Food and Agriculture

Objective

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

Enhancing Food Security through Mutant Crop Varieties

In 2008, Asia, Africa, Latin America and the Caribbean region, supported by the Agency, saw the introduction of mutant varieties which helped to increase food security (Fig. 1). For example, in India new mungbean mutant varieties with a short cultivation period and enhanced disease resistance are being grown in rice paddy fields during the fallow period, providing additional food for local consumption while boosting the income of farmers.

The Agency supported five regional technical cooperation projects on plant breeding in Africa, Asia and the Pacific, and Europe. These projects facilitated the exchange of germplasm, trained researchers in developing countries in the latest technologies and gave them access to valuable genetic material.

In Cuba, scientists and breeders from the national breeding institute, National Institute of Agricultural Sciences, working with farmers, developed a new line of drought tolerant tomato (R4-300). This new mutant tomato variety, which almost doubled the region's regular tomato yields to 65 tonnes per hectare (t/ha), was sold at $11.38/t in the first year of production, representing an increase of almost $7.78/t.

Fifteen plant breeding specialists from six member countries of the Cooperative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (ARASIA) attended a regional technical cooperation training course on plant breeding based on mutation induction and efficiency enhancing biomolecular technologies. The aims of this course were to: create an R&D facility; gain practical experience in implementing a technical cooperation project; and facilitate interaction and cooperation between the key researchers from the participating countries.

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FIG. 1. Mutant varieties of soybean in Vietnam.

crop varieties, including the discovery of genes controlling important traits, and understanding the functions and mechanisms of action of these genes. The symposium participants discussed the application of induced mutations in addressing such challenges as the bio-remediation of contaminated lands, improving crop production systems and crop resilience to climate change and variability.

Soil and Water Management and Crop Nutrition

Nitrogen and phosphorus are essential plant nutrients for food and fibre production. Developing countries use more than 55 million tonnes of nitrogen fertilizers with an estimated annual value of $16 billion. In 2008, the Agency published *Guidelines on Nitrogen Management in Agricultural Systems* to assist Member States in improving fertilizer nitrogen use efficiency and minimizing adverse effects on the environment. The publication describes how isotopic tracers can be used to improve overall nitrogen use efficiency, optimize biological nitrogen fixation and enhance sustainable agriculture.

To address the issue of phosphate deficiencies common in degraded soils, the Agency, in partnership with the International Center for Soil Fertility and Agricultural Development, developed a web based phosphate rock decision support system (PRDSS) as a tool for farmers and land managers to determine the appropriate phosphorous fertilizers to be used to increase crop productivity. This system is being used as part of a crop nutrition management package in Benin, Burkina Faso, Burundi, Chad, the Democratic Republic of the Congo, Mali, Rwanda, Senegal, Uganda and the United Republic of Tanzania.

Use of Isotopic Techniques to Increase Crop Productivity

Developing countries account for 95% of the world's production of rice and over 40% of the world's wheat production. The production of these cereals has recently been severely reduced by drought and a lack of irrigation water. As a result, enhancing water use efficiency has become a priority for rice and wheat cultivation in many parts of the world. Through a network of coordinated research activities involving 12 Member States, the Agency demonstrated the utility of carbon isotope discrimination (CID) to assess plant water use (Fig. 2), in particular the ability to discriminate carbon-13 from carbon-12 and their respective absorption of carbon dioxide in photosynthesis. This

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FIG. 2. Training Agency fellows in the use of the CID technique for evaluating wheat genotypes for greater water use efficiency.

FIG. 3. Soybean farming in Brazil using conservation agriculture to increase crop yield, improve soil quality and enhance land carbon sequestration.

successful CRP led to the CID technique being incorporated into wheat breeding programmes in China, India and Pakistan, in addition to government support in training scientists and supplying isotope ratio mass spectrometers for analysing carbon-13 and carbon-12. The CID technique is also being used by rice breeders in Bangladesh and China, and by the International Rice Research Institute to evaluate rice genotypes for salinity tolerance. CID promises to contribute to a significant saving of resources that would otherwise be used in more time consuming processes for evaluating or screening rice.

Soil Conservation Techniques for Sustainable Agricultural Management

In order to improve soil conservation techniques, the Agency supported a range of field activities in 2008 in Africa, Asia and Latin America. Both fallout radionuclides (caesium-137 and beryllium-7) and stable isotopes (nitrogen-15 and carbon-13) were proven to be essential tools in quantifying the effectiveness of soil conservation measures. The Agency also supported national research institutes in the use of fallout radionuclides, stable isotopes (nitrogen-15 and carbon-13) and soil moisture neutron probes to track soil redistribution (erosion and deposition), carbon, as well as water and nutrient movement under diverse soil conservation techniques in Algeria, Argentina, Australia, Austria, Bangladesh, Brazil, Chile, China, El Salvador, Indonesia, India, Kenya, Madagascar, Malaysia, Mali, Mexico, Mongolia, Morocco, Myanmar, Pakistan, Philippines, Poland, the Russian Federation, Sri Lanka, Tajikistan, Thailand, Turkey, Uganda, the United Kingdom, the United States of America, Uzbekistan and Vietnam.

Conservation agriculture (CA), an agricultural practice covering approximately 100 million hectares around the world, protects soil against erosion and improves soil fertility through the permanent presence of crop residues and crop rotation. In addition, CA reduces energy costs by reducing soil cultivation (tillage). Preliminary results obtained in 2008 from a CRP involving 12 national research institutes in Argentina, Australia, Brazil, Chile, India, Mexico, Morocco, Pakistan, Turkey and Uzbekistan indicated that CA enhances biological nitrogen fixation (as measured by nitrogen-15) by up to 10–15% and increases available soil moisture content by up to 20–30% at harvest (as measured by neutron probes). The research also demonstrated the unique role of nuclear techniques in quantifying the role of CA (Fig. 3) in enhancing soil carbon sequestration (based on carbon-13) and in reducing soil nitrogen losses (based on nitrogen-15 balance studies). CA was able to retain more soil organic carbon compared with conventional tillage because of less soil disturbance. Under rotations — including

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a winter legume — CA could sequester up to 17 mg of carbon per hectare more than conventional tillage in tropical red soils of the Brazilian semi-arid Cerrado region. Carbon-13 based studies indicated that this increase in soil carbon over 13 years of CA was attributable mainly to the returns of organic matter from crop residues. Soil organic carbon derived from the native vegetation was found to reduce substantially (by 11%) after 13 years of conventional tillage.

Sustainable Control of Major Insect Pests Using the Sterile Insect Technique

Over-reliance on pesticides, together with pre-harvest and post-harvest losses due to the continued incidence of pests, requires the development of improved methods of pest control. These methods involve biologically and ecologically based tactics such as the sterile insect technique (SIT) and related biological controls that can be applied as part of an area-wide integrated pest management (AW-IPM) approach.

FIG. 4. A female cactus moth (photograph courtesy of J. Carpenter).

The Agency achieved a breakthrough in 2008 with the development of rearing techniques for the olive fly, *Bactrocera oleae*, a severe pest of olive trees, resulting in the possibility of using SIT programmes against this pest. Significant improvements were made in streamlining egg collection techniques and in egg and larval handling, leading to a marked improvement in the productivity of female olive fruit flies in the laboratory.

In 2008, the Agency published 26 scientific papers in international peer reviewed journals on the development of SIT for tackling major pest insects.

With the support of FAO, the Agency and other partners, the United States Department of Agriculture (USDA) has been developing the SIT component for integration with other cactus moth control tactics. In Mexico, the establishment of an efficient cactus moth monitoring network allowed the detection of outbreaks of cactus moth on the Yucatan Peninsula. Intensive control activities, which included the shipment of sterile moths from the USA to these areas, resulted in the elimination of these outbreaks in late 2008 (Fig. 4).

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In support of the African Union led Pan African Tsetse and Trypanosomiasis Eradication Campaign initiative for the control of tsetse flies, the Agency developed in 2008 a dynamic mathematical model for the design of control strategies and to facilitate day to day decision making in the implementation of AW-IPM. This innovative model, which can be used interactively by both technicians and managers working in operational tsetse management programmes, introduces for the first time insect dispersal and some spatial complexity modelling.

To help African Member States manage tsetse species of economic importance, the Agency transferred the SIT to Ethiopia (*Glossina pallidipes*), Mozambique, South Africa (*G. austeni* and *G. brevipalpis*), and Senegal (*G. palpalis gambiensis*). The project in Senegal aims to eliminate *G. p. gambiensis* from the Niayes, an area located north-east of Dakar with a high density of livestock. In the initial phase of the project, emphasis was placed on training, followed by a feasibility assessment phase.

Following six years of Agency technical cooperation activities, Panama declared the Peninsula of Azuero and the southern part of Veraguas Province to be free of the Mediterranean fruit fly in 2008. Four years of systematic

surveillance confirmed the eradication of the fly, qualifying the region for the export of tomatoes, peppers and papaya without quarantine measures. In addition, this programme supported efforts to eradicate the West Indian fruit fly (*Anastrepha obliqua*) from the area. This is expected to boost the area's ambition to become one of the most important fresh fruit and vegetable exporting areas in Central America.

To support international trade in agricultural commodities, the Agency helped to develop international standards for phytosanitary measures (ISPMs) through the International Plant Protection Convention (which currently has 180 Contracting Parties). Following extensive country reviews, in 2008, a standard on the *Establishment of Areas of Low Pest Prevalence for Fruit Flies (Tephritidae)* (ISPM No. 30, 2008) was approved by the Commission on Phytosanitary Measures. In addition, the Agency provided expertise for the Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies, which developed several draft ISPMs in 2008.

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A *Model Business Plan for a Sterile Insect Production Facility* was published in 2008 to facilitate private sector involvement in the production of sterile insects in pest control activities. While providing an international perspective on issues such as initial capital costs and recurring operational expenditures for a sterile insect facility, the manual also offers tools to evaluate the feasibility of proceeding with the construction or expansion of a sterile insect production facility.

Early Diagnosis of Transboundary Animal Diseases

The early, rapid and sensitive diagnosis of transboundary animal diseases and those of a zoonotic nature remained a high priority for Member States in 2008. The Agency supported national efforts in these areas by hiring experts, organizing regional training courses and setting up CRPs on contagious pleuropneumonia, Rift Valley fever and peste des petits ruminants. Techniques using nucleic acid amplification for the detection and differentiation of highly pathogenic avian influenza and human pandemic agent H5N1 now permit diagnosis in one day as compared with one week using classical methods. The inability to stamp out avian influenza during the 2008 campaign highlighted the difficulties of finding it in the field, as it occurs mostly in 'backyard' chickens, which represent 70% of the world's chicken meat. Thus, the ability to perform rapid testing was reconfirmed as a major advantage, and the Agency is assisting in the validation of these technologies for wide scale use in developing Member States.

Gene Based Technologies in Livestock Breeding

Sheep and goats are among the most important livestock species, especially in developing countries. The genetic diversity of these species has not been fully exploited to increase the livelihoods of people due to the lack of organized breeding plans, among other key factors. In 2008, the Agency transferred information and best practices on nuclear and nuclear related DNA techniques and methodologies to several Member States. The Agency also developed an online genetic repository bank on sheep to graphically view the location of samples on Google reference maps, as well as an Internet based application for the Agency to liaise with Member State laboratories.

In a CRP on Gene Based Technologies in Livestock Breeding: Characterization of Small Ruminant Genetic Resources in Asia, results from the analysis of the genes that are responsible for production traits of small ruminants and information on the traits of those animals (i.e. lean meat, good quality milk, heat resistance, big heads, etc.) were collected from about 4000 sheep and goats from 89 breeds/populations, while nearly 40 goat and sheep breeds were genotyped for 15 microsatellite markers in order to search for favourable breeding traits. The collection of these data is important in facilitating the selection of superior animals for improving indigenous and locally adapted breeds with a direct impact on farmer households.

Artificial Insemination

Artificial insemination is the most widely used technique for genetic improvement and for increasing the productivity of livestock. It is associated with improved animal care, enhanced data recording and better livestock feeding in

farms. However, research work using progesterone radioimmunoassay (RIA) data showed that 45% of inseminations are associated with poor 'on-farm' management, thus affecting the efficiency of breeding programmes. In 2008, the Agency supported the establishment of laboratories in nearly 60 Member States for the use of RIA and enzyme linked immunosorbent assay, and developed computer applications to solve problems in farm management. As a result, shorter intercalving periods of three to four months and up to 20% better conception rates were obtained.

In the area of training and capacity building, 53 scientists received two to four months of fellowship training outside their own countries. Additionally, 113 experts in livestock attended Agency training courses or scientific meetings.

Improving Food Quality and Safety

The approval and commercial application of irradiation for food and agricultural commodities continues to gain acceptance worldwide, especially as related to the control of quarantined insect pests. The Agency's research activities contributed to the finalization of International Plant Protection Convention (IPPC) standards allowing the use of irradiation as a phytosanitary (quarantine) treatment.

Countries, such as Chile, Colombia, Egypt, Ghana, Guatemala, India, Indonesia, Jamaica, the Libyan Arab Jamahiriya, Malaysia, Mexico, Mongolia, Morocco, Nigeria, Peru, Sri Lanka, the Syrian Arab Republic and Uruguay, worked with the Agency in 2008 to assess the feasibility of using irradiation as a safe post-harvest phytosanitary treatment. The acceptance and growth of this technology has been demonstrated in part by information in the Agency's newly updated and revised databases on food irradiation clearances and facilities. These databases indicated that as of 2008, irradiation had been approved in over 60 countries to treat an estimated 500 000 t of various kinds of food — including spices, grains, chicken, beef, seafood, fruits and vegetables — in approximately 180 gamma irradiation facilities worldwide.

As part of its efforts to build capacity in Member States in the field of food safety, the Agency completed a technical cooperation project in Panama on the development and transfer of pesticide residue analytical methods utilizing carbon-14 radiotracers. It also assisted Chile in addressing deficiencies in its regulatory systems to satisfy auditors from Canada, China, Mexico, the USA, and the European Union, thereby keeping Chile's export markets open.

The Agency also combined research and capacity building through a CRP on the development of integrated analytical methods to assess the effectiveness of pesticide use, and a regional technical cooperation project on strengthening laboratory capacity to assess the implementation of good agricultural practices in the production of fruit and vegetables in Latin America. This initiative helped 15 countries to develop and optimize effective, economic, safe and environmentally sustainable production practices for fruit and vegetables and other agricultural commodities. Analytical methods for chemical hazards, including trypanocides, antimicrobial drugs, growth promoters and pesticides in foods, were also developed and transferred to Member States in 2008.

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More than 60 scientists and analysts were trained in radiotracer techniques and related analytical procedures by the Agency at its laboratories at Seibersdorf or in Member State laboratories. In addition, information on the role of nuclear techniques and analytical laboratories in food safety systems was widely disseminated, for example, through a 'Food Safety Summit' in China attended by more than 50 government scientists and food safety regulators.

Emergency response planning activities included Agency participation in a meeting of the Inter-Agency Committee on Response to Nuclear Accidents, in London in November 2008. The Agency also joined FAO, UNEP and WHO in a United Nations team to respond to a request from Mongolia to carry out field investigations into environmental and food chain contamination affecting human and animal health. Preliminary conclusions indicated that there are a number of possible causes of the observed symptoms in humans and animals, including industrial contamination of the environment and food chain and/or infectious animal disease. A follow-up FAO technical cooperation project was initiated.