Twenty years' collaboration in R&D for food and agricultural development

by Björn Sigurbjörnsson and Carl G. Lamm*

The joint FAO and IAEA programme on nuclear applications in food and agriculture celebrates its 20th birthday on 1 October 1984. How did it start?

Before 1964, both the Food and Agriculture Organization of the United Nations (FAO) and the IAEA had conducted limited programmes for the application of "atomic energy" in food and agriculture: FAO in the Atomic Energy Branch of its Agriculture Department, and the IAEA in a Unit of Agriculture in the Department of Research and Isotopes. Inevitably, there was duplication and overlapping and both FAO and IAEA realized the need for co-ordination. Negotiations between the Directors General of FAO and IAEA were initiated, and on 1 October 1964 special "Arrangements" were concluded for the establishment of a Joint FAO/IAEA Division of Atomic Energy in Agriculture.

The "Arrangements" provided that the Joint Division should be located at the IAEA Headquarters in Vienna within the Department of Research and Isotopes, where there are laboratory facilities nearby. FAO was made responsible for the employment of a Director, and the IAEA for the employment of a Deputy Director. The remaining personnel of the Joint Division are members of the staff of one or the other of the parent Organizations. The Director reports in the case of FAO through the Assistant Director General, Agriculture Department, and in the case of IAEA through the Deputy Director General, Department of Research and Isotopes.

The Joint FAO/IAEA Division of Isotope and Radiation Applications of Atomic Energy for Food and Agricultural Development (as it is now called) merges the objectives of both Organizations, although their terms of reference, philosophy and outlook are somewhat different. FAO is concerned primarily with the transfer of known technology for agricultural development and food production, and with the stimulation of needed research in national institutions. One of the IAEA's mandates is to encourage and assist research, development and the practical application of atomic energy for peaceful uses throughout the world. One of the most successful areas for the application of "atomic energy" is, indeed, in food and agriculture.

Dr Maurice Fried (USA) was Director of the Joint FAO/IAEA Division from its inception until 1982, when he retired. To a large extent it is thanks to his foresight and inspiration that the Joint Division has over the years found its place and gained recognition in international agricultural research and development.

The Joint FAO/IAEA Division

The objective of the Joint FAO/IAEA Division is to exploit the potential for application of isotopes and radiation techniques in research and development, to increase and stabilize agricultural production, to reduce production costs, to improve the quality of food, to protect agricultural products from spoilage and losses, and to minimize pollution of food and the agricultural environment. The programme supplements and supports priority areas of FAO and IAEA activities where isotope and radiation methods are particularly promising.

The Joint FAO/IAEA Division is organized by subject into six sections:

- soil fertility, irrigation, and crop production;
- plant breeding and genetics;
- animal production and health;
- insect and pest control;
- agro-chemicals and residues; and
- food preservation.

Laboratory support

The FAO/IAEA Agricultural Biotechnology Laboratory at the IAEA Seibersdorf Research Centre near Vienna actively supports joint FAO/IAEA programmes in soil science, plant breeding, animal production, entomology,

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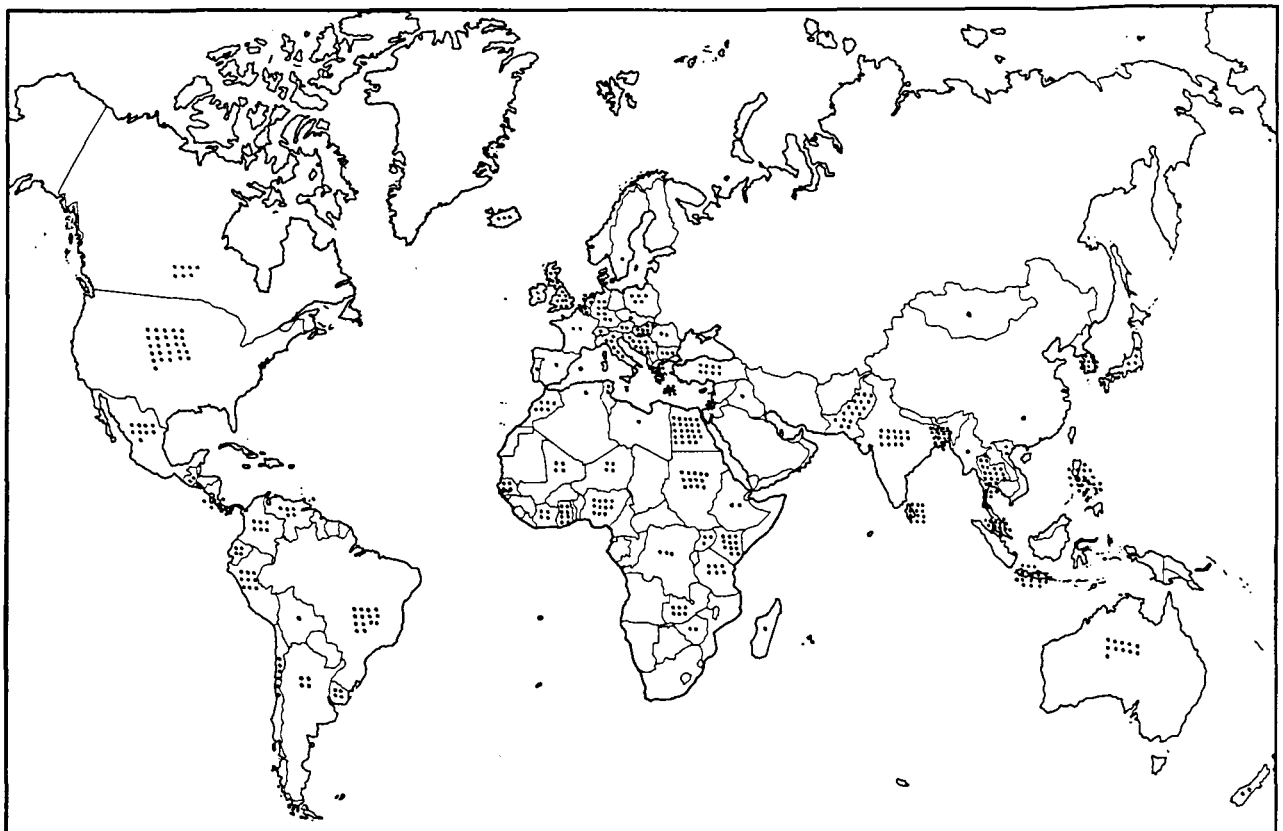

Distribution of research contracts, agreements and Technical Co-operation projects in the joint FAO/IAEA programme
No. of research contracts and agreements: 372 No. of Technical Co-operation projects: 133

Why use nuclear techniques in food and agricultural research?

Nuclear techniques have proved extremely valuable in a wide range of agricultural applications, such as creating new plant varieties, increasing the efficiency of fertilizer use, and optimizing animal nutrition; and in the biological control of insects, food preservation, and the development of safer and more effective pesticide formulations.

A wide range of techniques is available. For example, isotopes of practically all known elements exist in nature, and others have been created by man. Some isotopes are stable and others decay by emitting ionizing radiations. Both stable and radioactive isotopes can be easily detected and measured even in minute amounts.

It is possible to produce agricultural commodities such as fertilizers, feeds or pesticides which contain a larger amount of a given isotope than is found in nature. This isotope can then be used as a "label", or "tracer", to determine how much of a fertilizer nutrient which is applied to a crop is actually used, how much is left in the soil for future crops, and how much is lost and becomes a potential pollutant. Isotopically-labelled pesticides are used to find out how much of the pesticide finds its way to the target pest and how much goes astray – and, more important, where it goes. If insects are labelled with isotopes it is possible to follow their migration; and if hormones are labelled with isotopes their levels in tissues can be measured as a method of assessing an animal's reproductive status. Labelled compounds today find uses in almost every discipline of agricultural research.

Another major group of nuclear techniques is based on the use of the ionizing radiation emitted by unstable isotopes as they decay. Ionizing radiation is employed to induce mutants for plant improvement, to attenuate vaccines against animal parasitic diseases, to monitor soil water content directly in the field without disturbing the crop, to sterilize insects as a means of biological pest control, and to preserve food and reduce losses.

Widespread applications of nuclear techniques to problems in food and agriculture gained pace when artificially-produced radioisotopes of many important elements became widely available in the 1950s. More recently, stable isotopes of agriculturally important elements such as hydrogen, oxygen, carbon, nitrogen, and sulphur have become available at prices within the reach of the scientific community. Today, the uses of isotopes and radiation in food and agriculture permit quick solutions to a number of practical problems, and allow a more direct approach to others. In some cases, nuclear techniques offer the only solution to problems in basic and applied science.

and agro-chemicals. Research and development work using nuclear and related techniques is carried out in Member States, and the Laboratory provides training and various services, such as chemical and isotope analysis, mutagen treatments, supplemental investigations and model experiments. Food preservation activities are supported by the International Facility for Food Irradiation Technology (IFFIT) located at Wageningen, which is sponsored by the FAO and IAEA, and the Ministry of Agriculture and Fisheries of the Netherlands.

The Joint FAO/IAEA Division and its allied laboratory have a staff of more than 30 scientists from 23 countries. All have university degrees in subjects related to food and agriculture, and several years of experience in the application of nuclear techniques within their specialities. The majority have fixed-term contracts and are expected to return to their home universities or research institutes upon completion of two to four years of service with the Organizations. This turnover of staff ensures a welcome flexibility and a steady flow of technical ideas into the Joint Division, enabling it to respond actively to requests for assistance from Member States. Continuity is provided by long-term staff who compose about one quarter of the total.

The Joint FAO/IAEA Division derives its financial support from the pooled regular budgets of FAO and IAEA. Extra-budgetary support from individual donor Member States enables it to undertake a number of additional activities in developing Member States. The Joint FAO/IAEA Division also has technical responsibility for IAEA technical assistance field projects in food and agriculture, which account for some 20% of the resources available for IAEA technical co-operation programmes.

Activities

Three main groups of activities of the Joint FAO/IAEA Division can be distinguished. These are:

- co-ordination and support of research;
- technical assistance and training; and
- information exchange.

More than 360 research institutions or experimental stations in Member States are co-operating in some 33 co-ordinated research programmes at present. Each such programme attempts to solve a practical agricultural problem of economic significance for developing countries. Institutes in developing countries are normally given research contracts with nominal financial support, whereas institutes in the advanced countries participate without payment. The participants in such programmes meet periodically to review results and to discuss and decide on their future approach. Each programme usually has about 15 research contract and agreement holders, and can last up to five years. The world map indicates the distribution of research contracts, agreements and technical co-operation projects in the joint FAO/IAEA programme in April 1984. Tables 1 and 2 list these activities by subject matter and country.

The Joint FAO/IAEA Division currently has technical responsibility for 129 IAEA technical co-operation field projects, of which four are regional, in 53 developing Member States, providing training, expertise and specialized equipment. Among these are large-scale projects in Indonesia and Peru (UNDP), as well as in Egypt and Nigeria (multilateral). In addition to fellowship training, five to seven international training courses are arranged annually. Since its inception, the Joint FAO/IAEA Division has helped organize or supervise, or has participated in, 100 training courses or study tours. Ten of the training courses have been held in the IAEA Laboratory, and a large number of the more than 1000 trainees who have had fellowship in agriculture have also been hosted there since 1969. Analysis of the distribution of agricultural fellowships awarded since 1980 shows that 37.0% came from Africa, 36.0% from Asia and the Pacific, 13.3% from Latin America, and 13.7% from Middle East and Europe.

Scientific meetings are important in giving scientists from Member States the opportunity to exchange views and to keep up to date in specialized fields. Approximately one symposium and two seminars annually are organized as part of the joint FAO/IAEA programme. The publication of scientific results of practical importance obtained through the programme is also encouraged; some 100 publications in fields relevant to the joint FAO/IAEA programme have been issued since 1964. In many cases these are the only publications on the subject which are readily available to agricultural research workers in developing countries. The various sections of the Joint FAO/IAEA Division also maintain

Are nuclear techniques in food and agriculture new?

The history of research in nuclear sciences dates back to the last century. Names like *Roentgen, Becquerel* and *Curie* are well known: their research paved the road for applications in food and agriculture. Some examples:

G.V. Hevesy was a pioneer in the use of isotopes as tracers in studies of chemical and biochemical pathways. His classical experiment in 1923 in Copenhagen with living plants signified the start of isotope applications in e.g. soil, plant or animal research.

H.J. Muller and *L.J. Stadler* became the fathers of mutation induction through their work during the 1920s. In 1937 *E.F. Knipling* suggested that with small populations of insects it would be possible to rear, sterilize and release males as a biological control or eradication method.

X-rays were demonstrated to have a lethal effect on pathogenic bacteria in 1898, and this finding led to practical and important applications such as a method of preserving food.

After this embryonic start further development and practical application of nuclear methods applied to food and agriculture has gained pace at a tremendous speed.

Table 1. Research contracts and agreements in food and agriculture, active April 1984

Member State*	Subject: Soil science	Plant breeding	Animal science	Entomology	Agrochemicals and residues	Food preservation	Total
Argentina			1	1	1	1	4
Australia		2	8			1	11
Austria	1			1			2
Bangladesh	2	4	1			4	11
Belgium		2		1	1		4
Brazil	2	2	1		2		7
Bulgaria		2				1	3
Canada			4		3		7
Chile		1	1			2	4
China, Peop. Rep. of			1				1
Colombia			2				2
Costa Rica			1		2		3
Cyprus	1		3				4
Czechoslovakia				1			1
Denmark		1			1		2
Ecuador					1	1	2
Egypt		3	8		6	2	19
Ethiopia			1				1
France		1		1			2
Germany, Fed. Rep. of		4	1	1	2		8
Ghana	1	2		1	1	1	6
Greece	2	2		1	1		6
Guatemala		1					1
Hungary	1	2		1		3	7
Iceland	1		1				2
India	1	7			3	2	13
Indonesia	1	4	2	2	1	3	13
Iraq						1	1
Ireland		2					2
Israel		1	2	1			4
Italy		3		2	1		6
Japan		3				1	4
Kenya	1	2	2	4	1		10
Malaysia	1	2	5		1	1	10
Malta	1						1
Mexico	1		2	2			5
Morocco			4				4
Netherlands			1	1	1	1	4
New Zealand	2						2
Niger			2				2
Nigeria			3	6			9
Pakistan	1	6		1	4	2	14
Panama	2				1		3
Peru	1	3	3				7
Philippines	2	5			4	4	15
Poland		1	1		1	2	5
Portugal			1				1
Rep. of Korea		4	1	1		1	7
Romania			1				1
Singapore						1	1
Spain	1						1
Sri Lanka	1	1	3		1	1	7
Sudan	2		3		3		8
Sweden		1					1
Switzerland	1						1
Thailand	3	7	2		1	6	19
Trinidad	1						1
Turkey	1	1	1		2	1	6
Uganda		1		1			2
UK	1	2	4	4	2		13
United Rep. of Tanzania	1			1			2
Uruguay	1		1				2
USA	3	6	3	4	6	4	26
Venezuela			1				1
Yugoslavia			3		3	3	9
Zambia	1		1	1			3
Zimbabwe			1	1			2
Total 67 Member States	42	91	87	41	57	50	368

Research agreements awarded to institutes in developed Member States are normally on a cost-free basis.
* IAEA and/or FAO Member State.

Table 2. Technical assistance projects in food and agriculture, operational April 1984

Member State	Subject							
	General	Soil science	Plant breeding	Animal science	Entomology	Agrochemicals and residues	Food preservation	Total
Algeria							1	1
Bangladesh	1	1					2	4
Bolivia		1						1
Brazil	3	1	1	1	1			7
Burma			1					1
Chile		1					1	2
Colombia		2		1				3
Costa Rica				1		1		2
Cuba							1	1
Cyprus				1		1		2
Ecuador				2				2
Egypt		2		2	1			5
El Salvador	1							1
Ethiopia				1				1
Ghana	1				1			2
Greece		1						1
Guatemala	1							1
Hungary						1		1
Iceland				1				1
India	1							1
Indonesia	1							1
Ivory Coast		3	1					4
Kenya		1						1
Lebanon						1		1
Libyan Arab Jam.			1					1
Madagascar				1				1
Malaysia		1	1	2			1	5
Mali		2	2					4
Mauritius		1						1
Mexico			1	1	1		1	4
Mongolia			1					1
Morocco		1		1				2
Niger		1		1				2
Nigeria					2			2
Pakistan		1			1		1	3
Panama		1	1					2
Peru	1				1			2
Philippines						1		1
Rep. of Korea		1	1			1		3
Romania		1						1
Senegal		4						4
Sri Lanka		2		2	1			5
Sudan			1	3		1		5
Thailand		1		1		2	1	5
Tunisia		2						2
Turkey				2				2
Uganda				1				1
United Rep. of Tanzania		2			1	1		4
Uruguay		1		1				2
Venezuela	1	1	2					4
Vietnam			1				1	2
Yugoslavia			1					1
Zaire		1	1				1	3
Zambia		1		1	1			3
Total 54 Member States	11	38	17	27	11	10	11	125

regular contact with Member States by producing periodical Newsletters.

Other articles in this issue of the *Bulletin* describe activities of the Joint FAO/IAEA Division, and their impact on agricultural development, in more detail.

Current and future trends

There has been a general trend in the development of the programmes of atomic energy establishments in Member States toward a diversification of interests and activities, and away from strictly and exclusively nuclear

applications toward a broader, more inclusive approach. This is a natural development. The rapid development of nuclear technology has given rise to spin-offs and parallel developments in related fields, and in instrumentation and methods: for example, in chemical mutagens, in stable isotope, atomic absorption, nuclear magnetic resonance, and enzyme immunoassay techniques, insect pheromones, and in the study of natural predators and parasites of harmful insects.

The adoption of these complementary and supplementary approaches has greatly strengthened the programme, and the ability of the Joint FAO/IAEA Division to render an effective international service in the solution of real, practical problems in food and agriculture – which is its main objective.

"Winds of change" are now affecting the whole realm of biotechnology, including molecular biology and genetic engineering. The application of nuclear and associated techniques in these fields is a new and exciting prospect which the Division has been actively exploring. A majority of the programmes and nearly all of the laboratory activities at the Seibersdorf Research Centre are in fact of a biotechnical nature, interpreting the term broadly. Recognizing this, the FAO and IAEA administrations have designated the agricultural part of the IAEA Seibersdorf Laboratory, the FAO/IAEA Agricultural Biotechnology Laboratory.

The Division's programmes and activities are problem-oriented, rather than technique- and tool-motivated. The Division is not interested in elegant applications of nuclear tools and techniques if there is not a real, practical, need for them in agriculture.

Although work is carried out within the general framework of nuclear technology, programme development is not restricted to it. The Joint FAO/IAEA Division employs such related scientific approaches as are promising and needed to achieve satisfactory progress. Such allied approaches lie primarily within biotechnology. The Division intends to follow closely developments in biotechnology in its widest sense, primarily in order to assist collaborators in the developing Member States and to promote international co-operation and co-ordination in the use of nuclear and other related technologies to increase, stabilize, and protect food and agricultural production.

Highlights of the joint FAO/IAEA programme

The primary goal of the joint FAO/IAEA programme is to assist Member States and to promote co-operation between them in the use of nuclear techniques to improve food and agricultural production. The programme stresses activities in research and development relating to agricultural practices which require minimal material and energy inputs and have a minimal effect on the agricultural environment.

The broad objectives of the programme are:

In *Soil Fertility, Irrigation, and Crop Production:* Optimization of fertilizer and water management practices and biological fixation of atmospheric nitrogen in field crops under different farming systems through isotope and radiation-aided research.

In *Plant Breeding and Genetics:* Genetic improvement of crop plants for traits such as higher yields, early maturity, better lodging resistance, and resistance to pathogens and pests through mutation breeding.

In *Animal Production and Health:* Improvement of animal production and health through isotope-aided research on animal diseases, reproduction, nutrition, and environmental physiology.

In *Insect and Pest Control:* Control or eradication of major crop pests and disease vectors, with emphasis on the Sterile Insect Technique in integrated pest management.

In *Agrochemicals and Residues:* Improved protection of crops and animal products from pests by isotope-aided research to increase efficacy and safety, and to minimize environmental impacts of agrochemicals.

In *Food Preservation:* Reduction of post-harvest losses and promotion of safe food supplies by effective use of food irradiation.