plants and soils

Plant crop production may be increased and made more efficient by good fertilizer and soil management practices, including irrigation. Progress in acquiring an understanding of the relationships between soils and plants through the use of isotope and radiation techniques was reviewed at a symposium organized jointly by the Food and Agriculture Organization of the United Nations and the IAEA, held recently at Agency headquarters in Vienna.

At the opening meeting of the symposium Dr. O.B. Fischnich, Assistant Director General, of the Agriculture Department of the FAO, reminded participants that the current rate of growth of the population of the world was 2 per cent, and that it was estimated that the world population would reach 7000 million by the turn of the century. In the long term, he suggested, the solution to the problem of ensuring adequate food supplies must lie in effective control of the population growth rate, "but increasing agricultural production can do a great deal to alleviate the situation, as has already been shown."

Between 1954 and 1967 world food production had increased by 46 per cent, he said — about 2.9 per cent a year. But the population of the world was rising at the same time; the increase in food production per capita was only 30 per cent, or about 1 per cent a year. Both the developing and the developed countries achieved practically the same increase in total food crop production, but due to disparities in population growth rates the per capita increase in food production was 25 per cent (1.7 per cent a year) in the developed regions, and only 6 per cent (0.4 per cent a year) in the developing countries.

Nonetheless, the increases in food production which had been achieved were "dramatic". They had been brought about largely by the evolution and cultivation of new, high-yielding cereal varieties, particularly of wheat and rice, in the developing countries of Asia and Latin America, combined with modern fertilizer, irrigation and other agricultural practices. In Mexico, where the 'Green Revolution' might be said to have begun, use of a mutant strain of wheat had enabled wheat yield to rise from 530 kilograms per hectare in 1950 to 2530 kg per hectare in 1970. In India wheat production was only a little over 12 million tons in 1964-65, rising to 23 million tons in 1970-71.

"Although the Green Revolution has been so far limited to a few cereals and a few countries, the potential for the future is indeed very great," said Dr. Fischnich. "But it must be borne in mind that the successful cultivation of high-yielding crops depends very much on effective fertilization and other agricultural practices, and a proper understanding of the processes by which plants utilize nutrients and water, and the processes by which these are made available to the plants through the soil, is essential for increasing agricultural production." The value of applying isotope and radiation techniques to research in this field was well recognised, as was amply demonstrated by the number of papers presented — 55. (They will be published by the IAEA as Proceedings in a few months. In all, the symposium was attended by 116 scientists and research workers, from 34 countries and six international organizations.)

Dr. Fischnich expressed his particular pleasure that three sessions of the symposium were devoted to applications of isotopes and radiation techniques in forestry studies, "a field which in spite of its importance has received inadequate attention in the past." With the increasing acreage of man-made forest being cultivated today the need for more information on forest soils and problems related to the nutrition and fertilization of forests was becoming more apparent.

The background

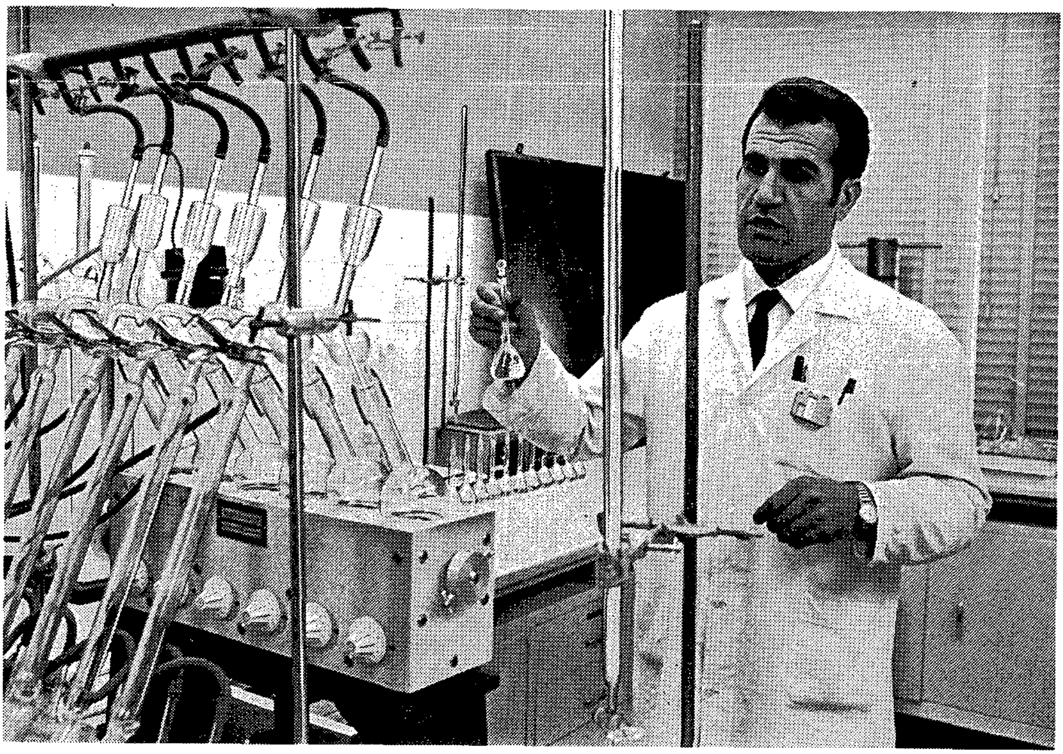
The last previous symposium to deal with the subjects covered here was held in 1966, since when there has been considerable progress. Attention was focussed at this latest meeting on research into soil physical and chemical factors affecting plant growth, the uptake and translocation of nutrients by plants, fertilizer usage and other soil management practices.

^{32}P and ^{15}N labelled fertilizers have been used extensively in coordinated research programmes of the FAO/IAEA Joint Division of Atomic Energy in Food and Agriculture relating to rice, maize and wheat. The technique used in their studies of the effects of variation in the time of application, the placement and the nature of the fertilizer consists in principle in applying the labelled fertilizer to the crop, and determing the percentage element in the crop that was derived from the fertilizer. Since annual crops such as these can be properly sampled an estimate of the total amount of fertilizer in the crop can be made.

But there are several reasons why this technique cannot be used for studies relating to tree crops. First, the quantities of labelled fertilizer required are generally much larger than for annual crops, so high costs would be involved. Secondly, it is not practicable to analyse a whole tree, and therefore the percentage element in the tree derived from fertilizer cannot be determined. Quantitative conclusions in the evaluation of fertilizer treatments are thus difficult to achieve.

Mapping acticity

In order to overcome these difficulties the Joint Division, together with the IAEA Laboratory at Seibersdorf, near Vienna, developed a technique for the mapping of root



"... a proper understanding of the processes by which plants utilize nutrients and water, and the processes by which these are made available to the plants through the soil, is essential for increasing agricultural production." Here, a scientist working in the Agricultural Laboratory of the Teheran University Nuclear Centre, Iran, checks the efficiency of fertilizer use by wheat plants, using a radioisotope tracer technique. Photo: United Nations/Muldoon

activity around trees. This technqiue consists in principle in the injection of labelled phosphate solutions into the soil in rings at appropriate depths and distances around the tree bole. The evaluation of treatments is made by comparing activity (measured in cpm ^{32}P per gram of dry matter) in successive samplings taken from a well-defined morphological position.

In experiments conducted under a co-ordinated research programme in which oil palm, cocoa, coffee, citrus, coconut and deciduous fruit trees were studied, the ^{32}P injections were made by crushing sealed glass ampoules containing about 300 μCi ^{32}P in 4 ml 1000 ppm phosphorus solution at 16 equidistant points around the tree, at the required distances and depths. The handling and dispensing of such ^{32}P in ampoules facilitated greatly field operations, and minimised radiation hazards and contamination risks.

Results achieved were described in a paper presented at the recent symposium by H. Broeshart (IAEA Division of Research and Laboratories) and D. Nethsinghe (Joint Division of Atomic Energy in Food and Agriculture), who noted that "this technique was adequate to indicate where the most active part of the root system was located, and from this the appropriate placement of fertilizers was inferred.

"It became clear, however, that only qualitative evaluation of treatments was possible, not only because of the difficulty of obtaining a representative leaf sample from a tree but also because the variability of ^{32}P activity within trees and between trees was very high and standard deviations of 100 per cent and more were frequently found..."

Investigations were therefore carried out at Seibersdorf with the object of developing methods that would permit a quantitative evaluation of treatments and at the same time reduce the high sampling and counting errors. In order to find out whether the high

variability was peculiar to ^{32}P a comparison was made between ^{32}P and ^{15}N injections in an experiment with apple trees. A second experiment was carried out with birch and ash trees, using ^{32}P and ^{33}P labelled solution for injection. It was reasoned that a double labelling technique using ^{32}P and ^{33}P, in which ^{33}P was always applied in a standard position with respect to the tree and ^{32}P at a location corresponding with the treatment being tested, would have the advantage that any effects specific to that treatment – such as those deriving from the depth or distance of the point of application – could be expressed in terms of a ratio to the standard treatment. In this way, tree-to-tree variability might be eliminated.

Details of the experiments are recorded in the paper. Broeshart and Nethsinghe conclude that "it is irrelevant whether root activity patterns are studied with ^{32}P or ^{15}N, since the outcome is qualitatively the same. On the other hand, the variability of the nitrogen data was considerably less than that of the ^{32}P counts, indicating that there may be some particular reason for the high variability of the latter."

But, since the high cost of ^{15}N was prohibitive for extensive injection experiments with trees, the other approach, whereby the activity of ^{32}P counts in leaf samples was expressed in terms of a ratio to the standard injection with ^{33}P made at one particular location near the same tree, proved "much more satisfactory. Not only is the variation of $^{32}P/^{33}P$ ratios much less than than that of ^{32}P activity, but also the double labelling method is quantitative and reflects the rate of injection. From an experimental point of view the $^{32}P/^{33}P$ ratio method has the advantage that it is irrelevant where the leaf sample is taken from. Any leaf sample from a tree receiving both ^{32}P and ^{33}P injections will have the same ratio as long as no specific pathways exist from certain parts of the roots to certain parts of the branches and/or leaves: the $^{32}P/^{33}P$ ratio method could, however, be used to study specific pathways in trees."

In practice, say the authors, it is now possible to study more practical methods of application of fertilizer. Further, in principle the double labelling method could be extended to include comparisons of different kinds of phosphate fertilizers. One kind would be the standard, labelled with ^{33}P and placed in one particular location. The fertilizer to be tested could be labelled with ^{32}P and the uptake expressed as the ratio to the standard.

The overwhelming advantage of this sort of technique is that results are obtained quickly. "Conventional" lines of research into the efficiency of fertilizer use on tree crops – evaluating yield after harvest for each of a variety of techniques of application – can take as long as ten years for a single series of experiments, and the results may not be conclusive even then. Work of the sort described here not only saves time; it permits more data to be gathered, data which may help both to increase production and to lower overall production costs.