Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Plant Breeding & Genetics Newsletter

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To Our Readers

Worldwide success in mutation breeding for food security – Achievement and Outstanding Achievement Awards, IAEA Director General Yukiya Amano giving opening statement and distributing Outstanding Achievement Awards. (For more on this event, see News on page 23)

The year 2014 has passed, and we prepare for 2015. Many things have happened this year; please allow me to highlight some salient facts about the Plant Breeding and Genetic sub-programme. 2014 saw the achievement of a very successful regional IAEA/RCA Technical Cooperation project RAS/5/056 on 'Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change'. In the mid-term project review meeting, it was highlighted that since inception, 17 mutant varieties have been officially released and that there are currently more than 100 advanced mutant lines in trials and more mutant populations in the pipeline for further selection and development. This project also demonstrated that mutation induction coupled with selection remains the cleanest and most inexpensive way to create varieties by changing single characters without affecting the overall phenotype. Our counterparts from RAS/5/056 also report on the beneficial products from mutant sorghum for human nutrition. The same is true for our colleagues participating in the CRP on food and feed, who report lignin modified sorghum mutant lines for animal nutrition (see Coordinated Research Projects (CRPs), page 17). In addition, the final meeting of another successful interregional TC project 'Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)', was held in Uganda, where it all began (see Past Events, page 15). The team of NAFA and TC got the IAEA Superior Achievement Team Award for the successful implementation of this project (see News, page 23).

This year, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture is celebrating its 50th Anniversary. On the occasion of this milestone of the Joint FAO/IAEA Division, Achievement and Outstanding Achievement Awards were initiated to honor and appreciate the successes of Member States in plant mutation breeding and to further promote the use of nuclear techniques for sustainable food security. Five Outstanding Achievement Awards and 18 Achievement Awards were handed out to the representatives of the concerned countries in the form of a certificate at an official ceremony during the 58th General Conference in the presence of the IAEA Director General on 24 September 2014 (for more on this event, see News on page 23).

Finally, I want to up-date you on the ReNuAL project. ReNuAL is an initiative to modernize the eight laboratories in Seibersdorf that belong to the IAEA's Department of Nuclear Sciences and Applications, five of which focus on food and agriculture. In the coming years, we expect the

construction of a new Insect Pest Control Laboratory (IPCL) to replace the existing IPCL, and a new Flexible Modular Laboratory (FML) to house three additional laboratories, by the end of 2017 (see ReNuAL, page 34)

What lies in wait for us 2015? Chinese Astrology has definite answers to this question. Owing to its five thousand years of existence, its answers may just prove to be astoundingly timely and accurate. 2015–2016 will be the Year of the Goat (Sheep, Ram). The Sheep (Goat) is Yin energy, a symbol of Peace, Harmonious co-existence and Tranquility. That is the primary and fundamental mood for this year.

In this spirit, please accept my wishes of Peace, Health and Prosperity for a brilliant 2015 (1436 in Islamic countries, 2558 in the Buddhist Era).

Pierre J.L. Lagoda
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Staff News

Farewell

Our colleague Brian Peter Foster left the Agency as Laboratory Head, and it is my task to say farewell to a friend. In the period of his tenure at the Agency, Mr Forster demonstrated a high leadership expertise, based on his supervisory, pedagogical and psychological skills. The Plant Breeding and Genetics Laboratory has progressed under his leadership and its achievements are owing to Mr Forster's dedication and motivation. He is a team player at heart, and this was also appreciated by the Agency Badminton Team winning the gold medal in two consecutive years at the Inter Agency Games. He was also instrumental in the Plant Breeding and Genetics team being granted the 2014 Superior Achievement Award (see News, page 25). We will miss his serene and efficient manners, his initiative and professionalism. Brian took up new challenges in Indonesia, a loss to us, a gain to his new colleagues.

Consultant

For every goodbye, there is a welcome. I have the pleasure to introduce a new colleague who will accompany the Plant Breeding and Genetics subprogramme as a consultant for a while: Mr Soeranto Human graduated from Bogor Agricultural University in Indonesia in 1981 and worked at the Agricultural Division of the National Nuclear Energy Agency (BATAN) since 1983. Continuing his studies at the Agricultural University of Norway, he got his M.Sc. in crop science in 1988 and his Ph.D. degree in plant breeding in 1992. As a researcher and Head of the Plant Breeding Group at BATAN during the period of 2005–2011, his research was mostly related to mutation breeding of cereal crops (sorghum and tropical wheat). Through the mutation breeding programme, three mutant varieties of sorghum and one mutant variety of tropical wheat had been produced and released officially by the Ministry of Agriculture. These mutant varieties had been widely developed by stakeholders including farmers, local agricultural offices and some private companies.

50th Anniversary

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

The occasion of the 50th anniversary of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has again been an exceedingly productive year. In addition to our ongoing activities reported extensively in this volume, we have taken this opportunity also to highlight several examples of tangible, sustainable results derived out of this unique partnership — beneficial to both our parent organizations and to our Member States — and to share these with our many stakeholders around the world and at the celebratory ceremony of this partnership.

- New communication materials outlining successes in the area of nuclear techniques: http://www-naweb.iaea.org/nafa/resources-nafa/IAEAsuccessStories-2014.pdf; http://www-naweb.iaea.org/nafa/resources-nafa/ProgBrochure-2014.pdf http://www-naweb.iaea.org/nafa/resources-nafa/LabBrochure-2014.pdf . We have also updated our website and urge you especially to check out our News section at http://www-naweb.iaea.org/nafa/news/index-ss.html

- On 29 September 2014, a ceremony was held in Seibersdorf to mark the 50th Anniversary of the Joint FAO/IAEA Division as well as the ground-breaking for the renovation of the IAEA's nuclear sciences and applications laboratories at Seibersdorf — including the FAO/IAEA Agriculture & Biotechnology Laboratories. This ceremony was honoured by the presence of the president and members of the IAEA Board of Governors, the IAEA DG and senior management, a representative of the FAO Director General, Ms Maria Helena Semedo (Deputy Director General — Coordinator of Natural Resources), and, believe it or not, all the former directors of the Joint Division since its inception in 1964.Achievement awards in mutation breeding were presented during the IAEA General Conference on 24 September 2014 by IAEA Director General Yukiya Amano. The awards were devised by the Joint FAO/IAEA Division to celebrate worldwide successes in this field and to promote the development of further sustainable crop varieties. The awards honour teams of scientists that have contributed substantively to global food security and sustainable agricultural development by using radiation to breed improved crop varieties.

The enormous contributions of the Joint FAO/IAEA Division and its numerous stakeholders worldwide to meet the changing needs of Member States through the peaceful uses of nuclear technologies are today clearly demonstrated in the shared goals of our two parent organizations and in the five strategic objectives of the FAO: to help eliminate hunger, food insecurity and malnutrition; to make agriculture, forestry and fisheries more productive and sustainable; to reduce rural poverty; to enable inclusive and efficient agricultural and food systems; and to increase the resilience of livelihood to disaster.

It is our fervent hope that, with the continued support and dedication of our numerous stakeholders worldwide, the Joint Division will also in future be able to provide excellent examples of the enormous contributions that peaceful nuclear technology can make to sustainable agricultural development. With this in mind, it is our unequivocal pleasure to take this opportunity to thank each and every one of you for your dedicated support to the Joint Division during the past fifty years — and to embrace your continued support in the decades ahead.

Background Information

Established on 1 October 1964, the FAO and IAEA created the Joint FAO/IAEA Division as a strategic partnership in order to mobilize the talents and resources of both organizations and hence to broaden cooperation between their Member States in the peaceful application of nuclear science and technology in a safe and effective manner to provide their communities with more, better and safer food and agricultural produce while sustaining natural resources.

Fifty years later, this FAO/IAEA partnership still remains unique, with its key strengths based on interagency cooperation within the United Nations family. It is a tangible joint organizational entity with a fusion of complementary mandates, common targets, a joint programme, co-funding and coordinated management. It entails close cooperation, greater efficiency and shared approaches, and geared to demand-driven and results-based services to its Members and to the international community at large.

Nuclear applications provide added value to conventional approaches in addressing a range of agricultural problems and issues, including food safety, animal production and health, crop improvement, insect pest control and sustainable use of finite natural resources. Over the past 50 years, this partnership has brought countless successes with distinct socio-economic impact at country, regional and global levels in Member States.

During the past 50 years the mission of the Joint Division has proactively evolved to embrace the adaptation to and mitigation of climate change and the adverse effects of globalisation, to increase biodiversity and to further contribute to agricultural development and global food security. Today, both FAO and IAEA strive to mobilize commitment and concerted action towards meeting the Millennium Development Goals and the Sustainable

Development Goals through appropriate use of nuclear and related technologies for sustainable agriculture and food security.

Strong synergies and benefits of this relationship include:

- Strengthened mandates of FAO and IAEA through the unique partnership.
- Facilitated cooperation and increased efficiency.
- Privileged access for Member States to invaluable knowledge.
- Institutional links with key stakeholders at local, regional and global levels.
- Platform for cooperation with other international organizations.
- Increased mobilization of resources and fund-raising capacity in food and agriculture.
- Fortified capacity for technology development and transfer to Member States through the joint laboratories.

Forthcoming Events

IAEA/RCA Workshop on Mutation Breeding and Supportive Techniques for Development of Bioenergy Crops, RAS/5/070, Vienna, Austria, 23–27 March 2015

Technical Officer: F. Sarsu

Most countries in the region are facing energy crises. A potential to alleviate these crises might potentially be given by the regional biodiversity to be developed as energy sources (i.e. oil plants and some plants producing carbohydrates that can be converted to bioethanol). On the other hand, there is a huge amount of unproductive land called 'marginal land' available in each country of the region. These soils can be utilized if integrated technology packages based on mutation breeding and best fit nutrient and water management practices are being applied. The productivity of those marginal lands might be improved, especially by growing bioenergy crops developed for these marginal areas. These crops would have the potential to improve the environment, increase rural income and offer a more robust crop in many of the above-mentioned regions. Through developing potential bioenergy crop agronomic technology packages with the application of nuclear techniques (mutation breeding; N-15 or C-13 isotopic techniques), it is expected that crop and land productivity will increase and, in turn, will help to protect the environment, enhance the ecosystem balance and improve farmer's welfare in the region.

This workshop will be organized under the TC project RAS/5/070 (RCA) on 'Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques'.

The purpose of this workshop is:

- To report and discuss the current status of bioenergy crops and its development in the region, especially through the application of nuclear technologies such as mutation breeding and supportive techniques for increasing marginal land productivity;
- To share knowledge and experience of bioenergy crop research and development among participating countries;
- To review and discuss the applied methodologies used in plant mutation breeding for improvement of bioenergy crop productivity in marginal lands (unproductive land);
- To identify the specific and common needs of the countries in the region, which can be addressed under this new project; including promising bioenergy crops, which need to be further tested and validated,
- To develop a strategy to upgrade the national capabilites, skills and infrastructure, strengthening the network of cooperation among the participating countries,
- To initiate, facilitate and strengthen collaboration in research and development of bioenergy crops among participating countries through common agreements such as germplasm exchange and/or training courses/expert missions in the regional framework.

The participants should come from participating Member States involved in the project, who are directly responsible for coordination and implementation at the national level. Seventeen Countries will be part of the project (Australia, Bangladesh, China, India, Japan, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Palau, and Republic of Korea, Singapore, Sri Lanka, Thailand and Vietnam).

Regional Training Course on Mutation Induction on Vegetatively Propagated Crops, RAF/5/066, Tangier, Morocco, 18–22 May 2015

Technical Officer: F. Sarsu

This training course will be organized by the International Atomic Energy Agency in cooperation with the Government of Morocco. It is open to candidates from partners participating at the AFRA project RAF/5/066 on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach.

The purpose of this course is to provide participants with theoretical as well as practical information on mutation induction in vegetatively propagated crops, and the application of *in vitro* propagation and *in vitro* screening techniques for biotic and abiotic stress resilience in crop breeding.

The course will include lectures and practical sessions on:

- Induced mutation for crop improvement;
- Mutation breeding procedures/methodologies and handling of mutated populations for vegetatively propagated crops;
- Application of mutagenesis in vegetatively propagated crops;
- Screening techniques for mutated population for biotic/abiotic stresses;
- Micropropogation and *in vitro* techniques;
- Security and safety in the laboratory.

The participants should come from all participating Member States involved in the project RAF/5/066. Additionally, they should be currently and actively working on mutation breeding and have basic knowledge in crop breeding especially on vegetatively propagated crops. The course will be profitable to scientists with at least a M.Sc. degree involved in plant breeding/genetics.

Third Research Coordination Meeting (RCM) on Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond, D2.30.29, Vienna, Austria, 22–26 June 2015

Technical Officer: F. Sarsu

Climate change is now largely accepted as a real and pressing global problem. The main impacts of climate change on agriculture will most probably be experienced through temperatures extremes (increase in minima and maxima), altered changes in rainfall patterns (in amount, spatial and temporal distribution), increased rates of evaporation, increased intensity and frequency of extreme events (floods and droughts), and raise of sea level affecting coastal areas where large quota of cultivated land are located (intrusion of salty water).

This CRP is focused on improving the grain yields of a major cereal (rice) and a major grain legume (common bean) under high temperature stress in the face of climate change. The aim is to develop new high yielding mutant varieties with improved quality under low input cultivation in a range of agro-ecologies, through broadening adaptability. The third and final RCM is planned to review the progress made under this CRP and evaluate data including advanced mutant lines with improved heat stress tolerance. Additionally screening protocols which have been produced under the project will be evaluated. Dissemination of the results, publicly accessible to all Member States, will identify success and failures within the project to make suggestions for further collaborative researches activities. (For more information, see CRPs on page 17)

First Research Coordination Meeting (RCM) on Efficient Screening Techniques for Mutants with Disease Resistance, (Working Title), Vienna, Austria, exact date to be decided

Technical Officer: B. Till

This CRP aims at developing and validating efficient methods for screening mutant populations to identify plants with enhanced resistance to disease. On a global scale, plant diseases result in approximately 10% yield losses annually. On a local scale, plant diseases can have devastating effects. For example, an outbreak of wheat stem rust race Ug99 can cause up to 100% losses. Most breeding lines are susceptible to the race and the pathogen spreads on the wind and has now been detected in many countries. Other examples include huanglongbing or citrus greening disease, roya (coffee rust), and banana tropical race four. These and other plant diseases are spreading and pose serious threats to global production and local economies and food security. Building off of the success from CRP on 'Enhancing the Efficiency of Induced Mutagenesis through an integrated Biotechnology Pipeline' (D2.40.12) and the TC project on 'Responding to the Transboundary Threat of Wheat Black Stem Rust' (INT/5/150), this CRP will focus on phenotypic and genotypic methods for disease screening and also on methods for identification of mutations causing enhanced disease resistance so that traits can be stacked and durability of new mutant alleles can be increased.

The project proposal still needs to be approved by the responsible Agency's authorities.

First Research Coordination Meeting (RCM) on Enhancement of the Efficiency of Mutation Induction by Physical and Combined Mutagenic Treatment, (Working Title), Vienna, Austria, exact date to be decided

Technical Officer: S. Nielen

During a consultants meeting in June 2014 (announced in Newsletter Nr. 33) a proposal for a new CRP on Enhancement of the efficiency of mutation induction by physical and combined mutagenic treatments has been discussed and drafted. Five consultants from five Member States (MSs) were invited to assist in designing the project and drafting the proposal: Dr Marie-Angèle Grandbastien, France; Prof Thomas Schmidt, Germany; Dr Yoshihiro Hase, Japan; Prof JS (Pat) Heslop-Harrison, United Kingdom; Prof Damon Lisch, United States of America. In order to better describe the content of the proposed project the meeting recommended renaming the working title into 'Irradiation-induced activation of endogenous mobile DNA to broaden the spectrum of useful traits in crop plants'. This CRP will characterize radiation-stimulated transposable element activity that contributes substantially to the generation of agronomically important and novel traits in crop species. The concept of this CRP was summarized as follows: Mutation breeding using physical mutagens has proved to be an invaluable resource for crop improvement. Most lesions caused by physical and chemical agents result in loss of gene function, limiting the range of traits they can produce. Fortunately, all plants contain endogenous mutagens that can produce a much wider variety of changes. Transposable elements, TEs, are naturally occurring endogenous DNA that moves within genomes. In doing so, they can cause insertional mutations, detected as new mutant phenotypes or by using bioinformatics. Because they carry regulatory information, TEs often alter, or 'rewire' gene expression. Although TEs are generally quiescent, there are specific conditions, such as exposure to ion beam radiation that can activate them. This proposal seeks to optimize the conditions under which the creative power of these endogenous mutagens can be activated by irradiation and then harnessed in order to broaden the range of traits available to farmers in member states.

The project proposal still needs to be approved by the responsible Agency's authorities.

Consultants with Section Head and Technical Officer in the Vienna International Centre, Vienna.

Past Events

Second AFRA Coordination Meeting on Improving Crops Using Mutation Induction and Biotechnologies Through a Farmer Participatory Approach, RAF/5/066, Mombasa, Kenya, 23–27 June 2014

Technical Officer: F. Sarsu

Meeting participants.

The meeting was organised by the Project Coordinator for RAF/5/066 in Kenya, Ms Miriam Kinyua. The second Coordination Meeting of RAF/5/066 was held with the following objectives:

- Review and discuss the details of the activities stated in the work plan to be implemented under the project RAF/5/066;

- Review the progress made over the last period;
- Review the work plan of the project and agree on national plans for the activities to be implemented at the national level;
- Identify and discuss measures to ensure sustainable continuation of work after completion of the project including exchange of material and information;
- Review the draft of 'AFRA Mutation Breeding Book'.

Mr Eric Cole, the Program Management Officer (PMO) from the IAEA Africa Technical Cooperation Department, addressed a warm welcome to the participants, stated the importance of the project and emphasized the objective of the meeting for the next five days. Ms Fatma Sarsu, Technical Officer RAF/5/066, gave a presentation on 'The FAO/IAEA Joint Division assistance to World's Agriculture'.

The following countries were represented in the meeting: Benin, Cameroon, Central African Republic, Egypt, Ghana, Kenya, Lesotho, Madagascar, Morocco, Namibia, Niger, Senegal, South Africa, Sudan, Uganda, Democratic Republic of the Congo and Zimbabwe.

Each Member State participant made a presentation showing progress achieved and results obtained under the project RAF/5/066 from 2012 to 2014, as well as the activities planned in support of the project. The details of these work plans were collegially discussed and gaps and bottlenecks analysed. The Program Management Officer (PMO) and Technical Officer (TO) provided managerial and technical feedback to the counterparts to further develop the work plans in order to achieve the overall objective of the project.

Implementation of the project is enhancing the regional capacity for field evaluation and dissemination of improved crop varieties using mutation breeding and biotechnology techniques, thereby assisting the AFRA Member States in the development and dissemination of improved staple and market oriented crops by induced mutations. The major achievements of this project include the following:

- Availability of research capability, basic infrastructure and trained manpower in most participating countries, (each year at least two regional training courses and expert missions are organized);
- Well-functioning tissue culture laboratories in 14 countries;
- Early generation and advanced induced mutant lines available in most participating countries;
- Increased official and public awareness of the benefits of mutation induction in crop improvement in most countries;
- Release and dissemination of induced mutant varieties for five crops (since 2012) in four countries (Egypt, Sudan, Kenya and Zambia;
- Introduction of new methodologies (such as drought tolerance screening) and biotechnologies (double haploid, molecular markers) in most countries;
- More germplasm and protocols collected and maintained;
- The number of publications is increasing and a regional mutation breeding book is drafted and planned to be published by 2016;
- More people trained in mutation induction, tissue culture techniques and molecular techniques;
- Number of countries involved in the project is increasing.

Plans for future project activities under the project RAF/5/066 were also completed, leading up to 2016. The participants updated the concept note for a four year regional project submitted by the AFRA Coordinator for 2016–2020 TC cycles. A new log frame was prepared and submitted through PCMF. It was agreed that adoption of the SMTA (Standard Material Transfer Agreement) should be encouraged in participating countries. It was also agreed that the sharing of protocols and other mutation related information and germplasm through networking should be improved.

Participants discussed national achievements and noted that the numbers of released mutant varieties and developed mutant lines have increased, efficiently addressing the regional challenges such as drought tolerance and disease resistance amongst others, in harmony with the project objectives. The progress of the TC project RAF/5/066 was recognized by the meeting participants, and experiences are being shared with new AFRA participating Member States, particularly those who are initiating plant mutation breeding projects. Additionally, it was stated that the project has efficiently been assisting the introduction of new methodologies (such as drought screening) and technologies (doubled haploids, molecular markers) in most participating countries.

The participants decided to prepare and publish a five chapter book on mutation breeding research in Africa (working title: 'Mutation Induction in Selected African Crops: Achievement and Challenges').

Regional Training Course on Mutation Induction and *In Vitro* Techniques, RAF/5/066, Pretoria, South Africa, 14–18 July 2014

Technical Officer: F. Sarsu

Meeting participants.

Under the Regional AFRA TC project RAF/5/066 on 'Mutation Induction and *In Vitro* Techniques', the International Atomic Energy Agency, in cooperation with the Government of South Africa through the CSIR Biosciences Council for Scientific and Industrial Research in Pretoria, organized this training course, which was facilitated by staff of the institute, with Dr Luka Mehlo as the Course Director. Twenty-five participants from Algeria, Benin, Burkina Faso, Cameroon, Central African Republic, Democratic Republic of Congo, Egypt, Ghana, Kenya, Madagascar, Mauritius, Morocco, Namibia, Nigeria, Sierra Leone, South Africa, Sudan and Zimbabwe attended the training course.

The purpose of this course was to provide participants with theoretical as well as practical information on mutation induction and applications of *in vitro* techniques and *in vitro* screening for biotic and abiotic stress resilience in crop breeding.

After the opening ceremony, the training course started with lectures on mutation breeding procedures/methodologies for crop improvement, handling of mutated populations and identification, evaluation and selection of mutant lines for biotic and abiotic stresses, as well as the basics of plant tissue culture, *in vitro* techniques and *in vitro* screening for mutation breeding. This was followed by an experimental part for basic plant tissue culture techniques; preparation of *in vitro* culture with different types of media containing plant hormones (multiplication media, haploid production media), ploidy analysis *in vitro* screening, preparation of explants, sterilization of material.

At the closing ceremony, participants had the opportunity to exchange opinions, suggestions and ideas for future cooperation between countries in the project. At the end of the training course, the participants were given certificates issued by the IAEA and signed by both, IAEA and CSIR, for successful participation.

Second Research Coordination Meeting (RCM) on Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System, D2.30.30, Bogor, Indonesia, 18–22 August 2014

Technical Officer: L. Jankuloski

Meeting participants.

The second RCM in Bogor, Indonesia was held in conjunction with the Workshop on Application of Nuclear Techniques for Increased Agricultural Production organized by the host institute SEAMEO BIOTROP. This enabled RCM participants and Indonesian researchers to share their knowledge and experience in plant mutation breeding.

Seven research contract holders (China, Indonesia, Kuwait, the Former Yugoslav Republic of Macedonia, Malaysia, Mongolia and Peru) and one agreement holder (United Kingdom) participated in the meeting. The technical contract holder from Austria could not attend the meeting, but he gave his presentation and participated in the discussions via Skype.

The project aims to improve the agronomy of cereal crops especially in respect to soil and water management, improve nutritional value and to improve the knowledge and skills base of participating Member States.

The major objectives of this CRP are to maximize the yields of mutant varieties. The crops chosen (sorghum, rice, barley and wheat) are those that can be used for both human food and animal fodder.

Each participant presented the achievements made within the CRP, particularly during the period after the last RCM in December 2012. The reports highlighted the methods used, results obtained in developing new mutant germplasm with improved nutrient quality traits.

All participants have identified mutant varieties and/or advanced mutant lines that are now subject to farming management practices to maximize yields in challenging conditions.

The second RCM was successful in regard to the following achievements:

- increased productivity of a mutant sorghum variety for fodder production
- new sorghum brown midrib mutant lines with low lignin content
- wheat mutant lines suitable for dual purpose use (food and feed) selected
- barley mutant lines with higher values for agronomic and quality traits identified
- rice mutant lines identified with increased nutritional characteristics (crude protein, P and Mg content) indicating that those mutant lines would provide more digestible organic nutrients to ruminants.

The CRP participants agreed to exchange the seed material from mutant varieties/lines and to evaluate under their environmental conditions.

The host organizer, SEAMEO BIOTROP, organized field trips to visit PT Rejo Sari Bumi, a cattle farm that uses sorghum mutant lines for cattle feeding.

Experimental field at SEAMEO BIOTROP.

The participants visited the laboratories and experimental fields at SEAMEO BIOTROP where the participants were able to appreciate the capacity of the tissue culture laboratory (30 000 teak plants produced per month). In the experimental field, a mutant population of sorghum was exhibiting a particularly high frequency of brown midrib phenotypes. Mr Supriyanto, from SAMEO BIOTROP, gave detailed information on current research in sorghum mutation breeding.

The Second RCM provided an opportunity to assess progress across all participating countries and to move the programme forward. The third Research Coordination Meeting is planned in July 2016 in Mongolia.

Regional (ARCAL) Training Course on Plant Improvement via *In Vitro* Mutagenesis for Improvement of Avocado Production, RLA/5/063, Uruapan, Michoacán, Mexico, 22–26 September 2014

Technical Officer: S. Nielen

This training course was organized jointly by the IAEA, the National Institute for Nuclear Research (ININ), the Universidad Michoacana de San Nicolás de Hidalgo (UMSNH), and the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP). The local coordinator was Dr Eulogio de la Cruz Torres from ININ. Researchers from 10 Latin American countries (Brazil, Chile, Cuba, Dominican Republic, Guatemala, Jamaica Nicaragua, Paraguay, Peru and Mexico) participated in this course, which focused on micropropagation and *in vitro* mutation induction for crop improvement in avocado. The course instructor was Dr Richard Litz, Professor emeritus, University of Flordia, USA. Avocado has a great economic importance in the region. Mexico is the world leader in avocado production with currently 142,146 hectares of cultivation and 1,264,141 tonnes of production. The training course was part of the Regional project RLA/5/063 on Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI).

Training Course participants.

IAEA/RCA Mid-Term Project Review Meeting on Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change, RAS/5/056, Yogyakarta, Indonesia, 6–10 October 2014

Technical Officer: S. Nielen

Meeting participants.

The overall objective of the meeting was to discuss and summarize the RAS/5/056 project progress with regard to the activities, implementation strategies and scientific methodologies used to enhance national capacity for the application of isotopic and nuclear techniques for developing and using improved crop varieties with best practice soil, water, crop and nutrient management for increasing the crop productivity. The meeting was conducted in Yogyakarta, Indonesia, 6–10 October 2014. Twenty-seven participants from Australia, Bangladesh, China, India, Indonesia, Malaysia, Myanmar, Mongolia, Nepal, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam, the Project Management Officer and Technical Officer of the IAEA and local observers attended the meeting. Each participant delivered a presentation on the research progress that had been achieved so far and also presented the future work plan. Within the lifetime of the project that started in 2012, 17 varieties have been officially released and there are currently more than 100 advanced mutant lines in trials and more mutant populations in the pipeline for further selection and development. The meeting agenda also included a technical visit programmes to the mutant fields of sorghum at Playen, Gunungkidul District, and to the rice segregating mutant population of M_2 generation at Klaten. Technical visits were also conducted to the Academy of Nuclear Technology (STTN) and to the Faculty of Agriculture, UPN University Yogyakarta where the TO gave scientific lecture on 'The Impact of Plant Mutation Breeding for Food Security'.

Forth Meeting on Developing Guidelines on Nuclear Techniques for Flood Mitigation, RAS/5/069, Vienna, Austria, 11–14 November 2014

Technical Officers: P.J.L. Lagoda and L.K. Heng

Floods are the most frequent among all natural disasters, and the East Asia and Pacific region, along with South Asia, is particularly vulnerable. Climate change and variability are expected to bring about increased typhoon activities, rising sea levels and out-of-phase monsoon seasons in South East Asia and other regions. These can bring about devastating floods in Cambodia, Laos, Pakistan, Thailand and Vietnam, endangering the lives and health of the population and cause serious losses in people's livelihoods, including food and livestock. In the past 30 years, the number of floods in Asia amounted to about 40 per cent of the total worldwide. More than 90% of the global population exposed to floods live in Asia, posing a serious and growing development challenge for fast growing low and middle-income countries in East Asia. The countries in Asia with large populations are particularly prone to recurrent flooding, resulting in countless loss of lives, injuries, diseases and trauma in addition to practically wiping out decades of investments in infrastructure and personal wealth of people. Floods have tremendous socioeconomic impact, reflected mainly through retarded development. A flood-stricken area must first be restored to normal before any development activity can be carried out. Restoration can take time. In addition to the directly determinable losses, there may be indirect potential losses. These result from unproductivity in many areas such as in business, trade and commerce, etc. All these losses can wipe out whatever gains that may have been achieved in economic development. Floods cause losses both to the gross domestic product (GDP) and to capital stock, thus hampering the growth potential of the country. Moreover, these losses also have a long-term impact on macroeconomy. Capital damages induce a lower GDP in subsequent years (to the extent of investment losses); and, output losses (caused during the flood-affected year) lower incomes and possibly reduce savings available for financing investments.

The International Atomic Energy Agency (IAEA) has extensive experience in providing technical support to its Member States in using nuclear techniques in combination with conventional approaches to provide an additional advantage in tracking the sources and pathways of diseases, nutrients, and soil and water movement within an agricultural landscape so as to provide an integrated solution to flood management-rehabilitation. Nuclear

techniques are used in combination with conventional approaches to provide an additional advantage in tracking the sources and pathways of diseases, nutrients, and soil and water movement within an agricultural landscape so as to provide an integrated solution to flood management-rehabilitation. The use of nuclear techniques in generating flood-tolerant crops combined with best soil-water-nutrient management practices as evaluated by isotopic techniques can also bring about a flood adaptation-rehabilitation approach. An effective use of isotope hydrology in flood management would be to strengthen Member State capacity in comprehensive water resources assessment, including river basin and groundwater systems, so that sound scientific knowledge is available for forecasting both the occurrence and the potential extent of flooding. In addition, a strategy can be developed to exploit the potential of floodplains to absorb the floodwater up to the extent possible and to fulfil the additional needs of drinking and irrigation through the utilization of groundwater from the floodplains. The Division for Asia and the Pacific (TCAP) now proposes to implement, in collaboration with international and regional stakeholders and development partners, a large scale multiyear project, which seeks to bring about an integrated solution to flood management, particularly post-flood events.

Emanating from the project RAS/5/069 first Coordination Meeting on Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia, held from 10–13 June 2014 in Vienna, a Task Force meeting of eminent experts was convened at the IAEA Headquarters in Vienna from 11–14 November 2014, for the purpose of developing Guidelines on Nuclear Techniques in pre-Flood mitigation and post-Flood management.

The guidelines were developed for the following four disciplines:

- Animal Production and Health
- Isotope Hydrology
- Plant Breeding and Genetics
- Soil and Water Management and Crop Nutrition

The developed Guidelines concern the application of nuclear techniques in a multi-sectoral approach for flood risk mitigation and post-flood management in particular:

During the pre-flood period:

- Characterize the inter-dependencies of soil and water conditions and agricultural systems
- Identify areas and systems at risk of flooding and develop effective flood risk and post-flood response strategies

During the post-flood period:

- Quantify how floods affected the distribution of water, soil, animal and plant agriculture
- Improve upon local area knowledge of flood mitigation

The Task Force Meeting was successfully concluded with the Guidelines on Nuclear Techniques in pre-Flood mitigation and post-Flood management developed, which will be disseminated to the project's Member States.

Meeting participants.

Final Coordination Meeting on Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI), RLA/5/063, Managua, Nicaragua, 17–21 November 2014

Technical Officer: S. Nielen

This meeting was organized to assess and review the progress and the achievements that have been made regarding implementation of the country and regional work plans. Thirteen National Coordinators from Argentina, Brazil, Chile, Colombia, Cuba, Dominican Republic, El Salvador, Ecuador, Mexico, Nicaragua, Paraguay, Peru and Venezuela, as well as the TO and PMO of the project participated in the meeting.

The meeting has drafted a final project report based on the presented results of each country. The TO has presented latest activities of the PBGS and PBGL with special emphasis on upcoming CRPs. The project has greatly contributed to strengthen the capacity in plant mutation breeding in the Region. Mutant lines in earlier and advanced stages are available in various crops such as quinoa, amaranth, native potato, wheat, beans, tomato, chipilin, avocado and banana. One of the successes of this

project was the release of the rice mutant variety SCS 118 Marques in Brazil in 2013. This variety was developed after gamma ray mutation induction and has excellent industrial performance and good consumer acceptance.

The meeting also was used as a very good opportunity to discuss the project design of the new proposal RLA2014030.

Meeting participants.

Eighth Coordination Meeting on Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley Phase II, RAS/5/058, Vienna, Austria, 25–28 November 2014

Technical Officers: F. Sarsu and P.J.L. Lagoda

Meeting participants.

The project was initiated at the 2008–2009 TC Cycle. Wheat and barley are the most important food crops contributing to food security and sufficiency in the ARASIA States Parties. However, Arab countries are the largest net importers of cereals in the World. Thirty-five percent of daily calories consumed in Arab countries come from wheat alone; this is driving the region's heavy dependence on cereal imports. While cereals are one of the most important crops for the region, most of cultivated areas depend on rainfall and production is affected by drought, disease, heat and salinity. New varieties with enhanced tolerance to drought are important to increase production in the areas. However, due to the complex nature of drought and its effects on various physiological activities of plants, improvement of drought tolerance has been prevented by the lack of necessary knowledge of methods and techniques in breeding programmes of developing countries. The aim of this regional project was to increase and evaluate genetic diversity in wheat and barley using nuclear techniques and plant biotechnologies.

For the previous cycle the participants adopted the SMTA (Standard Material Transfer Agreement) of the IT/PGRFA (International Treaty on Plant Genetic Resources for Food and Agriculture), thus spearheading the use of this legal enabling tool for access and benefit sharing. Oman, Saudi Arabia and Qatar, under the impetus of the project, backstopped by the Joint FAO/IAEA Division (Plant Breeding and Genetics subprogramme) have initiated national mutation breeding programmes. The main purposes of the meeting were:

- To review the overall achievements by the individual countries and by the Region since 2008;
- To discuss the details of the activities stated in the national and regional work plan to be implemented under the project RAF/5/058;
- To identify and discuss measures to ensure sustainable continuation of work after completion of the project including exchange of material and information with end users in the region;
- To review and finalize the draft project design for the new TC project for the TC cycle 2016–2017;
- Review the draft of the 'ARASIA Mutation Breeding Book'.

The meeting was opened by Ms Jane Gerardo-Abaya, Section Head, IAEA Technical Cooperation Department, who addressed a warm welcome to the participants. Ms Fatma Sarsu, Technical Officer, also welcomed the participants and offered a presentation on 'The Impact of Plant Mutation Breeding to Food Security'.

Project counterparts from Iraq (1), Jordan (1), Saudi Arabia (2), Syria (1) and Yemen (1) participated at the meeting and gave presentations on the status of the work done in their respective countries since the last meeting, particularly on the development of new mutant germplasm of wheat and barley. Participants held very informative discussions. Yemen released two barley and two wheat varieties for rain fed and irrigation conditions and most of countries have advanced improved wheat and barley mutant lines that are at the M_3 and M_7 stage in barley and wheat.

The participants decided to prepare and publish a book on mutation breeding research in ARASIA (working title: 'Improvement of Wheat and Barley through Mutation Breeding in ARASIA Member States'). The draft version of the book was discussed and further steps decided to

finalize and publish the book. The participants discussed the next phase of the project (2016–2017) and agreed on a draft Logical Framework Matrix, which is uploaded on to PCMF by the project lead counterpart (DTM) of the regional project (Yemen). The systematic use of the SMTA was encouraged by all participants to exchange genetic plant material.

Final Coordination Meeting on Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99), INT/5/150, Kampala, Uganda, 8–12 December 2014

Technical Officer: P.J.L. Lagoda

Meeting participants.

The final coordination meeting of INT/5/150 'Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)' was held in Kampala, Uganda, from 8–12 December 2014. Eighteen Member States and five national and international research institutions participated in this interregional Technical Cooperation project. The project succeeded beyond the initial expectations, and the plenary discussed the most productive way to make profitable use of the network built, the technologies developed and the varieties and advanced mutant lines produced.

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. Wheat stem rust had not been seen in fields 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 80–90 percent of global wheat varieties were susceptible; meaning most farmers in its path had no way to fight back.

Wheat 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 also can be spread by accidental human transmission — through clothing or plant material.

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 more than 20 countries. 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 US $1.23 billion. This presented a potential threat to global food security as well as the multi-billion dollar wheat market. In answer to this situation, the IAEA initiated an interregional Technical Cooperation Project, INT/5/150 'Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)', focused on using induced mutations to increase the genetic diversity of wheat which, in turn, increased the chances of developing wheat varieties with resistance to the black stem rust. In 2014, the two first mutant Ug99 resistant varieties were ready for Kenya's wheat fields, and six other countries had 13 new resistant lines in advanced field trials. The next most advanced line ready for release is a mutant wheat variety, with additional higher yield in Uganda, where it all began.

Joint FAO/IAEA Division experts and scientists from 18 countries and five national and international research institutions 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 FAO/IAEA Division experts set up the project work plan with participating countries. Samples of wheat seeds from participating countries were irradiated at the Joint FAO/IAEA Division Plant Breeding and Genetics Laboratory. Through this concerted effort, two resistant mutant varieties were released in Kenya, named Eldo Baraka and Eldo Mavuno.

Both mutant varieties showed good quality and adaptation in four environments tested: Nakuru, Narok, Kitale and Eldoret. Eldo Mavuno showed better adaptation in Nakuru and Eldoret than in Kitale. Both resistant mutant varieties have already been adopted by farmers in Kenya, where all commercial wheat varieties have succumbed to the disease. They are in high demand, with a preference for Eldo Mavuno (due to additional higher yield). Twenty tons of clean seed have been produced, but already the demand exceeds 180 tons (over 130 farmers applied for seed multiplication). Under the pressure of demands for seed, the University has built partnerships with three seed companies to aid in seed production.

This project demonstrated the effectiveness of mutation breeding in developing quickly new wheat varieties resistant to Ug99. These new resistant varieties are accessible to Member States and global wheat breeding community and will be used widely in breeding programmes to improve disease resistance in wheat in many regions.

Coordinated Research Projects (CRPs) and Research Coordination Meetings (RCMs)

Project Number	Ongoing CRPs	Scientific Secretary
D2.30.29	Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond	F. Sarsu
D2.30.30	Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System	L. Jankuloski
D1.50.13	Approaches to Improvement of Crop Genotypes to High Water and Nutrient Use Efficiency for Water Scarce Environment	K. Sakadevan and P.J.L. Lagoda
CRPs in Planning Stage	**Working Titles**	**Scientific Secretary**
	Enhancement of the Efficiency of Mutation Induction by Physical and Combined Mutagenic Treatments	S. Nielen
	Efficient Screening Techniques for Mutants with Disease Resistance	B. Till

Two new CRPs, each related to one of the two projects of our subprogramme (Mutation Induction and Mutation Screening), will commence during the new biennium. The timeline for implementation of both CRPs is: Consultant meeting and project formulation in 2014; start of project in 2015. Detailed announcements on the projects and how to participate will be published in due course.

Efficient Screening Techniques for Mutants with Disease Resistance (Working Title)

This CRP will develop screening methods for useful mutations needed for disease resistance to safeguard crop yields in an era of increased population growth and climate variation. New technologies will be exploited in developing techniques aimed at increasing the efficiency of detecting disease resistant mutants for plant breeding in Member States. Diseases and priority regions will be defined according to demands from Member States. New high-throughput methods in phenotyping and genotyping offer increased efficiencies in selecting novel disease resistance mutants for plant breeding.

This CRP builds on successes from the CRP on Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline D2.40.12, and is related to the TC project on Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99).

Enhancement of the Efficiency of Mutation Induction by Physical and Combined Mutagenic Treatments (Working Title)

The main task is to develop more efficient methods, protocols and guidelines for X and gamma ray driven mutation induction, as well as for ion beam irradiation to increase genetic diversity for plant breeding. This CRP will therefore include research on the enhancement of mutation induction through irradiation activation of genetic elements that move within the genome (transposable elements), and cause identifiable secondary mutations.

Increased biodiversity is needed to meet the breeding goals of the 21st century to provide stable yields in an era of population growth, climate variability and rising food costs. The need to generate new genetic biodiversity and increase productivity especially in regions affected by climate variation requires a number of approaches including striking new paths in mutation induction techniques. This CRP will contribute to uncover the full potential of mutation induction in order to broaden the range of traits available to farmers in member states.

This task is related to an ongoing CRP on Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants D2.40.13 (ended in 2014). Whilst the ongoing CRP is primarily concentrating on the spectrum of mutations in

the genes and also on identifying and characterizing the genes involved in mutagenesis in crop plants, the new CRP will focus on the repetitive part of the genome, which by far represents the majority in plant genomes.

Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond, D2.30.29

Technical Officer: F. Sarsu

This CRP has 11 research contract holders from Colombia, China, Cuba, India, Mexico, Pakistan, the Philippines, Senegal, the United Republic of Tanzania and Zimbabwe and five agreement holders from China, Japan, Spain and the United Kingdom and International Rice Research Institute (IRRI).

The overall objective of this CRP is to identify high yielding food crop germplasm contributing to sustainable food security (with a focus on a major cereal; rice and a grain legume; common bean) with improved resource use efficiency (water and nitrogen) and adaptation to temperature extremes (increased minima and maxima) as anticipated by climate change and variability for the next 20 to 40 years. The aim is to develop tools that allow plant breeders to use mutation programs together with efficiency enhancing plant biotechnologies to develop improved crop varieties with higher and wider adaptability to temperature variations.

All participating countries generated new mutant populations in rice and beans. Also, some countries used characterized mutant lines from previous projects. All of them have mutant lines at least at the M_3 generation, which tested tolerant for their responses to increased temperatures. Some participants have advanced/pre released mutant lines, which will be released to farmers by 2018.

Efficient screening techniques for identifying the positive mutants and shortening the screening procedures have been developed in order to attain the objectives more quickly and develop advanced mutant lines for multi-location trails. Each participating country has been establishing at least one or two protocols for whole plant, physiological, genetic and molecular studies. Mutant line screening protocols for rice and common beans have been developed under growth chamber and field conditions for confirmation of heat tolerance. In the particular case of beans, responses to nodulation and nitrogen fixation are closely monitored in order to identify the best symbiosis: plant/rhizobium is performing satisfactorily under heat conditions.

Additionally, gene expression was investigated under increased temperature conditions. Some genes involved in high temperature response, both in rice and beans, showed a significant change in expression patterns, which may play a role in stress tolerance. A detailed characterization of those genes under heat stress has to be carried out yet. Some countries are working on developing molecular markers of heat tolerance for marker assisted selection. The results of these studies will be disseminated by the end of this CRP.

Significant progress has been achieved so far in major areas of research on rice and common beans to accomplish the objectives of the CRP. It is expected that the identification of high yielding rice and bean germplasm, and the establishment of experimental protocols for physiological, genetic and molecular characterization, will be completed and prepared for dissemination during the next months.

The final RCM, where the results of this CRP will be evaluated and summarized, its output and outcome assessed, and draft publications initiated, will take place in Vienna, Austria, 22–26 June 2015.

Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production Systems, D2.30.30

Scientific Secretary: L. Jankuloski

The CRP is now in its third year and all contracts have been renewed. There are eight participating countries (Austria, China, Indonesia, Kuwait, the Former Yugoslav Republic of Macedonia, Malaysia, Mongolia and Peru) working on cereal crops that may be harvested for food and/or feed: barley, rice, sorghum and wheat. All participants have identified mutant varieties and/or advanced mutant lines that are now subject to farming management practices to maximize yields in challenging conditions. Success in tailoring agronomy for mutant varieties will be judged by take up by farmers, but already there are impressive outcomes, particularly in Indonesia where a mutant line is now grown in several regions on an increasing area. The next RCM is planned to be held in Mongolia in July 2016.

Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments, D1.50.13

Scientific Secretaries: K. Sakadevan and P.J.L. Lagoda

The CRP started in December 2011 and the first RCM was held in Vienna, Austria from 12–16 December 2011. The overall objective of this CRP is to increase crop productivity and food security by developing improved crop varieties and soil, water, nutrient and crop management technologies and quickly making them available to farmers, making their cropping systems

resilient to biotic and abiotic stresses in water scarce environment. The CRP is in its third year of implementation. Ten research contract holders (Bangladesh, China, Kenya, Malaysia (two participants), Mexico, Pakistan, Peru, Uganda and Vietnam), one technical contract holder (Peru) and one agreement holder (South Africa) participated in the meeting. The specific objectives are to:

- increase the productivity of crop varieties tolerant to environmental stresses under existing soil and climatic conditions, and
- enhance nitrogen and water use efficiencies of crops tolerant to environmental stresses through best practice soil, water, crop and fertilizer management practices.

The second RCM was held in Malaysia from 24–28 June 2013 and all participants attended the meeting. Key output from second RCM include:

1. Results of field studies evaluating improved varieties of rice, ground nut, mung bean and sesame under saline conditions in Bangladesh,
2. Yield, fertilizer use and information on economic benefits of ratooning rice cultivar Jiafuzhan was evaluated in Fujian Province, China.
3. Field studies established to evaluate sorghum varieties tolerance to acidity and drought stress in two locations in Indonesia and soil and plant data have been collected for further analysis,
4. In Kenya, four pre released varieties of English Potato were evaluated in four different locations for their response to the application of manure at different rates.
5. Information on yield, water and nutrient use efficiencies of three varieties and one advanced mutant line of barley, and five improved genotypes of quinoa suitable for high altitude which were evaluated in three different locations was provided for Peru,
6. Plant morphological characteristics and water and nutrient use for two improved mutant lines of rice adapted to aerobic conditions were evaluated in three locations in Malaysia,
7. Preliminary soil characteristics completed for two different agro-eco systems in Mexico and thirty two improved genotypes of Amaranthus were evaluated for assessing plant morphological characteristics from which varieties will be selected and evaluated for water and nutrient use efficiencies,
8. Preliminary field studies at two agro-ecological regions in Pakistan for quantifying wheat yield, nitrogen uptake and nitrogen use efficiency of improved varieties of wheat which has been developed for improved water and nutrient use efficiencies,
9. Screening for mutant lines tolerant to Ug99 and drought have been carried out wheat and South Africa.
10. Five different genotypes of wheat where evaluated for yield response to different rates of fertilizer application in five locations in Uganda
11. The effect of different levels of fertilizer application on yield and nutrient use for five soybean varieties was evaluated in three locations under two different cropping seasons in Vietnam.

The research contract for all projects has been renewed based on project progress reports and renewal proposals in October 2014. Data on yield, nutrient uptake and soil water have been collected from field studies involving improved crop varieties of rice, wheat, barley, quinoa, potato, amaranthus, soybean, and ground nut. The data is currently being analysed and will be presented by counterparts during the third RCM, which will be held in Mexico from 9–13 March 2015.

Technical Cooperation Field Projects

Project Number	Country/Region	Title	Technical Officer
ALB/5/007	Albania	Supporting the Improvement of Plant Productivity Using Radiation Techniques	L. Jankuloski/F. Sarsu
ALG/5/026	Algeria	Increasing the Genetic Variability for the Improvement of Strategic Crops (Wheat, Barley, Chickpeas and Dates) for Enhanced Tolerance to Biotic and Abiotic Stresses and the Development of Biotechnology Capacities	P.J.L. Lagoda/A.M.A. Ghanim
ANG/5/008	Angola	Using Nuclear Technology to Select Mutants of Cassava Resistant to the African Cassava Mosaic Virus and Various Diseases Affecting this Crop	S. Nielen/A.M.A. Ghanim
BDI/0/001	Burundi	Supporting Human Resource Development and Nuclear Technology Support Including Radiation Safety	P.J.L. Lagoda
BGD/5/028	Bangladesh	Assessing Crop Mutant Varieties in Saline and Drought Prone Areas Using Nuclear Techniques	L. Jankuloski
BKF/5/009	Burkina Faso	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques for Food Security and Poverty Alleviation	P.J.L. Lagoda/L. Jankuloski
BKF/5/013	Burkina Faso	Enhancing Sorghum Productivity by Breeding Resistant Varieties to Striga Hermonthica Strains in Agro-Ecological Zones	L. Jankuloski/P.J.L. Lagoda
BOT/5/009	Botswana	Using Radiation Technology and Biotechnology to Develop Mutant Lines of Important Crops with Increased Yield and Improved Nutritional and Hygienic Qualities	A.M.A. Ghanim/S. Nielen
BOT/5/012	Botswana	Improving Soil and Water Management Options to Optimize Yields of Selected Crops	A.M.A. Ghanim/S. Nielen
BUL/5/013	Bulgaria	Supporting Laboratory Upgrade for Improved Food Crops through Nuclear and Molecular Techniques	F. Sarsu/L. Jankuloski
CAF/5/006	Central African Republic	Improving Cassava Production through High-Yielding Varieties and Sustainable Soil Fertility Management by Using Isotopic and Nuclear Techniques to Ensure Sustainable Farming	P.J.L. Lagoda/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
COL/5/024	Colombia	Supporting Mutagenesis and Functional Genomics Applied to the Improvement of Rice	S. Nielen/B. Till
ERI/5/008	Eritrea	Supporting the Livelihood of Barley Farmers through Mutation Techniques and N15 Technology to Improve Malting, Food and Feed Barley Production	A.M.A. Ghanim
GHA/5/034	Ghana	Screening of M2 Population for Useful Mutants for Oil Palm Mutation Breeding	L. Jankuloski/S. Nielen
INS/5/039	Indonesia	Enhancing Food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Adaptation	L. Jankuloski/B. Till
INT/5/150	Interregional	Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)	P.J.L. Lagoda

Project Number	Country/Region	Title	Technical Officer
IVC/5/031	Cote d'Ivoire	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	P.J.L. Lagoda/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
IVC/5/035	Cote d'Ivoire	Improving Maize Crops Subject to Severe Soil and Climate Degradation through Induced Mutants Adapted to these Areas	P.J.L. Lagoda/F. Sarsu
KAZ/5/003	Kazakhstan	Increasing Micronutrient Content and Bioavailability in Wheat Germplasm by Means of an Integrated Approach	F. Sarsu/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
KEN/5/032	Kenya	Characterizing and Improving Germplasm of Selected Crops at the Molecular Level Using Nuclear and Biotechnology Techniques	F. Sarsu/S. Nielen
KEN/5/034	Kenya	Using Irradiated Improved Brachiaria Grass and Dolichos Lablab Species for Increasing Quantity and Quality of Milk Production and Reproduction for Smallholder Dairy Farms in Drought Prone Areas	S. Nielen/F. Sarsu
LAO/5/001	Lao, P.D.R.	Enhancing Food Security through Best Fit Soil-Water Nutrient Management Practices with Mutation Induction for Drought Resistant Rice	L. Jankuloski
LES/5/004	Lesotho	Using Nuclear Techniques for Improvement of Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production (Continuation of the on-going project)	S. Nielen/A.M.A. Ghanim
MAG/5/022	Madagascar	Strengthening Food Security	L. Jankuloski/F. Sarsu
MAG/5/023	Madagascar	Promoting Climate Smart Agriculture to Face Food Insecurity and Climate Change with Regard to Basic National Foods (Rice and Maize)	L. Jankuloski/F. Sarsu
MAK/5/008	The Former Yug. Rep. of Macedonia	Using Nuclear and Molecular Techniques for Improved Feed and Malt Quality and Safety in Barley	P.J.L. Lagoda
MAL/5/029	Malaysia	Applying Mutation Breeding and Optimized Soil, Nutrient and Water Management for Enhanced and Sustainable Rice Production	S. Nielen
MAR/5/020	Mauritius	Developing Stress Tolerant Banana and Tomato Varieties by Enhancing the National Capacity in Mutation Induction and Biotechnology	B. Till/S. Nielen
MON/5/021	Mongolia	Improving the Productivity and Sustainability of Farms Using Nuclear Techniques in Combination with Molecular Marker Technology	L. Jankuloski/S. Nielen in collaboration with Animal Production and Health Section
MOR/5/033	Morocco	Using Nuclear Techniques to Support the National Programme for the Genetic Improvement of Annual and Perennial Plants and to Develop Agricultural Production	P.J.L. Lagoda/A.M.A. Ghanim
MYA/5/020	Myanmar	Strengthening Food Security through Yield Improvement of Local Rice Varieties with Induced Mutation (Phase II)	S. Nielen/P.J.L. Lagoda
MYA/5/023	Myanmar	Evaluating Nitrogen Use Efficiency Using Low Nitrogen Tolerant Rice Varieties	P.J.L. Lagoda

Project Number	Country/Region	Title	Technical Officer
NAM/5/010	Namibia	Developing High Yielding and Drought Resistant Pearl Millet (*Pennisetum glaucum* L), Sorghum Bicolor (L) Moench, Bambara Groundnut (*Vigna subterranean*) and Cowpea (*Vigna unguiculata* (L) Walp) Following Up a Previous Project (PHASE II)	F. Sarsu/S. Nielen
NAM/5/012	Namibia	Developing High Yielding and Drought Tolerant Crops through Mutation Breeding	F. Sarsu/S. Nielen
NEP/5/003	Nepal	Improving Crop Yield for Food Security and Economic Growth by Using Nuclear and Molecular Techniques	S. Nielen/L. Jankuloski
NER/5/015	Niger	Improving Productivity of the Millet-Cowpea Cropping System through Development and Dissemination of Improved Varieties and New Water and Fertilizer Management Techniques	P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
OMA/5/002	Oman	Assessing the Suitability of Sterile Insect Technique (SIT) and Related Techniques for Combating Date Palm Insect Pests	P.J.L. Lagoda/ A.M.A. Ghanim in collaboration with Insect Pest Control Section
PAK/5/047	Pakistan	Developing Germplasm through TILLING in Crop Plants Using Mutation and Genomic Approaches	B. Till/S. Nielen
PAL/5/005	Palestine	Improving local Palestinian wheat and barley varieties for salt and drought resistance through mutation breeding and biotechnology	L. Jankuloski
PAL/5/006	Palestine	Enhancing the Performance of Durum Wheat Landraces by Induced Mutation	L. Jankuloski
PER/0/025	Peru	Developing Human Resources and Supporting Nuclear Technology for Addressing Key Priority Areas including Improvement of Cereals, Production of Hydrogels, and Cancer Management	S. Nielen
RAF/5/066	Regional Africa	Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA)	F. Sarsu/A.M.A. Ghanim
RAF/6/042	Regional Africa	Applying Nuclear Techniques to Design and Evaluate Interventions to Reduce Obesity and Related Health Risks	F. Sarsu/A.M.A. Ghanim
RAS/5/056	Regional Asia	Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change	S. Nielen/P.J.L. Lagoda
RAS/5/058	Regional Asia	Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change	P.J.L. Lagoda/F. Sarsu
RAS/5/064	Regional Asia	Enhancing Productivity of Locally-underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices	L. Jankuloski in collaboration with Soil and Water Management and Crop Nutrition Section
RAS/5/065	Regional Asia	Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications	P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section

Project Number	Country/Region	Title	Technical Officer
RAS/5/069	Regional Asia	Complementing Conventional Approaches with Nuclear Techniques towards Food Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	P.J.L. Lagoda
RAS/5/070	Regional Asia	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	F. Sarsu/P.J.L. Lagoda
RLA/5/056	Regional Latin America	Improving Food Crops in Latin America Through Induced Mutation (ARCAL CV)	S. Nielen/L. Jankuloski
RLA/5/063	Regional Latin America	Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI)	S. Nielen/L. Jankuloski
SEN/5/034	Senegal	Using an Integrated Approach to Develop Sustainable Agriculture in a Context of Degrading Soil Fertility, Climate Change and Crop Diversification	F. Sarsu/P.J.L. Lagoda
SEN/5/035	Senegal	Developing High-Performance Plant Varieties through Induced Mutagenesis to Improve the Productivity of *Jatropha curacas* L. Plantations and Contributing to Combating Rural Poverty	P.J.L. Lagoda
SIL/5/014	Sierra Leone	Enhancing Nutritional and Other End-User Postharvest Qualities of Rice and Cassava through Mutation Breeding	S. Nielen/L. Jankuloski
SRL/5/045	Sri Lanka	Establishing a National Centre for Nuclear Agriculture	F. Sarsu
SUD/5/033	Sudan	Enhancing Productivity of Major Food Crops (Sorghum, Wheat, Groundnut and Tomato) under Stress Environment Using Nuclear Techniques and Related Biotechnologies to Ensure Sustainable Food Security and Well-Being of Farmers	F. Sarsu/A.M.A. Ghanim in collaboration with Soil and Water Management and Crop Nutrition Section
THA/0/014	Thailand	Developing Applications of Ion Beam and Plasma Technology for the Induction of Crop Mutation, Gene Transfection and Biomedical/Biochemical Material Modification	S. Nielen
THA/5/054	Thailand	Increasing Adaptability for Adverse Environment Tolerance in Rice Germplasm Using Nuclear Techniques	F. Sarsu/S. Nielen
URT/5/028	United Rep. of Tanzania	Improving Crop Production and Productivity through the Use of Nuclear and Nuclear-Related Techniques	L. Jankuloski/S. Nielen
URT/5/029	United Rep. of Tanzania	Improving Rice and Barley Production through the Application of Mutation Breeding with Marker Assisted Selection	L. Jankuloski/S. Nielen
UZB/5/005	Uzbekistan	Developing Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity (Phase II)	F. Sarsu/S. Nielen
VIE/5/018	Vietnam	Adapting Rice-Based Cropping Systems to the Impact of Climate Change by Nuclear Mutation Breeding and Improving Nitrogen Use Efficiency Using Nitrogen-15 for Vegetables in Main Growing Areas	L. Jankuloski/P.J.L. Lagoda
YEM/5/008	Yemen	Introduction of Gamma Ray Irradiation Techniques for Agriculture Purposes	S. Nielen/F. Sarsu

Project Number	Country/Region	Title	Technical Officer
YEM/5/010	Yemen	Using Induced Mutations and Efficiency Enhancing Bio-Molecular Techniques for Sustainable Crop Production	S. Nielen/F. Sarsu
ZAI/5/019	Democratic Rep. of Congo	Developing Mutations, *In Vitro* and Molecular Techniques for Further Dissemination to Breeders and Pharmaceutical Plant Producers to Enhance the Livelihood of Target Populations	L. Jankuloski/B. Till
ZAI/5/022	Democratic Rep. of Congo	Using Nuclear and Biotechnology Techniques for Genetic Adaptation and Improvement of Staple Crops for High Temperatures and Water Stress	L. Jankuloski/B. Till
ZAM/5/029	Zambia	Evaluating the Impact of Nitrogen and Water Use Efficiency in Upland Rice	L. Jankuloski/F. Sarsu
ZIM/5/015	Zimbabwe	Developing Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content Using Mutation Breeding and Novel Techniques, Phase II	F. Sarsu/L. Jankuloski

Success Stories

Sweet Cherry Mutant Varieties Released in Turkey

Fruit crops are not the most prominent crop types in the FAO/IAEA Mutant Variety Database (MVD). Together with nuts they make up 2.4 % of all officially registered mutant varieties in the database. This does not mean that they are not important, it rather reflects that mutation breeding of these crops is often difficult and tedious. We therefore feature in this issue the release of two new sweet cherry (*Prunus avium* L.) mutant varieties in Turkey. Turkey is the main producer of sweet cherries and accounts for 20% of the global export market. The two varieties, ALDAMLA and BURAK, have been officially registered in 2014 by the Turkish Ministry of Food, Agriculture and Livestock. Both varieties were developed by irradiation of dormant buds of the parent variety 0900 Ziraat with gamma rays at 25 and 50 Gy respectively. Main improved characters of ALDAMLA are compact growth habit (70–80%), improved fruit quality and long petioles, whereas BURAK exhibits high yield, improved fruit quality and big size as improved traits. The mutation breeding project leading to the release started in the year 2000 and is described in detail in Kunter, B., Baş, M., Kantoğlu, Y., Burak, M. 2012. Mutation Breeding of Sweet Cherry (*Prunus avium* L.) var 0900 Ziraat. in: Plant Mutation Breeding and Biotechnology, Ed. Q.Y. Shu, Foster, B.P. and Nakagawa, H. Joint FAO/IAEA Programme, Chapter 34: 453–463. CAB International, ISBN: 978-92-5-107022-2.

Two new sweet cherry mutant varieties in Turkey: ALDAMA (R) and BURAK (L).

News

World Wide Success in Mutation Breeding for Food Security — Achievement and Outstanding Achievement Awards

In 2014, the year of the 50th Anniversary of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Achievement and Outstanding Achievement Awards were initiated to honor and appreciate the successes of Member States in plant mutation breeding and to further promote the use of nuclear techniques for sustainable food security.

Forty-three official nominations were received. An international selection panel was set up for the evaluation, and identified five Outstanding Achievement Awardees from Bangladesh, China, Indonesia, Peru and Vietnam (alphabetical order) and 18 Achievement Awardees from Afghanistan, Brazil, China (3), Cuba, Egypt, India, Republic of Korea (2), Malaysia, Pakistan, Sri Lanka, Sweden, Thailand, Vietnam (2) and Yemen (alphabetical order).

The main criteria for selection were the number of mutant varieties released, the farm area covered with these varieties, and the socio-economic impact such as additional income per year or value at farm-gate.

The Awards were handed out to the representatives of the concerned countries in the form of a certificate at an official ceremony during the 58th General Conference in the presence of the IAEA Director General, Mr Yukiya Amano, on 24 September 2014.

Background

The application of mutation techniques, i.e. gamma rays and other physical mutagens has generated a vast amount of genetic variability and is playing a significant role in plant breeding and genetics and advanced genomics studies. The widespread use of mutation techniques in plant breeding programmes throughout the world has led to the official release of more than 3200 mutant varieties from more than 200 different plant species, in more than 70 countries. These varieties provide higher yields, better quality, resistance to diseases and resilience to climate change and variability.

A large majority of these varieties (including cereals, pulses, oil, root and tuber crops, and ornamentals) have been released in developing countries, resulting in enormous positive economic impacts. Their contribution to the national economies is measured in billions of dollars, and they are grown on hundreds of millions of ha cropping area. Thus, plant mutation breeding is an efficient tool for preserving and enhancing global food security.

Outstanding Achievement Award Recipients

Bangladesh: Dr Mirza Mofazzal Islam, Bangladesh Institute of Nuclear Agriculture

Nine mutant varieties were released by this institute (fibre jute, vegetable jute, mungbean, chickpea) with improved yield and quality traits and are widely accepted by farmers for cultivation.

The mutant varieties have an increased yield ranging from 20 to 45% compared to other existing crop varieties and the area cultivated by these mutant varieties is increasing.

China: Team of Radiation Mutant Breeding, Jiangsu Academy of Agricultural Sciences

The team has released 17 mutant varieties, including eight rice, five wheat and four barely cultivars.

Three of the mutant wheat varieties together cover more than 30 million ha and create more than 30 billion Yuan RMB (about US $4.9 billion) of socio-economic benefit.

Indonesia: Plant Breeding Group, Centre for Isotopes and Radiation Application, National Nuclear Energy Agency, BATAN

Twenty mutant rice varieties have been released by the Plant Breeding Group. This represents 10% of the total rice varieties registered in the country, and thus has a major positive socio-economic impact.

Total income from one top mutant rice variety is estimated at US $2 billion. Hundreds of thousands of farmers in Indonesia and millions of Indonesian citizens have benefited from the release of mutant varieties.

Peru: Cereal and Native Grains Research Program, Universidad Nacional Agraria La Molina

In Peru, farming activities 3000 meters above sea level are very limited by the harsh conditions of the environment.

The Cereal and Native Grains Research Program produced improved mutant barley and Amaranth varieties, thriving at up to 5000 m altitude, thus providing the seven million Andean farmers living there with more food and income and enhancing their life quality.

Vietnam: Agricultural Genetics Institute, Vietnam Academy of Agricultural Sciences

Rice and soybean mutant varieties improve farmer's livelihoods: one top mutant rice variety from the Agricultural Genetics Institute created a total value of US $3.3 billion, an increase of US $537.6 million compared to the old varieties.

Soybean mutant varieties have brought product value of US $3 billion, and increased the income for 3.48 million farmers by 30%.

Achievement Award Recipients

Afghanistan: Dr Sekander Hussaini, Academy of Sciences of Afghanistan

Brazil: Research Group: Use of in vivo and in vitro induced mutation in plant breeding, CENA, IAC, IAPAR, EPAGRI, CENTRO DE MELHORAMENTO GENETICO DO FUMO, CLONE VIVEIROS E FRUTICULTURA, ESALQ, UNESP

China: XYW Rice Team, Institute of Nuclear Agricultural Sciences, Zhejiang University

China: Wheat Mutation Breeding Team, Chinese Academy of Agricultural Sciences

China: Genetics Breeding Team of SIAE, Sichuan Institute of Atomic Energy

Cuba: Dr Maria Caridad González Cepero, National Institute of Agricultural Science

Egypt: Dr Abdel Shafy Ibrahim Ragab, Nuclear Research Centre, Atomic Energy Authority

India: Plant Mutation Breeding Team, Bhabha Atomic Research Institute

Korea, Republic of: Radiation Breeding Team, Korea Atomic Energy Research Institute

Korea, Republic of: Rice Research Division, National Institute of Crop Science, Rural Development Administration

Malaysia: Malaysian Nuclear Agency

Pakistan: Nuclear Institute for Agriculture and Biology, Pakistan Atomic Energy Commission

Sri Lanka: Department of Agriculture

Sweden: Prof. Udda Lindqvist, Nordic Genetic Resource Centre

Thailand: Rice Department, Bureau of Rice Research Development, Department of Agriculture

Vietnam: Vietnam Academy of Agricultural Sciences & Vietnam Atomic Energy Institute

Vietnam: Phuong Tan Tran and Cua Quang Ho, Department of Agricultural and Rural Development

Yemen: Dr Abdulwahid A Saif, Agricultural Research & Extension Authority

Sorghum Mutant Varieties: From Research to Market

Contributed by: S. Human

For Indonesia, the negative effects of climate change increased adverse conditions for agricultural development: drought prone areas grew, especially in the eastern part of the country. To face the worsening conditions brought about by climate change and variability, a crop was sought that would require less agricultural inputs, being drought tolerant, has a good adaptability and with high economic value. The choice fell on sorghum. In certain areas sorghum had been recognized as a source of food, feed and fuel. However, sorghum was still regarded as a minor crop and its cultivation was limited and mostly grown by the local farmers in a specific region. Sorghum is not of Indonesian origin so that the available plant genetic variability was low. Attempts to increase sorghum genetic variation was achieved through a mutation breeding program which was conducted at the Center for Isotope and Radiation Application (CIRA), the National Nuclear Energy Agency (BATAN). The breeding objectives were to improve sorghum genotypes for improved yield and quality, and tolerant to adverse conditions brought about by climate change, such as prolonged drought.

From this breeding programme, three mutant varieties of sorghum, PAHAT, SAMURAI 1 and SAMURAI 2, have been officially released by the Ministry of Agriculture. These mutant varieties were then developed by stakeholders, including farmers, local agricultural offices and some private companies. As an example, PAHAT is grown by a private company, PTPN XII, in Banyuwangi, East Java (Fig. 1.). This company processed flour out of sorghum grain and from thereon many kinds of sorghum food products, like cookies (Fig. 2.), which are now available on the local market. Through market promotion, sorghum is being introduced as a healthy food because it has a low glycaemic index so that its products become popular to people suffering from diabetes (Fig. 3.). The glycaemic index indicates the food's effect on a person's blood glucose (also called blood sugar) level. Meanwhile, some local governments collaborating with BATAN often arrange sorghum field days to promote sorghum cultivation and technology transfer to the farmers (Fig. 4.). Sorghum cultivation in drought prone areas subsequently impacts positively on increasing land productivity, improving soil fertility, promoting sustainable agriculture development and ensuring food security in the country.

Fig. 1. Sorghum mutant variety PAHAT.

Fig. 2. Sorghum products available at market.

Fig. 3. Healthy food made of sorghum flour.

Fig. 4. Sorghum field day in the farmer society.

Announcements

Superior Achievement Award

The team from the Department of Nuclear Sciences and Applications and the Department of Technical Cooperation received the **One-House Award — Rapid response in protecting wheat from Ug99** for excellent cooperation that enabled the Agency to respond rapidly to an outbreak of the devastating black stem rust disease in wheat, known as Ug99. This is a wind-borne disease which can spread rapidly over a large geographical area region, potentially wiping out entire wheat crops. The Agency developed a project in 2009 in response to an outbreak in countries in Africa and the Middle East. The aim was to strengthen food security through mutation induction, screening for desired mutants and the rapid development of mutant varieties for farmers. A key component of the project was the production of new mutant germplasm using nuclear technology at the Plant Breeding and Genetics Laboratory in Seibersdorf. Through their dedicated work, the Team members contributed to technology transfer, the provision of materials such as mutant germplasm and irrigation systems, as well as technical advice and training to over 20 Member States. The project led to the production of thirteen wheat lines with major resistance to Ug99 in six countries. In 2014, two wheat varieties were released to farms in Kenya. This was an outstanding achievement by the team as these were the first wheat varieties to possess major gene resistance to Ug99. The new mutant varieties were released in record time - within five years of the initial seed irradiation treatment.

The IAEA Director General, Yukiya Amano, awarded the following staff members at a ceremony that took place in the Staff Assembly on six November 2014.

From the Department of Nuclear Sciences and Applications: Mr Pierre Jean Laurent Lagoda, Mr Brian Peter Forster, Mr Bradley John Till, Mr Abdelbagi Mukhtar Ali Ghanim, Mr Souleymane Bado and Ms Mirta Matijevic. **From the Department of Technical Cooperation:** Ms Thabisile Audrey Moleah.

From left to right: Ms T.A. Moleah, Ms M. Matijevic, Mr S. Bado, Mr Y. Amano, Mr P.J.L. Lagoda, Mr B.J. Till, Mr A.M.A. Ghanim — B.P. Forster absent.

On 9–13 February 2015, the Instituto Superior de Ciencias y Tecnologías Aplicadas (InSTEC) and the Centro de Aplicaciones Tecnológicas y Desarrollo

Nuclear (CEADEN) in coordination with the Agencia de Energía Nuclear y Tecnologías de Avanzada (AEN&TA) the WONP-NURT 2015 symposium, which will include a Workshop on 'Plant Mutation Breeding'. This workshop will be devoted to the state of the art applications in the field of nuclear techniques in agriculture, particularly regarding plant genetic improvement by means of radio-induced mutagenesis. It is expected to bring together outstanding national and international researchers, plant breeders and geneticists in this field. Topics included are:

- Development of new improved varieties trough plant mutation breeding;
- Establishment on *in vivo* and *in vitro* mutagenesis and selection protocols;
- Molecular marker techniques to assist mutant germplasm characterization and genotype identification;
- Gene expression and proteomic analyses associated with stress response in mutant genotypes.

For more and actual information of the Symposium and Workshop, please check http://www.wonp-nurt.cu

Developments at the Plant Breeding and Genetics Laboratory (PBGL)

Adaptive Research and Development to Leverage the Power of Induced Mutations

One of the great strengths of plant mutation breeding is that it does not require knowledge of mechanistic pathways that control agronomically important traits. In fact, it does not even require the knowledge that DNA is the genetic material; the first mutant variety was released nearly a decade before Oswald Avery's ground breaking experiments to prove the importance of deoxyribonucleic acid. Yet, understanding the location and type of induced mutation that confers some advantageous characteristic to a crop is of immense importance. To make full use of the new genetic diversity represented in the ~3200 officially released mutant varieties (www.mvgs.iaea.org), one would ideally have a complete catalogue of the mutant alleles, how they affect the crop (biotic or abiotic stress resistance, resilinace to climatic extremes, improved quality, etc.) and the ability to transfer these alleles into other germplasm. Indeed, the PBGL is receiving an increasing number of requests by Member States to identify the DNA mutations that are responsible for improved crops. The task of finding such mutations, however, is quite challenging. Crop genome sizes range from hundreds of millions to hundreds of billions of base pairs. An improved trait such as disease resistance may be caused by the change of a single base pair.

A traditional approach to identifying causative mutations is to first map the trait to a specific genomic region, followed by fine mapping and ultimately cloning the mutant gene to recover the sequence of the gene. Why is this important? Knowing the mutation that causes the trait provides a perfect molecular marker that can be used to rapidly introgress novel traits such as disease resistance into other breeding material. It is also important to broaden our understanding of function of genes and their role in important agronomic traits and understand how different mutation types alter the function of genes. The main challenge to this approach is that traditional mapping methods require careful genetic crosses and can take five or more years after the release of a mutant variety.

To bridge the gap between the released mutant variety and recovery of mutations responsible for the improved crop, the PBGL has been investigating various approaches to speed up the traditional mapping and cloning procedures. Promising approaches for recovery of chemically induced mutations have been described for model plants and smaller genome crops using whole genome sequencing technologies. The PBGL is focusing on gamma-induced mutations because this is the mutagen used to create the majority of the ~3200 officially released mutant crop varieties and gamma irradiation remains the most popular approach for many newly started mutation breeding projects. We have chosen two crops for our pilot tests: rice (representing crops with smaller genomes) and wheat (representing large genome crops). We have just begun this work and are collaborating with different groups to develop appropriate strategies. Our work with exome capture sequencing (reducing the amount of sequences evaluated from an entire genome to only coding sequences of genes) described in the last newsletter suggests that many gamma induced mutations in seed propagated crops may be large deletions. We are using this data to plan our experiments. Our goal is to develop a streamlined approach that is suitable for most crops and requires only minimal genetic crosses.

In addition to genome sequencing based projects described above, and the development of low-cost kits (described below), we are actively working on developing mutation based approaches suitable for vegetatively propagated crops. Since the last newsletter we have been collaborating with the University of Florida to explore the feasibility of developing a TILLING reverse-genetics platform for citrus. While we have just begun this work,

the preliminary results are promising. We have adapted our low-cost mutation assays to evaluate natural genetic variation in citrus (Fig. 1., Table 1.) and are testing different approaches for mutagenesis.

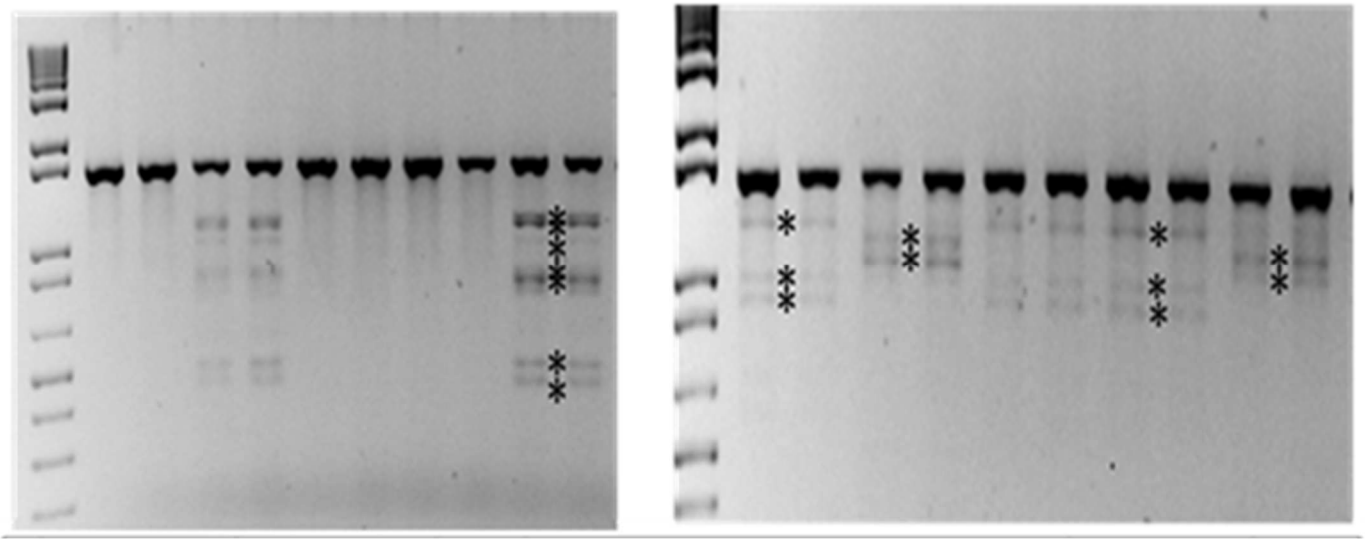


Fig. 1. Low-cost mutation discovery was adapted for the discovery of natural homozygous and heterozygous polymorphism in different citrus genotypes (top). Protein sequence evaluation shows many, but not all, amino acid substitutions are predicted to have no effect on gene function.

Table 1. Summary of nucleotide variation recovered in citrus.

#	View on Sequence	Nucleotide Change	Effect	Restriction Enyme Differences from REBASE		PSSM Difference	Zygosity
				Gained in Variant	Lost from Reference		
1	G C	A594G	K157E			3.2	Homo
2	G C	A640C	K172T	FnuDII	Bce83I, SmlI	10.1	Hetero
3	G C	T710G	S195R		RsaI, SeaI, TatI		Homo
4	G C	A749G	P208=	BcefI	BccI		Hetero
5	G C	A759G	K212E	Hin4I	MseI		Homo
6	G C	G796A	S224N	Tsp4CI	AluI, CviJI, NspBII, PvuII	-7.1	Homo
7	G C	T857C	I244=	BciVI, Hpy188I	AsuII, TaqI, XmnI		Hetero
8	G C	G896C	M257I	BinI, DpnI, MboI, XhoII	BcefI, SfaNI		Homo
9	G C	G899A	P258=	BccI	BcefI		Homo
10	G C	G1090T	R322M	AflIII, BspLUIII, NlaIII, NspI		2.9	Homo
11	G C	G1224C	V367L	BsmAI, Hpy178III		-10.9	Homo
12	G C	T1289C	N388=	MaeIII			Homo
13	G C	C1415T	D430=				Homo
14	G C	T1563G	F480V		AluI, CviJI, HindIII		Hetero
15	G C	C1731A	Q536K			-2.0	Homo

Pollen Irradiation for doubled haploid production in cucurbits

Haploid is the plant with the gametic set of chromosomes (n) and expected to be sterile if the chromosomes are not doubled to make the zygotic number of chromosomes (2n). Protocols have been developed to induce haploid plant production in various plant species using different methods such as anther/microspore and ovule culture, pollen irradiation and wide hybridization among few species. Haploids are either spontaneously doubled or induced to double through different treatments such as colchicine treatment. The doubled haploid technology has been widely used to accelerate breeding programs, increase efficiency of selection and produce inbred lines for hybrid production The PBGL is carrying out adaptive R&D to develop new protocols for doubled haploid production in crop plants that are of interest to our MSs with the objective of integrating these protocols in mutation breeding. Currently, we are developing a protocol on using pollen irradiation for haploid induction in cucurbits. Fruits are collected after pollinating flowers with irradiated pollens from the same species and haploids are verified by flow cytometry and subsequently doubled using colchicine treatment (Fig. 3.). An intern (Slovenia) and a number of fellows from different Member States (Bangladesh, Ghana and Sudan) are involved in development and training on these protocols to fine tune the procedures and integrate them in their mutation breeding projects back home. The procedures are also being taught during regional training courses organized by the PBG to promote wide use and dissemination.

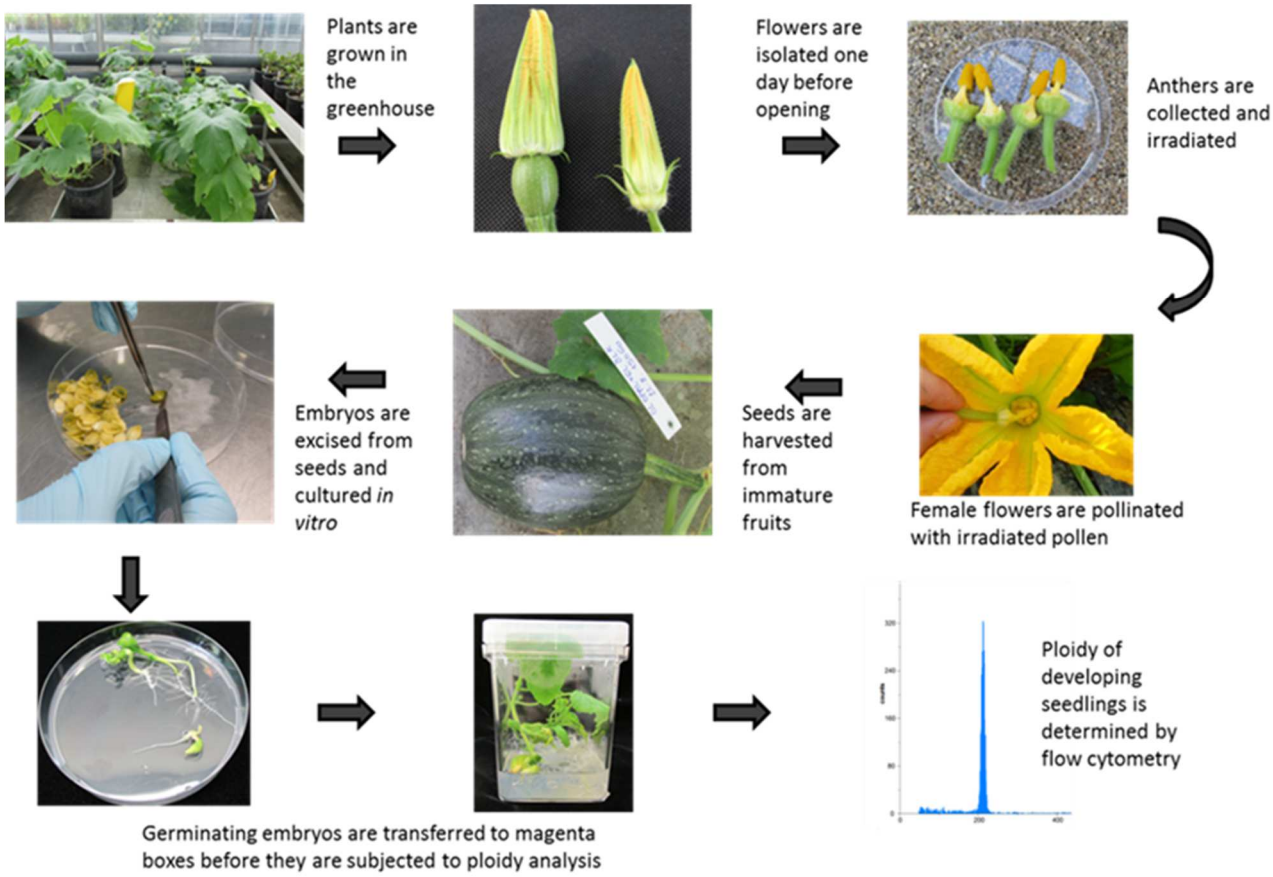


Fig. 3. Haploid production by pollen irradiation in oil pumpkin as an example of the protocols under development in the PBGL.

Irradiation Services

At the time of writing the PBGL has received at total of 42 requests for plant irradiation services from 24 Member State (MS) in 2014. These are listed below and included 36 plant species. The total number of irradiation requests since records began now stands at 1407. The trend of applying mutation induction to a wider range of crops continues as can be seen in requests for irradiation of a herb (sage), an ornamental tree (*Catalpa bignonioides* (Indian bean tree)) and biofuel crops (jatropha). For each request (unless otherwise stated), we carry out radio-sensitivity tests to determine the optimal irradiation dose for mutation induction (some examples are given below). We therefore normally request that MSs send to us sufficient seed for this initial test (usually 100–300 seed). Once the optimal dose is determined this is applied to the rest of the seed sample and the M_1 seed returned to the Member State.

Requests for mutation induction have been increasing in recent years and this is thought to be due, in part, to the regulations and restrictions imposed on setting up and refurbishing gamma irradiators; the source of gamma rays are radioactive isotopes such as Cobalt 60 and Cesium 137. The PBGL is therefore becoming increasingly important as an international centre for mutation induction using gamma irradiation. To offset this dependency and to increase capacity in Member States the PBGL is conducting R&D activities in the application of X ray and Ion Beam irradiation for mutation induction.

Request number	Country	Species
1366	Oman	Date palm, wheat, barley, banana
1367	Bangladesh	Wheat, groundnut, onion
1368	Bangladesh	Rice
1369	Algeria	Wheat (TA, TD)
1370	UK	*Vica faba*
1371	Germany	*Heliantus anus*
1372	Uzbekistan	Cotton, *Paulownia*
1373	Democratic Republic of Congo	*Jatropha curcas*
1374	Democratic Republic of Congo	Soybean
1375	Albania	*Phaseolus vulgaris*
1376	Lesotho	*Ipomea batotas*
1377	Slovenia	*Catolpa bignonioides*
1378	UK	*Triticum turigidum*
1379	Bangladesh	Lentil
1380	Sudan	Sorghum, cotton and brad wheat
1381	Iraq	Cowpea
1382	Benin	Maize, amaranthus
1383	Palestine	Barley, durum wheat
1384	Democratic Republic of Congo	Cassava
1385	Iraq	Sesame
1386	Jordan	Barley
1387	Jordan	Barley
1388	Syria	Wheat, barley
1389	UK	Wheat
1390	Democratic Republic of Congo	Maize
1391	UK	Potato
1392	Italy	Tomato, onion, *Latuca sativa*
1393	Nigeria	*Digitaria exilis* (Fonio)
1394	UK	Wheat
1395	Sri Lanka	Rice
1396	Albania	Wheat
1397	Sri Lanka	Onion, chili, soybean, nungbean
1398	Oman	Wheat, barley
1399	Senegal	Cowpea
1400	Uzbekistan	*Paulownia*
1401	Slovakia	*Pisum sativum*
1402	Nigeria	*Vigna unguculata*
1403	UK	Wheat
1404	Jordan	Barley, wheat
1405	Ghana	Sorghum, oil palm
1406	UK	*Hosta*
1407	Kuwait	Barley

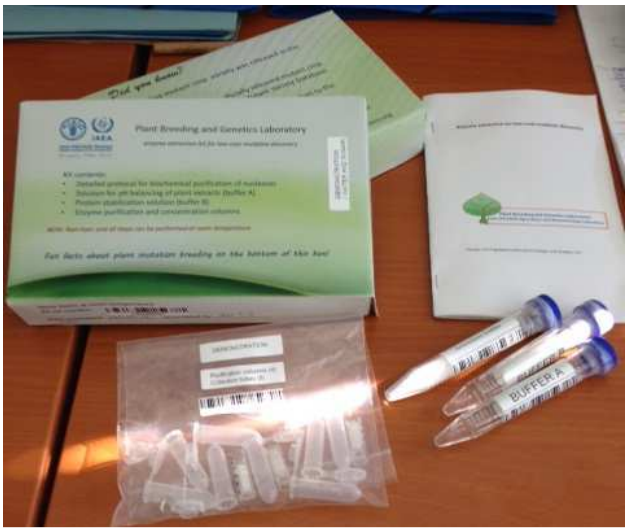
Kits

The Plant Breeding and Genetics Laboratory is happy to announce the development of a new kit to assist researchers in their efforts for molecular characterization of induced and natural mutations (see photo). This latest kit is designed for room temperature extraction of single-strand-specific nucleases used in enzymatic mismatch based polymorphism discovery assays such as TILLING and Ecotilling, and for the validation of production of doubled haploid plants. The kit provides all the materials needed to prepare approximately 3000 reactions worth of enzyme from 18mls of celery juice. All steps are performed at room temperature using a standard microcentrifuge Toxic chemicals and complex dialysis are avoided as compared to previous PBGL protocols. The kit was demonstrated to MS delegates at the PBG stand during the 2014 IAEA General Conference.

The enzyme extraction kit represents the third in a series of kits designed for molecular characterization of plants that we distribute to researchers upon request. Please contact us if you would like a kit. We also welcome you to contact us with suggestions for new kits or additions to our extant kits to improve their usefulness.

Kits distributed since the last newsletter:

- Low cost DNA extraction kits distributed to: Nigeria, Poland.
- Low cost mutation discovery kits distributed to: Nigeria, Iran, Pakistan.
- Low cost enzyme extraction for mutation discovery: Syrian Arab Republic.



The new enzyme extraction kit from the PBGL comes with a detailed protocol and all materials necessary to prepare 3000 reactions worth of nuclease for mutation discovery from 18mls of starting plant juice extract.

Professional Networking

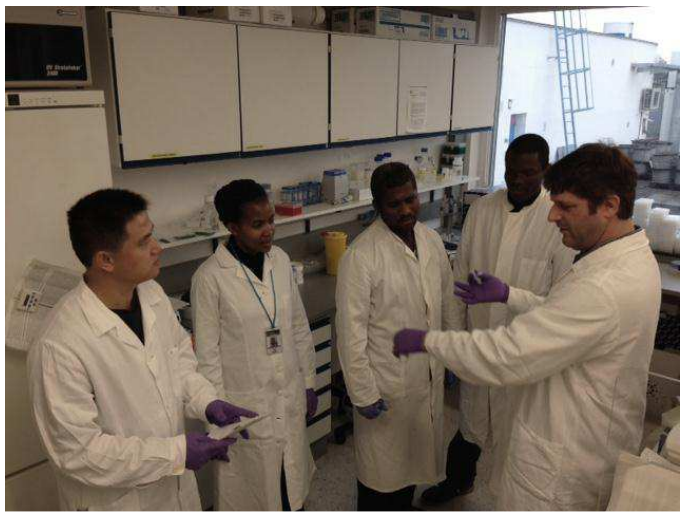
The PBGL thanks all of you who have connected with us on LinkedIN if you have not already linked with us, please feel free to connect:

(http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3). We are now linked with 248 researchers and are happy to continue to expand our connections to the broader plant sciences and agricultural community.

Human Capacity Development

Group Training on Low-cost DNA Extraction, Purification of Enzymes and Mutation Discovery

An *ad hoc* training course was organized by Mr B. Till from September 1–12 covering low-cost protocols developed at the PBGL for tissue desiccation, low-cost DNA extraction, bench-top enzyme purification and mutation discovery. This training represented the first PBGL training on enzyme purification using the new protocol described earlier in this newsletter. The training was scheduled to coincide with Scientific Visitors from Mongolia and Palestine. Additional participants included research fellows, interns and visiting experts from Bangladesh, China, Ghana, Poland and the United Republic of Tanzania.



Trainees are taught methods for purification of single-strand-specific nucleases from plant extracts.

Individual Training Activities

Cost-free Experts

Name	Country	Topic	Period
*Mr Lan Tao	China	Mutation induction and identification in rice	July 2013–June 2014
*Mr Zhiwei Chen	China	Mutation detection in rice	August 2014–July 2015

*Funded and supported by the Fujian Agriculture and Forestry University and the Chines Government, respectively.

Scientific Visitors

Name	Country	Topic	Period
Ms Binita Saraye	Mauritius	Participation in a scientific conference	February 2014
*Ms Johanna Gazinski	Germany	Mutation induction in barley seed	25–27 March 2014
**Ms Kamila Kozak-Stankiewicz	Poland	Validation of DH lines by enzymatic mismatch methods	July, November 2014
**Ms Joanna Nocen	Poland	Validation of DH lines by enzymatic mismatch methods	November 2014
Ms Myagmarsuren Yadamsuren	Mongolia	Mutation induction and detection in crop plants	September 2014
Mr Yamen A.S. Hamdan	Palestine	Mutation induction and detection in crop plants	September 2014
Mr Herve Nandkangre	Burkina Faso	Mutation induction and detection in crop plants	June 2014
Mr Mohammed Jouhar	Syria		September 2014
***Ms Malgorzata Kupc	Poland	Mutation induction and detection in crop plants	August 2014

*Funded by Saatzucht Josef Breun, Germany; **Funded by Kutno Sugar beet Breeding Company; ***Funded by Gdansk University of Technology.

Interns

Name	Country	Areas of training	Period
Ms Farzaneh Taassob Shirazi	Islamic Republic of Iran	Mutation induction in barley, screening and accelerated breeding	July 2011–December 2014
Mr Keji Dada	Nigeria	Mutation induction in coffee	July 2013–April 2014
*Ms Ayse Sen	Turkey	Mutation detection	May 2013–May 2014
**Ms Joanna Szablinska	Poland	Mutation detection in rice	June–September 2014
***Mr Md. Rani Hasanazzaman	Bangladesh	Mutation induction in rice, screening and accelerated breeding	December 2013–June 2014
***Mr Md Kamruzzaman	Bangladesh	Mutation induction in rice, screening and accelerated breeding	December 2013–June 2014
Ms Kristina Kosmrlj	Slovenia	Development of ion beam irradiation	June–September 2014
Ms Balachew A. Tsegahiwot	Ethiopia	Development of ion beam irradiation	May–August 2014
**Mr Krzysztof Kolloch	Poland	Mutation detection in citrus	July–September 2014

*Funded by the Turkish Government; **Partial funding by Erasmus fellowship; ***Funded by the Bangladesh Institute of Nuclear Agriculture (BINA).

Individual Fellows

Name	Country	Areas of training	Period
Mr Abderrahmane Hannachi	Algeria	Mutation detection in barley	November 2013–January 2014
Ms Babita Dussoruth	Mauritius	Mutation detection in banana	November 2013–February 2014
Mr Hery Lalao Lwyset Randrianarivony	Madagascar	Mutation induction and detection in rice	October 2013–January 2014
Ms Matumelo Alice Rafiri	Lesotho	Mutation induction in potato	August 2013–January 2014
Mr Motlatsi James Ntho	Lesotho	Mutation induction in potato	April–May 2014
Mr Privat Ndayihanzamaso	Burundi	Mutation detection	June–August 2014

Name	Country	Areas of training	Period
Mr Wonder Nunekpeku	Ghana	Mutation induction in oil palm	June–November 2014
Mr Enock Sapey	Ghana	Mutation induction in oil palm	June–November 2014
Ms Kaoutar El Achouri	Morocco	Mutation induction and detection in potato	November 2013–February 2014
Mr Aime Diamuini	Democratic Republic of Congo	Mutation induction and detection in cassava	February 2014– May 2014
Mr Motlatsi James Ntho	Lesotho	Mutation induction in potato and sweet potato	April 2014– May 2014
Ms Snigdha Roy	Bangladesh	Mutation induction and screening for abiotic stress tolerance	May 2014–October 2014
Mr Alomgir Kabir	Bangladesh	Mutation induction and screening for abiotic stress tolerance	May 2014–October 2014
Ms Nada Siddig Mustafa	Sudan	Mutation induction in wheat and sorghum	May 2014–October 2014
Mr Zeltni Abdessalem	Algeria	Methods in plant mutation breeding	June 2014
Ms Neema Yona	The United Republic of Tanzania	Mutation detection in heat stress tolerant rice mutants	September–November 2014
Ms. Wahiba Amri Epse Tiliouine	Algeria	Mutation detection in chickpea	September–November 2014
Ms Banumaty Saraye	Mauritius	Heat stress screening of tomato mutants	November–January 2014

Visitors to the PBGL

The PBGL continues to host a high flux of visitors. From July 2014 until the time of writing we have received over 24 visitors groups from various Member States, as well as internal groups. Visitors are keen to understand the role of the PBGL (and other NA-Laboratories), out impact and future vision.

July

- University of Ljubljana, Biotechnical Facility
- National Centre for Radiation Service, New Zealand
- Procurement Review Committee, IAEA
- Director-MTHR/Director-MTIT, IAEA

August

- Deputy Director General, NA-Department, IAEA
- Director-UNIS and UNIS and OPIC Staff
- Permanent Mission of Pakistan

September

- Permanent Mission of Malaysia
- Permanent Mission of the United States of America
- Radiation Protection, IAEA
- Ministerial Visit from Honduras
- Delegation from the Philippines
- High Level delegation from Burkina Faso
- General Conference Delegates (four groups)
- Ms Maria Helena Semedo, FAO Deputy Director General

October

- Members of the Standing Advisory Group on Nuclear Energy (SAGNE)
- Scientific Delegation from the United States of America
- Delegation from MTBF, IAEA

November

- National Liaison Officers
- Group of journalists from Jordan
- Department of Health, Australia

Plant Breeding and Genetics Laboratory Staff Travels to Member States

Mr A.M.A. Ghanim

Zagreb, Croatia

19–23 October 2014, visited the Laboratory of Ion Beam Interactions, Ruder Boskovic Institute, Zagreb, Croatia to conduct experiment on seed irradiation with Ion Beam for mutation induction as part of the PBGL collaboration to

develop protocol for mutation breeding using Ion Beam. Seeds representing different crop plants (wheat, barley, sesame, sunflower some vegetables and beans) were brought after desiccation and vacuum packing at the PBGL. The seeds were irradiated with a range of doses (50 to 750 Gy) and brought back to sown and evaluated for radio-sensitivity in the glasshouse of the PBGL.

Gaborone, Botswana

17–21 November 2014, visited Gaborone, Botswana to review the achievement of the TC project BOT/5/009 'Using Radiation Technology and Biotechnology to Develop Mutant Lines of Important Crops with Increased Yield and Improved Nutritional and Hygienic Qualities' with regard to mutation breeding aspects, lessons learned, verify the impact of provided inputs and discuss the inter-institution collaboration in implementing the remaining activities of the project after revising the workplan.

ReNuAL

Breaking Ground on the Future Nuclear Applications Laboratories

Participants join the DG in the groundbreaking.

On 29 September, IAEA Director General Yukiya Amano was joined in Seibersdorf by representatives of Member States and the Food and Agriculture Organization of the United Nations (FAO), as well as IAEA staff members, to break ground on the Renovation of the Nuclear Applications Laboratories (ReNuAL) project, and to celebrate the 50th anniversary of the FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture. There were over 200 participants, with 48 Member States represented.

ReNuAL is an initiative to modernize the eight laboratories in Seibersdorf that belong to the IAEA's Department of Nuclear Sciences and Applications. The project calls for the construction of a new Insect Pest Control Laboratory (IPCL) to replace the existing IPCL, and a new Flexible Modular Laboratory (FML) to house three additional laboratories, by the end of 2017.

DG Amano and DDG Semedo cut a 50th anniversary cake.

DG Amano was joined for this event by IAEA Board of Governors Chair Ms. Marta Ziakova, and FAO Deputy Director General and Coordinator for Natural Resources Ms. Maria Helen Semedo, who each delivered remarks in support of ReNuAL and the achievements of the Joint Division.

In his remarks, DG Amano said, 'Our symbolic groundbreaking today marks the start of the implementation of the ReNuAL project. I am confident that with the active support of Member States, by 2017, we will have a cluster of modern, well-equipped laboratories here in Seibersdorf that we can all be proud of.'

Moving from Planning to Construction

In July, an architectural and engineering firm was contracted to develop the conceptual designs for the Insect Pest Control Laboratory and the Flexible Modular Laboratory, and to update the master plan for the Seibersdorf site. This plan will guide the development to be carried out in the frame of ReNuAL and other related initiatives on the site.

Initial rendering of the new Insect Pest Control Laboratory.

The conceptual design for the IPCL has been completed, and will be completed for the FML by the end of November. Planning for the latter is more complex as it will house multiple laboratories and is being designed to allow laboratory space to be more easily adapted to different activities and needs, and to be modular to make any future expansion more cost effective. Renovation of the Nuclear Applications Laboratories

The IPCL will house laboratory sub-groups dealing with plant pests, livestock pests, human disease vectors and genetics/microbiology. The FML is designed to house laboratories with similar activities to maximize synergies, for example, through the sharing of equipment and certain types of laboratory space. For this reason, the FML will house the Food and Environmental Protection Laboratory, the Soil, Water Management and Crop Nutrition Laboratory, and the Terrestrial Environment Laboratory.

The purpose of the conceptual designs is to provide the basic layout and structure of the new buildings, and in

doing so to provide a greater degree of certainty regarding the costs of construction.

Upon completion of the conceptual designs, the detailed designs will be developed. These will build further on the conceptual designs and add greater detail by making more concrete decisions on smaller elements of the two buildings, such as the number, size and type of windows, and the number and type of light fixtures to be used.

Initial rendering of the new Flexible Modular Laboratory (FML).

With these designs and cost estimates, a tender for construction can then be issued, and it is estimated that construction will begin sometime in mid-2015.

Building Momentum in Resource Mobilization

As was reported to the 59th General Conference in September, ReNuAL has so far raised approximately €860 000 in cash and funding for cost-free experts. These funds and experts have been used to support the initial planning for the project and are now supporting the design work that is being carried out.

Also during the General Conference, China announced the in-kind donation of an irradiator that can potentially serve the needs of several laboratories: the Animal Production and Health Laboratory, the Insect Pest Control Laboratory and the Plant Breeding and Genetics Laboratory.

In the resolution related to ReNuAL that was passed by the General Conference, Member States expressed strong support for the project and requested its further development and implementation. Included in this was a specific request for the Secretariat to prepare thematic packages that would separate the various elements of the project into somewhat smaller components that would enable Member States to support specific programmatic areas according to their own interests and priorities.

The Secretariat will develop these packages once more detailed cost information from the conceptual designs of the Insect Pest Control Laboratory and Flexible Modular Laboratory is fully available.

Seeking Biosafety Level 3 Laboratory Capabilities

A number of Member States have expressed support for the establishment by the Agency of biosafety level 3 capabilities that would enable the Animal Production and Health Laboratory to respond to emerging challenges related to transboundary animal diseases. These capabilities are one of the group of project elements now defined as ReNuAL Plus (ReNuAL+), which was introduced by DG Amano in September to ensure that needs additional to those identified under ReNuAL can be addressed – provided the necessary extrabudgetary resources are available.

The process for licensing and constructing such a facility is complex and can take three to five years. For this reason, the Secretariat has been reviewing various options for obtaining biosafety level 3 capabilities. These include their establishment in Seibersdorf, or possibly at a facility in Mödling belonging to the Austrian Agency for Health and Food Safety (AGES in German). This facility already has biosafety level 3 capabilities and the associated infrastructure that is required, and therefore can potentially support the capabilities sought by the Agency.

AGES facility in Mödling.

The IAEA, the Government of Austria and senior AGES staff are in consultations to review the options available for the establishment of these capabilities. These consultations will continue in the coming months. Provided a mutually agreeable solution can be identified, the estimated resource requirements for obtaining the capabilities required by the IAEA will be determined and communicated to Member States.

Publications

Books

O.A. Huynh, J. Jankowicz-Cieslak, B.J. Hofinger, M.M. Beshir, R.G. Laport, B.J. Till: Low-Cost Methods for Molecular Characterization of Mutant Plants: Tissue Desiccation, DNA Extraction and Mutation Discovery, A Protocol. Springer *(submitted)*.

Peer-reviewed Book Chapters

J. Jankowicz-Cieslak and B.J. Till. Forward and Reverse Genetics in crop breeding. Chapter 8 in: Advances in

Plant Breeding Strategies Volume I: Breeding, Biotechnology and Molecular Tools. Eds: (*in press*).

B.P. Forster, B.J. Till, A.M.A. Ghanim, O.A. Huynh, H.Burstmayr, P.D.S. Caligari. Accelerated plant breeding *(submitted)*.

B.J. Till. (2014) Mining genetic resources *via* Ecotilling. In Genomics of Plant Genetic Resources, Volume 1. Managing, Sequencing and Mining Genetic Resources, R.Tuberose, A.Graner and E.Frison eds. Springer 349–368.

L.S. Lee, B.J. Till, H. Hill, O.A. Huynh, J. Jankowicz-Cieslak. (2014) Mutation and Mutation Screening. Chapter 8 in: Cereal Genomics, Methods and Protocols Series: Methods in Molecular Biology, Vol. 1099. Eds: Robert J. Henry, Agnelo Furtado. Humana Press, ISBN 978-1-62703-714-3.

S. Bado, B.P. Forster, B.J. Till, S. Nielen, P.J.L. Lagoda, M. Laimer. Plant Mutation Breeding: Current Progress and Future Assessment. Plant Breeding Reviews *(in press)*.

Z. Mbambo, R. Minnis-Ndimba, C. Pineda, B. Ndimba, S. Bado, J. Lin, T. Chikwamba, L. Mehlo. 2014. Proton induced X-ray emission and electron microscopy analysis of induced mutants of sorghum. In: Tomlekova N.B., M.I. Kozgar and M.R. Wani (eds.), Mutagenesis: exploring novel genes and pathways. Wageningen Academic Publishers, The Netherlands 183-196.

M.A.M. Abd Elbasit, A.M. Ali, H. Yasuda. (2014) Indigenous Water Saving Technologies in Arid and Semi-Arid Regions: Examples from Sudan Mohamed A. M. Abd Elbasit, Abdelbagi M. Ali, and Hiroshi Yasuda. Environment People and Development; Experiences from Desert Ecosystem, Edited by Mahesh Kumer Gaur and P. C. Moharana: pages 229-241; New India Publishing Agency, New Delhi, India, ISBN: 978-93-81450-79-6.

Peer-reviewed Journal Articles

T. Howell, I. Hale, L. Jankuloski, M. Bonafede, M. Gilbert, J. Dubcovsky (2014) Mapping a region within the 1RS.1BL translocation in common wheat affecting grain yield and canopy water status. Theor Appl Genet 127: 2695–2709.

F. Maghuly, J. Jankowicz-Cieslak, S. Pabinger, B.J. Till, M. Laimer. Discovery of polymorphisms and analyses of the genetic structure of Jatropha curcas accessions from three continents. Biotechnology Journal *(in press)*.

B. Jhurree-Dussoruth, J. Jankowicz-Cieslak, B.J. Till. Genetic Diversity Study of Dessert-type Banana Accessions in Mauritius using Low-Cost SNPs Detection Technology. Acta Horticulturae *(in press)*.

S. Bado, P. Bazongo, G. Son, A.M. Lykke, T.K. Moe, B.P. Forster, S. Nielen, A. Ouedraogo, I.H.N. Bassolé. Physicochemical characteristics and composition of three morphotypes of Cyperus esculentus tubers and tuber oils *(submitted)*.

Y.S.A. Mohammed, I.S.A. Tahir, N.M. Kamal, A.E. Eltayeb, A.M. Ali, H. Tsujimoto. Impact of wheat-Leymus racemosus added chromosomes on wheat adaptation and tolerance to heat stress. Breeding Science 03/2014; 63(5):450–60.

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Conference Abstracts

J. Jankowicz-Cieslak, L. Fragner, J. Szablinska, J. Vollmann, W. Weckwerth, B.J. Till. Induced mutations and 'omics' approaches for quality trait improvement in rice. 2nd International Metabolomics Austria (InMetA) 30 June–4 July 2014, Vienna, Austria.

A. Sen, J. Jankowicz-Cieslak, O.A. Huynh, I. Henry, L. Comai, B.J. Till. Mutation discovery platforms to facilitate forward and reverse genetics in cereals. The 2nd Plant Genomics Congress, 11–12 September 2014, USA.

B. Jhurree-Dussoruth, J. Jankowicz-Cieslak, B.J. Till, Genetic Diversity Study Of Banana Accessions In Mauritius Using Low-Cost SNP's Detection Technology. The 29th International Horticultural Congress: The fifth joint ISHS SEBA-ProMusa Symposium 'Unravelling the Banana's Genomic Potential' 17–22 August 2014, Brisbane, Australia.

F. Maghuly, J. Jankowicz-Cieslak, M. Laimer. High throughput polymorphism discovery and genotyping in a mutant population of Jatropha curcas. International Plant & Animal Genome XXII 11–15 Jnauary 2014, San Diego, CA, USA.

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J. Jankowicz-Cieslak, M. Rapacz, S. Fluch, M. Berenyi, E. Wischnitzki, C. Mba, B.J. Till. Revealing mechanisms of drought response in Musa. Plant Gene Discovery & 'Omics' Technologies, 16–19 February 2014, Vienna, Austria.

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B. Jhurree-Dussoruth, J. Jankowicz-Cieslak, B.J. Till, H. Kallydin, D. Burthia. Mutation induction and discovery in a Mauritian Dessert-type banana. Plant Gene Discovery & 'Omics' Technologies, 16–19 February 2014, Vienna, Austria.

B. Jhurree-Dussoruth, B. Saraye, J. Jankowicz-Cieslak, D. Burthia, S. Peerboccus, O.A. Huynh, B.J. Till. Adaptation of low-cost DNA extraction methods in developing countries. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.

B. Saraye, J. Jankowicz-Cieslak. A comparative study of low cost TILLING, EcoTILLING and LiCOR based assays for characterisation of tomato mutants and natural accessions. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.

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K.E. Dada, S. Bado, R. Matumelo, F.C. Anagbogu, M.A. Daniel, B.J. Till, A.M.A. Ghanim, B.P. Forster. (2014). Mutation induction in Arabica and Robusta coffee. Plant Gene Discovery & 'Omics' Technologies, 16–19 February 2014, Vienna, Austria.

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