IAEA

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

IN ACTION:
Nuclear applications in agriculture

On-the-ground success, Part II

CROATIA
Sterile insect technique

A 2010 pilot effort to use the sterile insect technique (SIT) to control an endemic Mediterranean fruit fly pest population in the mandarin-growing region of the Neretva Valley in southern Croatia proved very successful with the support of the Joint FAO/IAEA Division. After two years, the area under SIT application had 75 per cent less damage than the non-SIT area, which prompted quadrupling the target area from 1 000 to 4 000 hectares (ha). The expansion had the support of the entire Croatian industry in this region, including growers, packers and exporters. In fact, one of the packers made space available to receive 30 million sterilized male Mediterranean fruit fly pupae each week from mass-rearing facilities in Israel and Spain. The effort has continued to pay off. In 2012 and 2013, it allowed farmers to reduce insecticide use in the extended area covered by SIT by 20 000 litres per year and to decrease damage from the Mediterranean fruit fly by 96 per cent compared to the non-covered area. Furthermore, larval infestation in export shipments decreased to 0.2 per cent, leading to the decision by growers and authorities to gradually expand SIT coverage to the entire production area of 8 000 ha in the valley.

Growers protect mandarin crop and wetlands

Using environmentally-friendly pest control

The Neretva River delta in southern Croatia was once a wetland, but the area was reclaimed and is being used for mandarin orchards – a unique fruit so important to the economy of the area that 90 per cent of the local population is involved in the citrus industry. The area is about 12 000 ha, with one third devoted to mandarin which flourishes there while the rest remains as wetlands and has other uses. The area currently produces around 80 000 tonnes of mandarin a year, of which 70 per cent is exported, mainly to northern Europe and Russia.

Until recently, the growers accepted that, in spite of the intensive application of insecticides, they would lose about 30 per cent of their crop every year due to damage caused by Mediterranean fruit flies. The situation became more complicated when the protected wetlands that surround the production area were recognized as an important migratory route of European birds and wildlife, which meant a need for minimizing the use of pesticides. In addition, Croatia is now part of the European Union which has restrictions on pesticide use and on pesticide residue levels in fruits – restrictions that are expected to become even more stringent in the future.

Market success depends on timing

The mandarins grown in the Neretva Valley mature about five weeks earlier than other mandarin varieties exported from other production areas. Thus, the growers have a niche during which they have prime access to the market. This timing is critical because it is also the season when the Mediterranean fruit fly is especially prevalent. The problem is more than the amount of fruit that the pests destroy; some importing countries consider the Mediterranean fruit fly a quarantine pest and ban all imports from a specific country if some of the country's fruits are found to be infested.

Unable to increase pesticide use to maintain the lucrative export market, in this region, the Croatian citrus industry has moved to integrate nuclear technology. In 2007, in response to a request from the Government of Croatia, the Joint FAO/IAEA Division initiated technical and economic feasibility studies to determine if the area would benefit from the introduction of the sterile insect technique (SIT) to control the Mediterranean fruit fly. Following a positive finding, in 2010 the decision was made to initiate a pilot test area of 1 000 ha.

SIT is an environmentally-friendly insect pest control technology that relies on mass rearing and sterilizing male insects with radiation, and then systematically releasing them on an area-wide basis into crop areas. There, they mate with wild females but are unable to produce offspring. In Croatia, this means that twice each week between April and November, the growers import 11 million sterile male Mediterranean fruit fly pupae from biotech mass-rearing facilities in Israel or Spain. Once they emerge as adult flies, they are fed until they reach sexual maturity. Before they are released into the orchards, they are also exposed to aromatherapy to make them more attractive to wild females upon release.

Since introducing the SIT, the growers have reduced annual insecticide use by 20 000 litres and rejection of shipments by importers is a fraction of what it was two years ago. Although there were some start-up costs – to adapt the infrastructure to process the sterile flies and to train staff – the farmers quickly accepted this as a long-term sustainable solution to keeping their mandarin crops viable in a world of tightening regulations on pest presence and insecticide residues.

Benefits of area-wide SIT coverage

Because of the transboundary nature of insect pests, it is best to apply the SIT on an area-wide basis. Thus, growers plan to increase SIT coverage to the entire 8 000 ha Neretva Valley and eventually expand into neighbouring Bosnia and Herzegovina where Mediterranean fruit flies attack the peach, plum and apple crops. From the beginning, the Joint Division has offered guidance for handling the sterile flies, releasing them as part of an integrated pest management approach, and setting up an area-wide information system. This has allowed all growers to see the pest situation improve, in time and space, facilitating collaboration and ensuring participation in assessing and managing the pest population in the fields.

The goal is not eradication of the pest population, but rather to minimize the crop damage by controlling the pest at a level of prevalence that allows growers to time their exports in order to get the best price for their crops. This citrus industry in Croatia is valued at more than US $40 million and with introduction of the SIT, producers project that they will be able to increase production by 20 per cent a year, reaching 150 000 tonnes by 2020.

Partners:

Institute for Plant Protection, Croatian Centre for Agriculture, Food and Rural Affairs, Croatia

Growers Association "Mandarina", Croatia

Croatian Ministry of Agriculture, Croatia

Dubrovnik Neretva County, Croatia

Servicios Aereos Biologicos Y Forestales Mubarqui, Mexico

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

MAURITIUS
Local feed production

Mauritius, one of the world's top luxury tourism destinations, possesses one of the world's most pristine environments and is free from major tropical animal diseases. It also has had a continuous increase in demand, from both tourists and locals, for locally produced milk and meat. Yet, despite having all of these drivers, domestic food production has been confronted by the high price of imported concentrated feeds, and the island must depend on the import of milk and meat. The Joint FAO/IAEA Division has been assisting Mauritius in increasing its research capacities to render its dairy and meat industries competitive through producing feed locally, utilizing by-products and residues of the sugar industry and also using land that has become available due to the decline in sugar cane production.

Mauritius local milk and meat production

Shows increased competitiveness

Mauritius is an island nation in the Indian Ocean with an area of 2 040 kilometres squared. Its upper middle income economy, with per capita income of over US $15 591 in 2012, is one of the largest in Africa. The growth of its tourism industry, backed by well-designed and run hotels, has brought with it a rapidly increasing demand for milk and meat produced in Mauritius. There has also been an increased demand from domestic consumers for home-grown animal products. Yet, in spite of the fact that it possesses one of the cleanest environments in the world and is free from major tropical animal diseases, Mauritius still depends heavily on the import of milk and meat. This is mainly due to the high price of imported concentrated feeds, which limits domestic production.

Since the beginning of the 1990s, the Joint FAO/IAEA Division has worked with the Food and Agricultural Research and Extension Institute (FAREI) to assist Mauritius in building its research capacities to address animal nutrition and reproduction issues and, in turn, improve productivity. With this support, Mauritius now envisions having vibrant private dairy and beef industries based on using by-products and residues of the sugar industry and also using land freed from sugar cane production for feed production.

The Joint Division's work with FAREI included developing a repository of fodder germplasm through selective breeding of indigenous grasses and incorporation of tropical forages from elsewhere. In addition to abundant sugar cane tops, which can be collected and used as animal feed, as many as 18 fodder germplasms were identified and collected. In addition, through work with FAREI, forage agronomy was developed or optimized by analysing individual fodders to determine their nutrients and chemical compositions. The information on fodder production and conservation, nutritive values of various fodders and their uses in animal feeding were summarized and disseminated among farmers. Also a

fodder calendar was developed based on the availability of various fodders throughout the year.

Fodder crops available year-round

As sugar cane tops are only abundant from June through November, the fodder cultivation schemes have been designed to cope with the availability of green forages during the rest of the year. Most of the fodder germplasms developed and adapted grow year-round to fill the gap when sugar cane tops are not available. Among these fodders, important ones are elephant grass (*Peninisetum purpureum*), setaria (*Setaria sphacelata*), Guatemala grass (*Tripsacum laxum*), star grass (*Cynodon plectostachyus*), herbe fatak (*Panicum maximum*), herbe d'argent (*Ischaemum aristatum*), Bermuda grass (*Cynodon dactylon*), herbe bourique (*Stenotaphrum dimidiatum*), herbe sikin (*Bothriochloa pertusa*), herbe polison (*Heteropogon contortus*), calliandra (*Calliandra calothyrsus*), acacia (L*eucaena leucocephasla*), bois noir (A*lbizzia lebbek*) and poivrier marron (*Schinus terebentifolius*).

Fodder database supports increased productivity

A database of fodders and feeds and their nutrient compositions compiled by the project now assists extension workers, farmers and practicing veterinarians in establishing on-farm feed formulation in order to achieve improved productivity of the animals. In addition, capacities have been developed for conducting radioimmunoassays of progesterone in milk and blood, involving sample collection, preparation, analyses, quality

control and data management for better understanding of animal reproduction and reproduction-nutrition interactions. The technology and database developed by the local staff are now being implemented through FAREI's Extension Services to improve herd-level productivity, reduce production costs and greenhouse gas emissions to, in turn, support sustainable growth of the industry in the context of Mauritius's open market economy.

As a small country with limited financial and animal resources, this programme is a good example of collaboration with the Joint Division delivering added value. As experiences build, the Joint Division will support Mauritius in developing small-scale production systems to produce high-value animal food in a clean environment. The Joint Division will continue providing support for strengthening animal fertility improvement services and developing feed formulations by using local feed resources to increase the competitiveness of the domestic livestock industry. The Division will also work on policy issues that include dairy value chain studies and the development of a national breeding policy. These efforts will add further value to the Mauritius livestock industry.

Partners:

Food and Agricultural Research Council, Mauritius

Agricultural Research and Extension Unit, Mauritius

Food and Agricultural Research and Extension Institute, Mauritius

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

BOTSWANA
Veterinary laboratory

The contribution of livestock, especially the cattle industry's beef exports to the countries of the European Union, is an important socio-economic activity in Botswana. However, the livestock sector faces major threats from the transboundary animal diseases (TADs) that enter Botswana from neighbouring countries. Until recently, the Botswana National Veterinary Laboratory (BNVL) dealt with TADs by using conventional disease diagnostic methods. In order to speed up diagnosis and establish methods for early warning, prevention and control of TADs and other infectious diseases, the Joint FAO/IAEA Division assisted BNVL in developing and adopting modern molecular techniques such as polymerase chain reaction (PCR) and isotopic methods. This enabled BNVL to implement a quality management system according to ISO Standard 17025, which led to accreditation of 22 tests.

Botswana National Veterinary Laboratory

Improves cattle exports

The agricultural sector of Botswana, especially its cattle industry and beef exports to the countries of the European Union, remains a fundamental source of national subsistence and income. It occupies a place of importance alongside the diamond export industry which has been the principal driver of the high growth rate that lifted the country's annual per capita GDP to US $16 400 in 2013. The major livestock species in the country include 2.5 million beef cattle, 600 000 dairy cattle, one million goats and 500 000 sheep.

Yet the sector continuously faces the threat of transboundary animal diseases such as foot-and-mouth disease (FMD) and contagious bovine pleuro-pneumonia (CBPP), which are present in neighboring countries. If they come across the border into Botswana, they can have a significant economic impact on trade, demand and supply. At the same time, other infectious diseases such as tuberculosis, rabies and brucellosis pose significant threats to public health.

Increasing laboratory diagnostic capacity

Until recently, BNVL relied mostly on conventional disease diagnosis methods. These methods are not sensitive or fast enough to provide timely and reliable results, which delays disease detection and response to disease outbreaks.

The Joint FAO/IAEA Division supported the BNVL in strengthening its diagnostic capacity by training BNVL laboratory personnel and introducing modern techniques such as nucleic acid amplification tests (also known as PCR tests) and isotopic methods, which can detect a virus or bacteria in a very early stage of the disease. These tests not only help countries to adopt effective prevention and control measures, but they also help to establish early warning systems.

Providing control for many animal diseases

CBPP is a cattle lung disease, endemic in several countries in southern Africa, including Angola, Democratic Republic of Congo, Namibia and Zambia. After 56 years of freedom from that disease, Botswana had an outbreak in 1995 which led to the loss of 300 000 cattle at a cost of US $96 million before it was successfully eradicated in 1997. In order to maintain Botswana's freedom from CBPP, the Joint FAO/IAEA Divsion worked with BNVL to improve its molecular diagnostic capacity by providing training of laboratory personnel and by supplying equipment and reagents to strengthen its surveillance capacities. As a result of the improved capacity attained through the help of the Joint FAO/IAEA Division and collaboration with national and international laboratories, BNVL was granted the status of a World Organisation for Animal Health (OIE) reference laboratory for CBPP in May 2012.

Rift Valley fever (RVF) is a zoonotic disease of domestic ruminants caused by a mosquito-borne virus. Most severe in sheep, cattle and goats, the disease causes high mortality rates in newborn animals and abortion in pregnant animals. Historically, RVF was first recognized in 1930 in Kenya's Rift Valley. Since then, outbreaks of the disease have been reported in susceptible populations of several other countries in Africa including Botswana, Namibia and South Africa.

In 2010, tests conducted at BNVL indicated a RVF outbreak in Botswana, but the final confirmation came from South Africa's Onderstepoort Veterinary Institute (OVI). OVI used PCR and serological techniques for the diagnosis, techniques which were not available at BNVL at the time. Immediately after the disease was diagnosed, the outbreak was controlled by vaccination.

Through training and equipment provided by the Joint Division, the Botswana Department of Veterinary Services (DVS) is now able to carry out passive surveillance on animal abortion cases to ensure early disease detection and control. In addition, the BNVL has established PCR

testing systems within their labs and enzyme-linked immunosorbent assay (ELISA) systems to improve diagnostic capacity for rapid detection of RVF. This facilitates timely decision making by the authorities which, in turn, helps to improve the protection of public health.

BNVL implemented a quality management system according to ISO Standard 17025 and received accreditation for seven of the tests in 2007, and continues to work towards complete accreditation. Implementation of the management system is important for ensuring the quality of test results, which is required for effectively controlling diseases in the country and also for export purposes.

The Joint Division supported BNVL in the improvement of its management system through scientific visits to accredited laboratories and expert missions. By 2012, BNVL had increased its number of accredited tests to 22 – comprising food microbiology (14), histopathology (1) and serology (7). This accreditation, which is an on-going process that requires continuous improvement, contributes to the competitiveness of the livestock industry in accessing international markets.

Partners:

Ministry of Agriculture, Botswana

Botswana National Veterinary Laboratory

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

MONGOLIA
Animal health laboratories

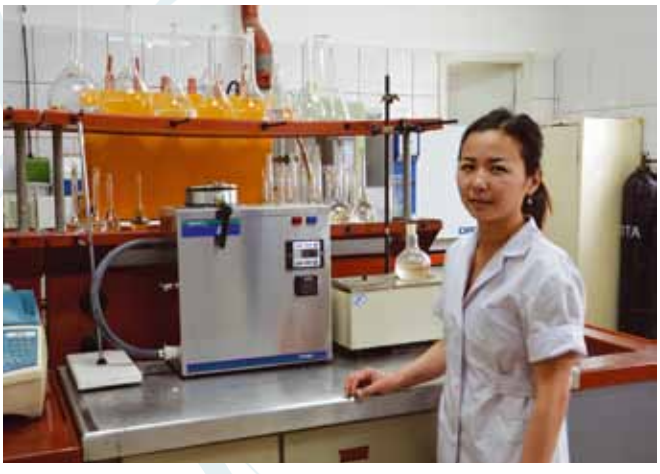
In Mongolia, 30 per cent of the population relies on nomadic livestock rearing. Livestock contributes 16 per cent to national GDP by providing meat and milk for domestic consumption and furs and skins for export earnings. Yet, over the decades, the livestock industry has been challenged by a lack of forage due to the country's long, deep winters, and by occasional flare-ups of foot-and-mouth disease (FMD). In 2009–2010, during a particularly severe winter compounded by FMD outbreaks, Mongolia lost 9.7 million animals, 22 per cent of its total livestock, which immediately affected meat prices and led to a 1.6 per cent drop in GDP. Support from the Joint FAO/IAEA Division has enabled Mongolian laboratories to improve animal nutrition and timely response to disease outbreaks. This has not only reduced animal losses but also increased farmers' incomes. The Joint Division also assisted the sector in developing and implementing short, medium and long term strategies for controlling FMD which, combined with improved diagnostic capacities, enabled the Veterinary Services of Mongolia to successfully contain FMD outbreaks in 2010–2011 and 2013–2014. In 2013, 24.8 million animals were vaccinated again.

Increased capacity to control animal disease

Improves productivity and herders' livelihoods

The Mongolian livestock industry drives the country's rural economy and contributes significantly to food security. However, growth in the industry has been confronted by inadequate feed and forage and occasional flare-ups of transboundary animal diseases, such as foot-and-mouth disease (FMD). Since 1987, the Joint FAO/IAEA Division has contributed to Mongolia's efforts to build capacity in animal production and health research and practices by training personnel and providing equipment and expert services at Mongolian veterinary laboratories. This included supporting the animal production research group at Mongolian State University of Agriculture (MSUA), and the animal health research groups at the Mongolia Institute of Veterinary Medicine (IVM) and at the State Central Veterinary Laboratory (SCVL).

At IVM and SCVL, the Joint Division assists in strengthening capacities in the diagnosis of animal diseases, especially transboundary diseases such as FMD. In addition to the development of human resources, standard operating procedures, guidelines and laboratory protocols, the SCVL also developed a biosecurity level-3 (BSL-3) laboratory to work on transboundary animal



diseases. These improved research and diagnostic capacities enabled the Veterinary Service of Mongolia to contain FMD outbreaks in 2013 and 2014. A 2014 mission from the Crisis Management Centre of FAO and the World Organisation for Animal Health (OIE) acknowledged that Mongolia was well prepared for addressing FMD outbreaks in the country.

Producing vaccines against FMD

Additionally, the Joint Division has supported the efforts of Biocombinat, a state-owned enterprise, in developing a vaccine reconstitution technology for addressing emergency FMD outbreaks in the country. The technology involves importing an inactivated, highly concentrated FMD virus antigen and then reconstituting and formulating 500 000 to one million doses of vaccines to be used for urgent containment of FMD outbreaks. The Joint Division has also supported the IVM Laboratory in developing irradiation technologies to produce vaccines against bacterial and viral diseases, and MSUA in developing its animal nutrition and reproduction laboratories.

MSUA also has increased its capacity for implementing various methodologies for treating animal feeds to improve digestibility. This, in turn, enhances the condition and productivity of animals' bodies, especially for enduring long and deep winters.

Improved feeding methods increase farmer income

Methodologies have been developed for enzyme treatments of crop residues and tested on-farm. At the end of the feeding trials, sheep weight increased by up to 13 per cent compared to controls on conventional feedings. For farmers selling meat, milk, breeding and wool from sheep, the improved feeding methods, when balanced against costs such as feed and medicines, led to an increase of up to US $23 for every sheep they had under intervention. As for cattle, the MSUV team developed and branded feed for cattle. Its benefits were demonstrated on-farm when the participating cows doubled their per-day milk production and increased farmers' incomes by up to US $170 per month. In addition, Mongolia has developed a national gene bank that preserves semen from indigenous animals, and has also implemented artificial insemination field services for cows and yak.

As many transboundary animal diseases such as FMD and peste des petits ruminants (PPR) are endemic in the region, the Joint Division is supporting efforts to build a regional disease control network. Building on the experiences in Mongolia, this network would provide a platform for China, India, Mongolia and Russia to work together to address issues of controlling transboundary animal diseases.

Partners:

Biocombinat, Mongolia

Mongolia Institute of Veterinary Medicine

Mongolian State University of Agriculture

State Central Veterinary Laboratory, Mongolia

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

MYANMAR
Livestock breeding

Recent political reforms and engagement with global markets have revitalized the economic growth of the Republic of the Union of Myanmar. This has meant increased purchasing power for the population and with it, increased incorporation of meat, milk and other animal-origin foods in the national menu. In addition to food, livestock also provides almost all the power and organic fertilizers used in crop production, which are instrumental in improving the country's rural livelihoods and food security. Assistance from the Joint FAO/IAEA Division has supported Myanmar in developing laboratories with molecular and nuclear techniques for genetic characterization of domestic animals, for delivering services to farmers that support animal breeding and for diagnosis and control of transboundary animal diseases. A new capacity to incorporate marker-assisted selection into an effective cattle breeding programme will also enable sustainable growth in the sector, allowing it to keep up with the expected growth of Myanmar's economy.

Molecular laboratory supports sustainable growth

of Myanmar livestock sector

The Government of Myanmar has prioritized its livestock sector as a tool to address poverty reduction and rural livelihood development. As an agriculture-based country, Myanmar relies heavily on livestock, not just for meat and milk production but also for draught power and manure to support crop production, all of which are critical for improving rural livelihoods and enhancing food security. The livestock and fisheries sector is responsible for 7.6 per cent of the country's total GDP.

Moving to further improve the sector, Myanmar has developed an animal genetics laboratory with the assistance of the Joint FAO/IAEA Division. Most of the country's indigenous cattle are draught animals, meaning they can work long hours tilling agriculture fields and pull carts with heavy loads. The genetics laboratory has now characterized Myanmar's three major breeds of cattle: Pyar Zein, Shwe Ni and Shwe Ni Gyi. Using molecular genetic analysis, the laboratory determined that Shwe Ni is a unique breed, distinct from Shwe Ni Gyi and Pyar Zein. This information will enable specialists to develop a selective breeding programme to develop Shwe Ni and Pyar Zein as dual purpose breeds that use females for milk and males for draught, and Shwe Ni Gyi as a dairy-type breed. This programme will involve animal identification, performance recording and the improvement of animal feeding and management.

Improved lab capacity leads to commercial dairy industry

Myanmar first introduced artificial insemination (AI) in 1975 using semen of exotic cattle breeds such as Friesian, Jersey and Norwegian Red to improve the milk productivity of local cattle. Facilities for collection and preservation of bull semen for an AI programme have now been established in the country. This includes training staff, procuring necessary equipment and developing and implementing protocols for running the AI programme. In 2013, the programme made about 32 000 AIs using frozen semen – over five times more than the 6 000 AIs done in 2004. In addition, Myanmar has developed a gene bank with a large repository of frozen semen.

The use of AI, improved forage management and extension activities from the Ministry of Agriculture Livestock Breeding and Veterinary Department have contributed to the development of several peri-urban dairy farming communities. In 2004, cattle rearing was considered a subsistence activity for crop production, and only a few market-oriented dairy farms existed – in Yangon and Mandalay. By 2013, Yangon had 10 commercial dairy farms, each with 80 to 520 head of cattle that produced more than 5 000 litres of milk a day. Similarly, the Mandalay region had 11 commercial dairy farms that collectively produced about 3 000 litres of milk. Along with this increase in the number of commercial dairy farms and cattle, the sector has seen a clear trend in increased milk production per farm and per cow which has contributed substantially to providing consumers with milk from domestic sources.

Animal disease laboratory produces FMD vaccines

The Myanmar livestock industry has been challenged by many transboundary animal diseases such as foot-and-mouth disease (FMD) which is endemic in the country. To counter the potential contraction of FMD in large populations of FMD-susceptible animals – currently estimated at 13.6 million cattle, 3.0 million buffaloes, 9.3 million pigs and 4.0 million sheep and goats – the National FMD Laboratory, which is supported by the Joint FAO/IAEA Division, produces about 200 000 doses of FMD vaccines for cattle and 50 000 doses of FMD vaccines for pigs annually. This number of doses is still low, but is a good start.

A new biosecurity level-2 (BSL-2) FMD vaccine and diagnostic facility, being built in Yangon with funding from the Government of Myanmar and the Japanese International Cooperation Agency (JICA) and technical assistance from the Joint Division, is expected to release FMD vaccines to be used in the field by the end of 2015. Additionally, a new FMD diagnostic laboratory is being constructed with financial support from the Myanmar Government and the Korean International Cooperation Agency (KOICA).

The Joint Division supports networking among Member States and, in this case, additional support from Japan and Korea further boost Myanmar's efforts for the improvement of animal health and productivity with the ultimate goal of enhancing sustainable food security in the country.

Partners:

Ministry of Livestock, Fisheries & Rural Development, Myanmar

Myanmar FMD Laboratory

Japanese International Cooperation Agency (JICA)

Korean International Cooperation Agency (KOICA)

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

INDONESIA
Food irradiation

In February 2014, a landslide swept away a remote Indonesian village in West Java, displacing more than 2 000 villagers. At the time, Indonesia's National Nuclear Energy Agency was participating in a Joint FAO/IAEA Division project that was using food irradiation to develop safe hospital food and emergency rations. When the project staff members learned of the landslide, they decided to use the technique to package safe rations for distribution at the emergency shelter. The staff was determined to give the shelter residents more than just the calories and nutrients they needed: the goal was to give them food that would make them feel good.

Irradiation: a matter of food safety

Emergency rations with a connection to home

What began in the 1970s as a method to provide quality food for space missions and was adapted as a method to ensure safe food for hospital patients with weakened immune systems has now expanded to yet another level: providing nutritious food rations in emergency situations when people are displaced and unable to return to their homes. The method employed here for all three of these groups is food irradiation.

Astronauts require food that has a long shelf life, is guaranteed not to make them ill and has a strong flavour because space is known to dull the sense of taste. For patients fighting diseases and dealing with weakened immune systems, the food must be very safe to eat, but it is also important that the food has a 'home-cooked' quality, which makes it more appealing for people dealing with long-term illnesses or chemotherapy as they often lose their appetites. For emergency rations, the food must be able to endure transportation and be stored at ambient temperatures as there is no refrigeration in difficult situations, such as in temporary evacuation centres.

Adding good taste to safe food

Originally, efforts to provide food to hospitals and emergency centres focused mainly on the safety and nutrition aspects. The role of the irradiation was to eliminate the risk of microbes that could cause infection or illness and to add to its durability. However, an international project on irradiated food launched by the Joint FAO/IAEA Division and involving institutes and hospitals in 16 countries promises to take food irradiation to a new level by addressing what they call the 'feel-good' factor. The aim is to make food that tastes good, can be fresh or cooked and will not cause illnesses even after shelf storage. The idea is that though people are in hospitals or temporary shelters, it does not mean that they cannot have the food they are used to, made the way that they like it.

Creating recipes for emergency rations

In trying times, food becomes particularly important, not only as a source of nourishment but also as a source of solace. The 2014 Indonesian landslide not only took away the villagers' homes and livelihoods, it also took away everything that was recognizable in their lives. Months after the landslide, 200 people still lived in a shelter far from home with nowhere else to go. Thus, to bring some pleasure into their lives, when they opened their food packets they found local foods, such as randang beef and tofu-based products. The recipes for the rations were developed by the Joint Division working together with Indonesia's National Nuclear Energy Agency (BATAN).

The process for making these meals is that once the dishes are prepared, they are sealed in pouches and

irradiated. This eliminates any micro-organisms that could spoil the food, enabling it to be transported to the distant refugee or emergency centres and stored at room temperature for a long time. Irradiation leaves no residues and does not affect taste or texture. The idea of packaging rations of familiar foods has also been adopted by China which put together an emergency ration pack that contained spicy sausage and noodles. When a Korean astronaut went into space, she took irradiated food packets that contained her national dish – kimchi. With irradiation, it is also possible to ensure that salads, fresh fruits and vegetables, and even ice cream are safe. The level of food safety is high enough for the foods to be enjoyed by hospital patients who would otherwise be on very severely restricted diets.

This particular use of irradiation accounts for only a fraction of the thousands of tonnes of food irradiated every year. In most cases, irradiation is a tool to ensure food safety but also to facilitate global food trade. However, as has been seen in space ships, hospitals and evacuation shelters, when the irradiated packets are delivered filled with home-cooked tastes, there is immediate positive feedback as the astronauts, the patients and the refugees can taste their connection to something familiar: home.

Partners:

Bhabha Atomic Research Centre, Food Technology Division, India

Centre National des Sciences et Technologies Nucleaires, Tunisia

Faculty of Food Science, Corvinus University of Budapest, Hungary

Instituto de Pesquisas Energeticas e Nucleares, Comissao Nacional de Energia Nuclear, Brazil
Institute for Application of Atomic Energy, Chinese Academy of Agricultural Sciences

Institute of Food and Radiation Biology, Bangladesh Atomic Energy Commission

Instituto Superior Tecnico, Campus Tecnologico e Nuclear, Portugal

Korea Atomic Energy Research Institute, Advanced Radiation Technology Institute

National Centre of Radiobiology and Radiological Protection, Ministry of Health, Bulgaria

National Nuclear Energy Agency (BATAN), Republic of Indonesia

Nuclear Institute for Food and Agriculture, Pakistan Atomic Energy Commission

Philippine Nuclear Research Institute

National Center for Electron Beam Research, Texas A&M University, USA

Queen's University of Belfast, United Kingdom

Sichuan Institute of Atomic Energy, China

Unidad de Actividad Aplicaciones Tecnologicas y Agropecuarias, Comision Nacional de Energia Atomica, Argentina

Universite du Quebec Institute Armand Frappier, Canada

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

VIET NAM
Food irradiation

Until recently, few consumers in western markets knew very much about the exotic and nutritious cactus known as dragonfruit – so named because its colour and shape are similar to the red eyes illustrators give to dragons. Native to Central America, it is now widely cultivated in Asia, especially Viet Nam. From very modest beginnings of around 100 tonnes in 2008, Viet Nam increased its dragonfruit exports to the US to 1 300 tonnes in 2013, an increase made possible because the fruit went through an irradiation process to keep insect pests from stowing away in the shipment, allowing it to be certified as irradiated, which enabled it to pass strict US import regulations. The Joint FAO/IAEA Division works throughout the world with countries such as Viet Nam, to help them to develop their own irradiation facilities, or to access others, in order to control pests and facilitate trade and, at the same time, reduce the need for potentially harmful chemical insecticides.

Preventing insects from hitch-hiking to new pastures

Irradiation opens markets and protects the environment

Irradiation has been used in the food industry for decades to control bacterial growth and food-borne illnesses and to prevent spoilage. With the proliferation of regulations necessary to deal with the exponential increase in global food trade, irradiation is being increasingly adopted to combat the spread of insect pests that can hide in fresh fruits and vegetables destined for export markets. In addition to controlling pathogens and slowing down the spoilage, light doses of irradiation can also keep insect pests from invading new territory where they could establish and breed with potentially devastating consequences for the environment and agricultural production.

The Joint FAO/IAEA Division has actively supported the development of irradiation as a safe and cost effective phytosanitary measure for fruits and vegetables, an effort that has begun to pay dividends. Irradiation is now being used on a commercial basis as a treatment that has minimal effect on fresh produce but maximum effect on the breeding potential of invasive insects. In addition to facilitating international food trade, it offers economic and environmental benefits by replacing costly and potentially harmful chemicals that can also impact ecosystems.

Increasing understanding of the irradiation process

The first commercial food irradiation, back in the 1950s, was limited to dried herbs and spices. Few foods were treated. This continued until the 1980s when the process was officially recognized as safe by the Joint Division and the World Health Organization (WHO). Once declared safe, proponents expected it to be adopted immediately by commercial interests, but that did not happen. People misunderstood the term ‘irradiation’, equating it with radioactivity, even though, in reality, food irradiation uses photons, electrons or x-rays, in a process similar to security screening methods used at airports, but using higher intensity beams. The food never comes into contact with radioactive material; the beams do the work without significantly changing the food’s temperature or affecting its nutritional value. Irradiation maintains the quality and increases the safety of the food. Other methods used to control pests, such as cold treatments, vapor heat or chemical fumigants, can change the texture or taste of the food, or leave chemical residues. That does not happen with low intensity irradiation.

The prescription for the appropriate irradiation dose – how strong, how long – must be exact. This means determining which doses work best for which foods and which insects. For example, the International Plant Protection Convention has a series of 14 irradiation standards, backed by scientific evidence gathered by the Joint Division, that prescribe the safe use of irradiation for addressing specific insect pests.

Building from this base, the Joint Division began in 2010 to work on developing a generic one-fits-all irradiation application that could apply to a host of different insects, particularly those that are of quarantine importance. It also worked with 17 countries in Asia to develop guidelines for good irradiation practices which are now publicly available for use.

Irradiation facilities for exporters and importers

In addition to establishing dose levels and strategies for irradiating fruits and vegetables against regulated pests, the Joint Division supports exporting countries in setting up their own irradiation facilities. For example, Viet Nam was previously unable to export dragonfruit to lucrative western markets due to insect pests, but now the country is equipped to use radiation treatment to eliminate the pests without affecting the fruit's safety or nutritional quality.

The Division also links exporters in poor countries that have no facilities to irradiation operations in importing countries, making it possible for them to irradiate their shipments on arrival. This means that though, for example, Pakistani mango growers do not have access to an irradiation facility in their country, they are still able to export their globally-appreciated mangoes to countries like the United States, where the importing country irradiates the mangoes upon arrival.

With the support of the Joint Division, over 60 countries have approved irradiation for more than 60 types of food products. Each year, some 500 000 tonnes of spices, grains, chicken, beef, seafood, fruits and vegetables are treated in 180 gamma irradiation facilities worldwide. For high-end consumers, this means year-round access to exotic fruits from around the world, but for local farmers and exporters in developing countries, this means a chance to compete in international trade, an opportunity they would be unlikely to have otherwise.

Partners:

Atomic Energy Commission of Syria

Centre for the Application of Isotopes and Radiation Technology, Indonesia

Centro de Energia Nuclear na Agricultura, Universidade de Sao Paulo, Brazil

Chinese Academy of Inspection and Quarantine (CAIQ)

Citrus Research International Ltd, South Africa

Department of Entomology and Nematology, University of Florida, USA

Estación Experimental Agroindustrial Obispo Colombres in collaboration with Comisión Nacional de Energia Atomica, Departamento Procesos por radiación, Argentina

Food and Environment Research Agency, Department for Environment Food and Rural Affairs, United Kingdom

Irradiation Department (Programa MOSCAMED), Mexico Fruit Fly Program

National Center for Electron Beam Research, Texas A&M University, USA

Nuclear Energy Department, Federal University of Pernambuco, Brazil

Nuclear Institute for Food and Agriculture, Pakistan Atomic Energy Commission

Research and Development Center for Radiation Technology, Viet Nam Atomic Energy Institute

Stored Product Insect Research Unit Centre for Grain and Animal Health Research, Kansas, USA

Technological Laboratory of Uruguay Irradiator, Laboratorio Tecnológico del Uruguay (LATU)

Tropical Phytosanitary Solutions, Australia

Turkish Atomic Energy Authority

Zoology Department - Desh Bandhu College, University of Delhi, India

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

LATIN AMERICA AND THE CARIBBEAN
Food safety laboratories

What began in 2006 as a network of 49 food safety laboratories in Latin America and the Caribbean has now expanded to include representatives from 19 countries in the region with many more expected in the future. The initial network was made up of analytical laboratories and supported by the Joint FAO/IAEA Division. It focused on addressing contamination problems and determining ways to improve environmental and food safety that had regional applicability as well as health, trade and economic benefits. Now known as Red Analitica de Latino America y el Caribe (RALACA), the network has established a host of regional monitoring mechanisms, working through committees that invite others to join in their work. The Joint Division has identified regional networks as a way to leverage the impact of food safety laboratories. The Division has helped to establish the framework for bringing regional laboratories together to share know-how and resources, and to move forward together in advancing their capacities for monitoring, evaluating and solving food safety problems in their countries or regions.

As the food supply chain globalizes

Food laboratories benefit from working in regional networks

As food production and trade have become more globalized, governments face the growing challenge of safeguarding food safety while ensuring there are no barriers to the abundant supply of quality food. Food safety efforts are increasingly pressured by a complicated international production-supply chain. Global food trade has more than tripled since 1990 with exports exceeding US $1 trillion a year. The market is competitive, drawing on developing and developed economies alike, but trade represents an increasingly large percentage of the GDP of many developing countries.

Multiple players – including producers, marketers, traders, food processors, manufacturers and distributors to retail and restaurant outlets spanning many different countries – are involved in the intricate food chain. This means that, in parallel, food controls (that are at different levels of development) have to transcend international boundaries, and actors must meet the international standards that underpin global trade. The controls are guided by a system of accreditation that laboratories should meet in order to safeguard consumers from the risk of exposure to chemical and natural contaminants associated with agricultural production and produce.

Supporting laboratories to monitor food supply

If not accredited, food safety laboratories seldom inspire national and international confidence among consumers, and cannot prove compliance to standards as required by importers. They end up having to outsource testing services to accredited laboratories beyond their borders, which can be both time consuming and expensive, impacting the national economy. The Joint FAO/IAEA Division assists its Member States in establishing sound laboratories – mainly through institutional capacity building – and supports them in achieving accreditation and setting up national food monitoring systems to enhance trade and meet public health requirements.

The Joint Division provides further support by helping to develop policies for working with those involved in food production and supply. The Division helps forge links among laboratories to build frameworks that enable

national laboratories to function efficiently and work together in regional networks.

Linking laboratories at regional level

Regional networks enable laboratories to harmonize analytical standards and control methods among their members who facilitate onward dissemination and sharing of technical information. For example, Red Analitica de Latino America y el Caribe (RALACA), the Latin American and Caribbean network, with support from the Joint Division, has shown the advantage of having laboratory peers networking in a multidisciplinary context.

The Latin American and Caribbean region now has 12 national programmes for monitoring chemical residues in foods, which were developed through RALACA and another Joint Division-supported regional network of 15 laboratories that monitor veterinary drug residues and related contaminants in food and feeds. These programmes ensure food safety and boost exports by using harmonized sampling and analytical methods that meet international standards. Over the past two years, more than 125 analytical methods have been developed and validated or re-validated to support measurement of contaminants in food and environmental samples. The Joint Division also supports the development of standard operating procedures for routine use in food control laboratories, and has trained more than 206 laboratory personnel in the region.

A similar network supported by the Joint Division has been established in Africa and currently includes food safety laboratories in 13 countries. Many of these are participating in proficiency and inter-laboratory studies, as well as sharing expertise and information, such as analytical methods.

The Joint Division also contributes to the development of policies guiding food production and supply which is in line with its work in forging national and regional laboratory networks. Given their benefits, the Joint Division continues to encourage laboratory networks, in order to mirror the globalization of food supply.

Partners:

Designated ministries of:

Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela. Others are Algeria, Botswana, Cameroon, Egypt, Ethiopia, Mauritius, Namibia, Nigeria, South Africa, Tunisia, Uganda, United Republic of Tanzania and Zimbabwe

Codex Alimentarius

Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA)

United Nations Development Programme

United Nations Industrial Development Organization

World Health Organization

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

SENEGAL
The sterile insect technique (SIT) – tsetse eradication

The Niayes region of western Senegal has a coastal microclimate well suited for exotic breeds of cattle, the kind that produce more milk and meat than domestic stock. Yet the area also suffers from infestation of a tsetse fly species, *Glossina palpalis gambiensis*. Tsetse flies are a major insect pest in sub-Saharan Africa that transmit animal trypanosomosis or nagana, a disease responsible for the death of at least three million animals each year. Presence of the fly has inhibited herd improvement because the more productive breeds have no tolerance to nagana, and preventative treatments are too expensive for local farmers. However, the situation is changing, thanks to a successful tsetse fly eradication campaign involving sterile insect technique (SIT). The programme, supported by the Joint FAO/IAEA Division and partners, has become a model project for other African countries.

Tsetse fly eradication allows sustainable livestock protection

Gives new life to Senegal's Niayes region

A feasibility study initiated in 2006 to determine the possibility of creating a sustainable tsetse-free zone in Senegal's Niayes region, found that 28.7 per cent of the cattle residing in and around the tsetse infested area were infected with trypanosomosis. Even when not fatal, this disease reduces livestock fertility, weight gain, milk and meat production, increases abortion and makes the animals too weak for ploughing or transport.

The study also found that the tsetse habitat in the area was extremely fragmented. Flies were present in small, but often highly dense, pockets that were isolated from other tsetse populations. Therefore, the removal of the Niayes population would be sustainable because there would be no risk that tsetse from other parts of Senegal would reinfest the area.

A parallel socio-economic survey and cost-benefit analysis, carried out on 277 farms found that farms outside the tsetse-infested area produced 38 per cent more milk, 64 per cent more meat and sold 2.8 times more livestock than similar farms in the tsetse-infested area. In addition, while 34 per cent of the farmers in tsetse-free areas owned the more productive improved breeds, only 6 per cent in the tsetse-infested areas owned them.

The survey estimated that there were 90 000 resident cattle in the Niayes area. With the eradication of tsetse, it is projected that farmers will be able to replace their

local breeds with exotic breeds at a rate of 2 to 10 per cent a year. As a result, farmers will increase their annual income by US $3.7 million because they will be able to reduce the cost of treating animals and also have more profit from selling milk and meat. Even though the cost of the programme is high with the need to train staff, establish infrastructure, and procure, sterilize, transport and release sterile flies, the cost-benefit analysis showed that by sustainably eliminating the vector, the programme will pay for itself in 13 to 18 years.

First the infrastructure, then the SIT

Based on results of the surveys, the Government of Senegal opted for an area-wide integrated pest management (AW-IPM) approach that included an SIT component. The project divided the target area into three 'blocks' and began activities in Block 1, using tsetse suppression methods, such as setting insecticide-impregnated traps and applying insecticide directly onto the animals. This reduced fly density to a fraction of what it had been, setting the scene for using the SIT as the final eradication component.

However, this required a great deal of preparatory activity before actually beginning the release of sterile males. Between 2008 and 2011 when suppression activities began, arrangements were made with a mass-rearing facility in Burkina Faso to produce and sterilize the appropriate strain of tsetse. A protocol was also established for transporting the sterilized pupae from Burkina Faso to Senegal, and a fly dispersal centre was established in Dakar to handle the received pupae. Trials

were held to test how the sterile flies would perform in the target area, and the project developed and tested a new adult male release system that utilized a gyrocopter that enabled efficient aerial releases over the fragmented habitat.

Although, statistically, it is too soon to say if the tsetse population has been eradicated in Block 1, no wild flies have been seen in the traps set by the project since 2012. In Block 2, trap catches have been reduced by more than 90 per cent indicating excellent suppression. Progress is also evidenced in the drastic reduction in disease prevalence – from 45 to 50 per cent in 2009 to 10 to less than 10 per cent in 2014.

Government looks to expand SIT area

Building on the success in the Niayes area, the Government of Senegal is looking at the feasibility of expanding to other tsetse-infested areas in the eastern part of the country. The timing is especially important as the tsetse habitat is expanding. Senegal has also been using the Niayes programme as a training ground for tsetse staff from Senegal and other parts of Africa, and Burkina Faso has constructed a larger mass-rearing facility for tsetse mass rearing.

Partners:

IAEA Department of Technical Cooperation

Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

USA Peaceful Uses Initiative

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

CHILE
Soil management

The forestry sector has become a driving force in Chile's national economy, with exports increasing from approximately US $4 million in 1970 to US $5.9 billion in 2011. However, the intensification of commercial forest and agricultural production in south-central Chile has increased soil erosion and associated water pollution due to sediment delivery from the vast disturbances caused by forest harvesting and replanting activities. A programme supported by the Joint FAO/IAEA Division and the Government of Chile, is using fallout radionuclides (FRNs) and compound specific stable isotope techniques to trace the sources of sediments, in an effort to further develop soil conservation strategies.

Developing soil conservation strategies

Protecting Chilean forest highlands from erosion

In the commercial forest areas of south-central Chile up to 3.9 tonnes of soil per hectare are lost to erosion each year after tree harvests. This is 78 times higher than erosion losses of undisturbed closed forests, which lose only 0.05 tonnes per hectare per year. This erosion poses a major threat to Chilean soil conservation and impacts government efforts to further intensify the forestry sector, which, in 2013, accounted for 7.4 per cent of the country's total exports. With the increasing occurrence of extreme and erratic weather events due to climate change, combined with the area's long and steep slopes, erosion may even be as high as 100 to 120 tonnes per hectare per year.

Sediment sources identified and quantified

With the support of the Joint FAO/IAEA Division, the research foundation Fondo Nacional de Desarrollo Científico y Tecnológico (FONDECYT), the Government of Chile and the Universidad Austral de Chile initiated a project aimed at investigating the impact of forest harvesting on fine sediment yield. This called for measuring the contribution of the main sediment sources – catchment surface, forest roads and stream channels – in forested catchments in south-central Chile during and after tree harvesting operations.

The catchments chosen and paired for study – Nacimiento and Los Ulmos – are located about 400 kilometres apart. They have similar soil types, but greatly differing mean annual rainfalls of 1 200 and 2 500 mm per year, respectively.

The project found that, prior to harvest operations, sediment sources are predominantly roads and streams.

After the harvest, however, there is a marked movement of surface material from forest slopes caused by soil disturbances during the harvesting process. Using sediment source fingerprinting, the relative contributions of the different sources in the study catchments to the sediment yields are currently being quantified to establish appropriate countermeasures.

Radionuclides such as caesium-137, lead-210, beryllium-7, potassium-40 and radium-226, as well as the organic carbon and total nitrogen content of soils and sediments, are used as fingerprints to identify key sources of fine sediment that reach the water bodies and to quantify the relative contribution of each source to the total sediment yield. The ability to trace the sources of these sediments, and hence to identify hotspots of land degradation, are essential in efforts to develop and optimize appropriate and cost-effective soil conservation strategies at the landscape level.

Knowledge of sediment sources improves management planning

The ability of the fingerprinting technique using fallout radionuclides to trace sources of these sediments and to identify hotspots of land degradation, is essential to efforts to develop and optimize appropriate and cost-effective soil conservation strategies at the landscape level.

Looking to the future, applying the information about degradation of hotspots and sources of fine sediments

identified by the project promises a reduction in the negative impact of commercial forestry operations on water quality. The information also supports improved and data-based decision-making processes for implementing enhanced and cost-effective sediment management practices. This will improve the factual basis of Chile's policy on Sustainable Forest Management Certification. In addition, an increased understanding of sediment sources and their relative contributions to fine sediment yields from forested catchments in south-central Chile, particularly during critical periods of disturbance by harvesting operations, will be applicable to other regions and landscapes with sediment-related environmental problems.

Partners:

Fondo Nacional de Desarrollo Científico y Tecnológico, Chile

Government of Chile

Universidad Austral de Chile

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

CUBA
Biological nitrogen fixation

Rice plays an extremely important part in the cuisine of Cuba and is the central ingredient of many of its national dishes. Cuba's annual rice consumption is estimated as high as 60 kilograms per capita, meaning each person in the country eats more than a kilo of rice a week. To meet this demand, Cuba dedicates some 200 000 hectares (ha) of land to rice production, but, until recently, due to soil infertility and the high cost of chemical fertilizers, the yields were low and more than 55 per cent of the rice consumed was imported. However, a relatively unknown forage crop has changed that. After studying the soil and water situation in Cuba's rice fields, the Joint FAO/IAEA Division worked with scientists and introduced farmers to sesbania, a tropical forage legume that can improve soil fertility through a process known as biological nitrogen fixation (BNF).

Rice production: what Cuba can teach the world

Offseason sesbania fertilizes rice fields

While globally rice fields were increasing steadily during the past decades, Cuba was seeing its rice productivity decrease to the point that its fields only produced enough to meet 45 per cent of consumer demand. As a result, the country was spending more than US $200 million a year to import rice. The government took a stand in support of its rice farmers, and in 2012, set a goal of increasing domestic rice production to 55 per cent of consumption by 2016.

The reason for the low yield was well recognized: soils were poor and needed fertilizer. However, Cuba did not produce fertilizer, and imported fertilizer was usually too expensive for poor, small-scale farmers to buy the in the amounts needed to improve their yields. The Joint FAO/IAEA Division, working with the Cuban Ministry of Agriculture, Instituto de Suelos, initiated efforts to introduce biological nitrogen fixation to Cuba's rice fields.

Nitrogen is a major nutrient required for plant growth, and biological nitrogen fixation (BNF) refers to a process through which certain types of plants, mainly legumes, absorb nitrogen from the atmosphere, convert it into plant nitrogen and then their roots leave it in the soil as residue, which serves as a natural fertilizer that can be used by subsequent crops.

Rice yields surpass government's goals

Collaborating with the Instituto de Suelos, the Joint Division evaluated the rice fields, studied the repository of legumes and forage crops that grew in the area, and determined that the forage crop, sesbania, would be the most appropriate off-season planting for the rice fields. By planting sesbania in rice fields, biological nitrogen fixation would help farmers produce their fertilizer naturally to enhance soil fertility. Thus, when rice was planted in the fields where the sesbania had just been harvested, the BNF had improved soil fertility, and rice yield increased by 35 per cent, or 1 tonne per hectare.

With 200 000 ha of sesbania planted to fertilize rice in Cuba, the rice production in Cuba increased to 70 per cent of consumption, far surpassing the goal the government had expected to meet by 2016. Post-harvest measurements, conducted by measuring stable isotopes in the soil, found that the sesbania plants had converted and produced between 50 and 200 kg of nitrogen per hectare for the subsequent rice crop.

A cornerstone of soil management

Nitrogen fixation is not a new technology. From the 1970s to the 1990s, the Joint Division defined and introduced the technology, determining the fixation potential of a large number of individual grains, forage and tree legumes. Since then, the Division has continuously added to and adapted the technique for various production systems. The work of the Joint Division has helped make biological nitrogen fixation a cornerstone of today's soil fertility management systems.

In this case of rice in Cuba, the Joint Division was able to refer to its portfolio of the various legume crops it had documented and compare that information to the specifics of the Cuban situation. Taking note of the attributes of the legumes and the needs of the rice field, the Division identified sesbania as the crop that would work best.

Not only did rice yields increase from 2.8 tonnes to 3.8 tonnes per hectare in the first rice planting after the sesbania was harvested, farmers were also able to reduce their use of chemical fertilizer by 48 per cent. The combination of increased yields and decreased fertilizer costs meant economic benefits of US $452 per hectare, not to mention the national benefit of the extra 200 000 tonnes of rice for consumption.

Continuing with the programme, the Joint Division and Instituto de Suelos are now working with the National Association of Small Scale Farmers to evaluate the nitrogen fixation potential for different agro-eco regions and have also set up farmer field days and offered training to continue introducing the benefits of crops capable of fixing nitrogen in the soil.

The Joint Division's work with Cuba is part of a 10-country Latin American project aimed at supporting resource-poor farmers by improving soil fertility and crop management. Three other countries in the project that also have high demands for rice – Brazil, Haiti and Panama – are also taking steps to pass on the concept of biological nitrogen fixation to their farmers.

Partners:

National Association of Small Farmers, Cuba

Instituto de Suelos, Cuban Ministry of Agriculture

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

KENYA
Plant mutation breeding

Wheat black stem rust, one of the most damaging diseases of wheat, had largely been under control for more than three decades when, in 1999, a new race of the fungus causing the disease was identified in the fields of Uganda. Named Ug99, to reflect where and when it was first identified, the deadly disease began to spread across East Africa to Yemen and as far as Iran, to the point that it threatened the wheat production of 18 countries and, potentially, global food security. In answer to this, the Joint FAO/IAEA Division, working with national and international research institutes, initiated a multi-country program focused on using induced mutations to increase the genetic diversity of wheat which, in turn, would increase the chances of developing wheat varieties with resistance to the black stem rust. In 2014, the first Ug99-resistant varieties, Eldo Ngano-1 and Eldo Mavuno-1, were ready for Kenya's wheat fields, and six other countries had new resistant lines in advanced field trials.

Advances in tackling deadly wheat disease

Potential boost for world's food supply

Wheat black stem rust can turn a healthy looking crop, only weeks away from harvest, into nothing more than a tangle of black stems and shrivelled grains. It is a highly mobile disease, which can spread rapidly over enormous distances. It spreads mostly through wind, but it can also be spread by accidental human transmission – through clothing or plant material.

Wheat black stem rust had largely been under control since the 1960s, mainly because researchers had developed wheat cultivars resistant to the disease. When Ug99 emerged in 1999, it proved to be a particularly devastating race. In fact, some 80 to 90 per cent of global wheat varieties were susceptible, meaning most farmers in its path had no way to fight back.

As the disease spread from its first sighting in Uganda, 17 other countries were considered at risk. The tolls mounted in each country where it emerged, eventually reaching an annual loss of 8.3 million tonnes of wheat grain production with a value of USD 1.23 billion. This presented a potential threat to global food security as well as the multi-billion dollar wheat market.

In 2009, the Joint FAO/IAEA Division initiated and led an interregional project to help in developing new wheat varieties resistant to wheat black stem rust. This project focused on mutation induction with a goal of increasing the genetic diversity of wheat, increasing the chances of finding varieties with resistance to Ug99 that could then be further developed.

Kenya leads the way toward Ug99 defence

Kenya, a hot spot of Ug99, has led the way towards a more diverse defence against Ug99. The early incursion of Ug99 into the country actually became an opportunity to set up a massive search for different sources of resistance to the strain. Each year, researchers in Kenya test as many as 50 000 lines of wheat in fields that are under high disease pressure.

Joint Division experts worked with breeders at Kenya's Eldoret University, advising on methods of mutation detection and screening for resistant wheat lines. At the beginning of the project, the Joint Division experts set up the project work plan with participating countries. Samples of wheat seeds from the participating countries were irradiated at the Joint Division Plant Breeding and Genetics Laboratory. Through this concerted effort, two resistant mutant varieties in Kenya, named Eldo Ngano-1 and Eldo Mavuno-1, were developed. These names translate from Swahili as Eldoret Story and Eldoret Harvest.

Unprecedented rapid development of resistant varieties

The two new varieties went from mutation induction to the variety being released for planting in less than five years – unprecedented for a process that usually takes much longer. Eldo Ngano-1 proved to be a major breakthrough, and regarded in Kenya as the first Ug99 resistant wheat variety. Due to its unprecedented rapid development, 54 tonnes of Eldo Ngano-1 seed were ready in 2014 for distribution to local farmers for the 2014 to 2015 season, with enough seed for 500 hectare (ha) in its first year of release. During the process, one thousand local farmers had visited demonstration fields in Kenya, and some of them were involved in seed multiplication. The seed gathered from the 2014 harvest will be used to expand the cultivation in 2015.

Other countries participating in the project expect to develop Ug99 resistant varieties from their own mutation-induced local wheat varieties. In six participating countries, 13 mutant lines resistant to Ug99 are in advanced evaluation trials as a prelude to variety release.

The Joint Division demonstrated the effectiveness of mutation breeding in developing new wheat varieties resistant to Ug99. These new resistant varieties are available to Member States and the global wheat-breeding community. They will be used widely in breeding programmes to improve disease resistance in wheat in many regions.

Partners:

National partners: Algeria, Egypt, India, Iran, Iraq, Jordan, Kenya, Lebanon, Oman, Pakistan, Saudi Arabia, South Africa, Sudan, Syria, Tunisia, Turkey, Uganda, Yemen

Bhabha Atomic Research Centre (BARC), India

Borlaug Global Rust Initiative (BGRI), USA

Chinese Academy of Agricultural Sciences (CAAS), China

International Center for Agricultural Research in the Dry Areas (ICARDA), Kenya

International Maize and Wheat Improvement Center (CIMMYT), Kenya

US Department of Agriculture – Agricultural Research Service, (USDA-ARS)

Western Australian Department of Agriculture and Food

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

FAO FIAT PANIS
IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

PERU
Mutation induction

Consumers in Lima, Peru, throng the counters of a popular bakery outlet because the baker has something new to offer; instead of the traditional bread made with wheat, this baker also uses flour made from barley – something that was relatively unimaginable until the Joint FAO/IAEA Division supported the development of a new mutant barley variety. The new barley variety has the quality needed to make its grains into dough and the taste to make it extremely popular with consumers. Known as Centenario II, the new variety was also bred for traits that protect it from extreme storms, and with loose hulls that can be removed easily which reduces labour. It is an important contribution to Peruvian agriculture that offers improved nutrition to consumers, increased yields and incomes to farmers in Peru and, thanks to its adaptability, it can also be made available to farmers in other parts of the world.

New mutant barley variety

The taste, quality and yield to improve Andean livelihoods

Centenario II, a new mutant barley variety, was specifically bred to thrive in the high Peruvian Andes mountains at altitudes of 3 000 to 5 000 metres. Due to its adaptability, it increases the food security of close to seven million people who rely on subsistence subsistence agriculture and related activities. Although barley has traditionally been a fodder crop in Peru, Centenario II's combination of adaptability and quality has made it sought after by both farmers and consumers. Consumers like the taste of its flour, while farmers like that it thrives in their fields in harsh environments and has yields that are six times those of other local barley varieties grown in the area. Farmers in the high Andes now produce enough barley to meet their personal food needs, with enough left-over for processing into pearl barley, flour and flakes. Due to the socio-economic impact of the improved barley varieties, the leading breeder was awarded the 2006 Peruvian Prize of Good Governmental Practices.

The relationship between the Joint FAO/IAEA Division and the Peruvian barley breeding programme goes back to the 1970s, when the Joint Division initiated efforts to improve this crop through mutation breeding. Over the ensuing decades, the Joint Division has worked with the National Agrarian University of La Molina. Their work has led to the development of nine improved barley varieties that are able to withstand the tough climatic conditions in high altitudes that can spawn powerful storms with high winds

and hail. These nine varieties account for 90 per cent of the barley grown in the Andes. Centenario II, the latest output of this collaboration, was under development for seven years.

Increasing biodiversity in barley with gamma rays

When the Government of Peru requested support in improving crop varieties for the high altitudes, it sought crops with increased yields, but also improved nutritional value. With the support of the Joint Division, the University of La Molina developed Centenario II through a process of inducing mutations – a technique that exposes plant seeds to gamma rays, a type of radiation. With this seed treatment, the radiation causes mutations in the genetic set up of the cells, similar to the natural spontaneous mutations that drive evolution.

In this case, the barley breeders looked for traits that would increase the barley's consumer appeal and nutritional quality. Thus, Centenario II was bred for "organoleptic properties" – the sensual aspects of food including taste, sight, smell and touch that can influence consumers. Centenario II contains proteins that give it the quality needed to make it into dough, a starch that enables it to be baked, and a taste that has made it extremely popular with both local consumers and those in the large cities of Peru's lowlands. This, in turn, has had the parallel effect of improving nutrition for consumers and income for producers. The combination of Centenario II's quality and quantity has had a double effect on income: it has increased yields by some 428 kilograms per hectare (ha) and – thanks to its popularity due to its nutritional value and taste – the price per kilogram has more than doubled.

Linking farms to factories to consumers

Each year since 2006, the University of La Molina has released 1 tonne of Centenario II seeds produced in a certified seed production area. The estimated cultivated area of Centenario II is 15 000 ha. The University of La Molina has helped small-scale farmers establish small factories to process the barley flour and farmer collectives to sell the products in markets in the cities. Mutant barley varieties have an average value of US $131.5 per hectare. In total, the nine mutant cultivars developed by the University of La Molina are cultivated on 135 000 ha, which is 90 per cent of the total Peruvian barley growing area. This contributes close to US $18 million to the Peruvian economy. Centenario II is replacing the former cultivars in the central highlands of Peru. The replacement means more products for self-sufficiency, improvement of household income through the sale of surplus barley, as well as better nutritional value. Current prices of Centenario II can reach US $488 to 533 per tonne because of higher grain quality.

Over the decades, as plant breeders have continuously developed crop varieties, they have enabled farmers to increase yields and improve global food security. While local varieties are well adapted to the conditions in a specific region, they have a narrow genetic base meaning they lack wide adaptability and are susceptible to new diseases. Mutation breeding can improve local varieties, adding new traits, which allow them to unfold their potential to flourish in changing environments and improve their performance. Centenario II, which purposely has a broader adaptability to environmental conditions, moves barley production in the right direction. Moving forward from the success of the Centenario II, it could be expected that mutation breeding can help more crops better adapt to harsh environmental conditions and changing climates.

Partners:

National Agrarian University of La Molina, Peru

Backus Foundation, Inc.

For further information
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa

FAO FIAT PANIS
IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture