NUCLEAR TECHNIQUES & FOOD SECURITY

FIELDS OF PROGRESS

BY JAMES DARGIE

Isotopes and ionizing radiation have been used throughout the past half century to provide practical solutions to many issues and challenges facing the world's food and agricultural development. Since the mid-1960s, the IAEA and United Nations Food and Agriculture Organization (FAO) have worked together through the Joint FAO/IAEA Division, using their combined technical and managerial expertise and experience to bring the benefits of nuclear technology to farmers and consumers.

Much has changed since 1965 when this collaboration was established. Most importantly, the countries that the partnership was set up to serve have experienced changes, often radical ones. The transition has been characterized in particular by devolution in governmental roles and functions, dramatic shifts in population to urban areas, increasing globalization of commerce, trade and communications, and intensification of global and regional regulatory schemes.

These and other political, social, and economic trends have and will continue to impact everyone -- especially those employed directly or through the food and agricultural sector. The importance of these factors may be difficult to understand by people in industrialized countries that are employed in industry, commerce, or even the public sector who increasingly benefit from global agri-business and abundant and affordable food supplies. Yet for the vast majority of the world's population -- people living in developing countries and where the national agricultural sector provides the food, raw materials, jobs, and incomes essential for everyday living -- they are matters of considerable concern.

They are also matters of rising concern to governments, which increasingly recognize that without further improvement in the food and agricultural sector -- the engine for sustainable development -- there can be little alleviation of hunger and poverty, the development of non-agricultural sectors, or improvement in the provision of public services to their populations.

These considerations in turn have focused minds on how the United Nations system can assist countries collectively and individually to promote development through agriculture in ways that bring equity in terms of access to food, and in an economically and environmentally sustainable manner.

The debate culminated in 1996 with the World Food Summit convened by FAO in Rome. The Summit was held against a backdrop of over 840 million people -- or 20% of all people living in developing countries -- being hungry and malnourished and the expectation that roughly 80 million more people would be added to the global population each year for the foreseeable future. The Summit not only raised awareness worldwide to the unacceptable and ever-widening levels of food insecurity between the industrial and most developing countries, but more importantly laid the foundation through its Plan of Action for promoting food security for all.

This Plan of Action put the onus on achievement firmly in the hands of countries themselves. It emphasized the role of UN agencies as facilitators for the development of appropriate international instruments, providing policy guidance, and for supporting actions for strengthening capacities at regional and national levels to carry out and sustain agricultural programmes. It also recognized the

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fundamental importance of agricultural research, extension and education. These areas were recognized not simply for improving and transferring knowledge and technology *per se*, but as the basis for developing and promoting the implementation of international, regional, and national instruments, standards, and policies based on sound science.

NUCLEAR TECHNIQUES IN PERSPECTIVE

Nuclear techniques are mainly tools for research that ultimately contribute to accelerated development. They should not be seen as an end in themselves but rather as adjuncts to other technologies for understanding and solving problems.

The key question which national agricultural research systems (NARS) and government decision makers have to address is why do we need nuclear techniques -- can't we manage without them? The answer depends on the nature of the problem. Invariably the problem can indeed be solved without nuclear applications. But for certain problems, they are needed to reach a satisfactory outcome. When applied, nuclear techniques must be integrated with non-nuclear (or conventional) technologies to achieve real value, and their use needs to stand upon a good base of research and knowledge.

From the perspective of the FAO/IAEA Joint Programme, a highly selective and result-oriented approach is therefore essential. The Programme exists to provide technical services to the agricultural communities and consumers within Member States of the IAEA and FAO. Nuclear applications are fostered only when essential for obtaining a better understanding or solution of a strategically important and widely recognized constraint to agricultural development, and not for encouraging research with limited prospects of practical application in the foreseeable future. The temptation to push nuclear technology for technology's sake is resisted to ensure that the Programme and its sponsors retain their relevance and credibility in scientific and political circles.

The Programme's relevance and credibility rest on its knowledge of intergovernmental and international priorities and agendas in areas of research and development. These are formulated within FAO itself and the Consultative Group on International Agricultural Research, a body which the FAO co-finances with the World Bank and other donors. Additionally, the Programme receives regular feedback from NARS. The feedback helps to ensure that the Programme is directed at issues and problems of strategic global and regional importance, and that it addresses national needs and priorities.

This article reviews results of selected projects of the Joint FAO/IAEA Division that have contributed to food and agriculture development. In some areas, it updates previous reports on the work of the Division and the FAO/IAEA Agriculture and Biotechnology Laboratory, which supports the Joint Programme.* The article specifically focuses on three of the key strategic issues earmarked for intergovernmental attention at the World Food Summit and earlier at the UN Conference on Environment and Development in 1992. Each can be addressed effectively through nuclear technology that is supported by other technologies, national capacities, and an enabling political and economic environment.

CROP & LIVESTOCK PRODUCTION

Meeting the food needs of expanding populations in developing countries is a formidable challenge. It must be met within the framework of their still low levels of *per capita* consumption and the changing food preferences of increasingly urbanized societies. Solutions will require sustaining strong growth in both basic food supplies and in high value crop and livestock products, and to do so in ways that will counter increasing global competition for these foods and commodities.

Meeting the challenge also demands that intensification and diversification are achieved in beneficial ways. They must ensure that the essential "public goods and services" provided by agriculture -- the soil, water, plant, and animal genetic resources -- are available long-term, and that any other essential inputs needed -- for example, fertilizers and pesticides -- do not pollute the environment or leave unacceptable levels of residues in the products.

See, for example, "Nuclear Techniques in Food and Agriculture Development: 1964-94", by Bjoern Sigurbjoernsson and Peter Vose, IAEA Bulletin, Vol. 36, No. 3 (September 1994).

Three further considerations must be borne in mind. First, most countries simply have no additional land on which to produce food and industrial crops or livestock. Second, in many countries, land is becoming increasingly affected by soil erosion, salinization, or acidification which reduces its productive potential. Third, the plant and animal genetic resources upon which agriculture and food production depends are undergoing rapid erosion due to widespread adoption of a few high-yielding varieties and breeds.

These trends need to be reversed through policies and technologies which support conservation and sustainable use of land, water, and genetic resource. Otherwise, the immediate and long-term needs for food production and security and social cohesion cannot be achieved.

The need for nuclear techniques to address these issues lies firstly in their unique sensitivity and specificity as markers. They can be used to measure -- more accurately than is possible by any conventional method -- those basic and yet strategically essential processes which take place within and between soils, plants, and animals and which drive the use and conversion of resources into useful products. Secondly, the need for nuclear applications lies in their capacity to bring about changes in the genetic make-up of plants.

These tools therefore make it possible to measure levels of biologically important elements and molecules and hence agriculturally important processes. They also make it possible to trace, or change, what happens during these processes, and to study the rate of what happens when changes in resource management and/or genetics are introduced. A further advantage is that they offer great potential for enhancing the diversity of crop plants.

All of this is, of course, nice science. But how does it help to improve crop and livestock productivity or to counter problems like soil salinity and erosion or for that matter enhance the conservation and sustainable use of plant and animal genetic resources?

Without going into all the technical details, the answers lie in using these different attributes of nuclear technologies for distinct purposes.

First, they can be used to better characterize what's going on within soils, crops, and animals under given systems of management. Then, the same mix of tools can be used to monitor the effects of interventions designed to reduce or eliminate the constraint in question. Finally -- and subject to positive results reinforced by pilot-scale trials -- the better practice or plant variety can be evaluated by decision-makers for its effective transfer to the end users and ultimate beneficiaries.

Following are some recent examples of this approach. They serve to illustrate how nuclear technology can be used not simply to increase product output, but to improve key components integral to sustainable food and agricultural development.

■ Efficiency of Water and Fertilizer Use in West Asia.

The Challenge: Most developing countries in semi-arid areas are experiencing severe water shortages and nitrogen fertilizers are expensive. Demand for higher value food and industrial crops is increasing due to rapid urbanization and the need to promote local off-farm employment to enhance access to food and commodity markets.

The Approach: Assist the NARS and participating farmers to use neutron moisture probes and nitrogen-15-labelled fertilizers for identifying, pilot testing and extending the use of technologies and management practices that lead to more efficient use of water and nitrogen fertilizers for growing crops. This particular activity focused on determining the advantages of providing water and urea through drip irrigation (fertigation) over the traditional practice of furrow irrigation and band placement of urea.

The Results: The amount of water used by cotton during the growing season was 4900 cubic metres per hectare (m^3/ha) using drip irrigation and 7600 m^3/ha when applied by the traditional surface method, a saving of 36%. The efficiency with which the water was used to produce crop biomass almost doubled when drip irrigation was used. Also, the amount of cotton seed harvested under fertigation was 22% higher than with traditional fertilizer and water management practices. Fertigation therefore proved to be a very efficient technology for maintaining or increasing crop yields while conserving both water and nitrogen fertilizer.

■ Production of Grain Legumes in Bangladesh.

The Challenge: Grain legumes such as lentil,

Photo: *Cotton under fertigation management in West Asia.*

chickpea, groundnut, mungbean, and soybean are an integral part of the daily diet in Bangladesh. Production satisfies about 90% of local demand, the shortfall being met by imported grains. Increased production is required on existing farmland to improve food security and save foreign exchange.

The Approach: Use the nitrogen-15 isotope dilution technique to identify elite rhizobial strains as inoculants and legume genotypes which have both high yield potential and are effective in fixing nitrogen. Increase national capacities to produce and control the quality of inoculants and to promote the benefits of the technologies among extension services and farmers.

The Results: Country-wide studies demonstrated the large potential to increase grain legume production through inoculation and genotype selection, a pilot plant for large-scale production and quality control of inoculants was established, and widespread application of the technology is expected to increase staple legume production by 25%, leading to savings on imports, including fertilizers.

■ Diagnosis of Soil Erosion.

The Challenge: Soil erosion is a major threat to global food security. Identification of cost-effective control measures both at the farm and landscape levels is hampered by inadequate and generally expensive methods. A diagnostic tool which could be easily and universally applied would underpin better soil conservation strategies.

The Approach: Develop capacities within NARS in countries with a range of climatic and landscape conditions to use the spatial and temporal distribution of fallout and naturally occurring radionuclides, such as caesium-137, for estimating rates of soil redistribution. Compare the results with data from existing methods to determine the potential of the nuclear method.

The Results: Caesium-137 provides a reliable means of measuring soil erosion and sedimentation on a landscape scale. The method is now being used to provide data for decision-makers to help plan approaches and technologies promoting better soil and water conservation.

■ Sorghum Crops in Mali.

The Challenge: Sorghum is the second most important food crop in Mali where it is grown on 560,000 hectares with an average yield of only 980 kg/ha. New higher yielding sorghum varieties using local germplasm are needed to improve food production and conserve biodiversity for future generations. Since farmers also want plants with tall stems for feeding cattle and building grain storage and shading canopies, an additional challenge is to meet this need.

The Approach: Assist the main plant breeding institute in Mali to integrate mutation methods within ongoing programmes on sorghum improvement. Work involved exposing local material to gamma rays, selecting desired variations, and then testing crops under different agro-ecological conditions in the field.

The Results: Eight improved mutants suited to various sorghum growing regions of Mali are now included in the list of varieties recommended to farmers by the Department of Agriculture. These mutants have a yield potential of 2000 to 2500 kg/ha and are between 1.5 and 4.5 metres tall with long panicles. Some are early ripening and others have improved tolerance to drought. Seeds have been distributed to 2000 farmers for wider field performance validation.

■ Chickpea Crops in Pakistan.

The Challenge: Pakistan is the world's third largest chickpea producer. Chickpea is an important and cheap source of protein and carbohydrates and an integral part of the daily diet. Annually, it is grown on more than 1 million hectares but yields are very low at around 600 kg/ha. One of the major constraints to higher yields is the crop's susceptibility to the widespread diseases *Ascochyta* blight and *Fusarium*.

The Approach: Assist the Nuclear Institute for Agriculture and Biology (NIAB) to implement a breeding programme to induce disease resistance in chickpea by mutation techniques.

The Results: The project led to the release of the first high yielding chickpea mutant variety -- known as "CM-72" -- resistant to *Ascochyta* blight. Chickpea yields in the Northwest Frontier Province are now about 45% higher than the average of the previous five years. A further mutant variety, "CM-88", has since been released with resistance to both *Ascochyta* blight and *Fusarium* wilt, thus providing an alternate source of resistance for chickpea growers. Both mutant varieties cover 70% of the total chickpea area in Pakistan.

■ Small Dairy Enterprises in Asia and Latin America.

The Challenge: Demand for livestock products is increasing fast in many developing countries due to urbanization and income growth. Milk and its processed products offer substantial opportunities for off-farm employment and better food security.

The Approach: Assist small scale producers and artificial insemination (AI) services to realize greater potential of cross-bred cattle by employing isotopes and hormone radioimmunoassays; and to identify diets based on local resources which meet both the higher nutritional needs and demands for better reproductive and breeding management required by these animals.

The Results: Supplements known as urea-molasses-multinutrient blocks (UMMB) and related formulations based on local ingredients were identified as cost-effective approaches to improve productivity while conserving and sustainably using natural resources. In Asia, around 1.6 million kg of UMMBs are currently fed to over 25,000 animals belonging to some 6000 farmers. Milk yields increased on average by 20% while the cost of feeding fell by a factor of three.

Likewise in Latin America, supplementation resulted in better utilization of the available fibrous feeds. It enabled farmers in some countries to raise four times as many animals than was previously possible per unit of savannah land.

Reproductive efficiency also improved dramatically. One result is that farmers are increasingly looking towards further increases in productivity through breed improvement utilizing AI. However, it is clear that by using progesterone measurement in milk, between 30% to 50% of the heat periods in cows are missed by farmers. Of the periods detected, between 15% to 20% are probably incorrect. Improvements in heat detection, timing of mating, and the overall efficiency of AI services reduced the intervals between calvings to conception by one to three months. This resulted in more milk and calves per lifetime of individual cows and 10% to 30% higher incomes to owners. In addition, reducing the number of AIs performed at inappropriate times saved the resources of AI service providers that would otherwise be wasted.

TRANSBOUNDARY INSECT PESTS & DISEASES

As crop and livestock production intensifes and diversifies, some risks are magnified. They include the risks of loss and damage to product quality from insect pests and the diseases which they transmit, as well as from a great variety of other diseases transmitted to livestock by viruses, bacteria, and parasites.

Additionally, some of these crop insect pests and a number of the viral and other disease of livestock (known as "List A" diseases) are subject to strict internationally accepted quarantine measures. These are drawn up under the International Plant Protection Convention administered by FAO and International Zoo-sanitary Code of the Office International des Epizooties (OIE), which are accepted by the World Trade Organization (WTO) as the standards for international trade under the Sanitary and Phytosanitary (SPS) Agreement negotiated under the Uruguay Round.

A number of developments are driving the demand, and urgency, for finding solutions. They include the increased

threat of these pests or diseases spreading across international borders. The threat is raised by the greater movement of produce and livestock, the trend towards greater use of pesticides, and the risk of unacceptable levels of residues and damage to plants, animal and insect genetic resources. Being sought are more integrated, biologically oriented, and area-wide approaches to pest and disease management that, where possible, lead to eradication.

The roles of nuclear techniques in this area have increased substantially in recent years. One role is through application of ionizing radiation to sterilize but otherwise not affect the behaviour of key insect pests, which are then released in large numbers to control or eradicate wild populations(the sterile insect technique, or SIT). A second role is through the use of radioisotopes to develop the specific tests (namely, the enzyme linked immunoassay, or ELISA) needed to diagnose and monitor the effectiveness of vaccination programmes against the major diseases causing livestock losses in developing countries and inhibiting trade.

Photo: A production centre for rearing tsetse flies in the Zanzibar eradication campaign was set up in Tanga.

Following are some examples of recent progress:

Eradicating the Mediterranean Fruit Fly from Regions in South America.

The Challenge: Chile and Argentina are among the major producers of temperate fruit in the world. The accidental introduction of the Mediterranean fruit fly (Medfly) into South America in the early 1990s forced farmers to eliminate fruit varieties most attacked by the pest and to initiate regular insecticide treatments to be able to sell worm-free fruit. Nevertheless, major fruit importing countries that are free of this pest require costly post-harvest treatments of fruit, or they quarantine the fruit, for fear of outbreaks originating from the presence of the Medfly in commercial shipments.

The Approach: Assist the Chilean Agricultural Service to implement a SIT eradication programme through construction of a Medfly mass rearing facility with a production capacity of about 60 million sterile flies per week, and to assist in the release of sterile flies by air. Also, assist Argentina to build a rearing facility with a weekly capacity of over 200 million sterile flies and to carry out an eradication programme in the provinces of Rio Negro, Nequen, and Medoza.

The Results: Eradication was achieved in Chile and the country is now an internationally recognized Medfly-free country. This status has significantly supported the expansion of its multi-billion fruit export industry. In Argentina, the quantity and quality of temperate fruit production have increased significantly, insecticide applications have decreased in commercial fruit orchards, and several fruit producing valleys are now recognized by neighbouring Chile as fruit fly free. In 1999, Chile allowed the fruit industries in Mendoza and Patagonia Provinces to use its ports for their fruit export.

Control of the Medfly in Israel and Jordan.

The Challenge: The Medfly can cause major losses in vegetable production in the Arava Valley of Israel and Jordan and its presence precludes access to lucrative export markets. The cost of insecticide spraying of backyards and agricultural areas is high and the continuous insecticide applications result in considerable environmental problems.

The Approach: Assist the countries' plant protection authorities and growers to embark on area-wide Medfly control, integrating the SIT with conventional methods using sterile flies imported from Guatemala.

The Results: Medfly populations in all settlements fell dramatically, as have the quantities of fruits and vegetables infested with larvae; also significantly reduced was insecticide use, since sterile flies have replaced bait sprays. The volumes and value of exports have expanded exponentially. Assuming the Arava Valley becomes Medfly-free, agricultural development and diversification will expand as producers take advantage of their pesticide and pest-free status to provide peppers and tomatoes to global markets.

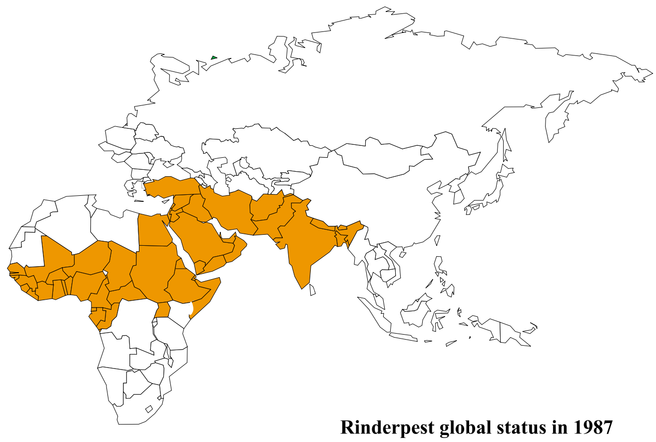
■ Eradication of the Tsetse Fly from Zanzibar.

The Challenge: The disease known as trypanosomosis affects livestock and humans throughout much of sub-Saharan Africa's 10 million square kilometres. It is transmitted by nearly 30 species of tsetse flies and represents a key impediment to the establishment of sustainable agricultural systems in many areas. Vaccination of cattle against the disease is not possible, and control of the flies and the disease with insecticides and drugs is a never-ending process. Eradication is the long-term solution; determining its technical feasibility required demonstration on an area-wide scale by integrating the SIT with the use of insecticides.

The Approach: Selected for the demonstration project was the 1500 km^2 island of Zanzibar, which had one species of the fly. A tsetse production centre for rearing about one million tsetse females was established at the Tsetse and Trypanosomiosis Research Institute in Tanga, Tanzania and over a period of 18 months about 60,000 sterile males were released each week over the island.

The Results: Intensive fly and cattle monitoring confirmed that the tsetse fly and the disease were eradicated from Zanzibar. This increases the potential for widespread introduction of more productive cattle breeds there.

GLOBAL STATUS OF RINDERPEST IN 1987 AND IN 2000



Rinderpest global status in 1987

Rinderpest global status in 2000

■ Global Eradication of Rinderpest.

The Challenge: Rinderpest is arguably the most devastating of all major cattle diseases. In 1986, the goal was set to eradicate it and the causative virus from the world by 2010. A proven vaccine was available. But a reliable and internationally accepted method had to be developed to diagnose the disease quickly and test the large numbers of blood samples coming into veterinary investigation centres for the purposes of monitoring the effectiveness of the mass vaccination campaigns and if necessary re-directing them.

The Approach: Assist national veterinary authorities to develop a rapid, simple, and standardised immunoassay test and the strategies and capacities to use it during mass vaccination campaigns. Thereafter, to identify remaining pockets and verify national freedom from disease and infection.

The Results: Data from using the test allowed quantitative performance assessment of vaccination programmes and post-vaccination surveillance activities, providing strong evidence that only seven countries now remain infected compared with over 30 countries in 1986. Chances now are high that global eradication will be achieved on target.

■ Control and Eradication of Foot and Mouth Disease in Latin America and Asia.

The Challenge: For the past 60 years, foot and mouth disease (FMD) has been the greatest non-tariff barrier to livestock trade and considerable effort has been made to bring it under control or eradicate it. Essential to these aims is effective and rapid diagnosis for targeting vaccination efforts and verifying that animals and regions are free of FMD.

The Approach: Assist national veterinary laboratories to develop and use the ELISA both to provide rapid and specific diagnosis and to distinguish vaccinated from naturally infected animals; this is an essential requirement for areas or countries moving towards international recognition of freedom from the disease.

The result: Chile, Uruguay, and parts of Argentina and Brazil are now internationally certified as free of FMD. Many other countries in Latin America and Asia have large FMD eradication programmes benefiting from application of these essential immunoassay tests.

FOOD QUALITY & SAFETY

Achieving food security depends not just on growing food and industrial crops, or on keeping livestock and protecting them from pests and diseases. It also depends on reducing unacceptably high losses which occur after harvest or slaughter, and on efforts to ensure that products reaching consumers are safe, of high quality, and do not pose unacceptable risks to plant and animal health.

A number of developments have focused attention on problems of food quality and safety. Developing countries are intensifying and diversifying production, more people are moving into large cities, and opportunities for trade are expanding. These developments increase the likelihood of spoilage and the risks to human health from pathogenic micro-organisms, pesticides and veterinary drug residues. They also raise the threat to plant and animal health from insect pests and disease agents which are subject to international quarantine restrictions.

Steps to ensure food quality and safety and plant and animal protection are essential components of consumer and agricultural protection in all countries. For countries seeking to enter or strengthen their position in global markets, these components have taken on growing importance since the establishment of the WTO and the agreements reached on Sanitary and Phytosanitary Measures and Technical Barriers to Trade. These agreements essentially set the prerequisites for trade. They are underpinned by the technical standards established by the FAO/WHO Codex Alimentarius Commission, the International Plant Protection Convention administered by FAO, and the International Zoo-sanitary Code.

One of the few technologies addressing these challenges is food irradiation. It has the ability to control spoilage and food-borne pathogenic micro-organisms and insect pests without affecting significantly the sensory or other attributes of food products.

In addition, nuclear analytical methods -- such as electron capture gas chromatography, X-ray fluorescence and RIA coupled with the use of isotopically labelled compounds -- are essential components of the armoury used by food control organizations. These organizations apply the tools for analyzing food samples for compliance with Codex standards as well as for improving sampling and analytical methods.

Over the past few years, significant progress has been made in various areas:

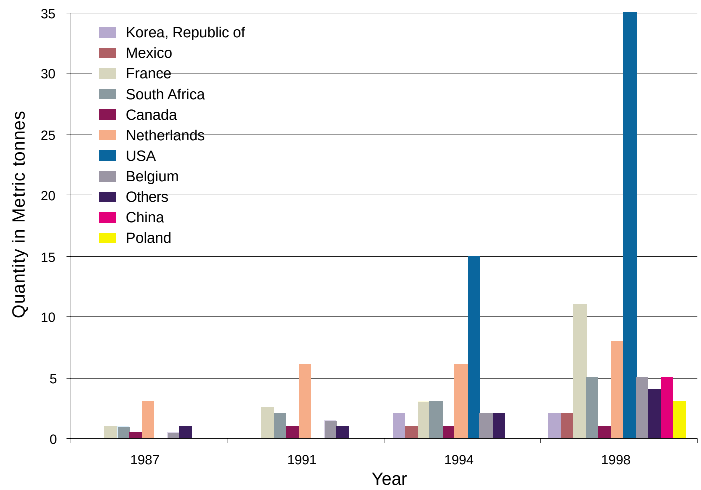
■ Controlling Food-borne Diseases.

The Challenge: The widespread and increasing incidence of food-borne illness caused by pathogenic bacteria and parasites and the consequent social and economic impact on the human population have brought food safety to the forefront of public health concerns. Hundreds of millions of people worldwide are affected by diseases caused by contaminated food. The toll in terms of human life and suffering is enormous, particularly among infants and young children, the elderly and other vulnerable groups.

The Approach: Assist national food control laboratories to generate data to determine the effectiveness of irradiation to control various food-borne pathogenic bacteria and parasites in food products such as meat, poultry, seafood and spices.

The Results: Many countries -- including Brazil, Belgium, Canada, China, Chile, France, Mexico, the Netherlands, South Africa, Thailand, and the USA -- are using irradiation to control pathogenic bacteria and parasites in several food products. Several large commercial irradiators are under construction, especially in the USA, for treating food of animal origin. Irradiation is widely applied to ensure hygienic quality of spices and vegetable seasonings in increasing quantities. *(See graph.)*

ESTIMATED QUANTITIES OF IRRADIATED SPICES AND SEASONINGS



Facilitating Trade in Fresh Fruits and Vegetables.

The Challenge: Fresh fruits and vegetables from developing countries are often infested by tephretid fruit flies and cannot gain access to markets in advanced countries which have strict quarantine regulations against such pests. Conventional quarantine treatments have technical limitations and some are being phased out globally because of environmental concerns.

The Approach: Generate data on the use of irradiation as a quarantine treatment against fruit flies and other major quarantine pests in fruits and vegetables. Have the information evaluated independently through the International Consultative Group on Food Irradiation to obtain international consensus on the technical feasibility of this application.

The Results: Irradiation as a quarantine treatment of fresh fruits and vegetables is endorsed by regional plant protection organizations which operate within the framework of the International Plant Protection Convention. Several countries, notably the USA and members of the Association of South East Asian Nations (ASEAN), have formulated policies or introduced regulations on this application. In 1995, small commercial-scale application started in the USA and a commercial plant for this purpose is under construction in Hawaii.

Food Contaminants and Residues.

The Challenge: Global trade liberalization in food and agricultural commodities requires that food exported from developing countries conforms to the safety and quality standards based on the provisions of WTO agreements. National food control laboratories in developing countries need assistance to strengthen their analytical capabilities for analysis of contaminants and residues in food destined for international trade.

The Approach: Establish an FAO/IAEA Training and Reference Centre for Food and Pesticide Control at the IAEA Laboratories for training, quality assurance services, and information on analytical methods for measuring food contaminants and residues. The target training group is personnel in national food control laboratories. The aim is to assist these laboratories to obtain national/international accreditation for analyzing contaminants and residues in food covered by Codex standards.

The Results: Over 100 personnel from food quality control laboratories have been trained on analytical and quality assurance methods for pesticides, veterinary drug residues and mycotoxins through five regional or interregional training courses at the Agency's Seibersdorf Laboratories, and in Hungary, Sweden, Republic of Korea, and Thailand. Subsequent participation of trainees in proficiency testing programmes confirmed the benefits and sustainability of the training provided. Increasing communication through an Internet accessible International Food Control and Residues Information System demonstrates the value of providing synthesized and objective information to food control laboratories.

TOMORROW'S HARVESTS

When people think about agriculture, they often think about the countryside and about farmers growing crops and keeping livestock. When they think about nuclear science and technology, they often think about nuclear reactors.

Few connect these two fields. Yet the emergence of reactor technology and modern agriculture during the second half of the 20th century followed fundamentally similar paths. Both were underpinned by substantial investments for building the intellectual capacities and infrastructures for basic and applied research to heighten knowledge, develop and innovate technology, and to set rules and standards.

The vast majority of countries have not benefited directly from nuclear power. Yet in one way or another, many benefit from the continuous flow of new products and the advances made through research and development and scientific study.

Today, farmers, processors, consumers, and government authorities are benefiting from the practices, technologies, and analytical methods that use or are derived from applying isotopes and ionizing radiation for food and agricultural development. In short, the investments made in supporting research and development in the nuclear, biological, and agricultural sciences have paid off.

Over the past half century, dramatic changes have taken place, transforming relationships between society and the land. As the new millennium opens, these changes are posing difficult challenges and new demands for effective international cooperation.

The first and foremost role of agriculture remains the production of food and primary goods which contribute to food security. This fundamental role still drives the agenda of the FAO/IAEA's Joint Programme.

Equally clear, however, is that agriculture and land also have environmental, economic, and social functions that are interrelated. Some technologies and transformations may have short-term disadvantages, such as lower productivity, before leading to longer-term economic and environmental impacts. Many changes, however, can work in the opposite direction, threatening long-term development through adverse effects on soil fertility, biodiversity, and food safety. National, regional, and international institutions must examine these and other factors to provide the best possible basis for allocating resources, establishing rules, formulating policy, and making decisions.

In recent years, the FAO/IAEA Joint Programme has increasingly advocated consideration of such issues by Member States. Progress in understanding the synergies and trade-offs between different functions to satisfy the future needs of the agricultural sector and society as a whole is necessary for formulation and selection of policies and practices. It also requires greater interdisciplinary cooperation within and between the NARS to engage in longer term strategic research as well as on immediate problems.

Within this overall concept of multi-functionality, the Joint Programme has moved strongly towards assisting countries to comply with some of the major internationally accepted conventions, agreements, and standards which increasingly support food and agriculture development. More attention is therefore directed at strengthening national capacities to apply nuclear technologies for assessing and managing the potential environmental and safety risks from practices that enhance food and agricultural productivity. In this way, the Programme is assisting the countries and institutions it serves not only to overcome problems affecting agricultural production but to recognize and respond to the emerging issues inluencing propects for global food security in the early 21st century. ❐