plants, protein and radiation

Nuclear techniques are a closed book to a poor farmer struggling to feed his family and himself. Nevertheless, research workers in many countries are actively attempting to use such techniques to improve the basic plant stock the farmer uses — and have already achieved some notable successes.

The contribution of radiation techniques to plant breeding was described at a symposium organized by the International Atomic Energy Agency (IAEA) and the Food and Agriculture Organization of the UN (FAO) held in Pullman, Washington, USA, in July last year. At that symposium, reported in Volume 11 No. 5 of the Bulletin, 65 new plant varieties, some of which are contributing to the "Green Revolution" in agriculture, were named; and the article recorded that the number of varieties was increasing all the time.

In June this year the Hofburg Congress Centre in Vienna was the scene of another symposium, this one entitled "Plant Protein Resources: Their Improvement through the Application of Nuclear Techniques." The meeting attracted about 120 participants from 38 countries, who discussed the progress they have made in both plant breeding and agronomic research and considered the possibilities for future work — and the application of nuclear techniques to that work.

A research worker studies the growth of barley in a field at the Seibersdorf laboratory of the IAEA. Photo: IAEA/Voitl

A highlight of the symposium was the announcement, at the closing session, of the fact that the Federal Republic of Germany intends to contribute aid worth more than three quarters of a million dollars to support a joint FAO/IAEA research programme aimed at increasing the protein content of important food crops by the use of nuclear techniques. This programme, in which scientists from many countries take part, is already helping to alleviate protein malnutrition, which is suffered at present by millions of people — especially in developing countries.

The Causes of Malnutrition

The long title given to the symposium was necessary in order to focus attention on an important aspect of this much wider problem. Since crop plants, especially cereal grains, are the basic food for most people who live in the less developed countries, they are necessarily the main

source of protein as well. But such plant sources are generally low in their content of protein and of essential amino acids — and are thus generally inadequate to meet the nutritional needs of the population.

One speaker at the symposium, Mr. W.M. Tahir, of the Plant Production and Protection Division of the FAO, pointed out that although technical innovation and improvement of production technology and resources could permit a steady increase in food production in the developing regions, "the real breakthrough would be possible only if the growth in population is kept well below the increase in food production." This, however, is a solution which may never be attained. Increasing the quantity and nutritional quality of the protein produced from crop plants is thus potentially the most promising way in which to combat protein malnutrition.

Are the research workers tilting at windmills? Or is there a real problem — and a real possibility for its solution? Evidently, the problem is all too real. A paper selected at random from those presented at the symposium begins in this way:

"Daily intake of protein in East Pakistan is only 57.5 grams per individual, minimal requirement being 63.5 grams; and of the 57.5 grams daily intake, only 13 per cent comes from animal sources. The rest comes from cereal grains, mainly from rice, since rice constitutes the main diet of our people. Rice varieties grown in East Pakistan, like other countries, are, in general, poor in protein both in quality and quantity. Search for new varieties of rice with higher content of protein has, therefore, become a dire necessity."

This is a statement which may be used to describe the situation not only in East Pakistan and for rice, but generally throughout many parts of the world. An FAO study showed that in 1968 the "developed" and "developing" regions produced 78.0 and 76.1 million tons of plant protein respectively, to be divided between 932.6 and 2638.6 million people. Per capita annual production of protein was thus 83.6 kilograms in the developed world, but only 28.8 kg in the developing world. The Far East and Mainland China together produced 33.7 per cent of the total world protein derived from plant sources, to be shared by almost 54 per cent of the world population. The Far East, with a population of 1 106 million people, produced the least protein per person in 1968 — only 24 kg. In this part of the world land resources are limited, so high-yielding varieties and varieties of plants with improved protein content are essential if the population is to be adequately fed. The dry statistics have a real meaning.

Achieving higher protein content

The techniques which may be used in this work are well known, and have been often described. Seed stock is irradiated to induce genetic mutations some of which may be useful — for example, those which confer increased protein content or improved balance between constituent amino acids. In addition, radioisotopic methods may be used to ease the task of screening the thousands of progeny from the irradiated stock for the desired characteristics of higher protein and/or better protein quality. Isotope techniques are also of great value in related studies

of plant nutrition and physiology, in which they are often the only means to obtain the desired results.

Papers presented at the symposium in Vienna reported some encouraging results. In Japan, for example, workers at the National Institute of Radiation Breeding, partially supported by the IAEA, found that the protein content of 545 mutants derived from a single rice variety ranged from 4.2 to 16.3 per cent. Since the original variety had 6.5 per cent the increased protein content of some of the mutants was remarkable. At the Institute of Cytology and Genetics in Novosibirsk workers obtained mutants of the Torsdag pea variety with a higher content of protein than the original variety: the original contained 21.8 per cent protein, while two mutants contained 25.1 per cent and 24.8 per cent, significant gains. Other research done in Sweden, in the Federal Republic of Germany, in India, in the Republic of China — all showed that higher protein content can indeed be achieved through induction of mutations.

Balancing the ingredients

The question is not simply whether total protein can be increased. It is important, as well, to ensure that the constituent proteins are present in the correct proportions to ensure maximum nutritional value. This fact was stressed in a paper presented by Mr. M. Cresta, of the Nutrition Division of the FAO, who pointed out that "in the case of rice, efforts should be directed towards increasing the total protein content without altering the essential amino acid balance as found in the conventional varieties. As regards wheat, maize, millet and sorghum, the chief aim should be to improve the balance of certain essential amino acids in the product through an increase in the content of lysine, the limiting amino acid in these cereals, or of tryptophan in the case of maize."

Such results can be achieved. But in all this work one is forced to return to one central problem. Mr. R. A. Luse, of the joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, put it in this way in a paper presented at the Symposium:

"Techniques by which large numbers of plant lines — particularly mutant lines — may be analysed for their protein content and nutritional quality are sorely needed .... For cereals and legumes, screening must involve the determination of total protein content and of the content of those essential amino acids which are present in such low levels as to limit the nutritional value."

A primary concern in this work to develop new screening techniques — for methods do already exist — is to determine their feasibility: "By this is meant answering not only the question 'is the analytical result accurate and sufficiently precise?' but also the questions 'is the method adaptable to large numbers of samples?' and 'does it result in the lowest cost per analysis?'"

Mr. Luse went on to describe some techniques which may offer promise, including double isotopic labelling of seed samples and subsequent analysis by thin layer chromatography; the radioisotopic assay of carbon dioxide from the action of decarboxylase on specific amino acids; the

determination of total nitrogen in seeds by fast neutron activation; and the use of a Carbon-14 labelled energy source to assist in the determination of specific amino acids by microbiological action. Such methods, he said, "represent techniques which are readily applicable to the problem of screening for protein." Others may also prove useable when taken beyond their present early stages of development.

It is important, too, to remember a point made in a recent FAO/IAEA publication, "Nuclear Techniques for Increased Food Production" (Basic Study No.22) — that "agricultural research, whether it uses nuclear techniques or not, is only an academic exercise unless the results are communicated to the farmer who can benefit from them. A mutual responsibility falls on research workers, administrators, advisory services and farmers themselves to ensure that knowledge does not go to waste... The results of this research, if properly utilized, can be of invaluable help in solving many of [the developing countries'] critical problems in food production."

Workers at the Tarapur power station engaged in connecting instrumentation for "in core" power range monitoring. Photo: Nuclear India