Food and Agriculture

Objective

To promote and contribute to the improvement of food security and safety to enhance Member State capabilities in the application of nuclear techniques for sustainable agricultural development.

Animal Production and Health

A major event in 2011 was the declaration of global freedom from rinderpest by FAO and the World Organisation for Animal Health (OIE). This significant achievement was celebrated during the Agency's 55th General Conference in September 2011 (Fig. 1). The commitment of the Agency was mentioned by the participants as a critical factor in the effort's success. Officials, including over 50 ministers and ambassadors, as well as dignitaries from FAO, OIE, the African Union–Interafrican Bureau for Animal Resources and the European Union celebrated this achievement.

FIG. 1. The Director General, Mr. Yukiya Amano with, from left, Mr. Ahmed El Sawalhy (African Union–Interafrican Bureau for Animal Resources), Mr. Kazuaki Miyagishima (OIE), Ms. Ann Tutwiler (FAO), and HE Mr. Gianni Ghisi (Ambassador of Italy and Chairman of the Agency's Board of Governors) during the celebration of the global freedom from rinderpest.

The Agency, in its joint programme with FAO, continues to develop and implement technologies for animal disease control. The new generation LAMP test to diagnose trypanosomosis, avian influenza, rabies, Rift Valley fever and foot and mouth disease (FMD) builds on the foundation established by the rinderpest programme. Field results indicate that the test kits are robust and do not need cooling of the reagents. Internet or mobile phone connections make it possible to take action immediately after a disease outbreak is detected. This helps Member States shift their efforts from reacting to a disease to detecting the disease at an early stage, even before the appearance of clinical signs (Fig. 2).

Technology transfer continued to be a priority in 2011. Member States received support through technical cooperation projects in the control or eradication of animal diseases, including those affecting people. For example, during the FMD outbreak in Mongolia, strategic vaccination guided by a surveillance programme was implemented. To help Mongolia control FMD, 200 000 doses of vaccine were delivered to the counterpart through a technical cooperation project. The action proved effective and the spread of FMD was contained. Over one million animals were saved directly, and another ten million indirectly. The Agency is assisting Mongolia in the development of a pilot facility for production of irradiated vaccines. Additionally, the Agency

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FIG. 2. On the spot diagnostic tools have significantly improved the early and rapid response to animal diseases.

is cooperating with FAO, OIE and neighbouring countries to establish a regional network for animal disease control.

In 2011, technology transfer in the field of animal production was directed towards four areas: (1) improved feeding practices; (2) improved reproduction through artificial insemination; (3) evaluation of genetic profiles to improve animal production; and (4) selection of other measures to improve animal production. In the tropics, climatic variations reduce plant growth and feed availability,

FIG. 3. Zambian farmer in a field of locally available feed.

leading to reduced productivity. Farmers in Zambia have traditionally kept animals on marginal pastures. Through a technical cooperation project, the nutritional value of locally available feed is being assessed to evaluate its ability to provide sufficient energy and/or protein for animals (Fig. 3). Results suggest that supplementing low quality diets with velvet bean is comparable to the use of commercial concentrates.

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In Niger and Cameroon, artificial insemination centres are utilizing local breeds. Improved reproduction has resulted in an increase in milk production of three litres per cow per day.

Food Safety and Food Control

In 2011, a CRP on 'Integrated Analytical Approaches to Assess Indicators of the Effectiveness of Pesticide Management Practices at the Catchment Scale' established and strengthened a network of analytical laboratories in Latin America (Argentina, Brazil, Chile, Costa Rica and Ecuador) and in Bulgaria, China, Kenya and the Philippines. The laboratories identified a series of biological and chemical indicators to assess the presence of selected high impact pesticides in surface water, sediments and foods. These indicators were subsequently integrated into a monitoring strategy to assess the effectiveness of pesticide management practices at the microcatchment scale, resulting in enhanced communication and effective feedback mechanisms between laboratories and agricultural producers.

More specifically, laboratory capacity was improved in nine laboratories, resulting in the validation of 24 analytical methods, the publication of 17 papers in scientific journals, 46 poster presentations at conferences, one book chapter, 34 keynote speeches, and the mentoring and training of 11 BSc and 6 MSc candidates. Further benefits included the improvement of quality assured procedures and the generation of local data on environmental pesticide applications, which are being used to establish and improve good agricultural practices, as well as more effective and targeted campaigns on the safe use of pesticides in the field. The pesticide contamination data generated by the CRP are being used by national regulatory authorities to support a holistic approach to food production through the use of nuclear and complementary technologies that improve food safety and environmental protection.

Approved in over 60 countries, food irradiation supports sustainable agricultural production by virtue of its ability to control spoilage, food borne pathogenic microorganisms and insect pests without significantly affecting sensory or other organoleptic attributes of the food. In 2011, a relatively small but growing proportion of food produced worldwide was irradiated to help minimize the risk of food borne illnesses or to maintain post-harvest product quality, making it possible to keep food longer while at the same time ensuring a higher level of food safety and quality.

Sustainable Management of Major Insect Pests

The international trade in agricultural commodities provides food, consumer goods and a livelihood to millions of people, but also promotes the spread of pests that damage commercial crops and the environment. Tephritid fruit flies cause severe damage to fruits and vegetables and are major quarantine pests that interfere with the export of horticultural commodities. The most cost effective management of fruit flies combines pre-harvest and post-harvest pest risk management measures. In support of these strategies, the Agency and FAO have developed guidelines that outline how the exporting country can integrate measures at the time of pre-harvest, harvest, post-harvest, export and transport, or/and at entry and distribution in the importing country.

Over the years, FAO/IAEA projects have assisted Guatemala in implementing the sterile insect technique (SIT) to suppress or contain pest fruit flies. In 2011, two areas comprising 300 000 hectares were officially declared free of the Mediterranean fruit fly, facilitating exports of fresh fruit and vegetables from these areas without the need for costly post-harvest treatments (Fig. 4).

A CRP on the 'Development of Standardized Mass-Rearing Systems for Male *Anopheles arabiensis* Mosquitoes' was completed in 2011. During the five year CRP, significant progress was made in developing and validating new mass rearing and sterilization procedures for mosquitoes. Among the equipment developed was: a larval tray–rack system; a device with the capacity to separate a mixture of one million larvae–pupae per hour; and a new larval diet to facilitate the establishment of colonies. Knowledge gained and several practical procedures that were developed are being transferred to Member States.

FIG. 4. Earnings in Guatemala from the export of non-traditional crops such as bell peppers, tomatoes and papayas (picture above) have increased several-fold due to Agency technology transfer that has enabled phytosanitary trade barriers to be overcome and thousands of rural jobs to be created.

A special issue of the journal *Genetica* on 'Molecular Technologies to Improve the Effectiveness of the Sterile Insect Technique' was published, representing the outcome of a CRP. The issue, which contains 15 scientific papers from leading researchers in the field of classical and modern biotechnology, reviews the state of the art in the use of genetics and molecular biology to generate improved strains for the application of SIT that produce only male insects for sterilization and release, or that carry identifiable markers to discriminate released and wild insects in the field.

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Efficient mass rearing of the target insect is fundamental for SIT, but its complexity for moth pests is often underestimated. A joint FAO/IAEA textbook, *Rearing Codling Moth for the Sterile Insect Technique* (FAO Plant Production and Protection Paper 199), was published in 2011. The book compiles information on the rearing of the codling moth in relation to the SIT. The integration of SIT with other control tactics offers great potential for the codling moth, and the book aims to support ongoing and future management programmes.

Crop Improvement through Mutation Breeding

A major achievement in 2011 was the development of ten advanced mutant wheat lines (some induced at the Agency's Laboratories in Seibersdorf) resistant to the black stem rust, race Ug99, by an interregional technical cooperation project that included 18 Member States and three international and two national institutions. The virulent race Ug99 appeared in East Africa in 1999 and quickly spread to Ethiopia, Kenya, Sudan and Uganda, overcoming the stem rust resistant genes that were protecting

breeding programmes. Recently, Ug99 caused 80% yield loss in Kenya, with outbreaks occurring in parts of Asia and in the Islamic Republic of Iran and Yemen. According to FAO, annual losses could reach $3 billion. As the plague may spread globally, new resistance is urgently required. The radiation induced mutant lines show promise in national yield trials in Kenya, where the disease is endemic (Fig. 5).

FIG. 5. Demonstration of Ug99 resistant wheat mutant lines in Eldoret, Kenya, at the second technical meeting of an interregional technical cooperation project.

In 2011, 14 new mutant varieties were officially released to farmers, most of which were produced directly with support from the Agency through the technical cooperation programme and CRPs. Data on these and on a further 132 mutant varieties (released in previous years) were added to the mutant varieties database in 2011 (see *http://mvgs.iaea.org*). The database now contains 3424 entries for 224 plant species. The latest additions were two mutant Egyptian safflower varieties, 'Insha 10' and 'Insha 11', released in 2011. An oil crop rich in linoleic acid (an essential fatty acid), safflower is used in cooking and has medicinal properties such as lowering cholesterol.

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In 2011, the Agency distributed low cost kits to Austria, Bulgaria, Poland, the Philippines and the Syrian Arab Republic for mutation detection in banana, lupin and wheat. In Poland, they were used for rapid selection of lupin mutants for anthracnose disease resistance. The kit contains a positive control, is quick, does not require specialized equipment and, most significantly, is very inexpensive.

A low cost mutation detection kit was developed by the Joint FAO/IAEA Programme for use in developing countries. This has been distributed to ten countries and applied to 12 crop species. In addition, over 100 fellows were trained.

Soil and Water Management and Crop Nutrition

The compound-specific stable isotope analysis (CSIA) technique, supported by methods using naturally abundant stable isotopes such as nitrogen-15 and carbon-13, has been used to identify critical hotspots of land degradation (Fig. 6). Such information is crucial in order to implement appropriate and cost effective on-farm conservation strategies. Results obtained in a 2011 CRP showed that mulch based cropping systems can reduce soil erosion by 90% in the mountainous uplands of northern Vietnam, while still retaining sufficient runoff water for lowland rice production.

FIG.6. Innovative isotope techniques identify hotspots of land degradation in mountainous northern Vietnam.

Through another CRP, farm ponds, on-farm wetlands and riparian buffer zones, all covering an area of 1–3% of the catchments studied, were found to be effective at capturing more than 90% of water originating from rainfall and surface runoff from these catchments during the rainy season. The water captured was shown by isotopic signatures of

oxygen-18, hydrogen-2 and nitrogen-15 to be a major source of nitrogen (up to 50% for plant growth) and was found to save up to $200/ha/year on fertilizer alone.

A technical document entitled *Impact of Soil Conservation Measures on Erosion Control and Soil Quality* was published in 2011. The report provides information on the use of fallout radionuclides in 16 countries in efforts to minimize soil erosion/degradation and develop sustainable watershed management strategies.

Through a regional technical cooperation project, the radionuclides caesium-137, lead-210, beryllium-7, potassium-40 and radium-226 have been used effectively as fingerprints to identify sources of sediment delivery to water bodies in forested catchments in south-central Chile. Information obtained in this project is currently being used to improve management practices in the Chilean forestry sector, which was valued at $5.5 billion in 2008 and accounts for 7.3% of Chile's exports.

Under a regional technical cooperation project, the isotope nitrogen-15 was successfully used to show that green manure application could increase rice yield by 20%, reduce mineral nitrogen fertilizer requirements by 50% and increase fertilizer nitrogen use efficiency by 25–45%. In Cuba, this translated into an additional income of $450/hectare to resource poor farmers.

For the first time in the Agency's history, a two week expedition to Antarctica was carried out by Chilean and Agency experts within the context of a regional technical cooperation project to assess the impact of climate change on soil degradation and soil quality in Antarctic ecosystems (Fig. 7). Information obtained through the use of stable and radioisotope tracers will be particularly useful in understanding the impacts of climate change on land degradation in the high Andes and elsewhere.

FIG. 7. Soil sampling in Antarctica (Ardley Island) for fallout radionuclide analysis will help to assess the impact of climate change on soil redistribution.

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