RADIOISOTOPES AND RICE

Considering that the vast majority of the population in the underdeveloped areas of the world live on rice, amazingly little is known about the physiology of the rice plant and its nutritional requirements. Traditional methods of rice cultivation, obviously adapted to local conditions, show a baffling variety and there are wide differences in yield and quality. While some of the differences may be ascribed to unalterable environmental variations, it is not unreasonable to expect that many cases of poor yield and quality can be remedied by the adoption of cultivation techniques which are more suited to the physiological characteristics and needs of the plant.

Radioisotopes can be effectively used in investigating some of these traits. Used as tracers, they can help to reveal the plant's behavior in relation to soil, fertilizer, and other environmental factors. Simpler methods of investigation may in fact be more elaborate and take much more time. In any case, not all processes can be studied by conventional methods. This will be clear if one refers to some of the peculiarities of rice cultivation which can at present be investigated only by isotope techniques.

For the most part, these peculiarities arise from the fact that in many parts of the world rice is grown on marshy or flooded land, sometimes on land under several meters of water. This creates a variety of unusual conditions which rice is peculiarly adapted to withstand. For example, nearly all plants need oxygen in the soil in their root zone, but rice seems to manage - in a way that is not yet fully understood - to do without it. Again, flooding induces chemical changes in the soil some of which are known to be unsuitable for plant growth but do not seem to affect the rice plant.

Oxygen Intake

The role of radioisotopes in studying such problems can be illustrated by some of the research already done in connection with possible means of oxygen intake by the roots of the rice plant. Generally speaking, plant leaves absorb carbon dioxide from the atmosphere in the presence of sunlight but at night take oxygen instead, as humans do. So far as the roots are concerned, there is a continuous intake of oxygen from the soil. If, however, the soil pores are blocked by flooding, oxygen from the atmosphere cannot get into the soil and the roots are starved of their oxygen supply. The question is: how does the rice plant cope with the situation? It may be that the metabolism of the rice plant - the chemical processes within the organism - is different from that of other plants. Radioisotopes offer a most effective tool for a study of the metabolic mechanism, and in the case of rice an investigation has been made with the help of radioactive carbon (C-14). Although not yet conclusive, some interesting results have already been obtained from these studies, suggesting that rice has a mechanism whereby hydrogen peroxide is excreted from its roots; this hydrogen peroxide releases oxygen, thereby maintaining the oxygen supply in the neighbourhood of the roots. Further studies may lead to a full understanding of the processes involved.

To stimulate research into problems of this kind, the International Atomic Energy Agency has placed several research contracts with agricultural institutes in some of its Member States. Some of these research projects deal with problems of soil-plant relations and fertilization, and rice is one of the main crops on which studies are being made. A panel of experts convened by the Agency met in Vienna in May this year to discuss some of the outstanding problems in the uses of radioisotopes in soil-plant relations and fertilization studies, and problems concerning rice were among the principal subjects considered. In a paper presented at the panel meeting, Professor S. Mitsui, of the University of Tokyo, reviewed some of the main uses of radioisotopes in studying problems of rice soils and rice cultivation and suggested several specific topics in this field which could be investigated by isotope techniques.

Fertilization Studies

A few research projects dealing specifically with rice are already being carried out under contracts awarded by the Agency. One of these, being conducted in the Agronomy Department of the College of

This picture of rice plants on a submerged plot of land in Indonesia illustrates one peculiarity of rice cultivation discussed in this article

Radioisotope research on the nutrition of rice, particularly its phosphorous uptake, is being carried out at the Agricultural Research Institute, Gyogon, Burma, under an IAEA technical assistance project. Members of an IAEA mission (third, fourth and fifth from right), which visited Burma last July, are seen here with the Director of the Institute (second from left) and the Agency's technical assistance expert (fourth from left)

Agriculture, National Taiwan University, is related to attempts to reclaim large areas of tidal land in Taiwan for agricultural purposes. So far as rice cultivation is concerned, there has been some success in these attempts, but it has been found that the high salt content of the soils retards root growth and results in inefficient use of fertilizer and low yields. In an attempt to improve fertilizer utilization, the feasibility of foliar application of fertilizer (that is, spraying the fertilizer on the leaves of the plant) is being examined under a research contract awarded by IAEA. Using rice as a test crop, studies are being made on the absorption, translocation and distribution of phosphate fertilizers labeled with radioactive phosphorus (P-32) and urea labeled with radioactive carbon (C-14) sprayed on the leaves of the plant.

If promising results are obtained from this work, it is proposed to undertake further research to study the wide-scale use of foliar fertilization. The project is obviously of considerable practical importance in connection with the development of marginal agricultural land. It has been the general experience of agricultural research workers in many parts of the world that foliar application of fertilizer can be much more effective than soil applications in sites where soil conditions such as low temperature or excessive alkalinity lead to ineffective use of fertilizer, but hitherto there have been no studies with rice on the possibility of overcoming the deleterious effects of soil salinity through the application of fertilizer to plant leaves.

Under another research project now in progress at the Institute of Plant Nutrition and Fertilizer, University of Tokyo, radioactive silicon (Si-31) is being used in studies to determine the value of silicon as a nutrient for rice. There has lately been increasing interest in the rice growing countries in the use of silicated slag as an additional fertilizer for the rice plant. It is believed that silicon helps to stiffen the straw of the rice plant. This is especially important in view of the fact that nitrogen tends to reduce the rigidity of the straw, making it flaccid and causing the rice plant to fall flat before the grain is ripe. This effect of nitrogen imposes a limit on the amount of this fertilizer that can be applied to rice. The difficulty can perhaps be overcome by the simultaneous application of silicon, because its stiffening effect on the straw would permit the application of larger amounts of nitrogenous fertilizer, leading to an increase in crop yields without the usual difficulties created by a weak straw.

As part of this research project, the Institute in Tokyo is also carrying out investigations into certain other aspects of fertilizer evaluation by means of isotope techniques. One of these concerns phosphorous absorption by crop plants from various compound fertilizers, particularly those in pellet form. It has been found that while in the case of rice the pellet form increases the absorption of phosphorus, it decreases the absorption in the case of wheat. Since this finding may have an important bearing on the application of pellet form fertilizer, the processes are being re-examined in order to obtain more conclusive evidence.

Uptake of Radioactive Wastes

Also at the same Institute, another important research project has recently been concluded under a contract placed by IAEA. This related to the uptake of radioactive wastes by lowland rice. Since the greater part of the world's rice is grown on flooded land and since nuclear reactors may be built in inland areas in some of the rice growing territories, it is important to find out to what extent radioactive wastes

Part of work done at the Agricultural Research Institute in Burma under the Agency's technical assistance project

that may be deposited in the flood water are taken up by the rice crop. And it is necessary to study both the absorption of radioisotopes by the soil and their uptake from the soil by the plant; both may reveal unique features because of the peculiar conditions under which rice is grown.

Preliminary experiments with radioactive strontium (Sr-90) and radioactive cesium (Cs-137) had shown that swamp rice tended to concentrate those elements more than upland rice. It was also believed that particular salts in the fertilizer applied - and rice cultivation uses heavy amounts of fertilizer - might affect the movement of radioactive substances in the soil and their uptake by plants.

One of the most important findings from the investigations carried out at the Institute in Tokyo related to the effect of ammonium on the uptake of radioactive cesium by the rice plant. An ammonium salt is the most common form of nitrogenous fertilizer for rice. Through a process, called nitrification, which is brought about by the action of bacteria, the nitrogen in the ammonium compound combines with oxygen to form nitrate, and it is in this form that nitrogen is usually absorbed by plants. In the absence of oxygen in submerged soil, the rice plant, however, takes up nitrogen directly in the ammonium form.

The research in Tokyo showed that the presence of ammonium in the soil increases the uptake by rice of cesium-137, one of the most important radioisotopes produced by nuclear fission. (The uptake of radioactive strontium, however, does not seem to be affected.) Since some of the radioactive material absorbed by the plant would be transmitted to man through the food chain, it is highly desirable to devise a method to reduce this uptake of radiocesium. Should the uptake of radiocesium prove in certain areas to be an important problem, nitrogen could be applied in rice cultivation in the form of nitrate, rather than in the form of ammonium, because radiocesium uptake is not increased by the presence of nitrate in the soil.

Here, again, the peculiar conditions of rice cultivation present a difficulty. In the absence of oxygen in the submerged soil, the oxygen in the nitrate is combined by the action of bacteria with various substances and what is left is nitrogen gas, which escapes into the atmosphere. This is known as denitrification. A suggested solution to the problem is to apply nitrate as a topdressing, i. e. to put it on the oxygen-rich surface layer when the crop has started growing, instead of ploughing it in before cultivation, so that the nitrogen can be absorbed by the plant before denitrification starts.

Genetic Changes

Attention has also been given in the IAEA research contract program to the possibility of breeding better varieties of rice through genetic changes induced by radiation. Quite a few research projects deal with plant mutation problems, and rice is one of the major crops with which experiments are being made. Some success has already been achieved in producing desirable plant characteristics in newly bred varieties. This, however, is a field in which it would be unrealistic to expect very quick results. The present state of advance in radiation induced mutations that may lead to crop improvement was reviewed a year ago at a scientific symposium organized jointly by IAEA and FAO at Karlsruhe, Germany.
