

# Food and Agriculture

## Objective

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

## Mutation Breeding and Its Impact on Food Security and Poverty Alleviation

The benefits from the widespread adoption and cultivation of better adapted and more productive mutant varieties translate into billions of dollars in additional income to farmers. In 2009, an Agency managed database for officially released mutant varieties was expanded to include 3100 entries on 170 species from 60 countries, covering every continent (<http://mvgs.iaea.org/>). The database provides an important service to producers and research institutions worldwide.

Based on Agency support to the national plant breeding programme in Bangladesh, the counterpart was able to release the rice mutant variety BINA Dhan-7 (Fig. 1). It is early maturing and high yielding, and therefore suited to difficult conditions in particular locations, such as in Bangladesh during the pre-monsoon period. This variety can be harvested about one month earlier than other rice varieties, and has similar yield and

high quality, enabling farmers to harvest three instead of two crops every year. Forecasts by FAO indicate that this variety may cover about 80% of rice acreage in parts of Bangladesh over the next three years.

In South Africa, one amaranth and two cowpea varieties developed for tolerance to drought, identified earlier and now ready for registration and release as new mutant varieties, represent an especially important resource for low income farmers living in drought prone or marginal lands. This success was achieved under a technical cooperation national project in cooperation with the South African Agricultural Research Council/Vegetable and Ornamental Plant Institute.

One focus of the Agency's activities in this particular area has also been to enhance

the use of induced mutations for plant functional genomics and trait identification through reverse genetics. A reverse genetics strategy, known as 'targeting induced local lesions in genomes' (TILLING), improves the efficiency of induced mutations to identify crops with superior traits, and expands knowledge of gene function. In 2009, the Agency developed and distributed a TILLING positive control kit, which can be used as a reference by Member States. This technology was transferred by means of group and individual training, oral presentations and technical support.

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FIG. 1. The new mutant rice variety, BINA Dhan-7, is tolerant to drought and has been released in Bangladesh.



FIG. 2. Taking soil samples from the High Pamir Mountains of Tajikistan to assess spatial FRN distribution and hence soil erosion deposition. (Photograph courtesy of Lomonosov Moscow State University, Russian Federation.)

To address the effects of drought and salinity on crops and soil, among the major concerns for Member States, the Agency developed and disseminated enhanced screening and selection techniques to allow plant breeders and scientists to identify a valuable mutant line with the characteristics to produce more, even under adverse conditions. These screening methods stemmed both from the contributions of counterparts and from the Agency's research programme on rice.

### Food Security and Sustainable Agriculture in Tajikistan

Only 7% of Tajikistan's land is suitable for agriculture. Furthermore, soil erosion and land degradation represent major threats to sustainable agricultural production. In 2009, the Agency supported Tajikistan in its efforts to use fallout radionuclides (FRNs), such as caesium-137 and beryllium-7, as tracers to obtain quantitative estimates of soil erosion in agricultural landscapes. Soil conservation measures such as strip cropping, mulching, gully rehabilitation, planting of shrubs and trees, planting of windbreak poplars and pasture rotation were found to be effective in reducing the soil erosion rate from 150 tonnes to 8–15 tonnes per hectare per year, and in preventing

the loss of valuable plant nutrients and organic carbon from the agricultural topsoil.

Based on the successful use of FRNs in quantifying soil erosion rates, Turkey joined this project and provided training support through its Ministry of Agriculture and Rural Affairs on the use of the geographical information system (GIS) for upscaling the isotopic data obtained for the area-wide

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control of soil erosion in Central Tajikistan. In addition, the success of this project attracted interest from UNEP, which integrated the project into one of its own projects on sustainable land management in the High Pamir and Pamir–Alai Mountains (Fig. 2). The project addresses the interlinked problems of land degradation and poverty in one of Central Asia's critical mountain regions through the promotion of sustainable land management practices, with the aim of improving the livelihood and economic well-being of smallholder farmers.

### Impact of Conservation Agriculture on Soil Quality and Water Use for Crop Productivity

Conservation agriculture (CA) is a farming system that includes minimum soil cultivation, permanent soil cover with crop residues, and the use of legume crops in crop rotations. A CRP completed



FIG. 3. Conservation agriculture for cereal crop in dry lands (in this case north-west Pakistan) to improve crop yield, soil organic carbon, soil nitrogen status and water use efficiency. (Photograph courtesy of the Nuclear Institute for Food and Agriculture, Peshawar, Pakistan.)

in 2009 addressed the issue of integrated soil, water and nutrient management in CA. The CRP participants, from Argentina, Australia, Brazil, Chile, India, Kenya, Mexico, Morocco, Pakistan, Turkey and Uzbekistan, demonstrated that CA can be implemented if constraints such as soil compaction, low soil fertility and lack of soil organic matter are removed. Using the stable isotopes nitrogen-15 and carbon-13, as well as soil moisture neutron probes, the CRP also provided data on the beneficial effects of CA in improving soil organic matter content, reversing soil fertility degradation and enhancing soil water holding capacity. Crop residues were shown to enhance soil nitrogen fertility (by 50–100%) and nitrogen removal (by 1–100%) from the atmosphere (through biological nitrogen fixation) by vegetable crops (for example, beans, lentils, lupins, peas and soybeans that capture nitrogen from the atmosphere for their growth). They also improved soil water holding capacity by 40% and nitrogen fertilizer use efficiency by a similar extent, which is attributable to the increase in soil quality (soil aggregate stability and soil microbial activity) (Fig. 3). In India, 20–30% more water was available under CA at a critical stage of grain filling. In Australia, 15% more water was available under the same conditions, and the soil sodicity (excessive presence of sodium) was reduced by half after

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13 years under CA, as compared with conventional tillage without crop residues.

### Sustainable Improvement of Animal Production and Health

The Agency organized an international symposium in June in Vienna to discuss strategies for the sustainable improvement of animal production and health, as well as research needs to increase food security in developing countries. The symposium concluded that more and better quality food would be needed in the future to satisfy global demand. This can only be achieved through the sustainable intensification of livestock production systems through the efficient use of locally available feed resources, adequate management practices and breeding programmes for raising indigenous animals with improved traits, and the development of early and rapid diagnostic tools for the control and prevention of animal and zoonotic diseases.

Methane is a potent greenhouse gas and has a serious impact on climate change; therefore, reducing enteric methane production in cattle is beneficial from an environmental perspective. More than 200 plants and plant extracts comprising browse, multipurpose trees, medicinal plants and spices from Africa, Asia and Latin America

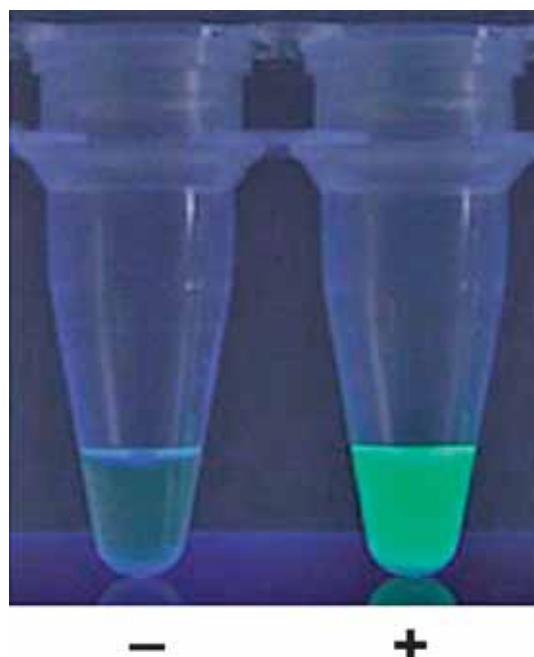


FIG. 4. A fluorometric green dye allows visual interpretation of the loop mediated isothermal amplification (LAMP) test result for the early and rapid detection of transboundary animal diseases such as the highly pathogenic avian influenza (HPAI).

were screened in 2009 for the effects of secondary metabolites using rumen molecular techniques to assess how they might reduce methane produced in the rumen (stomach). Seventeen of the plants and plant extracts inhibited methane production by 10–100% in vitro and by 11–35% in vivo.

In Honduras, the Agency supported a project in 2009 that increased milk yield in high yielding herds and meat productivity by 20%. The project integrated laboratory services to identify and promote the use of higher yielding cattle, to deliver early and rapid disease diagnosis (Fig. 4), and to control programmes and the introduction of improved feeds, feeding and management practices through the integrated use of nuclear techniques.

The Agency, together with the United States Department of Agriculture, assisted Bangladesh in developing a model for delivering self-sustained veterinary services to smallholder dairy farms. Known as the Community-based Dairy Veterinary Service, this approach is being used in many other parts of Bangladesh.

The selection of cattle for desirable productive traits, disease resistance and tolerance to adverse climatic conditions is mainly being done through phenotypic data. In order to enhance selective breeding practices, however, a greater

understanding of the genetic make-up of the different animal breeds is required. The Agency, as part of an international consortium, continues to provide resources for the international bovine genome sequencing project which studies parasite resistant Sheko cattle to help African farmers take advantage of selected gene carriers to improve livestock productivity. Genetic profiling will help cattle breeders select for desirable production traits by mapping DNA sequence variations in bulls. In 2009, the Agency co-authored an article in the journal *Science*<sup>1</sup>, providing a unique source of data to stimulate research for modifying the genetic make-up of ruminant livestock.

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## Sustainable Management of Major Insect Pests

The need to effectively control key insect pests to avoid very significant crop losses often results in the excessive application of pesticides that frequently miss their target and contaminate people, foodstuffs, soil and groundwater. The melon fly,

<sup>1</sup> THE BOVINE HAPMAP CONSORTIUM, Genome-wide survey of SNP variation uncovers the genetic structure of cattle breeds, *Science* **324** (2009) 528–532.

*Bactrocera cucurbitae*, is the most important insect pest of cucurbit vegetable and fruit crops, causing severe damage in Africa, Asia and in islands of the Indian Ocean and the Pacific Ocean. To suppress this pest, farmers resort to several weekly insecticide cover sprays, which — apart from the many other disadvantages — is a costly practice.

In Mauritius, a pilot project involving 135 small scale cucurbit growers on 110 hectares demonstrated the feasibility of producing high quality cucurbits through effective, environmentally friendly melon fly suppression methods, including use of the sterile insect technique (SIT), which minimized the use of pesticides. Growers were trained through expert support and meetings, and given incentives to ensure full participation in the melon fly suppression campaign. To evaluate the progress of the project, a survey was carried out in 2009 which indicated that the cost of cucurbit production had been reduced through a decrease in the use of pesticides, and melon fly infestation had been reduced to 5%. Up to 85% of growers claimed to have obtained an increase in both the quality and quantity of cucurbits, and 60% reported an increase in their profit. Overall, 97% of growers expressed satisfaction and stated that the melon fly project was

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beneficial to them. Given the success of this pilot project, growers from other areas in Mauritius have asked to participate. In view of the positive results, the Government of Mauritius has expressed interest in expanding the use of SIT and in the extension of the programme to other cucurbit growing areas.

The presence of major insect pests such as fruit flies is a significant barrier to the export of agricultural commodities from many tropical and subtropical developing countries. In 2009, Agency efforts focused on the more effective management of major *Anastrepha* and *Ceratitidis* fruit fly pests through the integrated application of SIT, opening lucrative export markets and bringing investments for the production of fruit and vegetables of over \$185 million to Central America in 2009. Currently, all exports of tomatoes and bell peppers from Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua originate from the fruit fly low prevalence areas established with the support of the Agency and FAO.

## Food Safety and Food Control

Agency collaboration with the European Union's ProSafeBeef Project resulted in the development



FIG. 5. Analysts training in sample preparation for the multiresidue analysis of anthelmintics at the Agency's Laboratories, Seibersdorf.

and validation in 2009 of a multiresidue isotope dilution assay for 38 anthelmintic drugs<sup>2</sup> which is suitable for risk assessment, survey and regulatory application for food safety (Fig. 5). The method was transferred to a partner laboratory in Brazil, which will be used as a training hub to transfer the method to eight countries in a regional technical cooperation project in Latin America. The method was also demonstrated to 22 participants from 20 countries in a train the trainers workshop in October 2009 at the Agency's Laboratories, Seibersdorf, and will be adopted by several partners in a related CRP.

In a technical cooperation project in Nicaragua, Agency counterparts have used nuclear and complementary techniques to improve production, product quality and analytical techniques to control residues of veterinary drugs and hormonal growth promoters in bovine meat exports. They also reported in 2009 that the strengthening of the National Residues Laboratory of the Ministry of Agriculture and Forestry, including the introduction of new analytical techniques and a radioassay

developed by the Agency, have helped to increase the export of Nicaragua's meat, shrimp, peanuts and honey.

Food irradiation, which is traditionally used for food preservation and extension of shelf life, has now evolved for post-harvest insect control (quarantine) purposes. Most recently, the Agency ensured the successful adoption of eight irradiation treatments it developed for pests of quarantine importance through the International Plant Protection Convention (IPPC) Commission on Phytosanitary Measures for inclusion in the standard<sup>3</sup>.

A CRP that commenced in 2009, on the development of generic irradiation doses for quarantine treatments, will continue the development of other generic and specific doses for pests and pest groups of quarantine importance (29 insect species from 13 arthropod families) for eventual adoption by the IPPC, thereby reducing technical barriers and facilitating international trade in agricultural produce.

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<sup>2</sup> These are drugs that destroy or cause the expulsion of parasitic intestinal worms.

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<sup>3</sup> FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, *International Standard for Phytosanitary Measures, Phytosanitary Treatments for Regulated Pests*, IPPC publication No. 28, FAO, Rome (2009).