Non-power uses of nuclear technology

Helping the developing countries effectively

by H. Seligman*

One of the important statutory tasks of most United Nations organizations is to help the developing countries. The method of achieving this is very well established by the UN. It consists of giving advice, granting fellowships, arranging training courses, donating equipment and granting financial help. The IAEA also operates research contracts and agreements, and plans co-ordinated research on specific subjects.

If important new techniques are to be effectively introduced into developing countries, all the above aspects have to be carefully balanced. In addition, owing to the availability of its many scientists and its own laboratory, the IAEA can combine all the different possibilities of assistance in a unique way, and a number of projects have been executed by using all these components. This article will show that the way of giving help varies considerably in each case, demonstrating the great flexibility of the Agency, and that the resulting benefit to the country receiving help (in cases where a price-tag can be attached) can be extremely high.

In several cases, such technical assistance projects necessitate the transfer of a novel technology. Even if this is not the case, some, usually considerable, preliminary development work must be done in order to adjust to the conditions in the country concerned. Often the meteorological conditions, agricultural environment, and ecology are entirely different from those areas where such projects have been tried before.

This article will concentrate on only a few projects — some completed, others still active. The following points will be shown:

• The different origins of a project: country's request; visit by a scientist; discussions at a conference or smaller meeting; etc.
• The different methods of financing of a project: Technical Assistance budget; United Nations Development Programme (UNDP); Government funds; private funds.
• The ways used to help the project: expert visits; training; equipment; research contract or agreement; laboratory work, including fast problem-solving research.

The Joint FAO/IAEA Division of Isotope and Radiation Applications of Atomic Energy for Food and Agricultural Development has a long history of many achievements. The benefit of many of their projects is considerable against a relatively small cost.

Disease-resistant pearl millet mutant

Pearl millet is a staple food in many parts of the world. In one country, India, it became disease-ridden. The yield decreased very fast and it looked as if, under these conditions, it could not be planted any more. Scientists from India approached the IAEA, and joined an Agency co-ordinated research programme in 1970 with the aim of breeding a disease-resistant mutant which, at the same time, kept or even enhanced all the other desirable properties. During the programme, seeds of the mother of the hybrid variety were irradiated and a desired disease-resistant mutant was eventually produced. This mutant was used to re-establish a resistant and high-yielding hybrid variety. The Agency supported this programme for seven years to a total amount of $32 000. India spent $120 000 during that time. The disease-resistant form increased the yield immediately by 3000 tons, resulting in a US $3 to 4 million per year gain: a cost-benefit ratio, over seven years, of at least 1 to 10 000.

More recently, an even better hybrid has been produced. The close contact between the Agency and India's scientists, the research contracts, the many meetings, discussions, and visits were essential to the success of the project.

Biological control of the tsetse fly

The Agency has long experience in developing all the essential components for pest eradication by applying the sterile insect technique. This was first developed for the Mediterranean Fruit Fly, and later applied to other pests including a hazard for human and animal life in Africa, the tsetse fly.

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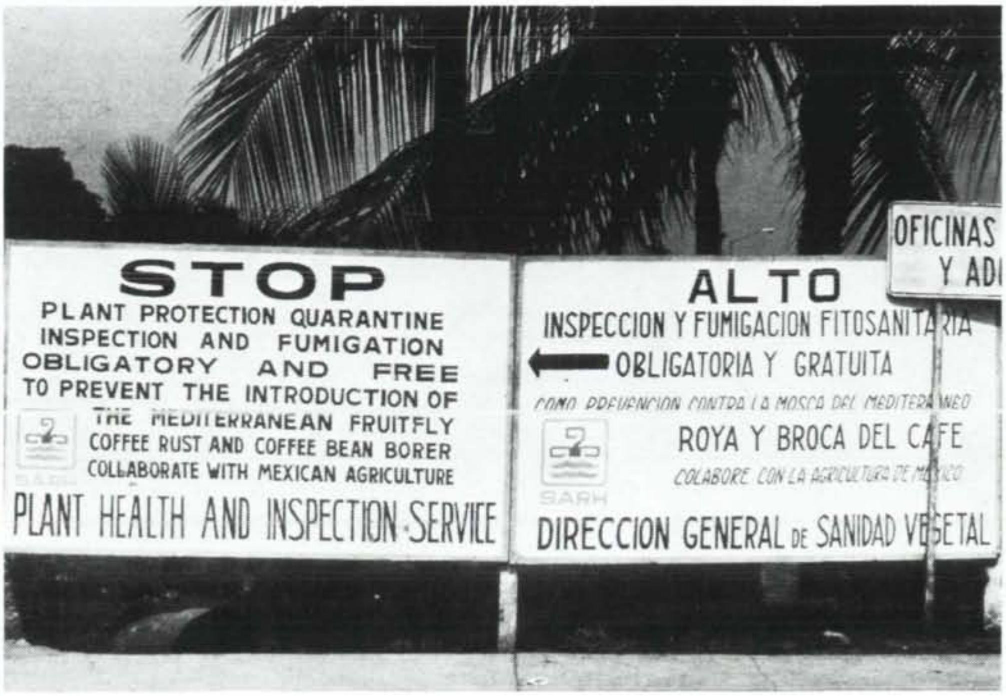


The loss in fruit crop and the cost of conventional control of the Medfly in Mexico amounted to US $1 billion a year – equal to about eight times the IAEA's total annual budget. By use of the Sterile Insect Technique as the central component of an integrated pest-management programme, Mexico succeded in eradicating the Medfly in 30 months.

Nigeria has tried to control the tsetse fly for many years by well-established techniques like spraying insecticides (DDT, Dieldrin, Endosulfan). These were only partially successful and had many undesirable environmental effects. After discussions with the IAEA, Nigeria therefore decided to introduce the sterile insect technique and, as a first step, to treat an area of 1000 square kilometres by the end of 1984. In the past, this technique had been shown to be effective against several types of insect, as demonstrated in small projects in Zimbabwe in 1968–69, in Tanzania, and in Upper Volta. The Nigerian Federal Government and the Agency agreed to try to eradicate the tsetse from a semi-savannah area of north-central Nigeria, using the sterile insect technique together with conventional methods. First, ecological tests were necessary to gain important information. After these trials were successfully completed, appropriate procedures were developed to start regular anti-tsetse operations in Nigeria and possibly later in other affected areas in Africa.

After general discussions and meetings, an agreement was signed and in early 1979, the area was selected and the environmental monitoring system installed. Later that year, the rearing facilities were completed. By January 1982, the feed-bait was in operation and two months later, the release of the sterile insects had started. The total staff of this project numbers fifty people.

The Agency's involvement consisted not only of the long-term research, which had started years earlier, but also of helping to adjust the technology for the rearing, sterilization, and release of 10 000 to 12 000 sterile male flies per week, coming from a colony of roughly 100 000 female flies. The colony was made possible by the introduction of a new artificial feeding method developed at the Agency's own Laboratory at Seibersdorf, near Vienna. In addition, staff had to be trained, and equipment, including an irradiation source, supplied (many parts of the equipment were developed at the Agency's own laboratory). The Agency eventually helped to set up the whole organizational system. The amount of work involved can be seen from the fact that roughly three professional staff members from the Agency have worked for years on this project.

The funding of this project is interesting. The cost, roughly US $750 000 per year, has been covered by voluntary contributions from some developed countries like Belgium, Federal Republic of Germany, Italy, Sweden, and the United Kingdom. The resulting benefit should be of interest, not only to Nigeria, but to the whole African continent.

A cost-benefit ratio has not yet been accurately evaluated, but practically no development can take place in this area as long as it is infested with the tsetse fly. The area will be available for agriculture once the pest is removed.

Mediterranean fruit fly in Mexico

A similar project to the tsetse programme is the eradication of the Mediterranean Fruit Fly (Medfly) from Mexico. The loss in fruit crop and the cost of conventional control (which was not successful) amounted to US $1 billion per year. This sum equals eight years of the Agency's total present budget. The Mexican Government asked the Joint Division for help in using the sterile insect technique to free Mexico from the Medfly. Practically all the necessary elements for such an operation had been developed at the Agency's Seibersdorf Laboratory over many years: the rearing of the insects; their handling; the best way of sterilization; and convenient release techniques. The technology had to be transferred, and the operators had to be trained in all these activities; and equipment to the value of US $200 000 had to be supplied. In fact, for the first tests, some of the flies were reared and shipped from the Seibersdorf Laboratory to Mexico. In the case of the Mediterranean Fruit Fly, it is necessary to produce 500 million flies per week, and the newly created Mexican organization achieved this in a very short time. Incredible as it may sound, the Mediterranean Fruit Fly was eradicated from Mexico within 30 months. The facility, which has been built by the Mexican Government, will also be used to free neighbouring Guatemala of the Medfly.

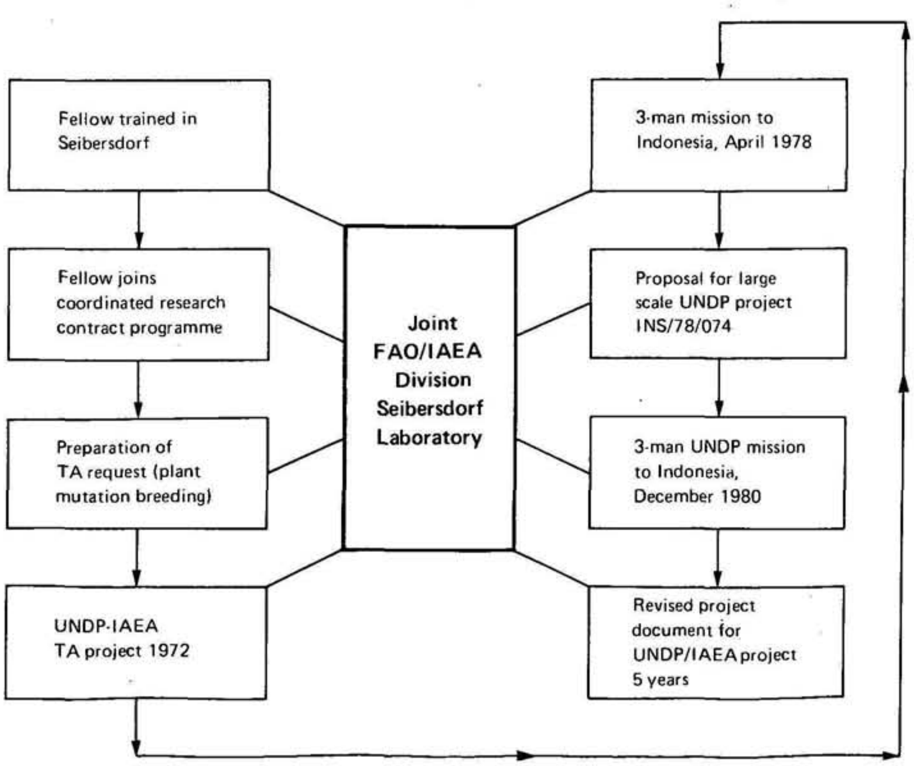
Medical dosimetry

In the course of visits to many developing countries over a number of years, Agency scientists noticed that the doses given to hospital patients being treated with radiation were not quite correct because there was a lack of available standards. After many private discussions in 1967, an Expert Meeting was held in 1968 and the dosimetry requirements for radiotherapy centres were established in order that cancer patients should receive the right amount of ionizing radiation.

This project is an excellent example of the intimate and fruitful collaboration between the Agency and the World Health Organization (WHO). These two organizations decided to establish regional centres for dosimetry standards. WHO designated a number of laboratories in developing countries as regional reference centres for secondary standard radiation dosimetry. The purpose of these laboratories was to bridge the gap between primary measurement systems and the users of ionizing radiation, the hospitals. In 1976, a Joint IAEA/WHO Secretariat for this network was established. The initial years of work were so successful that now 40 member laboratories in 30 developing countries, supported by 12 national primary standard laboratories and five collaborating international organizations, take part in this project. The Seibersdorf Laboratory is the centre of the network and is used for intercomparisons, training, and advice. The doses now measured show a vast improvement in the limits of error, and by means of this standardized control many hundreds of patients in many countries have benefited from the establishment of these secondary standard laboratories.

Agricultural project in Indonesia

This project to improve plant breeding, plant nutrition, soil science and pest control is an excellent example of how, through the different Agency facilities like the Seibersdorf Laboratory, the research contract programmes, and normal technical assistance outlets, what started out as the training of one Fellow turned into a US $4.5 million UNDP project.



How the training of one Fellow at Seibersdorf developed into a multi-million dollar technical assistance project.

Originally, a Fellow from Indonesia attended a Seibersdorf training course on radiation-induced plant breeding. On his return to Indonesia, he thought that this method could be of great benefit to his own country. After the normal administrative difficulties had been overcome, and with the Agency's advice in all phases of this programme (as can be seen from the diagram), this eventually developed into a general agricultural programme for making use of isotopes and radiation in agriculture in Indonesia. A total sum of some US $4.5 million is earmarked for the five-year programme; roughly one-third of the total will be paid by the UN Development Programme. This project envisages extensive plant-breeding activities in rice, wet-land varieties, soybean, mungbean, wheat, and sorghum. In soil-plant nutrition, the programme covers mainly the technology for nitrogen fertilizer application, and the study of ecological conditions. A pest control service will be set up using, if possible, the sterile insect technology. The whole programme needs 18 scientists and 32 technicians.

Regional co-operative agreement for Asia and the Pacific

Another example of the Agency's versatility in executing research and development programmes for the benefit of developing countries is shown in the RCA*. It started in 1964 as a small programme between two countries and the Agency, and consisted of training and research in solid-state physics. Eventually, this programme developed into the present, much wider, one in which 12 countries are participating and which covers many fields of nuclear technology. The financing of this project is somewhat unusual, support coming from UNDP and from several donor countries, not all of them developed nations. The total amount spent last year was US $3.5 million, of which the UNDP paid US $3 million. The Agency's research programme is closely integrated with practically all the activities. Nine projects are at present very active. These are the following:

Use of radiation-induced mutations for the improvement of grain and legume production;
Food irradiation;
Use of nuclear techniques in improving buffalo production;
Radiation sterilization of medical supplies;
Health-related environmental research;
Maintenance of nuclear instruments;
Isotope applications in hydrology and sedimentology;
Semi-dwarf mutants for rice improvement; and
Industrial applications of isotopes and radiation technology.

Some of the projects have been running now for five years and the preliminary investigations have been concluded. Among the many projects, only three particularly interesting ones, which are nearing commercialization, will be mentioned here. They are food preservation, sterilization of medical products, and vulcanization of natural latex rubber.

Food preservation by irradiation could benefit the region not only by reducing losses of food but also by expanding the trade of surplus food during the peak season. Among the foods which have been investigated for suitability of irradiation treatment are mangoes, spices, onions, and dried fish. The use of chemicals to fumigate mangoes may be phased out due to concern about the health effects of the chemical residues: irradiation and mild heat treatment can eliminate fruit-fly larvae and extend the shelf-life of the fruit. The dose required to destroy insects in dried fish has been established in preliminary investigations, and laboratory work has been concluded on spices and on sprout-inhibition in onions. These projects will be extended to semi-commercial scale in the region.

Preliminary laboratory experiments have paved the way for the introduction into the region of radiation sterilization of medical products.

As a result of investigations under the RCA, a 1000 ton/year pilot plant for the vulcanization of natural latex rubber by radiation will be built in the region.

Buffalo project

One project under the Regional Co-operative Agreement which may have a very favourable cost-benefit ratio is the buffalo project. The water buffalo is a valuable animal: it provides milk, meat, power, and transport. As a working animal drawing a plough, the buffalo can be a major agricultural aid, opening up arable land.

In many parts of Asia the production of buffalo has declined to dangerously low levels. To remedy this situation and to lay the foundations for an increase in animal production, the Agency in 1976 sponsored a co-ordinated research programme on the use of radio-immunoassay and isotope techniques to study the physiology of the water buffalo. The nutritional and water needs of the buffaloes, as well as some diseases, have been studied with the use of radio-isotopes. Attempts have been made, by administering hormones, to reduce the intervals between calving. Modern radio-immunoassay methods have been used to monitor how the reproductive status of the water buffalo varies with changes in diet, weather, and other local conditions.

By applying the knowledge gained through these studies, local farmers can improve the animals' food and water supplies, thus not only increasing once more the number of animals but also improving the quality of individuals. Given the importance of the buffalo, these improvements could be of great significance for the region.

* Regional Co-operative Agreement for research, development, and training related to nuclear science and technology in Asia and the Pacific region.

Hydrology

The Agency has a long tradition in fostering and doing its own research in the application of radioactive and stable isotopes for hydrology work. Methods have been refined with which the movements and the age of groundwater can be determined. The origin of groundwater can be found, the recharge of reservoirs assessed, and the total volumes of water and water-flow can be studied. Over the years, mainly as a sub-contractor to the Food and Agriculture Organization, the Agency has had to solve many hydrological problems. At the same time, by further developing the methods and through its training activities, the Agency has built up expertise such that more than twenty countries have asked it for help in setting up isotopic hydrological laboratories. Two simple examples will demonstrate how isotope techniques were able to establish the hydrology of an area where water was urgently needed for nearby large cities.

Bangkok needs more water. Groundwater is used there, but it must, of course, be a renewable source. Under a research co-ordination agreement, a co-ordinated programme was organized and the necessary facilities set up to measure the distribution of isotopes in the environment. The first success was to show that one area of groundwater was of a non-rechargeable kind, and that there the water could only be "mined". The study had therefore to be extended to another region in order to find a renewable source. The project was financed by the Government of Australia, which also gave technical help to the project.

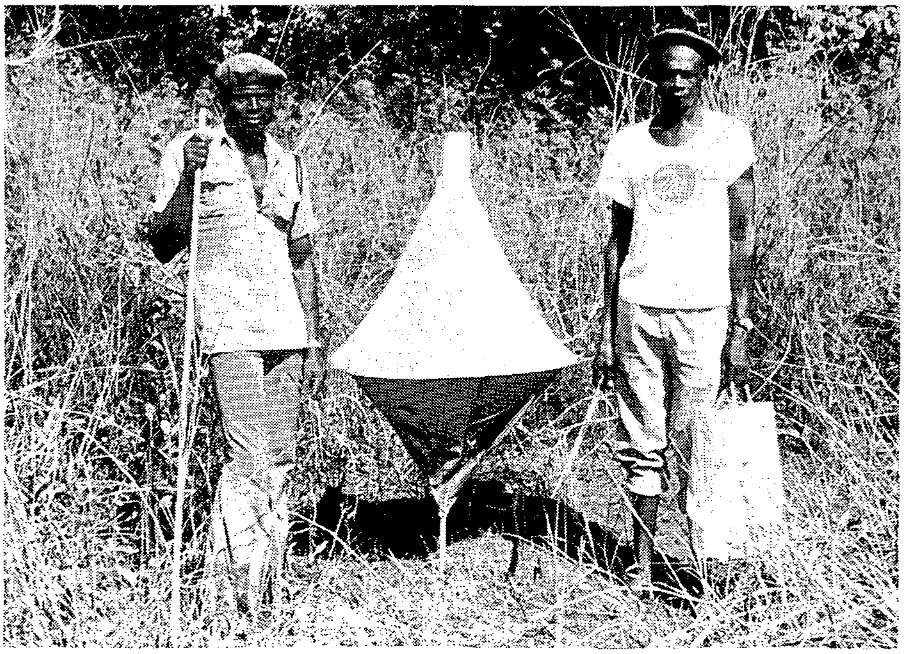
A similar case is the enlargement of the Athens water supply. The Agency's involvement started with visits and advice, and eventually some of the water was analysed at the Agency's Laboratory. The Agency's technical assistance programme then helped train scientists, provide research contracts, and establish an isotope hydrological laboratory in Greece. In this case a fresh water source from a certain Kalamos spring complex was looked into, and was found to be recharged from another system. The probable underground path of the water was established and the source identified where the fresh water component originated: this had to be done so it could be tapped before it was contaminated by sea-water. Again, the benefit was relatively big because, without isotope techniques, many bore-holes would have been necessary, and many long-term tests would have been required.

Multi-million dollar benefits

These few examples have shown that the Agency is not only very versatile in its subjects (many purely industrial projects have not been mentioned here) but also is well able to integrate all the elements needed for the success of such technical assistance projects.

The history of the Agency has proved that, through training in the right scientific direction, given in worthwhile fields, with special advice from experts, and with the help of the technical assistance facilities, the seed money can blossom and, in fact, has blossomed into many millions of dollars of benefits, in some cases thousands of millions of dollars. In many cases, it is doubtful if the projects would have materialized at all without the work and help given by the Agency's laboratories.

This article is not meant to be an exhaustive survey of useful and successful projects. It was intended only to demonstrate how, with some ingenuity and enthusiasm, the many possibilities can be streamlined to aid worthwhile projects at modest costs to the Agency, and with great benefit to the countries concerned.



The Nigerian Federal Government and the IAEA have agreed to try to eradicate the tsetse fly from north-central Nigeria using the Sterile Insect Technique. The tsetse is the vector of sleeping sickness in humans and of nagana in animals. Before the eradication programme could get underway, however, the local behaviour and distribution of the tsetse had to be studied. The photograph shows two project-workers with one of the 'conical traps' in which tsetses were captured for analysis.