IAEA

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

IN ACTION: Nuclear applications in agriculture

On-the-ground success

The process: it starts with a need

Coordinating and supporting research

When presented with a problem, the Joint Division initiates a Coordinated Research Project (CRP) which brings together 10–20 institutions from developed and developing countries to work together towards a solution. The Joint Division coordinates some 40 research projects at any one time, with the combined participation of around 500 research institutions and experimental stations in member countries. CRPs usually last for five years and results are published so they are available to all.

Providing technical and advisory services

While the Joint Division's CRPs take advantage of the knowledge that can be gained and shared through scientific networks, its Technical Cooperation Projects (TCPs) further anchor it to the farmer's fields. The Joint Division provides scientific and technical support to over 200 national and regional TCPs annually, offering expert advice and capacity building through training courses, on the application of nuclear techniques for recipient countries.

Providing laboratory support and training

The Joint Division's laboratory, situated 35 km from its headquarters in Vienna, is unique in the UN system. It specializes in applied research, development and transfer of nuclear-related methods in food and agriculture, but also provides training to scientists through individual fellowships and group training courses. This includes guidance in both the science and in the hands-on use and maintenance of laboratory equipment as well as in quality assurance and quality control in laboratory environments.

Collecting, analyzing and disseminating information

The Joint Division provides a variety of information services, including conferences, symposia, seminars and advisory panels. It also publishes technical and public information documents that arise from its research, meetings, CRPs and TCPs, as well as newsletters, periodic reviews and computer databases.

IN ACTION: Nuclear applications in agriculture

A sampling of success

From the Application of Nuclear Techniques in Food and Agriculture

This packet contains a selection of project and programme outcomes that connect the research and development activities and technology transfers of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture with farmers, their fields, animals and production processes. The work of the Joint Division is more than science – it also is the application of science.

The Joint Division uses the knowledge and information it garners from its research and development activities to support its overall goal of mobilizing peaceful applications of nuclear science and technology in order to improve global food security, reduce poverty and support sustainable use of the world's natural resources. The Joint Division's staff of scientists and technical experts helps identify, develop and adapt cutting-edge nuclear technology that can add value to global agricultural research, and then transfer it to the fields of the world's farmers where it can help improve yields, while ensuring food safety for consumers and protecting the environment.

The stories contained in this packet give a snapshot of how the Joint Division works with governments, researchers, NGOs and farmers, enabling them to benefit from nuclear techniques and related biotechnologies to solve practical agricultural problems. It offers a field-level view of what the Joint Division's expertise and support mean to farmers, food processors and food traders – on the ground.

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

TURKEY: potato farmers

Drastic reduction in water and fertilizer use

An inventive technique that enables potato farmers in Turkey to combine water with fertilizer and send it to their plants through a precisely targeted drip irrigation system has greatly reduced farmers' need for water and fertilizer. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture introduced the method, known as "fertigation" as a way to help farmers increase their profits by cutting back on expenses, while at the same time avoiding potential harm to the environment that can result from over use of nitrogen fertilizers. As a result, some farmers report reducing their need for water and fertilizer by half while maintaining the same potato yields. Both the national and provincial governments are so pleased with the programme, they now provide subsidies to the farmers for investment costs of the drip irrigation system.

Throughout the potato producing areas of Turkey, large sprinkler irrigation systems spray water across the fields. This system has helped make Turkey one of the world's largest producers and exporters of potatoes. Yet, it turns out, only 35 percent of that water actually benefits the potatoes. The other 65 percent is wasted. It either runs off the packed earth or it soaks through to the soil that is below the plant root.

This water waste also impacts other aspects of potato production. Because potato is such a high value cash crop, Turkey's farmers fertilize intensively, using water-soluble nitrogen fertilizers. Again, if the sprinkler irrigation system uses too much water, it can dilute the fertilizer and decrease its efficiency. This is especially critical considering the expense of purchasing the fertilizer and the environmental damage it can cause if used incorrectly.

In order to overcome this unnecessary waste and potential environmental hazard, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has introduced an innovative irrigation technology that means enormous savings for farmers – reducing water use by 50 percent and fertilizer use by 40 percent. Known as "fertigation", this system combines drip irrigation which uses a series of pipes and tubes to deliver small amounts of water directly to the plant with fertilization – sending the fertilizer through the same tube system as the water, straight to the roots where it needs to be. This ensures that no extra fertilizer is left above the ground to be absorbed into the atmosphere and that no extra fertilizer leaks deep into the soil where it has the potential to make the groundwater poisonous for human consumption.

Neutron probe
Isotope tracer

Working with the Turkish Atomic Energy Agency in cooperation with the Nigde Potato Research Institute and the Soil and Fertilizer Research Institute, the Joint Division also introduced the local farmers to soil moisture neutron probes (SMNPs) which enable them to measure the moisture content of their soil and then adapt their irrigation to the exact amount of water needed. They also have introduced techniques for labeling stable isotope tracers to measure the fertilizer uptake of the crops which again, helps farmers adjust and pinpoint the amount of fertilizer they need to put through the fertigation system.

In the first years of the project, the area under drip fertigation increased from 500 ha in 2005 to 4 000 ha in 2007 to 7 000 ha in 2010. The explanation for this remarkably fast uptake by Turkey's potato farmers is quite simple. Transition from sprinkler to drip fertigation requires an initial investment of around US$200 per hectare. However, once that investment is made, the farmers capitalize on savings in time, energy and fertilizer costs, amounting to an estimated US$2 000 per hectare per year. Those kinds of savings have a powerful impact on the farmers' profits. One of the first farmers to adopt fertigation reported that he had cut his fertilizer and water applications by half yet still had the same potato tuber yields, and that the system also prevented diseases from affecting the crop.

The national government is so pleased with the positive response to the transition, it now subsidizes 50 percent of the investment costs for the drip irrigation systems, knowing that it will not only increase savings for the farmers, it will help protect the environment above and below those farmers' fields and also conserve the country's precious water resources. Further support to the project is now coming from the major potato growing provinces, Nigde and Nevsehir, which also are offering financial subsidies to the potato farmers for their fertigation investments. Looking ahead, drip fertigation systems could soon be supplying water and fertilizer to some 10 000 ha of potatoes, which based on the savings of US$2 000 ha per year, comes to a total annual savings of US$20 million for Turkey's potato farmers.

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BANGLADESH: rice farmers

Crops can grow and support family nutrition in spite of salty soil

In the low-lying coastal areas of Bangladesh, salinity affects approximately 2.9 million hectares of land. Until recently, this limited the farmers of the area to planting one rice crop a year and having to watch their fields lie fallow due to salinity for the other seven months. A pilot water management project of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has identified salt-tolerant local crops varieties and, using neutron probes to measure soil moisture and set irrigation levels that will not affect soil salinity, made it possible for local farmers to plant a second crop after the rice harvest. The new crops, such as groundnuts, mungbean and chickpeas, add to local nutrition, but also fix nitrogen which improves the soil quality for subsequent seasons. Plus, the income from the second crop means farmers no longer must leave the area to seek employment in cities. From two pilot areas, the project is scaling up to cover about 1.8 million hectares, more than half of the coastal region.

Each spring, right after the monsoon rains finish in Bangladesh, farmers rush to their fields to plant their rice crops. It is the only time of year they can grow rice, because the heavy rains dilute or wash away the salinity that builds up in the delta's low-lying soils. They use harvested monsoon rainwater to flood the rice during its growing season and then harvest in August. During the subsequent months of the dry season, the intrusion of tidal water from the coast increases the soil and water salinity eightfold. This natural salinization is a major threat to crop production, meaning a seven-month fallow season for some 90 percent of the arable land in the coastal areas.

As a result, many men move to the cities after harvesting their rice, looking for work to supplement their income, because their families cannot survive on income from one rice crop a year. The Bangladesh capital, Dhaka, already considered the world's fastest growing megacity, has to absorb the seasonal migration of the men from the coastal areas along with the estimated 3-400 000 migrants who arrive there each year, all of which adds up to untold social problems. This seemingly insurmountable annual scenario held back development in the coastal region which is one of the most populated regions on earth, with a density of more than 200 people per km^2.

In 2007, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, in collaboration with the Bangladesh Institute of Nuclear Agriculture, launched a pilot effort to develop water management practices that could reclaim the coastal land from their saline soils and ensure year-round

productivity. There were two parallel efforts: first, to identify salt-tolerant crop varieties to recommend to farmers and, second, to find ways to use brackish water to irrigate crops at a level that would not affect soil salinity.

At the two pilot sites, scientists evaluated and assessed crop varieties for their tolerance to salinity but also evaluated their potential to thrive if irrigated with water accumulated in ponds and natural depressions. Using carbon isotope discrimination methodology, which enables scientists to determine plants' water-use efficiency and drought and salt tolerance, scientists identified several local saline-tolerant crops, including varieties of wheat, mungbean, mustard, sesame, chickpea, tomato and groundnuts that could be planted during the fallow season and enable the farmers to have a second crop.

The next step, after the crops were planted, involved using neutron probes to measure the soil moisture in the field, and carbon isotope discrimination to analyse a leaf of the new plant which would indicate how much water the plant could use efficiently. By making a pre-selection of appropriate crops, then testing them in the field as they grew, scientists developed a good picture of how much water the plant needed, enabling them to set irrigation to levels that would not increase soil salinity. At the same time, these leguminous crops fix nitrogen in the soil, and thus leave the soil in better condition for the next rice crop. In addition, having this vegetative cover which reduces evaporation, has actually reduced soil salt concentration from 6.9 to 1.8 grams per kg, a fourfold decrease.

For the project, the most important outcome is that farmers in the pilot areas now can plant and harvest second crops, adding nutritional diversity to their diets and improving income. The saline-tolerant varieties were quickly accepted by farmers in the pilot areas who found they generated additional incomes of about US$2 000 per hectare per season. Already 2.5 million farmers grow a second crop and as the project scales up from its two pilot locations, it predicts 5–7 million farmers will be growing a second crop in the next ten years.

Looking ahead, the Joint Division has shown that by choosing crop varieties carefully and designing well-targeted irrigation strategies, it will be possible to introduce and harvest a second crop on potentially up to 2.6 million hectares of highly fertile coastal lands that would otherwise lie fallow. Just a simple calculation shows that such a second harvest could potentially add 4 million tonnes of wheat or other crops to the national breadbasket which, multiplied by wheat's market value in August 2011, comes to US$2 billion for the national economy, a number that might go even higher with a different crop. Already farmers who used to leave for cities at the end of the rice season have settled back at the coast.

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KENYA: Maasai pastoralists

Crops thrive despite drought

Throughout their history, the Maasai have relied solely on herding for survival, viewing their livestock as both a sign and source of wealth. However, increasingly frequent and severe drought in the area they occupy across southern Kenya and northern Tanzania and the lack of land has meant devastating losses in cattle herds, leading the government to initiate programmes to introduce the Maasai to a new survival strategy – crop production. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture is working to introduce small-scale drip irrigation technologies to the Maasai who have no tradition of crop production but recognize that their survival depends on being able to make the most efficient use possible of their scarce water resources.

For the Maasai, livestock are more than their primary source of income. They are a cultural necessity. When Maasai greet each other, they don't ask about the other person's family. They ask about their animals. A Maasai prayer translates as "May the creator gives us cattle and children."

In the Maasai culture, the men herd the animals. When there is a drought, they must take their herds to greater and greater distances searching for water and pasture, leaving women and children behind. Their pastoralist culture has never included growing crops because they have always relied on meat, milk and blood from cattle for protein and calories. However, as the drought scenario has worsened across Kenya and Tanzania, a huge number of animals have died, herds are smaller than ever, and the Maasai have had to rely on purchasing rice, maize and potatoes produced in other areas.

At the request of the Green Belt Movement, an NGO working in the area, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has coordinated with the Kenya Agricultural Research Institute (KARI) to introduce the Maasai to cropping, as a way to help them grow their own food and improve their nutrition. As they have no tradition of growing crops, the programme started by teaching horticulture techniques, introducing crops such as kale as well as fruit trees that provide nutrition but also have market value.

However, success requires more than learning how to farm. Due to the difficult agricultural conditions in the area, the Joint Division also works with KARI to

Neutron probes

identify simple but sophisticated nuclear techniques that will enable the Maasai to make the most efficient use possible of their scarce water resources in order to have optimum production.

While it might seem far-fetched to imagine Maasai pastoralists employing nuclear techniques to start agriculture in the arid landscape of East Africa, the Joint Division has supported KARI in developing low-cost, small-scale irrigation technologies based on the use of neutron probes and isotope tracers that are specifically designed to meet the needs of the Maasai. The Joint Division provides fellowship training to ensure KARI scientists are able to use the techniques and then KARI passes the technology on to the Maasai.

In this case, the techniques focus on drip irrigation, which increases water use efficiency. This calls for applying water directly to the plant roots through a network of pipes and tubes, thus reducing water losses through evaporation or due to water draining away below the plant's root. KARI scientists assist the farmers, using a soil moisture neutron probe to measure the moisture levels. The neutron probe is not a new technology. In fact, it was developed in the 1950s, but the Joint Division determined that it remains the best technology for use by the Maasai.

Going a step further, this irrigation system also can be used to target use of nitrogen fertilizers. Nitrogen is critical for agriculture, but it is an expensive commodity and can be difficult to find in rural areas. It also can cause severe environmental problems if it is not used correctly. If too much is spread on the soil, the extra that is not taken up by the plant is released into the atmosphere as a greenhouse gas emission making it a climate hazard. If too much goes into the soil, nitrogen leaching can occur, which means that the excess drains through the soil and, if it reaches the level of the ground water, it can make the water unsuitable for human consumption. More importantly, it can amount to a substantial financial loss for the poor farmers.

By delivering nitrogen fertilizer through the same pipes as the irrigation water, the fertilizer also goes directly to the area of the plant root where it is needed. Known as "fertigation", it relies on stable isotope tracers to test how well the nitrogen is taken up by the plants. With this information, the farmers know exactly how much fertilizer and water is needed and can adjust the amount accordingly. This not only saves the water resources, it also saves on the cost of unnecessary fertilizer as well as the energy and time needed to produce and spread the fertilizer.

For traditional pastoralists such as the Maasai, there is no question that times have changed. Population pressure has meant more need for agricultural land, but at the same time, changes in land tenure now allow personal rather than tribal ownership and new owners have fenced traditionally communal lands. That, combined with the enormous loss of animals due to drought, has led many Maasai to appreciate the importance of crop production in bridging food shortages and improving family nutrition. In addition, the vegetable farming has encouraged men to stay closer to the family so they can help with the crops. Thanks to the success in the pilot area, other Maasai communities have begun vegetable farming, knowing they have more potential for success, thanks to the application of nuclear techniques.

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GLOBAL: rinderpest eradication

Early and rapid disease diagnostic networks and technologies

The announcement in June 2011 that the devastating cattle disease, rinderpest, had been eradicated worldwide marked the end of decades-long campaign that brought governments, international organizations, scientists and farmers together, into a global network. Spearheaded by the World Organisation for Animal Health (OIE) and FAO, the Global Rinderpest Eradication Programme (GREP) delivered the ultimate gift to the world's farmers – the gift of freedom from fear of one of history's worst animal diseases. This successful campaign, in which the Joint FAO/ IAEA Division of Nuclear Techniques in Food and Agriculture and the Department of Technical Cooperation played a key role, closes the door on one scourge. Yet, the world still must deal with many other major animal diseases that require concerted efforts in diagnosis, surveillance, risk evaluation and risk management. Today, the Joint Division envisions building on the networks established during the rinderpest eradication campaign and moving ahead in its efforts to control, prevent and eradicate other animal diseases that remain so devastating to the world's farmer's livelihoods.

Rinderpest has been responsible for catastrophic epidemics around the world for at least the last 1000 years. Also known as the "cattle plague", rinderpest has wiped out countless herds of domestic cattle, yak and other hooved animals as well as their wild relatives, leaving in its wake economic ruin, famine and even has been blamed for the weakening of the Roman Empire. Folklore also maintains that Genghis Khan sent rinderpest-infected cattle into the herds of his enemies to wipe out their food supply, making them easier to conquer.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture's involvement with rinderpest dates back to the 1980s, when it added its diagnostic expertise to a vaccination programme that led to the control of rinderpest in 22 sub-Saharan African countries. Although the efforts initially appeared very successful, residual pockets of rinderpest were left, which allowed renewed outbreaks of disease. This served to demonstrate that moving from control to eradication of rinderpest would require better diagnostic tools, maintenance of a "cold chain" to ensure the efficacy of the vaccines, and a stronger veterinary infrastructure.

Enzyme linked immunosorbent assay

From this beginning, the Joint Division with the support of the Technical Cooperation Department, working closely with other international organizations through the Pan-African Rinderpest Campaign (PARC) which began in 1987 and GREP which began in 1994, changed the focus of its animal health activities and developed programmes to promote the new enzyme linked immunosorbent assay (ELISA) technology. The ELISA was developed from assays that used

radio isotopic tracers for the diagnosis, monitoring and surveillance of livestock diseases, but by adapting the test to a technology that utilized enzymes as markers, allowed large numbers of samples to be tested in a relatively short time with quantifiable results. Most importantly, the assays could readily be deployed to national veterinary laboratories in the form of standardized kits. This led to the development of an ELISA specifically for rinderpest detection which was distributed by the Joint Division together with investment in building capacity of the veterinary services in at-risk countries through individual and group training and workshops.

The Joint Division worked on many levels, with governments, international organizations and researchers, to build capacities for national laboratories, improve epidemiological studies and data management, and set up networks. These networks were critical elements in an unremitting campaign to develop and deploy diagnostic tests to determine where the disease was, where it was spreading, which animals were infected and at risk, and at the same time, to monitor the efficacy of the vaccination campaign. These networks proved an ideal forum for the Joint Division to establish guidelines and mechanisms for countries to report their surveillance results and, eventually, their freedom from rinderpest. It is only now, when the disease has been eradicated, that the socio-economic impacts of rinderpest eradication are being fully appreciated. Rates of return in individual countries in Africa range from 11 percent in Côte d'Ivoire to 118 percent in Burkina Faso. Chad credits a 3 percent increase in its GDP to the absence of rinderpest. Overall, eradication of the disease has meant some US$920 million in annual economic benefit to the African region.

Of course, rinderpest is not the only transboundary animal disease that has devastating impacts on farmers and their livelihoods. Thus the Joint Division envisions building on the networks, laboratories and veterinary services set up and equipped in the fight against rinderpest to work on the eradication of other diseases such as peste des petits ruminants and contagious bovine pleuropneumonia, scourges of sheep and goats, and cattle respectively. The goal now is to improve regional networks further and strengthen the capacity of laboratories to target more than one disease at a time. Sick animals do not show their visas at national borders. This means that transboundary diseases cannot be eradicated one country at a time. It requires regional and in some cases international efforts. When the PARC programme began in 1988, no one knew if it would be effective. It took 20 years and the development of successful vaccines and diagnostic tests along the way – but in the end, the result was clear and today, the world has one less disease threatening global food security.

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ZAMBIA: livestock farmers

Animal productivity improved with bean once considered poisonous

The farmers of Zambia once considered the velvet bean (*Mucuna purensis*) poisonous. Now, farmers have learned that in fact, this grain legume is highly nutritious and, as a feed supplement, can increase livestock production, thanks to a study of locally available feed resources conducted by the University of Zambia in collaboration with the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. Livestock rearing is one of the leading farming activities practiced by rural communities in Zambia. Traditionally, these farmers have reared indigenous animals at a subsistence level for their own household consumption. However, in recent years, the Zambian government has encouraged farmers to improve animal productivity in order to create employment and generate income. Discovering the potential of the velvet bean is helping to make the government's vision a reality.

DNA sampling
Stable isotope technology

Traditionally, Zambian farmers have kept indigenous animals, leaving them to forage for feed and water on their own. However, what is locally available for grazing does not have all the nutrients the animals need, making it essential to evaluate the nutritional value of the feed resources the pasture areas have to offer, looking for those with potential to provide energy or protein supplementation for milking animals. The velvet bean enters the picture as a supplemental feed identified through a University of Zambia project in partnership with the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

While Zambian farmers measure the productivity of their animals in terms of the amount of milk and meat and number of calves they produce, this is not the total picture of why they keep livestock. Animals provide many other services, such as manure and draught power, and can be a ready source of cash and other cultural needs. Thus, farmers do not necessarily make a priority of selling animals for slaughter, even under extreme drought conditions. Owning animals is a measure of wealth, so they are interested more in herd size, rather than how well each animal produces.

As for milk, it is mainly for family nutrition. Because of lack of marketing infrastructure, unless the farmers live close to an urban area, there is no formal market for milk and, therefore, they have no incentive to increase production. They also are not enthusiastic about any feeding schemes that will add more work to their lives, such as having to harvest, transport or process fodder. However, farmers are aware that well-fed, healthy animals produce more calves,

and any measure that will enhance this trait is likely to prove a good selling point for any farmer.

In support of the government's request to improve the livestock sector, the Joint Division initiated a project to improve production of milk and meat by developing livestock feeding and management strategies. The application of nuclear techniques in this project included DNA sampling and subsequent genotyping to identify the animals' genetic characteristics and determine the nature of their gene pool. Once the genetic makeup of the local breeds is understood, the next stage is to develop a cross breeding plan to upgrade indigenous animals by crossing them with exotic breeds, but also making sure to maintain the biodiversity of the indigenous animals.

Most farmers have no way of determining the nutritive value of feed. Through the use of stable isotope technology, the project was able to analyse grasses, plants and tree legumes already growing in the project area and determine their potential as animal feed. Through their work, the researchers discovered that the velvet bean had the high-protein nutritional characteristics they were looking for, that it grew well locally, and the entire pod could be processed into a mixture to feed the animal at the time of milking. A local farmer who participated in the project decided to become the velvet bean entrepreneur of the area. He turned his land over to velvet bean production, growing and processing the beans into the supplement mixture that his neighbors bought to feed their cattle.

Once the supplemental feeding began, the cattle began producing more milk – sometimes in less than a week. Farmers also recognized other benefits that came from the improved nutrition. Healthy animals are more resistant to diseases, making them less costly.

Almost instantly, the velvet bean entrepreneur had a hard time keeping up with demand of farmers who recognized the impact the supplement had on their animals. Today, the system has become self-sustaining, with the entrepreneurial farmer now known as the velvet bean source in the area.

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MONGOLIA: pastoralist herders

Foot-and-mouth disease disaster averted

During the winter of 2010, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture received a host of correspondence from Mongolian herders with messages such as, "Thank you, you saved my animals," and "We received vaccine from the local veterinary station. You make the difference." It also received a message from the Mongolian government, offering its "sincere gratitude" for continued support. The reason for the outpouring of appreciation was the Joint FAO/ IAEA Division's herculean effort in thwarting an outbreak of foot-and-mouth disease (FMD) in Mongolia. In the big picture, the success of the effort grew out of more than two decades of partnership between the IAEA and the Government of Mongolia.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture with support from the Technical Cooperation Department began working with the Government of Mongolia in the late 1980s to identify areas where it could apply nuclear techniques to improve its livestock productivity. In the 1990s, it continued with a programme to introduce modern techniques for the diagnosis and control of infectious animal diseases. This included establishing a laboratory and training personnel to carry out nuclear and nuclear-related techniques to increase the proficiency of livestock disease diagnosis. The Joint Division also has worked with the sector to introduce isotope tracing to improve animal feeding schemes and breeding. As expected, this long-term effort by the government to improve the capability of its veterinary laboratories to deal with diagnosis and control of transboundary animal diseases made the difference – it meant that when FMD flared up in 2010, the country was prepared.

The livestock sector is a main pillar of the Mongolian economy with more than 43 million head of livestock in a country with a human population of only 3.1 million. However, it is also a country of extremely severe climate which can cause large variation in herd numbers.

At the start of each winter, most herders start moving their animals toward the capital city of Ulaanbaatar, often culminating with 20–30 million head kept in close proximity to the capital, hoping to increase the likelihood of their animals' surviving the harsh weather. The winter of 2009–2010 was especially harsh and millions of animals died, while those that survived were often left weak and susceptible to disease.

Polymerase chain reaction
Gamma irradiation

In the lead up to the winter of 2010–2011, FMD was reported in animals coming toward the capital from near the Russian border. It became a race against time to identify which of the seven strains of the virus the animals were carrying and to set up a plan for controlling the spread of disease before the animals reached the more densely congregated animal holding grounds near the capital.

The two decades of partnership and preparation paid off. There was strong commitment from all those involved in addressing the outbreak. They were supported by clear chains of command and lines of communication established among a number of agencies at the national, provincial and local levels. The authorities demonstrated considerable concern for the well-being of affected herders and made the recovery and sustenance of affected people a clear priority. About 30 000 livestock infected by FMD virus were killed and buried.

Thanks to the Joint Division's efforts in developing laboratory facilities, training personnel and establishing veterinary service networks, the government was well prepared to take immediate steps using diagnostic kits, also provided by the Joint Division. With field diagnosis, no time is lost taking samples to laboratories, critical days or even hours during which the disease would continue spreading. In order to identify the virus type, antigen ELISA, real-time, and real-time reverse transcriptase-PCR tests were carried out that confirmed the presence of the FMD virus as type O. Additionally, non-structural ELISA was used to distinguish vaccinated from naturally infected animals, and confirmatory tests including genotyping were conducted at the World Organisation for Animal Health's (OIE's) reference laboratory in Vladimir, Russia.

This confirmation of the virus type enabled scientists to specify the vaccine strain best suited to protect livestock and control the disease. In November 2010, the IAEA provided 200 000 emergency doses of the vaccine for the animals determined to be at the highest risk. Animals in eastern districts and those at the highest risk were vaccinated and, in January 2011, the Mongolian veterinary authorities were able to send a final report to OIE to confirm that FMD was under control.

The Joint Division held a follow-up meeting with the Mongolian veterinary authorities at its headquarters in Vienna to address the issue of increasing the country's transboundary animal disease diagnostic and control capacities. In addition to fighting disease, the Joint Division also supports programmes to improve animal nutrition. This is not only beneficial for livestock productivity, it also means that if animals do become sick there is a better chance for recovery.

The IAEA is supporting the vaccination of 15 million animals with FMD type O vaccine donated by Russia, with the Joint Division providing technical support. At this point, the vaccine must be given every six months, which is a major undertaking in a country such as Mongolia with its nomadic herders spread across its vast plains and steppes.

Although Mongolia successfully controlled the FMD outbreak in the eastern provinces where the disease was first diagnosed by using vaccination and biosecurity measures, it will need to maintain surveillance for FMD in the long term to keep the disease under control. Fighting transboundary animal diseases begins with prevention and, as was found in Mongolia, early diagnosis, separation of healthy and sick animals and timely vaccine delivery are the winning combination.

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SRI LANKA: vegetable farmers

Meet the Lanka cherry: a new tomato

Tomato, one of the most widely cultivated vegetables in Sri Lanka, is highly susceptible to bacterial wilt, a devastating soil-borne disease. Traditionally, when Sri Lankan farmers selected which varieties of tomato to grow, they chose those with resistance to wilt over those that had higher yield or better quality. In recent years, as Sri Lankan consumer demand for tomatoes has increased, due to their nutritional value and versatility as well as their attractive market price, farmers have looked for improved varieties, including those with better yield and quality in terms of size, colour, shape and, of course, taste, for the market.

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For the tomato growers of Sri Lanka, a 2005 project that brought together the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Sri Lanka Horticultural Crop Research and Development Institute had a less-is-more element of special interest to it. The goal of the project was to develop a small "cherry" tomato that would have the taste, quality and size needed for high consumer appeal but also would have resistance to bacterial wilt.

The Joint Division's relationship with Sri Lanka dates back to the 1970s when plant breeders were focused on improving varieties of plantains and bananas. At that time, the Joint Division worked with the Sri Lankan scientists, supporting them in improving their techniques for plant genetic mutation – speeding up the plant breeding process to develop new varieties that had improved traits. Thus, in 2005 when the Sri Lankan breeders began working with the Joint Division to improve tomato varieties, they had already honed their skills working on other crops.

The breeders chose to work with seeds of the Manik variety, because it has natural resistance to bacterial wilt and high yield potential. However, it also suffers from irregular shape and low fruit weight, two traits that would need to be overcome in the mutation and selection process. Thousands of seeds were transported to the Joint Division laboratory near its headquarters in Vienna where they were treated with high enough doses of gamma rays to bring about a change in the DNA, then transported back to Sri Lanka where they were planted and grown at the Horticultural Crops Research and Development

Gamma ray
Mutation induction


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Institute in Gannoruwa. As the plants grew and the mutations that resulted from the irradiation became visible, the breeders made selections, looking for those that had the desired small size, but also the color, taste, yield and even stem quality that would make harvesting easier for the farmers. Over the course of the next four growing seasons, the breeders continued narrowing their options, selecting and re-planting the varieties that showed the traits they were interested in.

Sri Lankan farmers also participated in the selection process, planting the selected varieties in their fields and testing them for adaptability to growing conditions as well as disease resistance. Eventually the breeders and farmers settled on their desired "cherry" tomato, Sri Lanka's first cherry tomato and thus named the Lanka cherry.

In June 2010, the Sri Lanka Department of Agriculture officially released the Lanka cherry to farmers. In the first growing season, they immediately found the new variety easy to cultivate, less prone to pest and disease and well accepted by the market, an enormous improvement over the original Manik variety. They also found ready-made markets, not just supermarkets but also the tourism industry, restaurants and even airlines were happy to purchase the small pear-shaped but extremely tasty Lanka cherry.

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PERU: high Andes farmers

Ancient grain gains new respect and updating

It's a big leap from the ancient Incas of the high Andes of Peru to NASA astronauts on space journeys, but kiwicha – a highly nutritious Andean grain – has been part of both worlds. And now, thanks to the support of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in applying nuclear techniques to kiwicha breeding, the crop has new traits that have changed its appearance, improved its yield, and given it a new role as an export crop with potential to improve the quality of life for people who still farm in the high Andes region where the Incas planted kiwicha thousands of years ago.


Luz Pando

From Incan tombs to outer space, kiwicha (*Amaranthus caudatus*) grains have taken flight in recent decades, with modern science proving that the ancients of the Peruvian Andes knew what they were doing when it came to making nutritional decisions. Growing at altitudes of 3–5 000 meters, scientists have determined that this staple food of the Incas has 30 percent more protein than common cereals such a rice and wheat, it reduces hypertension and cholesterol, is high in dietary fiber and minerals such as iron, magnesium and manganese, and is gluten free. With that knowledge, these grains that have been found sprinkled around 4 000-year-old Andean tombs also gained the respect of the US National Aeronautics and Space Administration (NASA). NASA included the nutritious kiwicha as a supplement in astronaut meals.

Thanks to millennia of adaptation, kiwicha has natural resistance to pests, which means it needs no or very little application of pesticides and fungicides. This not only makes it safer for consumers and less expensive to produce because farmers do not need to buy the inputs, it also gives it entree to the high-end organic markets.

In spite of the fact that kiwicha was a well-adapted staple in the Andes and had provided local people important nutritional benefits for millennia, when the Spanish arrived in the 1500s, they replaced kiwicha cultivations with wheat and barley. Pockets of kiwicha still grew wild at high altitudes, but it remained nearly forgotten until modern scientists began looking at its potential for improving local nutrition and as an export crop to markets hungry for nutritious health

Gamma ray
Mutation induction
DNA markers


Luz Pando

foods. Peru has a population of 29 million, with 34.8 percent living in poverty. For the 3 million people living from subsistence agriculture in the Andean highlands, increasing export potential of kiwicha could have great benefit for the area.

The Joint FAO/IAEA Division for Nuclear Techniques in Agriculture began working in Peru in the 1970s. At that time, local Andean crops were limited by the altitude at which they could grow, which meant that people living in the highlands had to come down to the valleys to buy their grains, such as wheat and barley. Breeders were aiming higher up the slopes and using nuclear techniques in plant breeding was a way to get there. The Joint Programme worked with the Nuclear Breeding Department of the University of La Molina in Lima, focusing on mutation breeding of wheat and barley and, by the 1990s, had released new varieties that could grow in higher altitudes.

The Joint Programme became involved with kiwicha in 2005, through a project focused on increasing the food supply and income of farmers in the Andean highlands of Peru. Kiwicha already grew in the highlands but had an unappealing purple colour which affected marketing, and no uniformity of size which complicated harvesting. Thus, aiming to improve efficiency and export value, the breeding programme ended up with a variety that had larger grains, higher yields under marginal conditions, plus a creamy gold colour and uniformity – called the Centenario – in 2006. The work went very quickly because the Peruvian plant breeders already had experience in plant mutation and had selected the seeds they wanted to improve. The Joint Division supplied lab equipment and trained staff in how to use it, and offered guidance on screening for qualities such as nutrient content.

Initially, the seeds received doses of radiation to initiate the mutation process. The radiated seeds were planted first in greenhouses and, upon sprouting, those that had developed the sought-after mutations were selected for replanting in experimental fields. When this second generation of plants grew, researchers invited local farmers to participate in the third and fourth rounds of selection, adding their expertise to determining which mutation traits might prove beneficial. At the same time, those involved in the selection were careful to select varieties that maintained the inherent advantages of the kiwicha, such as its disease resistance and water tolerance.

To ensure this, experiments were conducted using nuclear isotopes to determine how the selections absorbed water and DNA markers to screen for presence or tolerance to *Sclerotinia sclerotiorum*, a fungal disease which is always a threat to kiwicha. These lab experiments paralleled more practical testing of the third and fourth generation seeds, such as planting and growing them in a field where the *Sclerotinia* sp. disease was present to determine if the plants had disease resistance, and also to test their yield, length of growing period and tolerance to salinity. On an even more practical level, although not part of the project objectives themselves, flour was made from the grain and tested in common cake and biscuit recipes, just to determine if it would give consumers the texture and taste they were looking for.

This is a case of a product being bred especially for export to high end markets and succeeding. Exports of kiwicha to Japan increased tenfold, from 20 metric tonnes in 2002 to 200 metric tonnes in 2009. To date, Kiwicha is cultivated on more than 450 ha of land by small farmers, NGOs, enterprises and public and private institutions, with harvests reaching 5 000 kg per hectare at altitudes as high as 3 000 metres.

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VIETNAM: rice exporters

8 new rice varieties dominate export market

The young Vietnamese farmer carrying his harvested rice wasn't born when the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture began the work that has enabled him to have such reliable harvests. The work of the Joint Division in improving rice varieties for the fields of Vietnam dates back to the 1970s, when a post-war population boom was increasing food demand at the same time that changing climates had begun causing flooding and salt pollution which led to crop losses. These low production levels not only meant less food for the people of Vietnam. They also meant that the increased demand for export rice could not be met.


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When the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture began working with Vietnamese scientists, its role was to pass on techniques of genetic mutation that could be used to improve local soybean and rice varieties. Although the overall goal was to meet increased food demand, the focus was not simply on developing varieties with higher yields. It also was necessary to insure the new varieties would be more resistant to pests and tolerant to environmental problems such as the salt inundation.

Mutation induction – applying nuclear and efficiency-enhancing biotechniques to speed up the natural mutation process of plants – has become an extremely successful component of modern agriculture. What could take tens of millions, if not hundreds of millions of years in nature is reduced to a decade or less through irradiating seeds with gamma rays to change their DNA structure. However the use of the radiation is just the first step of the process which depends on the input of local farmers as well as the nuclear scientists.

Once irradiated, the seeds are planted and, as they grow, scientists examine them to identify any mutations that have arisen due to the changed DNA. They select the ones that best serve their purposes for further study and development. Local farmers also participate in the selection process, bringing their knowledge of how the new mutations might actually respond in the field and how they might serve their needs.

Gamma ray
Mutation induction

In the early days of its relationship with Vietnam, the Joint Division equipped labs and trained scientists in genetic mutation techniques. By the 1990s, their

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new varieties had increased production and, seeking to expand its focus to meeting export demand, Vietnam established a partnership between the Joint Division and the Institute of Agricultural Science of South Vietnam (IAS). In this arrangement, the Joint Division provided irradiation services and advice to go along with it. IAS scientists brought their seeds to the Joint Division laboratories outside of Vienna to be irradiated and then took the irradiated seeds back to Vietnam for the planting and selection processes. Once the seeds grew, they invited local farmers to help in determining which traits were the best to pursue, making the selection while growing them under local conditions

Starting in the early 2000s, Joint Division experts went to the region of Vietnam where rice is produced to do an evaluation of the site and set up yield trials and demonstrations. This included assessing the selected mutant varieties that are growing in the area. The Joint Division and IAS also set up Farmer Field Schools, to include the local farmers in the growing and analysis of the new varieties but also in disseminating information to other farmers. This ensured that the farmers would not only have access to the seeds, they would have access to the knowledge needed to grow the rice properly, including cultivation and fertilization techniques, and efficient water management.

Thanks to the process which allowed scientists, as well as participating farmers, to select mutations with potential to meet local needs, this partnership produced eight excellent rice varieties that not only have higher yields, they tolerate the salt inundation of Vietnam's soils. As the technology advances and local plant breeders increase their skills, mutant rice varieties will increasingly be bred to have the traits they need to survive and thrive in specific conditions. As they are developed, they will be released to farmers for further testing in the fields.

In the case of the eight new varieties, the most important results were their high yields, but in addition to their salt tolerance, they also showed improved grain quality, disease resistance, tolerance to pests and better adaptation to environmental stress. And the process continues. Plant breeders continue to seek further improvement, now working to improve the nutritional value of the new varieties which already account for 80 percent of Vietnam's rice export.

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SOUTH AFRICA: citrus growers

Moth pest controlled and environment protected

In the late 1990s, scientists from the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture were working in South Africa on a programme to help table grape exporters apply the sterile insect against fruit flies, when growers told them about another damaging pest that was having an extremely negative effect on South African citrus exports – the false codling moth. The Joint Division in collaboration with the United States Department of Agriculture (USDA) joined the fight and, since then, has worked with partners in South Africa developing a new technology and establishing a public-private partnership to overcome the problem. By 2010, the programme was treating a 4 000 ha citrus area in the Western Cape's Citrusdal Valley, greatly reducing insecticide applications and infestation levels.

Ana Rodriguez

When it comes to fighting one of the most serious enemies of the citrus export industry in South Africa, it doesn't matter if growers are rich or poor. Whether they have 1 ha of orange trees or 1 000 ha, each farmer benefits from combating a common enemy – the false codling moth, a native of Africa and among the world's most feared invasive pests.

The method used for managing the pest in orchards and surroundings – the sterile insect technique – is an environment-friendly method for the biological management of pest populations that is applied on a permanent basis in combination with other control tactics to suppress pests. As its name implies, the sterile insect technique calls for mass-rearing and sterilizing a large number of male insects and then releasing them weekly to mate with wild females who will then produce no progeny due to the males' sterility. For this method to work, all growers must work together to ensure there is total coverage of the area.

The South African citrus producers asked the Joint Division to support development of the sterile insect technique for false codling moth, because insecticide-based control mechanisms had become ineffective. The insects had developed resistance to most existing pesticides, leading to increased applications of the chemicals. This not only caused health problems for field workers, it also left chemical residues on the fruit too high to meet export standards.

The false codling moth also represents a major phytosanitary barrier to exports. It is confined to Africa, but with greater cross-border trade increasing the chances of it showing up in other areas and global warming allowing its survival in previously

inhospitable areas, many countries have set strict pro-active quarantines. For example, if the false codling moth establishes a presence in the southern and southwestern United States, it would cause multi-billion dollar losses. As a result, the USA has set up quarantines under which entire consignments can be rejected if single larvae are found, and conducts border searches so stringent that it reports finding one larva in a piece of fruit in a passenger's luggage in 2009. The cost was also high for South Africa as an exporter. In 2004, the estimated annual loss incurred by the citrus industry of South Africa as a result of false codling moth infestation was US$14 million.

When the South African citrus growers asked for support, the idea of integrating the sterile insect technique for false codling moth with other control tactics was new. Thus, in 2002, the Joint Division set up a research project together with Citrus Research International, the Citrus Growers Association, the Agricultural Research Council (ARC) of South Africa, and the USDA Agricultural Research Service. There was a lot of background work to do, to determine if these invasive insects could be reared at an industrial level.

Moths have a complex life cycle and rearing them requires collecting eggs, developing an artificial diet to feed the emerging larvae, and establishing appropriate conditions for the caterpillars to grow and adult moths to thrive. It is also necessary to determine the radiation dose needed for sterilizing the moths and the age when it works best. Finally, field cage and field evaluations are needed for testing the impact of the various doses on moth behaviour, all the while keeping the process at an economically viable level. By 2006, all issues had been addressed, and the local stakeholders, together with the private sector and the Joint Division set up a pilot sterile moth release project that resulted in 95 percent decrease of the false codling moth population and the damage they caused. With that level of success, the South African citrus industry decided to fast-track the process, moving toward area-wide application and commercialization of the insect-rearing segment.

A private company, Xsit (Pty) Ltd, was established to support South African biotechnology, with the continued support of the Joint Division and the ARC. Xsit built a false codling moth rearing facility with a capacity of 15 million sterile moths per week, in Citrusdal, Western Cape, which produces the majority of the citrus exported from this province to the USA market. What began as a pilot on 35 ha in 2006 had expanded to 4 000 ha in 2010–2011, treating the valley's entire citrus crop – infestation levels for naval oranges dropped from 7.9 per tree in 2007 to 1.2 in 2010.

For now, one of the main jobs of Xsit is ensuring that all producers – large and small – remain committed to the programme. With the initial success, there is fear that some may drop out, assuming that if their neighbors remain in the programme, they will still benefit from the low pest population. Xsit uses a geographic information system to map moth densities and even can monitor the ratio of sterile to wild moths. It then puts out weekly reports that basically point to those growers not doing the work on their farms, thus relying greatly on peer pressure to keep the blanket coverage needed for continued success.

Described as a project where everybody wins, the use of the sterile insect technique against false codling moth has reduced insecticide applications, thereby improving the health of field workers as well as neighboring communities who all have less exposure to pesticides. In addition, fruit losses have been reduced and fresh citrus exports maintained, improving job security for those who work in the sector. For now, the programme is expanding into other citrus-producing areas in South Africa, and research is underway to assess the potential of using SIT against other pests that attack other crops in South Africa. If the false codling moth should appear in another part of the world, the SIT technology is now available for this pest and can be adapted to join the fight wherever needed.

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CENTRAL AMERICA: export farmers

Control of fruit fly doesn't stop at national borders

Pilot projects developed as teaching tools for Central American farmers facing the need to suppress fruit fly pests proved so successful that, instead of just being used as demonstrations, they moved directly into import-export agreements. A major importing country accepted the results of the projects demonstrations as validation that the project areas had low pest prevalence and thus met their import standards. These agreements were the final step of a seven-year project that began in 2001, when the seven countries of Central America approached the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture for help in reducing fruit fly prevalence in their region.

Traditionally, Central American countries mainly produced crops such as coffee, banana and sugarcane. These crops are not affected by Mediterranean and other types of fruit fly pests, and thus growers never had to meet the strict export standards required for many high-value tropical crops that are fruit fly hosts.

However, since the 1990s, growers have dealt with the frustration of constantly fluctuating international market conditions and increasingly lower prices for their traditional commodities. In response, they have attempted to diversify their production and grow more high-value horticulture commodities such as tomatoes, bell peppers and papaya for export.

This created a new problem. These new crops are hosts for fruit flies, meaning that the growers would need to meet standards for exporting to countries free of such fruit fly pests. These importing countries simply would not accept fresh produce without proof that fruit flies would not accompany the shipments. This meant that investment in these new crops would remain very restricted, as long as this phytosanitary problem could not be overcome.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture knew from previous experience with other fruit fly eradication and containment projects in the region that success would require more than just releasing sterile fruit flies. Such a regional project would require coordination among all stakeholders, with Central America taking a holistic approach to problem solving and establishing complementary phytosanitary policies in the region.

The Joint Division proposed an initiative that focused on an area-wide approach – including use of SIT, where necessary – to establish pilot areas of low-pest prevalence. The initiative also called for cooperation among governments, fruit growers and international organizations in Central America.

The project, launched in 2001 with the support of the Joint Division, offered a complete technical package. Growers first of all learned to measure the size of the fruit fly populations in their fields and adjacent areas and how to suppress the populations with measures other than SIT as part of an integrated pest management approach. They also learned the appropriate steps for successful SIT application, how to monitor and measure the resulting levels of insect prevalence, how to establish database methods for proving they actually had achieved low prevalence and how to inform the World Trade Organization (WTO) and the International Plant Protection Convention (IPPC) of their results. Finally, they learned how to negotiate their potential export agreements with importing countries.

The project also invited a major importer, the United States, to check the pilot areas established in the different countries where the work was underway and to participate in outlining work plans for export. This ended up enabling the countries to move immediately into exporting their produce because the USA was able to validate the results and the pilot areas became the basis for actual import-export agreements.

Although common practice in international trade called for proving that export areas were pest free, as early as 1995, the WTO had broached the idea that "low" pest prevalence in the field might have the same mitigation of risk as pest-free areas. In 2001, when the project started, the Joint Division experts working on the pilot projects were aware that the IPPC was in the process of preparing a standard for fruit fly areas of low prevalence, anticipated that the phytosanitary rules might change in the middle of the project and prepared for it. Thus in 2008, when the IPPC issued the standard allowing "low-pest prevalence for fruit flies", the Joint Division's Central America project already had been working in that direction for several years.

When the pilot project ended in 2007, the Joint Division enhanced these activities throughout the region, in two or three locations per country, aiming toward establishing low prevalence areas. As a result, import-export arrangements have been set up, and private sector entrepreneurs are investing in tropical fruit and vegetable production, growing their size and hiring more rural workers. In most cases, 80 percent of the workers are women who work in the processing, packing and quality control areas, and 20 percent are men who work in the field. At the same time, other support industries are springing up, such as fresh fruit and vegetable packing and transport companies, thus ensuring local growers can meet the increased export demands that have resulted from meeting the low pest prevalence standard.

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MIDDLE EAST: fruit and vegetable farmers

Medfly suppression with sterile males is a bridge to peace

Scientists, politicians, and farmers from Israel, Jordan and the Palestinian Authority are winning a long but largely invisible fight. Their common foe: the Mediterranean fruit fly, or medfly, one of the world's most destructive agricultural pests. Among their allies: the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the tools of nuclear science and technology. The result of this unique joint activity in the region is higher production, lower use of pesticides, and increased fruit and vegetable production for local markets and for export.

In this region where military no-fly zones typically rule, a plane loaded with a unique cargo of 7 million sterilized male flies makes a two-hour flight between the Red Sea and the Dead Sea. It is the only plane authorized to fly freely in this region.

Twice a week, this unlikely "fly bomber" releases millions of sterile males into the air, allowing them to swarm into the Arava/Araba Valley shared by Israel and Jordan. The medflies are bred for birth control so any mating of these sterile males with wild virgin females of the pest populations yields no offspring. If left to multiply in the wild, medflies wreak havoc on citrus and many other fruits and vegetables, quickly turning crops into infested mush.

Scientists call this pest-control technology the sterile insect technique (SIT). It is an environmentally friendly method, with a basic "birds and bees" concept. No offspring means a dwindling fly population over time, through systematic and targeted campaigns combined with other strategic measures on an area-wide basis.

That's what is happening in the Arava/Araba Valley, using a pest to fight a pest, with a unique and winning partnership between Israel and Jordan. The Joint Division has supported the project since the mid-1990s, and is currently expanding to other areas which also include the Palestinian Authority.

For Israeli farmers, success means they can sell produce, such as bell peppers, to lucrative export markets such as the United States, where imported fruit and vegetables must come from fruit-fly-free areas. The bell peppers are grown

inside enormous greenhouses – cool oases of reds and oranges on lush green plants – that dot the desert landscape. The SIT programme has helped convince tough regulators in the USA and elsewhere that the Arava/Araba Valley's production is free of infestation.

As a result, bell pepper production in the Arava/Araba Valley has grown a hundredfold since the programme started, and increased from less than US$1 million in exports a year in 1998 to US$150 million in exports today. With the use of SIT, the need for pesticides to control the medfly has fallen significantly, benefitting exports to the Europe.

For Jordanian farmers, yields have improved, and fresh farm produce is rising as are exports to their Gulf neighbours and, recently, to Eastern European markets. There also is better quality fruit for the local market because the medfly is not the problem it once was.

The Joint Division helped set up pilot projects and supplied sterile male medflies to Israel and Jordan in 1998, four years after Israel and Jordan signed a peace treaty and related cooperation agreements. The Palestinian Authority joined the partnership one year later, and now has the capacity to adopt the technology. The Joint Division funded the partnership for many years, as did the USA which provided a four-year, US$2.5 million grant.

The sterile flies are now bred in a commercial mass-rearing facility in Israel called Bio-Fly, run by specialists who received training at the Joint Division's laboratory near its headquarters in Vienna, as well as in Chile. It now produces 20 million sterile male flies each week for release over the valley to mate with wild females.

Further north, the situation is very similar. Farmers were relying heavily on pesticides to control medflies and other pests which have been known to destroy up to 25 percent of their crops. Fortunately, the science alliance has been expanded to this area and in both the West Bank and Jordan's northern valley, Palestinian and Jordanian fruit growers have started releasing sterile flies. Hopes are high that the integrated use of SIT will help them reduce the damage this pest inflicts on their produce.

In the days up until the mid-1990s, mistrust clouded the medfly partnership, but years of cooperation and communication since then have paid off. With the help of the Joint Division, Jordanian, Palestinian and Israeli technicians have been brought together at the same discussion table to develop future plans for jointly controlling this and other pests in their common areas and for using available sterile flies from the facility in Israel. For the region's agricultural leaders, the success of the medfly project feeds hope. In recognizing the three partners working together to protect their shared region, a former Israeli minister called the medfly a "bridge to peace".

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LEBANON: fruit and vegetable growers

Laboratory ensures food safety for consumers and trade

When the Lebanese government established its Atomic Energy Commission in 1996, the goal was to promote peaceful applications of atomic energy, with a focus on food contamination monitoring to ensure food safety. Thus, one of its first steps was to establish the Laboratory for the Analysis of Pesticides and Organic Pollutants, known as LAPPO – a laboratory that uses nuclear techniques to provide services to the country's food producers, such as testing their production for agrochemical pollutants. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has worked with LAPPO since its earliest days, assisting in setting up and improving its laboratory capabilities and providing specialized training for the staff.


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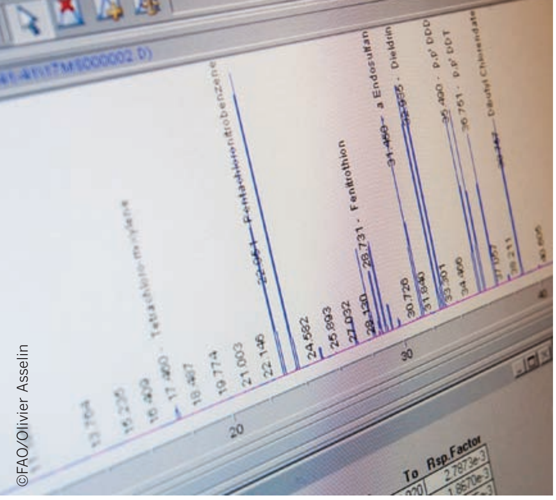
Over the years, LAPPO has established ongoing relationships with many of the country's farmers, offering its analytical services and raising awareness of the importance of complying with the safety requirements that govern food production. As a result, Lebanese farmers are better educated and aware of the importance of minimizing pesticide residues in their fruits and vegetables and therefore follow strict pest control procedures. They choose lower impact pesticides and also minimize the number of pesticide applications to produce safe and wholesome foods.

With the Joint Division's support, LAPPO also implemented a quality control and assurance system, and was able to undertake a series of proficiency tests which led to its receiving laboratory accreditation from the International Organization for Standardization (ISO) in 2010 which recognized the quality of its work.

With this recognition, LAPPO began a formal upgrading programme. Again, with the support of the Joint Division, the upgrading included procuring new equipment that would increase the level of testing it could perform and enable it to meet the analytical service demands placed on it, including expanding analytical services to cover the analysis of veterinary drugs in meat products. Of course, adding new equipment is just half of the equation. The Joint Division is also supporting building the capacity of the staff to work with the new equipment and new methodologies. This has included sending Lebanese scientists to workshops and fellowship programmes conducted by



the Joint Division at its headquarters in Vienna and also sponsoring them at other capacity building activities in France and Belgium. There also have been workshops at LAPPO itself, for staff to become familiar with the new equipment and learn which methodologies provide the most accurate and reliable results for their farmer clients.

The lab already offers analytical services to more than 1500 Lebanese farmers. The farmers who send their samples to the lab for testing are very interested in discussing analytical results and receiving advice from the LAPPO experts. They know that by using the services offered by LAPPO, they have improved the value of their products. These farmers can demonstrate to both local and export markets that their fruits and vegetables are safe, which has notably improved trust between farmers and traders. As word has spread in Lebanon's agricultural communities, the number of samples analysed per year has tripled.

Lebanon is not a major food exporting country. Most of its production is consumed domestically while most of its exports are mainly within the Gulf region. In 2010, its food exports totaled US$324 million, compared with industrial exports that reached US$3.3 billion.

The services provided by LAPPO are not specifically focused on increasing global food exports, but having a high quality lab in the country is a critical step in positioning the country's agricultural export sector to grow. At the same time, the laboratory assures national retailers and consumers and ensures that the food the agriculture sector produces is safe for everyone.

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URUGUAY: livestock producers

Increasing exports thanks to improved laboratory

Uruguayan beef has a good reputation – grass-fed cattle raised in the open under natural conditions, with an abundance of fresh feed and clean water. But in the world of international trade, good agricultural production practices are not enough to satisfy consumers and importers. They want certification that meat products meet international standards. Thanks to the support of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in strengthening the country's Michael C. Rubino Veterinary Laboratory, which tests meat products, Uruguayan food producers can provide proof that their production is safe for consumers. This means ensuring that it does not contain any harmful residues of veterinary drugs or other contaminants. The Joint Division has similar projects throughout Latin America.

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Uruguay entered the global meat export market in a big way in 1995 when it was declared free of foot-and-mouth disease by the World Organisation for Animal Health (OIE). Except for one outbreak near the Argentine border in 2001, Uruguay has remained free of the disease. It has established quality control labs and now exports beef worldwide, even to the highly controlled North American markets which now accept both its fresh and processed meat products.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture works throughout Latin America to help countries improve the proficiency of their meat control laboratories. If veterinary medicine must be used in livestock rearing, the Joint Division helps the countries adapt and apply the tests that will demonstrate that it has been used correctly. In the case of Uruguay, the beef it produced was actually residue free, but this could not be proven to importers until there was an approved laboratory system in place.

Today, the beef industry represents 6 percent of Uruguay's gross national product with 80 percent of national production exported to some 80 countries. However, global meat trade has become increasingly competitive and food quality control and import-export standards increasingly stringent. Thus Uruguay's livestock sector is highly committed to maintaining a state-of-the art certification system.

Multi-residue detection using mass spectrometry

In 2010, the Joint Division began working with Uruguay to improve its laboratory facilities. It introduced a methodology that allows for multi-residue

detection of antibiotics using mass spectrometry – a methodology developed in France but, with the support of the Joint Division, modified to meet Uruguay's specific needs. Multi-residue analytical methods enable the more efficient and cost-effective detection of multiple veterinary drug residues in complex food matrices at the same time, which favorably compares to the onerous, expensive and time consuming traditional analyses of individual contaminants. Not only must measurements prove that meat products contain no contaminants, are safe for consumers and meet international standards, Uruguay also must prove that its methods of analysis and sampling are calibrated according to international protocols.

The small size of the country has allowed Uruguay to streamline its meat-supply chain to ensure flexibility plus fast action and reaction to customer demand. It also has enabled a well-functioning national surveillance system that includes educating smallholder farmers as well as large commercial enterprises about the importance of following strict guidelines for meeting international standards. For example, a farmer who achieves a 50 percent increase in milk yield after using a chemical additive in the feed naively adds even more chemical to get a further increase – not realizing that the animal will eventually develop resistance to the chemical and, at the same time, could actually exceed legal limits for chemical residues. Thus, the national laboratory has the possibility of monitoring what goes through the slaughterhouse and can give feedback to farmers to help them improve their animal husbandry and, in turn, support the national livestock sector.

Building from the example of Uruguay, the Joint Division is working to establish a network of national and regional reference laboratories throughout Latin America - including in Argentina, Bolivia, Chile, Costa Rica, Haiti, Nicaragua and Venezuela – helping them harmonize protocols for methods of analysis and sampling, and enabling the more advanced laboratories, such as Uruguay's, to help the less developed ones implement quality assurance programmes. Already the involvement of the Joint Division has enhanced the competitiveness of the countries they have worked with by demonstrating their commitment to improving their meat production standards, for their own consumers as well as for their export markets. In the case of Uruguay, beef production has increased 67 percent in the last 15 years, it ranks seventh in the world for beef export and among the highest in the world for beef consumption per person.

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INDIA: mango growers

Irradiation opens the door for exports

An import-export door re-opened when the United States agreed to import mangoes from India after banning them for 20 years because of quarantine concerns over pest infestation and questions about pesticide use. The agreement was reached after extensive negotiations that ended when India agreed to irradiate all mango exports to the United States, thus eliminating or greatly reducing the threat of mango pests from overseas affecting USA agriculture. According to newspaper accounts when the agreement was finalized, gala parties were thrown to herald the deal. International standards that define 14 different irradiation treatments to protect plants such as mangoes from invasive pests have now been accepted by the International Plant Protection Convention. Those standards are backed up by scientific evidence gathered by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.


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For well over 4000 years, the mango has been part of the cuisine and culture of India, which today is the world's largest mango producer. Although mango is cultivated commercially in 87 countries, India alone accounts for more than half of global production. Thus, it was a cause worth noting when the USA lifted its 20-year import ban on Indian mangoes. The deal was sealed when India agreed to irradiate its mangoes before exporting them.

Irradiation calls for exposing mangoes to low doses of gamma rays that will kill any pests they may be carrying or prevent them from being able to reproduce. This is achieved without altering the taste or texture of the fruit. In the case of mangoes, there are no USA-approved chemical pesticides or treatments that can control the pests. Only irradiation has been accepted as an approved control measure. Irradiation is also used on a host of other agricultural products – fresh produce, meat, grains and spices – to kill harmful pests as well as disease-carrying bacteria, such as *E coli* or salmonella, and to prevent spoilage. Other treatments, such as heat, cold or chemical fungicides do not serve as well, because they can damage the food products or leave harmful chemical residues.

Interest in irradiation has grown in recent years as global food trade has increased. Because this increased trade allows more opportunities for pests and diseases to cross borders, it has led to more stringent import-export standards and quarantine requirements, as was the situation with Indian mangoes. Although individual countries set their own standards, they are usually guided


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by the global standards of the International Plant Protection Convention (IPPC) and the Joint FAO/WHO Codex Alimentarius Commission.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture provides the technical and analytical background upon which these standards are based. Between 2007 and 2011, the Joint Division supported the research and technical development of 14 irradiation treatments to protect plants from invasive pests and presented its findings to the IPPC for review and adoption as international standards. Between 2009 and 2011, the IPPC adopted all 14 of the treatments the Joint Division had presented, giving the food trade industry important and safe new options for protecting their production and opening avenues for increased food trade.

In parallel to this work, the Joint Division works with developing countries to determine their capacities for meeting the standards and, if necessary, helps them identify and adapt the appropriate technologies for their specific needs. For example, methyl bromide is highly effective in pest control but can be toxic to humans if used incorrectly, and it also has ozone depleting characteristics. As a result, countries must phase out its use in order to meet new environmental and safety standards. However, in turn, they now can rely on irradiation to accomplish the same benefits without the potential health or environmental threats. The Joint Division is on hand to provide the kind of technical support they need to make the transition.

Today, over 60 countries have approved irradiation for more than 60 types of food products. Each year, an estimated 500 000 tonnes of food, including spices, grains, chicken, beef, seafood, fruits and vegetables, are treated in 180 gamma irradiation facilities worldwide.

At this point, India has only one USA-approved irradiation facility and only those mangoes treated at this facility can be exported to the USA. India has never been a major exporter, mainly because of home-grown demand, plus quality, logistic and infrastructure issues. However, the opening of the mango market, with more than 600 tonnes of mango on their way to the USA, was hailed as the opening of a new era. The irradiation plant was recently upgraded for multitasking and is not only equipped for quarantine treatment of fruits but can also be used to inhibit sprouting, rid stored commodities of insects, and for the microbial decontamination of spices and dry ingredients. Commercial interests in India say this is a sign that exporters now recognize the importance of market requirements and of committing to meet quality standards.

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The work of the Joint FAO/IAEA Division is broken into five separate but interrelated subprogrammes:

- soil and water management and crop nutrition
- plant breeding and genetics
- animal production and health
- insect pest control
- food safety and control

All work of the Joint Division is guided by a mission statement that recognizes its unique place in the world of agricultural research:

To strengthen the capacity of FAO and IAEA Member States in the use of nuclear and related techniques to improve food security and sustainable agriculture, and to disseminate these through international cooperation in research, training and other outreach activities.

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