged in breeding major food crops; and establishment of systematic international testing on induced mutant lines and varieties and standardization and mechanization of methods of recording and analyzing data in international trials and mutant collections. The Section has developed international programmes outlined below.

International Mutation Group. Scientists from 11 countries in Europe, America and Asia co-operate in a co-ordinated programme of research on the production and use of induced mutations in plant breeding. These scientists work with many crop species, mostly cereals. Nearly all of them operate on the basis of research agreements, receiving no financial aid from the Agency.

One of the tasks of the group is to study means of improving the efficiency of mutation induction to gain a degree of control over the process. The objective is to induce a maximum number of desired mutations with minimum physiological and genetical damage to the plant. Another task is to study the means of improving the utilization of desirable mutants. This includes methods of handling the treated material and subsequent generations, and the utilization of the selected mutants as new varieties or their use as parent material in cross-breeding programmes.

The group also serves as an informal advisory body on mutation breeding and genetics.

Manual on Mutation Breeding. A part of the responsibility of the group mentioned above and associates working with them is to contribute to the preparation of a Manual on Mutation Breeding which the Joint FAO/IAEA Division plans to publish this year. Preparatory work was begun in 1964 by Professor Åke Gustafsson who has compiled comprehensive reviews of the radio-biology and mutation breeding work in several major crop plants. Shortened versions will be included in the manual together with methodology and background information.

The need for such a manual is felt to be urgent, particularly for breeders who work in countries where library facilities are inadequate and opportunities to consult with colleagues are limited. It is hoped that the manual will help breeders in deciding when the use of induced mutations can be of the greatest benefit in their programmes, and spare them the effort of repeating preliminary surveys of general radiation effects before starting the practical applications.

Neutron Seed Irradiation Programme. This programme is being set up to standardize methods of exposing seeds to neutrons in reactors and measuring

and reporting dose. Under contract with the IAEA, the Austrian Atomic Energy Research Organization has developed a seed irradiation facility (lead and boron pot with a revolving specimen capsule) for use in pool-type reactors. Contracts have been concluded with India, Thailand, Philippines, Bulgaria, Brazil and Austria to install the facility and to carry out co-ordinated studies. The IAEA Laboratory at Seibersdorf is perfecting a technique of using barley seedling growth as an indicator of biological response for comparing different reactors.

Rice Mutation Breeding Programme. Since 1964, a co-ordinated programme of research on the use of induced mutations in rice breeding has been carried out for Southeast Asia. The participating scientists are located in Ceylon, India, Japan, East and West Pakistan, the Philippines, the Republic of China, and Thailand. Rice breeding projects in Brazil and Guyana are also associated with this programme. The individual projects receive support in the form of a research contract which includes the cost of travel to annual co-ordinating meetings. Two such meetings have been held, one in Bangkok in 1965 and another in Manila in 1966. The third is scheduled for Taipei in June 1967.

Two co-operative projects have been organized for the induction of resistance to blotch in wheat. One is being carried out in Kenya and the other in Argentina. It is hoped to establish in 1968 a co-ordinated programme of research on the use of induced mutations in protein-rich plants, particularly soybeans, groundnuts, beans, peas and other legumes.

Uniform International Trials of Wheat and Rice Mutants. Last year, uniform international trials of promising mutants of durum wheat developed at the Casaccia Nuclear Energy Centre in Italy, were established in the Near and Middle East. The trials were grown in Tunisia, Libya, Egypt, Lebanon, Syria, Iran, India, Turkey, Cyprus and Italy. Israel and Greece joined the programme this year.

In co-operation with the International Rice Research Institute, trials of *indica* rice and observation plot tests of *japonica* rice have been conducted in a number of Southeast Asian countries. Mutant lines included those developed in India, Japan, the Republic of China, Thailand and the United States.

Standardization of Procedures in Crop Research Data Recording. In co-operation with FAO and the International Biological Programme, work is being done towards standardization of crop research records and mechanization processing. Several study groups have discussed the development of standard record formats and procedures. The Joint FAO/IAEA Division's uniform international trials of rice and wheat already make use of computer-printed field books. FAO hopes eventually to establish world-wide germ plasm collection records.

Research by the Plant Breeding and Genetics Unit of the IAEA Laboratory at Seibersdorf. Various projects on mutagenic effects of gamma and neutron irradiation are being carried out relating to neutron dosimetry and the measurement of biological effectiveness of the various types of ionizing radiations in reactors. Studies are underway on chemical mutagens for comparison with ionizing radiations including the effects of combination treatment.

Seeds of rice, wheat, barley, beans and tomatoes have been submitted to mutagen treatments for various projects in Asia, Africa, South America and Europe. The co-operating laboratories provide Seibersdorf with all information and results deriving from these experiments.

The Section also provides training to scientitsts from Member States and assists in the organization of training courses on the use of mutations in plant breeding.

ATOMIC WAR ON INSECTS INTENSIFIED

Intensive research work in many countries using nuclear methods aimed at reducing the immense food losses caused by insects have led to a number of important trial operations this year. Some are now in progress in Capri, the famous Italian tourist island, and in Central America. Both are directed against the Mediterranean fruit fly, which attacks most fruit in tropical and sub-tropical countries. Similar methods are also developing to combat other insect pests.

THE ISLAND CAMPAIGN

From April until October Capri will be the site of the first full-scale trial application in Europe of the "sterile male" technique for the control of the Mediterranean fruit fly. Many millions of laboratory-reared flies will be released as an important test of their ability to compete and survive in a natural population. The experiment is being conducted by the Italian National Committee for Nuclear Energy (CNEN) and Ministry of Agriculture, under the technical guidance of the Agency and the United Nations Food and Agriculture Organization (FAO). The agencies have made arrangements for obtaining the flies from Israel. In that country a number of organizations and institutes have been taking part in the long programme of research and preparation.

Lest holiday-makers should be concerned, the flies also visiting the island make for fruit trees, not people, and although nuclear techniques are involved there can be no harmful effects to anything living. Even the fruit is not affected, since the sterile females do no damage. The large numbers of laboratory-reared flies are necessary to ensure that wild male flies are outnumbered so that the