Food and Agriculture

Objective

To enhance capabilities within Member States for alleviating constraints to sustainable food security by the application of nuclear techniques.

Sustainable Intensification of Crop Production Systems

Plant mutation breeding has been thoroughly modernized by the advent of high throughput technologies using molecular genetics, of which mutation induction represents the leading technology. Characterized by a maximum of mutant plants in a minimum of time, the use of this technology enables the production of improved and higher yielding crops that are hardier in harsh environments and have enhanced nutritional value, which helps mitigate micronutrient malnutrition.

There has been significant progress in plant mutation breeding worldwide, fostered by the application of novel molecular biology tools. In 2007, an Agency technical cooperation project in Asia developed and facilitated the exchange of more than 20 new food crop mutant varieties among participating countries. In the tsunami affected areas of Sri Lanka, farmers began growing a high yielding, salinity tolerant mung bean variety (VC2917A) originally developed by Chinese breeders. Excellent field trial results have also been reported in Thailand for soybean varieties from Vietnam and the Republic of Korea, in Sri Lanka for groundnuts from Indonesia and Bangladesh, and in the Philippines for mung beans from Pakistan. Under the same project, Indian breeders developed 12 mutant groundnut varieties, which are estimated to cover about 45% of the groundnut growing area in India.

Mutation breeding clearly is the methodology of choice for Vietnam's farmers, as some 50% of rice and soybean varieties under cultivation in Vietnam were developed using mutation techniques and biotechnologies enhancing efficiency. Long term Agency support enabled Vietnamese breeders in 2007 to improve crop production in both lowland and highland areas, with consequent enhancements in food security and farmers' incomes.

Molecular techniques for screening crop genetic material continued to be incorporated into Agency activities in 2007. This screening reduces both costs and the time invested in evaluating up to maturity large mutant populations in the field. In 2007, the Agency made significant progress in the development of protocols and the use of low cost options in the application of reverse genetics technologies — such as targeting induced local lesions in genomes (TILLING) — to tropical crops such as tef, finger millet, yam, plantains, bananas, roots and tubers, which are known as orphan crops. Of great value for the economies of developing countries, orphan crops are often both commodity and cash crops, and help mitigate food scarcity.

The Agency's training activities in 2007 emphasized the acquisition of skills in these areas. At the end of May 2007, 20 trainees from 20 Member States attended the 7th FAO/IAEA Interregional Training Course on Mutant Germplasm Characterization Using Molecular Markers at the Agency's Laboratories, Seibersdorf.

Tackling Soil Degradation

With only 11% of the Earth's surface currently cultivated, and about 24% (3900 megahectares) potentially arable, it is crucial to develop technology packages to minimize soil degradation and to sustain crop production in tropical acid soils. In 2007, the Agency supported technical cooperation projects using nuclear and isotopic techniques for soil management in Benin, Brazil, Burkina Faso, Cuba, Mexico, Nigeria and Venezuela. These techniques revealed genotypic differences in nitrogen and phosphorus use efficiency in cereals and legume crops. Studies in Brazil and Mexico also showed that the inclusion of multipurpose legume species as cover crops/green manures in the cropping system contributed a higher level of nitrogen to soils, with good potential to reduce fertilizer inputs without reducing yield in subsequent cereal crops. The isotopic techniques were proven to be essential tools in collecting quantitative information related to nitrogen and carbon cycling and dynamics in tropical acid soils, as influenced by zero tillage and other soil conservation measures which greatly enhance soil organic matter accumulation and soil carbon stocks.

An updated and improved web based database on standardized phosphate rock (PR) solubility measurements provided greater accessibility

of information to a larger audience, including researchers, rural educators (agriculture extension workers), farm managers, farmers, policy makers and fertilizer companies. It also enabled users to make better informed decisions on the direct application of PR as compared with commercial water soluble phosphorus fertilizers.

Improving agricultural water management is a high priority given that the agricultural sector accounts for 75% of freshwater consumption. In 2007, the Agency developed guidelines providing water resource managers, land holders, agriculture extension workers and researchers with information on how to obtain the best performance from a variety of soil moisture monitoring equipment. The guidelines provided two important conclusions. The first was that the field calibrated neutron moisture meter (NMM) remains the most accurate and precise method for soil profile water content determination in the field. Moreover, it is the only indirect method capable of providing accurate soil water balance data for studies of crop water use, water use efficiency, irrigation efficiency and irrigation water use efficiency with a minimal number of access tubes. The second was that electromagnetic sensors (i.e. capacitance sensors) exhibit much more variability in the field than either the NMM or direct soil water measurements.

Based on these conclusions, an interregional training course on the use of nuclear and related techniques to measure storage, flows and the balance of water in cropping systems was held at the Agency's Laboratories, Seibersdorf, in October. The course provided the participants from 21 Member States with the tools to separate plant transpiration (the beneficial use of water for plant growth) from evapotranspiration using the combined isotopes of water (oxygen-18 and deuterium) and carbon (carbon-13) (Fig. 1). The course also provided new estimates for refining input parameters and validating/testing of the FAO crop water productivity model in the development of better irrigation strategies.

Sustainable Intensification of Livestock Production Systems

The use of rapid and sensitive nuclear and nuclear related diagnostic technologies for the detection and control of emerging transboundary animal and zoonotic diseases has received special attention from Member States to counter outbreaks of animal diseases. In response, two expert meetings and six national and regional training courses were held at which more than 140 animal production technicians and health diagnosticians were trained.

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Agency collaboration with FAO and WHO provided technologies, diagnostic support and training in response to the emergence of Rift Valley fever (RVF) in the Horn of Africa, which in January 2007 left at least 200 people dead in northern

FIG. 1. A participant in a training course on air, plant and soil sampling to determine oxygen-18 and deuterium for separating evaporation and transpiration components from evapotranspiration.

Kenya. These efforts included an epidemiological study to help the disease risk assessment currently being undertaken by CRP participants at the Kenya Agricultural Research Institute in Nairobi, through the collection of sera from 47 farms in six provinces known to have the mosquitoes that transmit RVF. Control efforts are also being revolutionized through the evaluation of isothermal polymerase chain reactions as highly sensitive tools to rapidly diagnose high risk diseases and deliver immediate results.

The Agency provided support to Member States through training and the supply of equipment and reagents for the measurement of progesterone levels using nuclear based techniques to identify non-pregnancy three weeks after an attempt at breeding. These techniques provide much higher rates of precision, especially when compared with conventional 60 day methods. Artificial insemination is a well established technology to improve breeding quality through the introduction of more beneficial characteristics, and in this regard Agency assistance provided farmers in Bangladesh, Cameroon, Honduras, Mongolia, Niger and the United Republic of Tanzania with the technology to improve the quality of their stock and to increase milk sales by 37% through the use of artificial insemination.

The Agency collaborated with the International Livestock Research Institute and the US Department of Agriculture in using gene based nuclear technologies to understand the genetics of economically important traits in small ruminants. Genetic markers were developed within these genes for use in testing animal populations to select animals with superior traits; from the 800 genes screened, 149 were involved in animal immunity. These CRP results, as well as the Agency's genetic resource database containing 726 blood and DNA samples from 12 countries derived from 32 small ruminant breeds for genetic mapping, will greatly benefit Member States and help the Agency to target technical assistance programmes.

Sustainable Control of Major Insect Pests using the Sterile Insect Technique (SIT)

Continental Europe's first large scale Mediterranean fruit fly (medfly) mass rearing facility was inaugurated in Valencia, Spain, in April 2007 under a cooperative agreement with the Agency, which provided the design, technology and training for the centre. This, the world's second largest 'insect factory', has the capacity to produce 500–600 million sterile male flies per week, and provides the means in the Valencia region to suppress destructive medfly populations in an environmentally friendly manner. The investment marks a major step forward in area-wide pest control for a region that accounts for 80% of the country's citrus exports, while at the same time reducing the use of insecticides and strengthening Spain's position as one of the world's top exporters of citrus fruit.

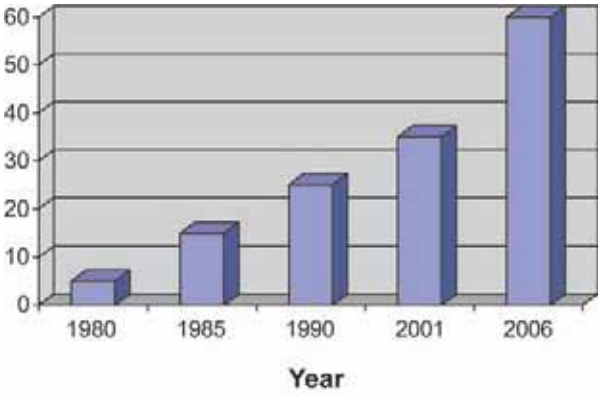

FIG. 2. Country approvals of food irradiation.

In Addis Ababa, Ethiopia, the Tsetse Mass Rearing and Irradiation Centre of the Southern Tsetse Eradication Project (STEP) was officially inaugurated on 3 February 2007 by the Deputy Prime Minister of Ethiopia in a ceremony held in conjunction with an African Union/African Development Bank donors' meeting in support of the project. The STEP project applies SIT as part of an integrated pest management approach to eventually create a tsetse fly free zone for two species (*Glossina pallidipes* and *G. f. fuscipes*) in a 25 000 km^2 area of fertile, under-used agricultural land, and to foster sustainable agriculture and rural development in the Ethiopian Southern Rift Valley.

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In the past year, increased and improved detection methods have been put in place and expert advice and training were provided through an Agency project for control of the cactus moth, *Cactoblastis cactorum*, which attacks prickly pear cacti (Opuntia). The moth was first detected in 1989 in the south-eastern USA and has since

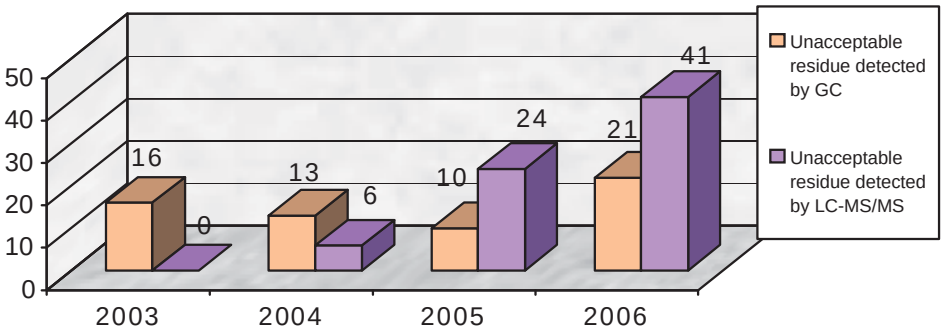

FIG. 3. Liquid chromatography tandem mass spectrometry enhances the capability to analyse pesticide residues (GC: gas chromatography; LC-MS/MS: liquid chromatography–mass spectrometry/mass spectrometry.

advanced westwards along the Gulf of Mexico. Results in 2007 indicate that the sterile moth release pilot programme has been successful, as the pest has not been detected west of Dauphin Island, Alabama, where it has been since 2004. In Mexico, an effective trap monitoring network allowed the early detection of an outbreak of cactus moth on the island of Mujeres in the Yucatan Peninsula. After intensive eradication activities the pest has not been found on the island.

Improving Food Quality and Safety

The approval and commercial application of irradiation as a quarantine treatment for agricultural commodities is gaining acceptance worldwide (Fig. 2). In recognition of the importance and potential use of irradiation on a commercial scale, some 75 specialists attended an FAO/IAEA regional workshop in Mexico City in 2007. An important result of the workshop was a recommendation to strengthen activities at the regional level, including the implementation of a programme on the use of irradiation as a phytosanitary measure through the FAO Regional Office for Latin America and the Caribbean.

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Laboratory capacity is necessary to enable countries to provide feedback on the implementation of sound production practices and to meet food quality requirements for enhanced consumer protection and increased international trade. In 2007, results were collated from a five year CRP on the development of strategies for the effective monitoring of veterinary drug residues in livestock products in developing countries. The project involved 16 countries and resulted in the development of capabilities to produce in-house reagents and test kits for immunoassay screening of important antibiotic residues in laboratories in Africa, Asia and Latin America. Guidelines on the validation of screening methods were developed and adopted by the project partners and confirmatory mass spectrometric methods were developed and validated in laboratories in Asia and Latin America.

Related activities included an interregional training workshop in September at the FAO/IAEA Training and Reference Centre for Food and Pesticide Control at the Agency's Laboratories, Seibersdorf. Scientists from 20 Member States were trained on methodologies for veterinary drug residue analysis. Several analytical methods were developed or adapted and validated at the laboratories, and presented at international conferences, published in the scientific press and used in training courses. Support was also provided for technical cooperation projects in nine countries on residues of veterinary drugs in foods.

The use of effective pesticide management practices will also be facilitated through the application of the results of a CRP, completed in 2007, on testing the efficiency and uncertainty of sample processing for the analysis of food contaminants. The CRP resulted in the collation of studies on the behaviour of pesticide residues under different sample preparation conditions and variables (Fig. 3). This information will help food control laboratories to take account of variabilities related to sample preparation procedures in the evaluation of analytical results so as to ensure a realistic estimation of the overall sampling

uncertainty and to avoid trade disputes over maximum residue limits for pesticides.

Agency efforts in the areas of consumer protection and international trade are expected to be enhanced by the IAEA Collaborating Centre for eLearning and Accelerated Capacity Building for Food and Environmental Protection (EACB), inaugurated in 2007 at the Centro de Investigación en Contaminación Ambiental (CICA) of the University of Costa Rica. CICA was designated as the lead institution, or 'Collaborating Centre', acting in cooperation with the Advanced Radiation Technology Institute of the Korea Atomic Energy Research Institute and the Food Science and Technology Programme of the National University of Singapore.