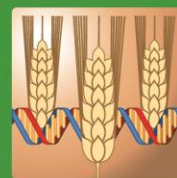




Joint FAO/IAEA Programme  
Nuclear Techniques in Food and Agriculture

# Plant Breeding & Genetics Newsletter



<http://www-naweb.iaea.org/nafa/index.html>

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## To Our Readers



*Flowering in coffee cuttings (Plant Breeding and Genetics Laboratory glasshouse) can be exploited in speeding the production of mutant generations.*

A new biennium has started and we are already half way through the first year. I want to focus your attention on two events that are developing and forthcoming:

The Member States of IAEA have called for an initiative to renovate and modernize the Nuclear Sciences and Applications Laboratories in Seibersdorf, called the ReNuAL project. In the 52 years since the IAEA's Nuclear Applications Laboratories in Seibersdorf were established (five of which are in the field of agriculture under the Joint FAO/IAEA Division), there has been no comprehensive renovation or significant upgrading of equipment to ensure the continuing ability of the laboratories to respond to Member States' growing and evolving needs. The objective of the ReNuAL Project is to ensure that the laboratories are fit-for-purpose and appropriately positioned to meet the evolving needs of member countries with adequate

infrastructure in place for the next 20 years. The goals are to:

- Redesign and expand the current infrastructure to ensure the efficiency and effectiveness of laboratory operations and services to better meet the current and future requirements of member countries;
- Ensure that the laboratories remain a vibrant research and training institution that continues to attract highly qualified scientists and other staff committed to advancing applied nuclear sciences to serve the needs and interests of member countries.

The ReNuAL project includes in its first phase those elements to be achieved from 2014–2017 within a €31 million target budget established by the Director General. Ground-breaking is planned for 29 September 2014, with completion by December 2017. We are dependent upon additional financial support and donations of the countries we serve, in order to be able to realize all the necessary renovation works. Read more about this initiative on page 25.

This year we also celebrate the 50th anniversary of the Joint FAO/IAEA Division. This provides an opportunity to honour the endeavours of individuals, teams and institutions in Member States in increasing sustainable food security through plant mutation breeding: Outstanding and Superior Achievement Awards to celebrate successes in plant mutation breeding. The Awards will be officially announced at the Vienna International Centre (VIC) (IAEA, Vienna, Austria) during the 58th General Conference 22–26 September 2014 (see page 24).

About the R&D at the Plant Breeding and Genetics Laboratory (PBGL) in Seibersdorf, we can report some exciting news on *in vitro* mutation induction in potato and

coffee (see ‘Developments at the Plant Breeding and Genetics Laboratory, Seibersdorf’ on page 26). Further, you will find some information on our low cost protocols developed for low budget, low infrastructure laboratories.

Related to the technical and scientific support PBG is providing to Member States, a continuing success story is the fight against Ug99 (see page 22). In addition to the first mutant wheat variety resistant to Ug99, released in Kenya in 2014, Eldo Ngano 1 (Eldoret Story 1), our counterpart in Kenya announced the release of a second resistant variety Eldo Mavuno 1 (Eldoret Harvest 1). Based on this success, a new CRP will be proposed on biotic stress (tentatively

including coffee rust, Black Sigatoka and Panama Disease Tropical Race 4 in banana, greening disease in citrus and wheat rusts). A second new CRP will also be launched on mutation efficiency (see pages 12–14).

This year, three Coordinated Research Projects (CRPs) finished successfully with a fourth and final Research Coordination Meeting (RCM). You can find details inside this newsletter on these and much more.

*Pierre J.L. Lagoda*  
*Section Head*

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## Staff News

### New Staff



It is my pleasure to welcome a new staff member to the Plant Breeding and Genetic's (PBG) team: Ljupcho Jankuloski was born in the Former Yugoslav Republic of Macedonia in 1970. He holds a B.Sc. in Field Crop Production and a M.Sc. and Ph.D. in Genetics and Plant Breeding from the Faculty of Agricultural Sciences and Food, Skopje, Macedonia.

Recently promoted to Head of the Plant Breeding and Genetics Department, Ljupcho has extensive experience in mutation breeding (wheat and barley) and is familiar with the optimal use of nuclear and biotechnology methods for the induction and detection of genetic alterations in plants leading to the improvement of important characteristics such as yield, product quality and resistance to diseases. His department recently established the first mutation breeding programmes in Macedonia, and with support from the IAEA capacity in mutation breeding was set up (laboratory development and staff training). This has resulted in the first mutant lines to be entered into National List Trials for variety release in Macedonia. Ljupcho has a comprehensive grasp of all the technical skills required in plant mutation breeding from design to execution to successful outcomes of breeding objectives. This is backed by a sound understanding of genetic principles and the application of relevant technologies (gene mapping, marker assisted selection, tissue culture and accelerated plant breeding). He lectured to undergraduates and supervised post-graduate researchers. He represents an ideal complement to the PBG's staff, based at the VIC in Vienna (mailto: l.jankuloski@iaea.org).

## Staff Success Story



*The IAEA badminton team.*

Brian P. Foster (first on the left), Laboratory head of Plant Breeding and Genetics (Seibersdorf), won the Gold Medal with his Badminton Team at the 41st Annual United Nations Inter-Agency Games, New York, the United States of America (USA). The United Nations Inter-Agency Games were started in the early 1970s, but this is the first time the athletes are competing in the United States; all previous games have been in Europe. About 1 000 staff representing all United Nations operations in over 100 countries from Afghanistan to Kosovo were facing off against each other in a three-day Olympics-style competition at Hofstra University in suburban New York on 25–27 April 2014. Once a year United Nations employees, who try to promote peace and harmony around the globe, are battling each other in fierce competitions on soccer fields, swatting birdies in badminton and striving for check-mates on the chess table. These are amateur athletes competing entirely for the enjoyment of sport, but there remains a fiery will to win. As Brian met the challenge to prevail in Badminton, PBG pledges to meet the challenge of global sustainable food security. Well done, Brian!



**Joint FAO/IAEA Division**  
of Nuclear Techniques in Food and Agriculture  
*50 years, 1964–2014*

## 50TH ANNIVERSARY: 1964–2014 & Beyond

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

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 globalization, 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.

Ren Wang  
*Assistant Director-General*  
FAO

Daud Mohamad  
*Deputy Director General*  
IAEA



## Forthcoming Events

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

Technical Officer: F. Sarsu

This training course will be organized by the International Atomic Energy Agency in cooperation with the Government of South Africa. It is open to candidates from AFRA project RAF/5/066 on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA) project partners. Through the RAF-AFRA series TC projects, several of the participating national research institutes have been able to establish plant biotechnology laboratories including plant tissue culture and molecular biology and train staff on the basic aspects of these technologies. The purpose of the training course is to provide capacity development in crop mutation breeding through: i) Mutation induction for crop improvement; ii) Phenotyping and genotyping to screen mutant populations; iii) Basics of efficiency enhancing plant bio-techniques; iv) Establishment of adequate *in vitro* screening protocols (including micro propagation and plant tissue culture procedures); v) Good laboratory practices.

The participants from all the participating Members States involved in project RAF/5/066 are invited. Designated trainees should be currently and actively working in mutation breeding and have basic knowledge in crop breeding and *in vitro* techniques. The course will be tailored to scientists with at least a M.Sc. degree involved in plant breeding/genetics. Participants should have a strong affinity and interest in modern plant breeding methods involving mutation induction, mutation screening (high-throughput phenotyping and genotyping) and techniques that can facilitate the breeding process.

### 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 Officers: B.P. Forster and L. Jankuloski

The major objectives of this CRP are to maximize the yields of mutant varieties. The crops chosen are those that can be used for both human food and animal fodder. The project involves eight participating countries and four

major crops, namely wheat (the Former Yugoslav Republic of Macedonia, Mongolia), rice (China, Malaysia), barley (Austria, China, Kuwait and Peru) and sorghum (Indonesia). The project aims to improve the agronomy of the crop especially in respect to soil and water management, improve nutritional value and improve the knowledge and skills base of participating Member States.

The First RCM took place in Vienna in December 2012 from which short term objectives were established. These included the identification of mutant varieties or advanced mutant lines for food and feed. The Second RCM is planned for August 2014 in Bogor, Indonesia. Indonesia has made significant progress in this CRP as the counterpart has identified advanced mutant lines of sorghum that performed well in various locations. One in particular, CTY-33 is high yielding and is grown on an increasingly large scale and has been used in feeding trials of cattle. The Second RCM provides an opportunity to assess progress across all participating countries and to move the programme forward. The next objectives are to develop soil and water management practices that maximize yield and to begin quality testing (nutritional analysis) for food and feed.

## Past Events

### Regional Training Course on Detection of Homogeneity and Better Quality of Advanced Mutant Lines, RAS/5/058, Doha, Qatar, 17–21 November 2013

Technical Officer: A.M.A. Ghanim



Regional training course participants.

The purpose of this training course was to build capacity in mutation induction, phenotypic and genotypic screening for desired mutants and efficiency enhancing techniques with emphasis on wheat and barley. The course was organized through TC project RAS/5/058. The training course was hosted by the Biotechnology Centre of the Ministry of the Environment in Doha, Qatar. The course was attended by 18 participants from Iraq, Jordan, Lebanon, Oman, Qatar, Syrian Arab Republic and Yemen and. The training programme was composed of presentations on the theory of

plant mutation breeding and provided practical sessions. Areas covered by the lectures included:

- 1) Introduction to mutation induction and detection.
- 2) Development and handling of mutated populations including homogeneity testing.
- 3) Phenotypic and genotypic screening for mutants.
- 4) Tools and resources for the identification of causal genes producing mutant phenotypes.
- 5) Introgression strategies to transfer mutant characters into adapted genetic backgrounds.
- 6) Mutation breeding for abiotic stresses (emphasis on drought tolerance).
- 7) Efficiency enhancing and accelerating techniques for mutation breeding.

The practical sessions demonstrated:

- 1) Radio sensitivity tests for wheat and barley. Seeds were irradiated at the PBGL (Seibersdorf) and planted for demonstration during the course. Participants were able to record data on germination and seedling growth, from which they constructed radio-sensitivity graphs and determined the optimum dose for mutation induction in wheat and barley varieties.
- 2) Immature embryo culture in wheat and barley to speed up generation times.
- 3) Recognizing phenotypes (Bowman isolines): a set of mutants was delivered by PBGL and grown up by the host ready for demonstration during the course.
- 4) Web resources to identify candidate genes: participants were able to use the web resources to construct DNA primers for mutant genotyping.

The participants acquired information and hands-on skills in mutation induction and detection, mutant phenotyping and *in vitro* techniques, which will assist them in their efforts to establish plant mutation breeding in their home institutes.

## **Regional AFRA Training Course on Basic Mutation Breeding Techniques, RAF/5/066, Cotonou, Benin, 2–6 December 2013**

Technical Officer: F. Sarsu

Under the regional TC project RAF/5/066 AFRA II on Improving Crops Using Mutation Induction and Biotechnologies through a Farmer Participatory Approach, the International Atomic Energy Agency (IAEA) in cooperation with the Government of Benin, Université d'Abomey-Calavi (UAC) organized a training course on basic mutation breeding techniques. The training course was attended by 19 trainees from 12 African Countries: Algeria (1), Benin (7), Cameroon (1), Central African Republic (2), Ghana (1), Kenya (1), Madagascar (1),

Namibia (1), Nigeria (1), Sierra Leone (1), Democratic Republic of Congo (1) and Zimbabwe (1).

The main focus of this training was the use of mutation induction for plant breeding. The trainees were thoroughly tutored on the key steps on mutation breeding such as:

- Mutation induction for crop improvement (procedures/methodologies) in general and specifically mutation induction techniques in vegetatively and seed propagated crops;
- Mutagens: concepts and sources;
- Establishment of dosimetry assays and determination of LD;
- Handling mutated populations and identification, evaluation and selection of breeding lines;
- Basic statistical analyses and principles of experimental design;
- Establishment of proper screening protocols for biotic and abiotic stresses.



*Regional training course participants.*

The training course included lectures, roundtable discussions, and consultations on methodologies and their application under field conditions. The participants stated that this was an exciting exercise on getting hands-on practice in the field. At the end of the training course, the participants were given certificates issued by the IAEA and signed by both the IAEA and the UAC.

## **National Training Course on Enhancing Productivity of Major Food Crops under Stress Environments using Nuclear Techniques, SUD/5/033, Khartoum, Sudan, 19–30 January 2014**

Technical Officers: F. Sarsu and A.M.A. Ghanim

A two-week national training course was organized through TC project SUD/5/033 at the Biotechnology and Biosafety Research Center of the Ministry of Agriculture in Khartoum, Sudan from 19 to 30 January 2014. Mr William Thomas (James Hutton Institute) and Mr Abdelbagi Mukhtar Ali Ghanim (Plant Breeding Genetics Laboratory,



Joint FAO/IAEA Division) gave lectures and practical information. The course was attended by 35 young plant breeders from national research stations and universities. The training lectures included:

- 1) Introduction to mutation induction and detection;
- 2) Development and handling of mutated populations including homogeneity testing;
- 3) Phenotypic and genotypic screening for mutants;
- 4) Tools and resources for identification of causal genes producing mutant phenotypes;
- 5) Introgression strategies to transfer mutant characters into adapted genetic backgrounds;
- 6) Mutation breeding for abiotic stresses (emphasis on drought tolerance);
- 7) Mutation breeding efficiency enhancing techniques.

The practical sessions comprised radio sensitivity tests for wheat and sorghum. Seeds were irradiated at the PBGL (Seibersdorf) and sent to be planted in order to demonstrate growth responses after treatment. Participants were able to measure effects on growth and produce radio-sensitivity graphs from which optimum dose treatments could be determined for mutation induction in wheat and sorghum using both X ray and gamma ray sources. Embryo culture and anther culture methods for wheat and sorghum were also demonstrated with respect to speeding up plant mutation breeding. In addition the course provided practical tuition in recognizing mutant phenotypes, with examples from standard mutant stocks in barley (Bowman isolines, supplied by the PBGL). Participants were also instructed in the use of web resources to construct primers for mutant genotyping. Participants were able to have hands-on experience in mutation induction, screening in the field and handling of mutant populations including useful biotechnologies. The young researchers are regarded as being part of the future of plant breeding in Sudan and this training was designed to increase their abilities and knowledge in the application of plant mutation breeding in the country.



Participants recording radio-sensitivity data in the field in Sudan.

## National Training Course on Mutation Breeding and Developing Biotic and Abiotic Stress Resistant/Tolerant Varieties, ZIM/5/015, Harare, Zimbabwe, 3–7 February 2014

Technical Officer: F. Sarsu

Course Director: P. Matova



Participants evaluating mutant cowpea lines at Crop Breeding Institute.

The national training course is part of the TC project ZIM/5/015 on Developing Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content Using Mutation Breeding and Novel Techniques and has been organized by the Division of Crop Research, Ministry of Agriculture, Mechanization and Irrigation Development of Zimbabwe. Twenty two participants from national stakeholders attended the course, which provided lectures and practical sessions on screening and breeding methodologies for biotic stress resistance and abiotic stress tolerance and field demonstration/screening of cowpea, Bambara groundnut. Two external lecturers from the International Institute of Tropical Agriculture (IITA) and the University of Zambia, School of Agricultural Sciences, Department of Crop Science, were invited to give lectures on the application of mutation breeding techniques for developing biotic and abiotic stress resistant/tolerant varieties and screen mutant lines under field conditions. Dr Christian Fatokun, a plant breeder/molecular geneticist, who has nearly 20 years' experience as a researcher in breeding cowpea and Dr Kalaluka Munyinda, Crop Improvement Seed Expert-Senior Lecturer, gave lectures and practical information on breeding for biotic and abiotic stress tolerance and utilization of appropriate biotechnologies for screening of cowpea, Bambara groundnut.

The training course included lectures, roundtable discussions and consultations on the above topics and consolidated proper screening protocols adapted to the traits to be selected. The participants emphasized, that these practical protocols would be very useful for their future research.



## National Training Course on Mutation Breeding and Efficiency Enhancing Technologies, OMA/5/002, Muscat, the Sultanate of Oman, 2–6 March 2014

Technical Officer: P.J.L. Lagoda



This three week, TC funded, national training course in Muscat (Sultanate of Oman) focused on key crops for Oman, namely date palm, wheat, limes, and banana. 14 nationals (eight men, six

women) were trained by means of lectures, roundtable discussions and practical laboratory demonstrations and exercises on the following topics: radio-sensitivity testing in seedling assays (materials provided by the PBGL), low cost DNA extraction (materials and protocol provided by the PBGL), molecular markers in mutant genotyping, selection/screening and mutation breeding (including TILLING) and data analyses. During this training, the PBGL protocol for TILLING and the low cost DNA extraction protocols were demonstrated and transferred via lectures, hand-outs and practical, hands-on laboratory exercises. A noteworthy outcome is the fact that, for the first time, the trainees succeeded in extracting date palm DNA using this simple protocol (DNA extraction is difficult in date palm). The protocol was therefore well received by the trainees and the Date Palm Research Center (DPRC). The training course was judged to be a success by the trainees. In general, the trainees found the course to be 'very useful', but would have preferred more practicals. The Director General of Agriculture & Livestock Research attended the closing ceremony and expressed his country's appreciation to the IAEA and of the course, and confirmed the interest of Oman in, and support of, the national mutation breeding programmes initiated recently with the support of the Agency. National training courses supported by the IAEA are a valuable means to transfer knowledge and know-how.

## Regional (ARCAL) Training Course on Molecular Methods for Characterization of Mutant Germplasm derived from Native Crops and Crops of Interest in Latin America and the Caribbean, Bogotá, Colombia, 17–21 February 2014

Technical Officer: S. Nielsen



*Training course participants.*

This training course was implemented in the laboratories of the Universidad Distrital Francisco de Caldas in Bogotá under the direction of Dr Luis Armando Quevedo. Besides local participants, nine scientists from Argentina, Bolivia, Brazil, Cuba, El Salvador, Nicaragua, Paraguay, Peru and Venezuela attended the course. Lecturers from the host University, from the University of the Andes, and from the University of Buenos Aires, Argentina, gave introductions into molecular methods for mutation detection in plants. This included lectures and exercises on marker assisted selection; mutation detection using Targeting Induced Local Lesions in Genomes (TILLING); screening of mutant populations for tolerance to salinity; Real Time PCR for expression analysis of genes associated with stress response (salinity, high temperature); isolation and analysis of proteins involved in stress responses; basic bioinformatics tools. The Plant Breeding and Genetics Laboratory (PBGL), Seibersdorf, has provided a test kit with DNA, enzymes and primers for the application of the low cost TILLING protocols that have been developed and published by the PBGL (for more information on PBGL protocols see <http://www-naweb.iaea.org/nafa/pbg/public/manuals-pbg.html>). The course was very positively evaluated by the participants.

## Regional AFRA Training Course on Methodologies and Mechanisms for Screening against Biotic and Abiotic Stresses, RAF/5/066, Tsumeb, Namibia, 24–28 March 2014

Technical Officer: F. Sarsu



*Participants evaluating mutant cowpea lines at Mannheim Research Station.*

The IAEA in cooperation with the Government of Namibia, Ministry of Agriculture, Water and Forestry organized a training course under the regional TC project RAF/5/066 AFRA III on Improving Crops Using Mutation Induction and Biotechnologies through a Farmer Participatory Approach. The training course was attended by 21 trainees from 13 African countries: Algeria (1), Benin (2), Central African Republic (2), Cameroon (1), Egypt (1), Ghana (2), Mauritius (1), Morocco (1), Namibia (5), Sierra Leone (1), Tunisia (1), Democratic Republic of Congo (2) and Zimbabwe (1).

The main focus was on mutation induction, mutation screening and breeding for biotic and abiotic stress tolerance in crop breeding. Theoretical lectures as well as practicals included handling of mutated populations, identification, evaluation and selection of breeding lines and demonstration/screening of cowpea, millet and sorghum under field conditions. Participants were taken to Mannheim Research Station 10Km outside Tsumeb, which is one of the big Government Research Stations, where the mutation experiment on pearl millet, cowpea and sorghum is carried out under this regional project and TC project NAM/5/010. The trainees were taught how to evaluate and select for various traits including biotic and abiotic stress. The participants and lectures also helped the project counterparts in evaluating the mutant population, which is now at the M<sub>5</sub> generation. The participants stated that this was an exciting exercise in hands-on practices in the field.



*Regional training course participants.*

## Fourth Research Coordination Meeting (RCM) on Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline, D2.40.12, Vienna, Austria, 7–11 April 2014

Technical Officer: B. Till



This CRP was initiated in 2008 and will end in 2014. The fourth and final RCM was planned to review the progress made under this CRP, finalize plans to publish data, identify critical areas where further investigation is needed, evaluate the efficacy of the various approaches promulgated throughout the CRP, identify mechanisms to sustain networks after the close of the CRP, and to evaluate approaches for transfer of proven technologies developed within the CRP. One output of the CRP is to publish a practical guide on methods developed in plant mutation induction and mutation detection for crop improvement.

For detailed information regarding this CRP, see page 16.



## Fourth Research Coordination Meeting (RCM) on Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops, D2.30.28, Cusco, Peru, 7–11 April 2014

Technical Officer: S. Nielen



*Meeting participants.*

The objective of the CRP was to improve varieties of local crops with increased yield and crop quality, enhanced levels of micronutrient contents, other nutritional factors and market-preferred traits through induced mutation techniques and supportive biotechnologies. For this final RCM, which was excellently organized by the local host, Dr Luz Gómez Pando, 13 CRP participants from 10 countries came together in Cusco, Peru. The Scientific Secretary gave an introductory presentation on the history of the CRP, on achievements made so far, and on the outputs to be expected from the final RCM. Each participant presented the results obtained during the lifetime of the CRP. The working document of the CRP was updated and the main achievements elaborated and formulated. It was decided to publish the analytical and screening methods that have been optimized or developed within the CRP in a book of protocols. This shall facilitate the transfer of CRP outputs to TC projects on similar topics. A highly informative field visit was made to the Andenes Experimental Station of the Instituto Nacional de Innovación Agraria (INIA) in Zurite, Cusco, where the local genebank and the cultivation of various native Andean crops were demonstrated.



*Field visit to the Andenes Experimental Station, INIA, Zurite, Cusco.*

## Regional (RCA) Workshop on Application of Ion Beam Radiation Technology in Plant Mutation Breeding, RAS/5/056, Jeongeup, Republic of Korea, 14–18 April 2014

Technical Officer: S. Nielen



*Regional workshop participants.*

This workshop was hosted by the Advanced Radiation Technology Institute (ARTI) of the Korea Atomic Energy Research Institute (KAERI). It was a follow up of the previous technical meeting in Mongolia and the regional training course on ‘Application of New Mutagenesis Approaches in Crop Plants’ in China. The objective of this workshop was to report on and discuss efficient mutation induction methods, particularly ion beam radiation technology, for plant mutation breeding. A total of 16 scientists from 16 participating countries (Australia, Bangladesh, China, India, Indonesia, Japan, Republic of Korea, Malaysia, Mongolia, Myanmar, Nepal, the Philippines, Pakistan, Sri Lanka, Thailand and Vietnam, and one FNCA expert on ion beam technology from Japan were invited. The participants gave presentations on the progress and achievements of their individual projects. Technical background on ion beam technology and its use in crop breeding was provided by Dr Atsushi Tanaka from Japan Atomic Energy Agency (JAEA) the ion beam experts Dr Kye-Ryung Kim (Proton Accelerator Research Center, KAERI) and Dr Jae-Hong Kim (IBS). In a separate session, participants discussed and drafted an outline of a brochure with protocols and guidelines on using ion beam irradiation technology for mutation breeding.

An International Symposium on ‘New Trend and Technology of Mutation Breeding’, organized by ARTI, KAERI, was held to commemorate the opening of the local Radiation Breeding Research Center. The symposium was opened by Dr Keun Ban Oh, Director General of Advanced Radiation Technology Institute, KAERI. All participants of RAS/5/056 attended this symposium together with the scientists from ARTI, KAERI and local research institutions and universities. Seven of the participants of

RAS/5/056 from China, Indonesia, India, Australia, Malaysia and Japan also delivered technical presentations on new trends and technology in mutation breeding.

## **Fourth Research Coordination Meeting (RCM) on Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants, D2.40.13, Vienna, Austria, 5–9 May 2014**

Technical Officer: P.J.L. Lagoda



*RCM participants.*

The fourth RCM of this CRP was organized at the IAEA headquarters in Vienna. Twelve agreement and research contract holders from Argentina, Bulgaria, China, Germany, India, Republic of Korea, Poland, Portugal, Switzerland and the United States of America met to finalize reports, plan further publications and follow-up actions. Each of the participants delivered a presentation on the results achieved in their respective activities. The highlights of the presentations were as follows:

Induced mutations have been widely used in plant breeding and more recently in plant functional genomics research, e.g. isolation of genes and determination of their function. Progress has been made towards understanding the genetic control of mutagenesis, but it is mainly limited to model plants and caused by internal mutagenic chemicals (e.g. reactive oxygen species). The understanding of genetic control in plant mutagenesis, which is vital for the proper application and manipulation of mutation induction for enhancing genetic variation and plant mutation breeding, is still very limited. Through this CRP, a Plant Mutagenesis Database, publicly accessible to all Member States, has been established, containing information on genes involved in DNA damage response and repair from a variety of plant species as well as a list of mutants defective in these genes. Homologous genes, involved in DNA repair and mutagenesis in crop plants (rice, wheat, barley, pea, soybean, tomato) have been characterized, their function determined using genetic variants produced through chemical and/or physical mutagens. Some of the genetic variants constitute potentially valuable genetic resources for efficient mutation induction. Furthermore, the spectra of mutations induced by various mutagens have been investigated using high throughput mutation screening

technology platforms. Based on the research findings, improved protocols for mutation induction and screening, as well as their application will be developed supporting breeding new varieties. In detail:

An efficient, light-dependent repair activity for the removal of DNA photoproducts from nuclear rRNA, chloroplast and mitochondrial genes has been discovered and the repair kinetics characterized in barley.

A repository of Arabidopsis, barley, rice and brachypodium genes involved in DNA replication and repair has been established (bEST-DRRD; <http://www.best.us.edu.pl>). This database is open to accept additional data on more crops.

The effect of a barley chloroplast mutator has been studied for the first time using the TILLING technique. These mutator mutants exhibit enhanced frequencies of transitions, transversions and indels in a number of plastid genes.

Three mismatch repair deficient mutant rice lines allow for investigating the usefulness of repair pathway gene deficient lines to increase mutation density and specificity.

Based on the feedback and discussions from the group following the presentations, the following was suggested:

In order to address the increasingly urgent demands to safeguard food security in the face of the negative effects of changing climate and a growing world population, the encouraging results produced by this CRP need to be further developed for plant researchers and breeders to capitalize upon. The resources provided by this CRP should be used to investigate possible strategies for the enhancement of mutation induction efficiencies.

It is strongly recommended to explore the possibility of a follow-up CRP focusing on defining spectra of transmissible mutations induced by a variety of genotoxic agents. Next generation sequencing technologies would be one way to address these issues. Another topic to address is the implication of toxicity of the mutagenic agent curbing mutation efficiency: is the toxicity of the mutation agent a limiting factor in the mutation efficiency? Could DNA repair mutants be utilized to achieve high levels of mutagenesis with relatively low toxicity? More DNA damage repair gene mutants need to be explored.

## **Consultants Meeting on Enhancement of the Efficiency of Mutation Induction by Physical and Combined Mutagenic Treatments, Vienna, Austria, 2–6 June 2014**

Technical Officer: S. Nielen

A consultants meeting was organized in order to formulate the proposal for the new CRP on Enhancement of the



Efficiency of Mutation Induction by Physical and Combined Mutagenic Treatments (working title). Five invited scientists from France, Germany, Japan, the United Kingdom (UK) and the United States of America (USA) contributed with their expertise and technical advice to the design of a project, which aims at increasing the potential of mutation induction in crop breeding. This CRP should identify new and improved ways on the use of nuclear technology, which will help our counterparts to meet their local breeding challenges. More news on this new CRP will be published in the coming Newsletters.

## Regional Asia Training Course on Plant Mutation Breeding and Efficiency Enhancing Techniques, RAS/5/058, Seibersdorf, Austria, 10–20 June 2014

Technical Officer: A.M.A. Ghanim



*Training course participants.*

A two-week regional training course took place at the PBGL, Seibersdorf. Ten participants (Iraq (5), Jordan (3) and Syrian Arab Republic (2)) from member countries of the TC project RAS/5/058 on Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change attended the training course. In addition, one scientific visitor (Burkina Faso) seven fellows (Algeria, Bangladesh (2), Burundi, Ghana (2) and Sudan) and three interns (Ethiopia, Poland and Slovenia) at

the PBGL participated in this course. Lectures, practicals and demonstrations were presented by staff of the Plant Breeding and Genetics Laboratory and Section. The training covered areas of mutation induction and detection, techniques to enhance the efficiency of mutant development and accelerate mutation breeding programme such as rapid generation cycling, doubled haploid methods and molecular markers. Participants were trained in methods of seed irradiation for mutation induction including measurements of radio-sensitivity. The training course was focused on wheat and barley, which are key crops for the member countries. Participants practiced procedures in anther and microspore culture of wheat and barley for the induction of haploid plants and *in vitro* culture of immature embryos for rapid generation cycling of selected mutant lines.

## Consultants Meeting on Efficient Screening Techniques for Mutants with Disease Resistance, Vienna, Austria, 23–27 June 2014

Technical Officer: B. Till

Plant diseases are major contributors to yield loss. On a global scale, biotic stresses are threatening a broader range of crop genotypes due to climate change and variation that allows pathogens into new environments. Breeding for genetic resistance to disease remains a very important approach towards addressing this problem. A narrow genetic base, insufficient evolutionary time for allelic diversity and adaptation, and vegetative propagation, are all factors that hinder traditional breeding approaches. Induced mutation provides allelic diversity to overcome these bottlenecks. A consultants meeting took place to promulgate strategies to increase the efficiency of using induced mutations to improve disease resistance in different crop species. Disease topics discussed included coffee leaf rust, citrus greening, banana tropical race four and wheat stem rust. The consultants evaluated the efficacy of different approaches and helped us determine if it is appropriate to develop a Coordinated Research Project with a focus on induced mutation methods for plant disease resistance. More news on this new CRP will be published in the coming newsletter.

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

Project Number	Ongoing CRPs	Scientific Secretary
D2.30.28	Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops	S. Nielen
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	B.P. Forster and L. Jankuloski
D2.40.12	Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline	B. Till
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 January 2015. Detailed announcements on the projects and how to participate will be published in due course.

## CRP on 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).

## CRP on 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 (ends 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.

## **Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops, D2.30.28**

Scientific Secretary: S. Nielsen

This CRP aimed at making available new germplasm resources with improved yield and nutrient quality. It addresses the problem that most of the major staple crops are often deficient in essential vitamins and minerals and that more than 40% of the world's population suffers from malnutrition, with respect to micronutrients like vitamin A, iron and zinc. The strategies applied to reach the project's goal comprise utilizing efficient phenotypic screens and genotypic markers to identify in mutant collections individuals exhibiting traits of interest that would be incorporated into breeding programmes. Both, the resulting genetic resources and the methodologies for identifying them constituted the main expected outputs from this CRP.

The project started January 2009 and had its first RCM in Vienna, Austria, 29 June–3 July 2009, the second meeting 11–15 April 2011 in Pretoria, South Africa, the third RCM was held 15–19 October 2012 in Hangzhou, China, and the fourth and final RCM in Cusco, Peru, 7–11 April 2014. Fourteen research groups from 12 countries (Bulgaria, China, Denmark, Germany, Ghana, India, Kenya, Peru, South Africa, United Kingdom, Ukraine, and the United States of America) have participated in the project, thereof nine under Research Contracts, three under Research Agreements, and two under Technical Contracts. In course of the project new mutant germplasm collections from elite varieties of the target crops barley, sorghum, sweet potato, maize, wheat, tomato, potato, pepper, rice, and soybean have been developed. One rice mutant variety (China) and two maize mutant inbred lines (Ukraine) with improved nutritional quality have been officially released. Products with health benefits from rice, wheat and barley mutant lines have been developed and commercialized in China and Peru. This CRP also contributed to an increased knowledge of the metabolic pathways and genes affecting phytate, carotenoids, tocopherol, flavonoids and resistant starch biosynthesis, documented by numerous scientific publications. Efficient phenotypic screening methods for resistant starch, increased carotenoids and increased tocopherols were developed or optimized. These include colorimetric assays for phosphate and phytate for barley

and wheat flour and for starch composition in maize and wheat and a method for HPLC analysis of some carotenoids (lutein, zeaxanthin, lycopene, beta-carotene). Moreover, retrotransposon based markers systems were adapted for rapid and robust genotyping of mutant lines. In order to make these methods available for other research groups (e.g. in TC projects) working on improvement of nutritional quality, a book with hands-on protocols for screening and analysis of mutant populations will be published. A comprehensive publication with the results of the individual CRP projects will be published as well in due course.

## **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).

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 higher temperatures (increase in minima and maxima), altered changes in rainfall patterns (in amount, spatial and temporal distributions), increased rates of evaporation, intensity and frequency of extreme events (floods and droughts), and a rise in sea level affecting coastal areas where large quota of cultivated land are located (intrusion of salty water).

The CRP is focused on improving the grain yields of a major cereal (rice) and a grain legume (common bean) to high temperature stress in the face of climate change. The CRP aims to develop new high yielding mutant varieties with improved quality under low input cultivation in a range of agro-ecologies, through broadening adaptability.

This CRP is being implemented steadily in all participating countries. The M2 generations of rice and common bean are being screened, in laboratories, screen houses and fields. Even though it is quite early to account for solid achievements, it could be noted that most efforts have been put in establishing reliable and solid screening protocols, which in turn should later ensure the selection of the most suitable mutated genotypes. The efforts made in the analysis of the genomic responses have been substantial. Thanks to the release of the common bean genome sequence early this year, a wealth of genes involved in tolerance to heat are foreseen. The major output of this CRP will be enhanced protocols and guidelines to enable

improved responses to abiotic and biotic stresses under increasingly adverse and variable conditions.

The next RCM is planned to be held in Dakar, Senegal to present latest results and discuss further actions to meet project activities during the first half of 2014.

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

Scientific Secretaries: B.P. Forster and L. Jankuloski

The CRP is now in its second 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 second Research Coordination Meeting is planned from 18–21 August 2014 in Bogor, Indonesia.

## **Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline, D2.40.12**

Scientific Secretary: B. Till

The Greek philosopher Heraclitus of Ephesus is credited with the quote: ‘The only thing constant is change’. This is no more true than in the science of plant breeding where the technological landscape has been evolving rapidly over the past five years. This CRP, which began in 2008 and closes in 2014, focuses on evaluating and adapting methods for mutation induction, mutant population development and screens to identify mutants of interest. The aim was to enhance the efficiency of induced mutation for the plant breeders. In some cases the work of CRP participants resulted in the improvement of protocols and guidelines for

standard procedures that have been used by plant breeders for decades. On the other hand, completely new techniques and approaches, not available at the start of this CRP, were tested and evaluated. While space limitations prohibit a thorough summary of all the accomplishments of participants, regular readers will recall highlights described in past Newsletters. Here are a few more highlights that were recently reported at the final RCM held in Seibersdorf, Austria from 7–11 April 2014:

- Development of a low-cost root phenotyping screening platform for barley mutants.
- Establishment of a barley TILLING resource and characterization of drought tolerant mutants.
- Establishment of a novel approach to mutation induction in barley via genome editing.
- Protocols and guidelines for low-cost validation of doubled haploid production.
- Establishment of low-cost methods for tissue collection and DNA extraction.
- Protocols and guidelines for rapid chimera dissolution in mutant banana.
- Establishment of cell-culture methods for mutation induction of Cuban banana varieties.
- Optimization of somatic embryogenesis for mutation induction in cassava.
- Methodologies for embryo rescue in cassava.
- Establishment of non-destructive Near Infra Red Spectroscopy mutant screening in rice.
- Protocols and guidelines for the selection of mutant rice for aroma and iron content.
- The development of four improved rice mutant varieties currently in farmer trials.
- The development of efficient Next Generation Sequencing methods for mutation discovery in rice.

As a final output of the CRP, the participants are planning the publication of a book of validated protocols and guidelines that plant researchers and breeders can use to integrate induced mutations into their ongoing research and applied pipelines. Combinations of new technologies and improvements to traditional mutation breeding approaches provide important tools to address the continuing pressures on global food security. Heraclitus was right, change is constant. Optimistic readers can take solace in the fact that the negative changes affecting global food production can be addressed in part by the positive changes in improving the efficiency of plant breeding.



## 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/B.F. Forster
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/B.P. Forster
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/B.P. Forster

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/5/001	Lesotho	Improving Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production to Alleviate Hunger, Poverty and Environmental Degradation	S. Nielen/A.M.A. Ghanim
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

Project Number	Country/Region	Title	Technical Officer
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
NAM/5/010	Namibia	Developing High Yielding and Drought Resistant Pearl Millet ( <i>Pennisetum glaucum</i> L), Sorghum Bicolor (L) Moench, Bambara Groundnut ( <i>Vigna subterranean</i> ) and Cowpea ( <i>Vigna unguiculata</i> (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/5/001	Nepal	Improving Nepalese Cardamom Using Nuclear and Molecular Techniques	P.J.L. Lagoda
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/B.P. Forster
PAL/5/006	Palestine	Enhancing the Performance of Durum Wheat Landraces by Induced Mutation	L. Jankuloski/B.P. Forster
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/B.P. Forster
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

Project Number	Country/Region	Title	Technical Officer
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
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
RER/5/017	Regional Europe	Enhancing Productivity and Quality of Major Food Crops	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 <i>Jatropha curacas</i> 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



Project Number	Country/Region	Title	Technical Officer
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
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, <i>In Vitro</i> 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/5/027	Zambia	Developing Maize Genotypes for Drought and Low Soil Fertility Tolerance	F. Sarsu/L. Jankuloski in collaboration with Soil and Water Management and Crop Nutrition Section
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

## Feature Stories

### International Contest on Technological Innovation in Quinoa

Contributed by: S. Nielen



*Award ceremony of the International Contest on Technological Innovation in Quinoa. Dr Luz Gómez Pando (5th from left) received the second prize.*

On the occasion of the International Year of Quinoa 2013, which was declared by the United Nations General Assembly 'in recognition of ancestral practices of the Andean people, who have managed to preserve quinoa in its natural state as food for present and future generations, through ancestral practices of living in harmony with nature' an International Contest on Technological Innovation in Quinoa was organized by Peru's Ministry of

Agriculture and Irrigation. Awards were given for the best technological innovations that contribute to reduction of production costs, raising productivity, or quality improvement of quinoa.

We are very happy to announce that our distinguished colleague and counterpart Dr Luz Gómez Pando from the National Agricultural University La Molina, Peru, was awarded the second prize for the work 'Development of improved new mutant lines for the Peruvian coast'. In this work seeds of two local native cultivars were gamma-irradiated with dosages of 150 Gy, 250 Gy and 350 Gy. Mutant lines with changes of branch number, pedicel length, plant height, life-cycle duration, stem and foliage colour, and leaf morphology were registered. In M<sub>4</sub> generation improved lines with higher yield were identified, which are adapted to the coastal area and tolerant to heat. The results have demonstrated the potential of using nuclear techniques for fast enhancement of local native cultivars, which in many cases need to be improved in one trait only.

The award ceremony took place on 22 April 2014 at the Government Palace in Lima and was attended by the President of the Republic, Al Excmo Sr Ollanta Humala Tasso, the First Lady, the Minister of Agriculture and Irrigation, Mr Juan Manuel Benites, the FAO Representative in Peru, Mr John Preissing, the Special Ambassador of the International Year of Quinoa, Ms Nadine Heredia, and other government authorities.

### Photo Story of the Development of 'EldoNgano I', the World's First Ug99 Resistant Mutant Wheat Variety

Ug99 causes catastrophic yield losses



**The problem:** Ug99, so called because it was first discovered in Uganda on wheat in 1999 is a virulent race of fungus *Puccinia graminis*. The disease is known as black stem rust and can cause complete failure of wheat crops. Hot spots of disease became established in Uganda, Kenya and Ethiopia. The spores of the disease are air borne and easily spread by wind. 8.3 M tonnes of lost wheat grain per year (US\$ 1.23 billions)

Participants of INT/5/150 at a meetings in Kenya



**The response:** In 2009, the growing concern of Ug99 led to the establishment of the IAEA project INT/5/150: 'Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)', which involved over 18 countries and five national and international institutions: Algeria, Egypt, India, Islamic Republic of Iran, Iraq, Jordan, Kenya, Lebanon, Oman, Pakistan, Saudi Arabia, South Africa, Sudan, Syrian Arab Republic, Tunisia, Turkey, Uganda, Yemen, ICARDA, CIMMYT, Department of Agriculture and Food of Western Australia, Chinese Academy of Agricultural Sciences, Joint FAO/IAEA Division.

Gamma cell Radio-sensitivity test



**Mutation induction:** Mutation induction treatments were carried out at the Plant Breeding and Genetics Laboratories (PBGL), Seibersdorf in 2009 by irradiating seeds of selected wheat varieties from participating countries using gamma rays. The optimum dose was determined by radio-sensitivity testing of seedlings treated with different amounts of gamma irradiation.

Seeds were transferred using the Standard Material Transfer Agreement warranting access and benefit sharing.

Field testing at Eldoret, Kenya



**Screening for resistant mutants:** Irradiated seeds were sent to Eldoret in Kenya which is a hot spot for the disease. Agency support to Kenya also included the establishment of irrigation systems and this allowed two generations of wheat to be grown and tested per year.

13 resistant lines were selected in wheat varieties from six countries: Algeria, Iraq, Kenya, Syrian Arab Republic, Uganda and Yemen.

Individual training, Mr Ego at the PBGL



**Training:** In parallel with the field testing for Ug99 resistance in Kenya, an individual fellowship training programme was set up at the PBGL for Mr Amos Ego from Kenya to learn skills in mutation induction, mutation detection, advancement of mutant lines and their validation using DNA analyses. Inter-mutant line crossing was initiated as a first step in genetic studies to determine how many new mutant resistant genes had been created and whether these were related to known resistance genes.

Certificate of 'Eldo Ngano1'



**Published by Authority of the Republic of Kenya**

(Registered as a Newspaper at the G.P.O.)

Corrigendum: Release Name ELDO NGANO1

[http://kenyalaw.org/kenya\\_gazette/gazette/volume/840#78](http://kenyalaw.org/kenya_gazette/gazette/volume/840#78).

**Success:** The first Ug99 resistant mutant wheat variety was released in Kenya in February 2014 and named, 'Eldo Ngano1' (Swahili for 'Eldoret Story1'). Six tonnes of seed were produced for distribution to farmers to grow. 'Eldo Ngano 1' has been swiftly followed by 'Eldo Mavuno 1' (Eldoret Harvest1') which received Kenyan government approval in May 2014.

In addition one promising resistant mutant line from Uganda is being prepared for official testing and release.

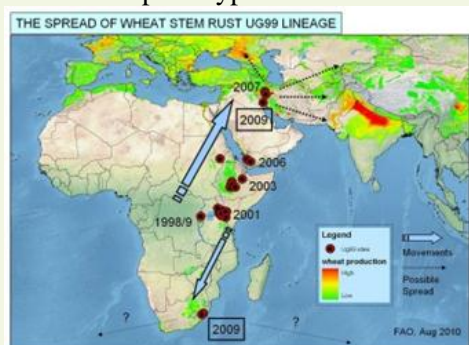
Group training at PBGL



**Additional money:** Extra-budgetary funding was sourced to support a special training workshop at the IAEA, Vienna/Seibersdorf, December 2013 to discuss the next steps and challenges. These included the exchange of seed of resistant mutant lines for breeding, biotechnologies to speed up the transfer of the mutant resistant genes into elite lines of other Member States, and the development of DNA methods to screen for disease resistance.



Spread of the disease:  
<http://www.fao.org/agriculture/crops/rust/stem/stem-pathotypetracker/en/>



**Continuing the fight:** Ug99 continues to spread globally and has now reached Islamic Republic of Iran. There are also suspected reports of disease occurrences in Europe. It is therefore essential that mutant lines are developed and utilised world-wide to safe guard wheat crops from this devastating disease. The PBGL is currently involved in genetically fingerprinting and bar-coding seed (quality control) for distribution to Member States.

## Low-cost Methods for Molecular Characterization of Plants

Readers following the field of Plant Breeding know that it is an exciting time to be working in the discipline. It is hallmarked by fast-moving innovation in the areas of genomics, phenomics and accelerated generation times. DNA based approaches are at the heart of a powerful suite of tools that allow researchers and breeders to discover, monitor and exploit both natural and induced nucleotide variation to control and understand heritable traits. At the heart of all of these approaches is DNA extraction. A range of approaches exist, yet many rely on the availability of liquid Nitrogen, -80C freezers, constant power supplies, the use of toxic chemicals and/or the use of expensive commercial kits. All can be barriers for laboratories in developing countries. To address this, the PBGL has gone back to basic principles to develop protocols for low-input and non-toxic tissue collection and genomic DNA extraction. By early 2013 work was completed in the development of protocols that utilized silica gel for the desiccation of leaf tissue for storage at room temperature and utilized chaotropic salts and potassium iodide for the extraction of high quality DNA. Methods were validated in several crops including barley and sorghum and a module was developed for IAEA training courses. This was unveiled in 2013 at three separate training courses held in the PBGL, Seibersdorf. All three were highly popular with trainees, some of whom had never performed molecular biology techniques previously, and were able to produce good quality DNA. With validation at training courses at the PBGL, the training module was extended to other international locations. In March of 2014, the protocols were taught at an IAEA sponsored training course in Oman where trainees successfully prepared DNA from date palm (For more details, see National Training Course in Oman on page 9). The methods cost about 1/10th the cost of standard commercial kits and are growing in popularity. The PBGL has begun developing a positive control kit to

assist MSs in optimizing the methods for their favourite crop species.



*Students at the Oman training course learning low-cost methods for tissue collection and DNA extraction.*

## News

### Superior and Outstanding Achievement Awards in Plant Mutation Breeding

#### Introduction

The occasion of the 50th Anniversary of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture provides an opportunity to honour the endeavours of individuals, teams or institutes in Member States in plant mutation breeding for increasing food security.

The Joint FAO/IAEA Division is therefore seeking nominations for Superior and Outstanding Achievement Awards to celebrate the successes and promote further applications of mutation breeding. Any plant breeder, plant breeding team or institute that has made outstanding achievements in mutation breeding applying nuclear

techniques and contributed to food security may be nominated. These are special one-off awards to celebrate the Joint Division's 50th Anniversary; they are not annual awards.

The Awards will take the form of a certificate and they will be officially announced during the 58th regular session of the IAEA General Conference, which will be held at the IAEA's Headquarters in Vienna, Austria, from 22 to 26 September 2014.

## Nomination Procedure

### Basic Criteria

A nominee may be an individual, a team or an institute. The nominee must have made an outstanding contribution to the advancement of plant mutation breeding using nuclear techniques to meet food security issues of the country or countries to which the nominee is assigned. The contribution must be clearly identifiable and should involve successes, over the past 20 years, in developing and releasing mutant varieties of plants. In exceptional circumstances, nominations may be based on major achievements in plant mutation breeding over a longer period of time.

Achievements should include the number of mutant varieties released to farmers and information on contribution to food security and their socio-economic impact. A Nomination Form is provided in which details are requested on crop, improved traits, take-up by farmers, acreage covered, period of cultivation, socio-economic impact as well as any special technology development in plant mutation breeding.

### Selection Panel

A Selection Panel will review all submitted nominations and make recommendations for awards. The Selection Panel will be chaired by the Director of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and will include staff members of the Joint Division's Plant Breeding and Genetics Section, selected FAO staff members and internationally acknowledged experts in the application of nuclear techniques in plant breeding.

### Submission of Nominations

Nominations must be submitted using the Nomination Form which is available on the Joint Division website (<http://www-naweb.iaea.org/nafa/pbg/index.html>) or by request to the Joint Division (Email: [Joint.Division@iaea.org](mailto:Joint.Division@iaea.org)). The form provides a means of listing measurable achievements. Completed forms should be endorsed by governmental authorities, including the Permanent Missions to the IAEA or FAO. They must be received by the Joint Division no later than 4 July 2014.

Nominations received after that date or submissions not containing the completed Nomination Form cannot be considered. The Selection Panel will collect and distribute appropriately all documentation concerned.

## ReNuAL

With respect to ReNuAL, the PBGL aims to assist the Member States in the use of mutation breeding to develop improved crop varieties. The future objectives of the PBGL aim to address:

- Adaptive R&D in developing more efficient methods in plant mutation breeding to improve food security.
- Development of tools and methods for the improvement of crop varieties in response to the effects of climate change.
- Capacity building in Member States to increase the efficiency of mutation breeding and to enhance biodiversity.
- Technology transfer to Member State laboratories and plant breeders.

Major facilities required by PBGL for ReNuAL are: 1) a greenhouse to grow a wide range of crop plants; 2) X ray facility to develop new protocols for mutation induction, and 3) screening facilities to detect mutants at the plant and DNA levels.

For more details on ReNuAL visit: <http://www-naweb.iaea.org/na/renual/>.

## Ion Beam

The PBGL has access to an ion beam facility at the Laboratory of ion beam Interactions, Ruder Boskovic Institute, Zagreb, Croatia. The Zagreb Institute has a collaborative agreement with the IAEA Laboratory of Instrumentation, Seibersdorf, which enables us to have beam time free of charge. This is a new area of work for the PBGL initiated in 2014. Two interns have been recruited and are engaged in the design and construction of sample platforms to support seeds for irradiation treatments and to determine radio-sensitivity after ion beam treatment and ultimately an examination of the mutant spectrum induced. The initial work will focus on wheat and barley.



*Seeds prepared for ion beam irradiation (top two rows – barley; bottom two rows – wheat).*



*Seed exposure to ion beam irradiation, note the fluorescence of two seeds (bottom row) as they pass into the ion beam.*

## Developments at the Plant Breeding and Genetics Laboratory (PBGL)

The first half of 2014 has been a period of great excitement and pride for the PBGL. Two mutant wheat varieties with resistance to Ug99 were released in Kenya; the significance for us in the PBGL is that the laboratory played a major role in supporting the Technical Cooperation Project: ‘Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)’ which produced this success. The initial seed irradiation was done at the PBGL and we were also involved in individual and group training of participants of the TC project.

The laboratory continues to have three major activities: 1) Research and Development (R&D), 2) Training (group and individual) and 3) Service (irradiation requests). Recent notable achievements in our R&D activities include the development of *in vitro* methods for potato mutation induction, work, initiation of work on ion beam irradiation and the development of low cost kits for DNA extraction and characterization. We continue to have a dynamic flow of trainees with six interns and 16 fellows from 14 Member States hosted at the PBGL in the first half of 2014. One group training course was held at the PBGL, on ‘Plant Mutation Breeding and Efficiency Enhancing Techniques in June 2014. The PBGL also contributes to group training courses held in other Member States in supplying irradiated standards to demonstrate radio-sensitivity testing and low cost kits for DNA extraction and characterization. The PBGL provides an irradiation service to Member States for plant mutation induction. In 2013 a record number of requests (over 100) were made and 2014 is shaping up to be another busy year for irradiation requests.

## Adaptive Research and Development to Enhance the Efficiency of Using Induced Mutations for Crop Improvement

Plant mutation breeding works because the act of mutagenesis creates changes in the DNA sequence of plants that affect the plant’s characteristics (phenotype) and are stably heritable and passed from generation to generation. The ability to record and characterize those induced DNA changes accurately is a potentially powerful tool for both breeders and basic researchers. The efforts of the PBGL in this area can be classified into three broad categories: 1) Development and adaptation of methods for the rapid and accurate discovery of novel induced mutations, 2) Use of discovery technologies to monitor and optimize the mutation induction process, and 3) Adaptation of basic molecular methodologies so that they are low-cost, reduced in toxicity and suitable for laboratories in developing countries.

The technology landscape in the area of plant genomics is evolving rapidly. This makes for an exciting but busy time to be a researcher in the field. Of the many tools (both bench and bioinformatics) being developed, only a handful are specifically optimized for discovery of rare induced mutations. Amplicon based approaches for the recovery of induced point mutations, like those caused by chemical mutagens, are now quite mature and work well across species. Broader spectrum mutagens, such as gamma and X ray irradiation, are more challenging. The PBGL is collaborating with Professor Luca Comai and Dr. Isabelle Henry to develop strategies for the recovery of mutations in gamma irradiated crops. Owing to the fact that plant genomes are quite large, whole genome sequencing approaches remain cost-prohibitive for all but the best funded laboratories. The collaboration, therefore, seeks to explore methodologies for mutation recovery from reduced representation libraries. Currently, efforts are ongoing to use exome capture strategies to catalogue gamma induced mutations in both seed and vegetatively propagated crops. Preliminary data are promising with candidate deletions of between 100 and 700 kilobases being recovered. Interestingly, the same dosage applied to two different genotypes did not give the same result even when standard LD50/GR50 dosage optimizations were used to calibrate the treatments. This suggests that more can be done to optimize gamma irradiation dosages for mutation breeding. We envision a time in the future when sequence based approaches will be used routinely to calibrate dosages and greatly enhance the efficiency of mutant population development.



Emerging technologies such as next generation sequencing are often expensive and require specialized expertise. When considering plant mutation research and breeding in different settings, it is appropriate to identify the most appropriate technologies by evaluating factors such as: ease of use, cost, toxicity, sustainability and suitability to address the scientific questions or problems. For example, a panoply of relatively easy-to-use molecular marker techniques are available that can provide a snapshot of the diversity of germplasm collections. Most techniques, however, are not appropriate for the evaluation of induced mutant populations unless mapping populations have been developed. The PBGL continues its work on developing and adapting appropriate methods that are suitable for most laboratories equipped for basic molecular biology. For example, no matter what DNA based methodology is used, the starting point is the proper isolation of plant tissues and extraction of high quality genomic DNAs. As described in the Success Stories section of this Newsletter, the PBGL has developed protocols and a training curriculum for low-cost methods that obviate the need for expensive and energy-consuming -80C freezers, liquid nitrogen and toxic organic chemicals. This has now become a standardized training module for training courses held in the Seibersdorf Laboratories and for courses held in Member States. Detailed protocols have been produced and the PBGL has developed a kit that contains all the materials and buffers for scientists to test the methods in their own laboratories. Methods have also been developed for low-cost discovery of induced point mutations and small indels. The PBGL is now working to develop a formalized publication containing these protocols. There is still work to do in this area. For example, current protocols for the extraction of single-strand-specific nuclease require expensive preparatory centrifuges and some expertise on protein dialysis. Additionally, most laboratories utilize UV fluorescence and expensive gel documentation systems to capture electrophoresis data. The PBGL aims to streamline these and other approaches to make basic molecular characterization more accessible.

The phenotyping team of the PBGL has been involved in various activities, during the reporting period. These include the development of protocols for efficient mutation induction and techniques for the rapid advancement of mutant populations and lines. Mutation induction and sensitivity evaluations after gamma and X ray irradiation have been evaluated for cereals (wheat, barley, sorghum and rice), horticultural crops (tomato, chilli, eggplant, cucumber and onion) and oil crops (sunflower, peanut and sesame). These materials were brought and handled by fellows from various Member States (Bangladesh, Mongolia, Sudan, Lesotho and

Madagascar). Radio-sensitivity studies have been extended beyond the seedling testing in the glasshouse to the assessment of growth, fertility and seed set in the field. Different sources of irradiation are being tested in the field including treatments from three gamma irradiators and two X ray machines.

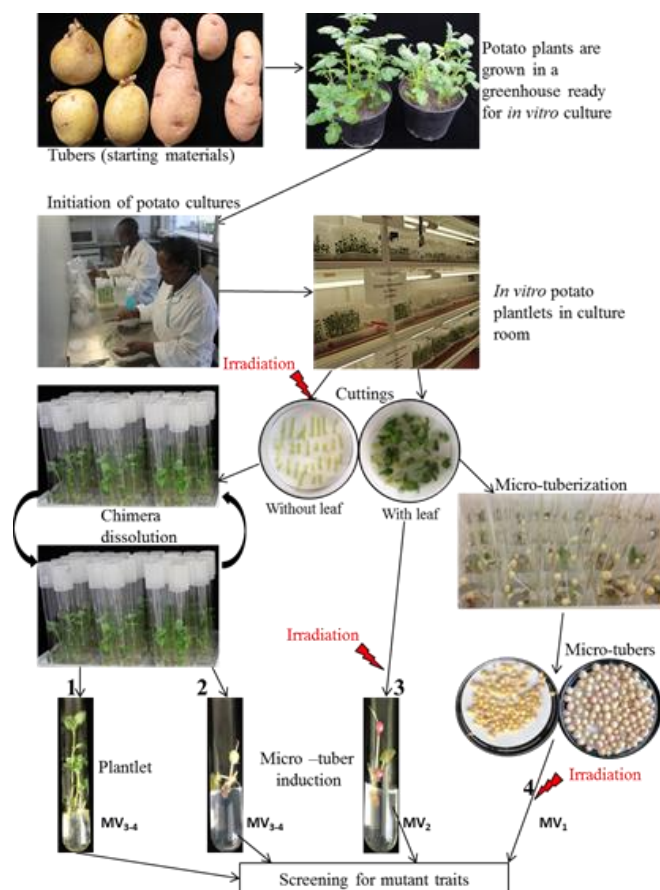
Efficiency enhancing techniques in plant mutation breeding include doubled haploidy and rapid generation cycling. Doubled haploidy methods include anther and microspore culture and studies are underway for wheat, barley, rice, cucumber and tomato. A number of Fellows from Member States have been trained in these techniques. A new Flow Cytometer was installed and has been used to determine ploidy in haploidy and doubled haploidy investigations. Currently, it is being utilized by fellows to develop doubled haploid protocols in cereals and vegetable crops. Procedures for *in vitro* mutation induction in potato are nearing completion (see below for an outline of the various methods). Similar methods are being developed for sweet potato, and some other vegetatively propagated plants such as robusta coffee and lemon. Progress has been made on developing rapid generation cycling in sorghum and barley. This has been achieved through the management of environmental conditions that encourage early flowering (reduced water supply, continuous lighting and growing plants in small pots) and *in vitro* embryo culture. These methods can be used to speed up the advancement of mutant lines. Evaluation of different genotypes and mutant germplasm is ongoing for salt tolerance testing in rice, wheat and barley and we aim to publish this as a protocol for screening.

### ***In Vitro* Methods for Mutation Induction in Potato**

Potato (*Solanum tuberosum*) is an important vegetable and staple food worldwide. It is a tetraploid outbreeding species which maintains a high degree of heterozygosity. The crop is vegetatively propagated. The main problems facing potato production are yield loss due to diseases such as late blight disease and pests such as potato cyst nematode and Colorado beetle. In developing countries many traditional varieties suffer from poor yield with reduced tuber size and have undesirable traits such as sunken eyes which reduce their economic value. Mutation breeding aims to improve such traits in these favoured local varieties, in 2013 the PBGL received requests for potato mutation induction from Kenya, Lesotho and Morocco. Because of this demand the PBGL set out a series of experiments aimed at optimising methods for *in vitro* mutation induction in potato. The starting materials were tubers from target varieties from Kenya, Lesotho and Morocco which were sent to the PBGL through the Standard Material Transfer Agreement.

Tubers from the three Member States were grown up in the greenhouse to provide shoot materials to initiate *in vitro* shoot cultures. Sterile, disease and pest free shoot cultures were established and then multiplied rapidly. These cultures were used in radio-sensitivity tests to determine the optimal dose treatment using gamma irradiation for mutation induction. Treatments include:

1. Irradiation of *in vitro* nodal cuttings (without leaf) followed by *in vitro* shoot propagation to dissolve chimeras.
2. Irradiation of *in vitro* nodal cuttings (without leaf) followed by *in vitro* shoot propagation to dissolve chimeras, followed by *in vitro* micro-tuber production.
3. Irradiation of *in vitro* nodal cuttings (with leaf) followed by *in vitro* micro-tuber production.
4. Mutation induction by irradiation of *in vivo* micro-tubers.



### Comparison of Methods in Potato Mutation Induction

Method	Time line	Chimera dissolution	Irradiated materials	Deliverable planting materials	Minimum quantity recommended	Shipment of planting materials	Downstream issues
1	6–12 months	Rounds of <i>in vitro</i> sub-culture	<i>In vitro</i> leafless nodal cuttings	<i>In vitro</i> plantlets MV <sub>3-4</sub>	1000	<i>In vitro</i> plantlets, requires specialized shipment	Plantlets require acclimatization before planting
2	6–12 months	Rounds of <i>in vitro</i> sub-culture	<i>In vitro</i> leafless nodal cuttings	Micro-tubers MV <sub>3-4</sub>	1000	Micro-tubers, easily transported	Micro-tubers may require treatments to induce germination
3	4–6 months	Limited to micro-tuber production	<i>In vitro</i> leafless nodal cuttings	Micro-tubers MV <sub>2</sub>	1000	Micro-tubers, easily transported	Micro-tubers may require treatments to induce germination
4	4–6 months	None	Micro-tubers	Micro-tubers MV <sub>1</sub>	1000*	Micro-tubers, easily transported	Micro-tubers may require treatments to induce germination

\*A micro-tuber is capable of having several eyes (growing points) and therefore several different mutant genotypes can be produced from one MV1 micro-tuber, and this can be exploited to increase the population size in the next generation.

In the first half of 2014 the PBGL returned the following mutant populations:

- To Kenya — over 1800 micro-tubers from three potato varieties;
- To Lesotho — over 1400 micro-tubers from four potato varieties;
- To Morocco — over 2500 micro-tubers from one variety.

These are to be tested for novel traits of interest in the respective Member States.

The PBGL is currently evaluating the various options with a view of establishing a protocol for in vitro mutation induction in potato. Currently Member States provide conventional tubers as starting materials, but there is now a practical option for Member States to produce micro-tubers themselves and send these on for mutation induction. The choice of the various options depends on the facilities (mutation induction and tissues culture) available in the Member State. Training in these techniques has been provided to fellows from Lesotho (x2), Morocco and Nigeria

## Irradiation Services

The total number of requests for 2013 was 105 from 34 Member States, this was a record number of requests for irradiation services, and brought the total number of request to 1365 since records began. At the time of writing the PBGL has received at total of 20 Member State (MS) requests for plant irradiation services during the first months of 2014. These are listed below and included 26 plant species and 34 varieties/genotypes. The total number of irradiation requests since records began now stands at 1386 and it is looking like 2014 is going to be another very busy year for plant irradiation services. The trend of applying mutation induction to a wider range of crops continues to increase and in the first part of 2014 we have seen requests for irradiation of a herb (sage), an ornamental tree (*Catolpa bignonioides*) and biofuel crops (jatropha, giant cane). However, most mutation induction requests are for staple food crops. For each request (unless otherwise stated), we carry out radio-sensitivity tests to determine the optimal irradiation dose for mutation induction (some examples are illustrated 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<sub>1</sub> 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.

## Irradiation Service Requests in the First Part of 2014

Request number	Country	Species
1366	Oman	Date palm, wheat, barley, banana
1367	Bangladesh	Wheat, groundnut, onion
1368	Bangladesh	Rice, tomato
1369	Algeria	Bread wheat, durum wheat
1370	UK	<i>Vicia faba</i>
1371	Germany	Sunflower
1372	Uzbekistan	Cotton, paulownia
1373	Democratic Republic of Congo	<i>Jatropha curcas</i>
1374	Democratic Republic of Congo	Soybean
1375	Albania	<i>Phaseolus vulgaris</i>
1376	Lesotho	<i>Ipomea batatas</i>
1377	Slovenia	<i>Catolpa bignonioides</i>
1378	UK	<i>Triticum turigidum</i>
1379	Bangladesh	Lentil
1380	Sudan	Sorghum
1381	Benin	Maize, amaranth
1382	Iraq	Cowpea
1383	Sudan	Bread wheat, sorghum, cotton
1384	Democratic Republic of Congo	Cassava
1385	Palestine	Durum wheat, barley
1386	Sudan	Sunflower, sesame





Radio-sensitivity tests in bean seedlings (far left), sunflower seedlings (middle) and potato in vitro cuttings (far right). From left to right in each photograph: control (zero irradiation) followed by increasing irradiation doses. Note that low dose irradiation often results in stimulated growth and high doses cause lethality (no germination and seedling death). Doses recommended for mutation induction normally lie between growth reduction doses of  $GR_{30}$  and  $GR_{50}$ .

## Kits

Two separate kits have been developed to assist researchers in the use of low-cost assays for the molecular characterization of plants. Several years ago we announced a kit for low-cost discovery of point mutations and small indels that are either naturally occurring or induced. More recently the PBGL has developed a kit for low-cost DNA extraction. Both are available upon request.

Kits distributed to Member States since the last Newsletter:

- Low cost DNA extraction kits distributed to: Algeria, Malaysia, Oman, Tunisia.
- Low cost mutation discovery kits distributed to: Colombia, Malaysia.

## Cost-free Expert

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

\*Funded and supported by the Fujian Agriculture and Forestry University and the Chinese 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

## 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

## Standards Provided for Training Courses

Training materials to demonstrate radio-sensitivity testing: irradiated seeds of wheat and sorghum were provided to Sudan for a national training course 17–30 January 2014 and for a national training course in Oman during January 2014.

## Professional Networking

The PBGL thanks all colleagues from around the world who have joined us on the professional networking site LinkedIn. We now have connections on all continents on Earth with the exception of Antarctica. If you haven't already linked with us, please feel free to connect (<http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3>). We would be especially happy if anyone stationed in Antarctica joined us. We expect that any plant breeders there would be experts in cold tolerance!

## Human Capacity Development

In the first part of 2014 the PBGL hosted one consultant, two cost-free interns and six fellows and organized a group training course (details below). At the time of writing the PBGL is organizing a regional group training course on: Plant mutation breeding and efficiency enhancing techniques, 10–20 June 2014 (RAS/5/058).

Name	Country	Areas of training	Period
***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

\*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
Mr Wonder Nunekpeku	Ghana	Mutation induction in oil palm	June–November 2014
Mr Enoch 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 Privat Ndayihanzamaso	Burundi	Mutation induction in vegetatively propagated crops	June 2014– August 2014
Mr Zeltani Abdessalem	Algeria	Methods in plant mutation breeding	June 2014



Training of individual fellows in salt tolerance screening in rice.

## Group Training on Chemical Mutagenesis of Barley Seed

An *ad hoc* training course was organized by Mr B. Till from 23–27 March on methods of chemical mutagenesis of seed propagated crops. All steps of the PBGL developed protocol were taught from seed preparation to post-mutagenesis decontamination. Participants from four Member States attended (Democratic Republic of Congo, Germany, Nigeria and Turkey).



## Visitors to the PBGL

The PBGL continues to host a high flux of visitors. At the time of writing we have received over 60 visits from Member States. Many of the visits are related to the ReNuAL project as Member States are keen to understand the role of the PBGL (and other NA-Laboratories), out impact and future vision.

### January

- Permanent Mission of France
- Permanent Mission of the State of Kuwait
- The Permanent Mission of Belgium and Belgium journalist
- Eritrean Science and Technology Development Agency
- FAO TCSR (resource mobilization group)

### February

- CVT Valorisation Sud, France
- IAEA NA-TC Directors
- Permanent Mission of Viet Nam

### March

- FAO Communications
- Recently appointed National Liaison Officers/Assistants for Brazil, Bolivia, Columbia, Cuba, Dominica, El Salvador, Guatemala, Haiti, Panama and Venezuela
- Safeguard trainees
- ReNuAL consultants

### April

- National Liaison Officer for Rwanda
- Diplomats from Armenia, Austria, Bulgaria, Burkina Faso, Croatia, Czech Republic, Denmark, Ecuador, EU, Finland, France, Islamic Republic of Iran, Italy, Latvia, Libya, Luxembourg, Mexico, Namibia, the Netherlands, New Zealand, Oman, Pakistan, Peru, the Philippines, Portugal, Romania, Russian

Federation, San Marino, Serbia, South Africa, Spain, Sudan, Switzerland, UK, USA, Uruguay and Yemen

- IAEA Staff Council Team

### May

- Friends of ReNuAL
- USA Office of Management and Budget and Permanent Mission of USA
- Friends of ReNuAL with the Ambassador of Permanent Mission of South Africa
- ROSATOM, Russian Federation
- IAEA MTPS (procurement) Staff
- IAEA Environmental Laboratory, Monaco
- SAGTAC (Standing Advisory Group on Technical Assistance and Cooperation for the IAEA) Members

### June

- Delegation of the European Union to the International Organizations in Vienna

## Conferences Attended

Bradley J. Till attended and gave a presentation at the International Plant & Animal Genome XXII, San Diego, CA, USA, 11–15 January 2014.

Abdelbagi M.A. Ghanim attended and gave a presentation at the 2nd International wheat Stripe Rust Symposium in Izmir, Turkey, 28 April–1 May 2014.

Joanna Jankowicz-Cieslak, Souleymane Bado, Abdelbagi M.A. Ghanim, Mirta Matijevic, Farzaneh Taasob-Shirazi and Bradley J. Till attended and gave presentations at the Translational Cereal Genomics, Vienna, Austria, 9–12 February 2014.

Joanna Jankowicz-Cieslak, Owen A. Huynh, Bradley J. Till, Ayse Sen, Tao Lan, Babita Jhurree-Dussoruth, Binita Saraye and Dada Keji attended and gave presentations at the Plant Gene Discovery & 'Omics' Technologies, Vienna, Austria, 16–19 February 2014.

Souleymane Bado, Abdelbagi Mukhtar Ali Ghanim, Babita Jhurree-Dussoruth, Binita Saraye, Md. Rani Hasanazzaman, Md. Kamruzzaman and Kaoutar El Achouri attended and gave presentations at the Applied Vegetable Genomics, Vienna, Austria, 19–22 February 2014.



## Plant Breeding and Genetics Laboratory staff travels to Member States

### Mr B. P. Forster

#### Maribor, Slovenia

Visited the Botanic Gardens of the Faculty of Agriculture of the University of Maribor, Slovenia in connection with irradiation to produce novel mutants in ornamental trees.

### Mr B. Till

#### San Diego, USA

Attended the Plant and Animal Genome XXII International Conference 11–15 January 2014 to give an oral presentation in the Banana Genomics workshop covering R&D activities carried out by the PBGL. Data collected by PBGL staff on mutation induction in banana, models for chimera dissolution, physiology of drought response and also low-cost methods being validated in developing countries through TC project MAR/5/020 were all presented. *Ad hoc* planning meetings were also held at the conference with experts in the field of wheat disease screening in order to develop strategies for characterization of Ug99 resistant lines being developed through TC project INT/5/150.

### Mr A.M.A. Ghanim

#### Khartoum, Sudan

19–30 January 2014, travelled to Khartoum to lecture in a national training course organized through TC project SUD/5/033 on mutation breeding and supporting biotechniques for the improvement of wheat and sorghum. The course was hosted by the Biotechnology and Biosafety Research Center, Agricultural research Corporation, Sudan.

#### Izmir, Turkey

28 April–1 May 2014, attended the Second International Wheat Stripe Rust Symposium at Izmir and delivered an oral presentation on ‘Mutation-induced variability for improved yield and rust resistance in spring wheat under hot irrigated environment’.

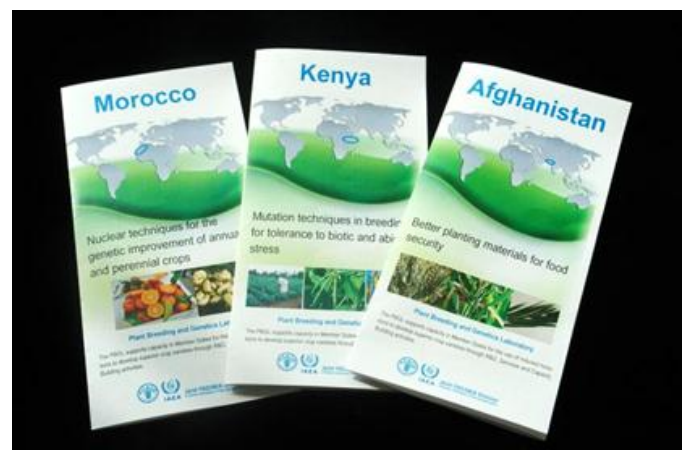
#### Zagreb, Croatia

27–29 May 2014 visited the Ruder Boskovic Institute, Zagreb to initiate collaboration on Ion Beam irradiation for mutation induction.

## Information sheets for visitors to the PBGL

We have produced several information sheets for visitors. These are country based and describe the problems facing agriculture, the crops of importance, interactions with the FAO/IAEA Joint Division and training at the PBGL. These sheets are mostly produced by our fellows during their training at the PBGL and have proven to be very popular with visitors. We have revisited our format and developed new look template, the first to be transformed and shown below. We now have 22 country sheets.

1. Afghanistan
2. Bangladesh – major crops (4th edition)
3. Bangladesh - vegetables
4. Burkina Faso
5. China
6. D.R. Congo
7. Indonesia (2nd edition)
8. Kenya (2nd edition)
9. Kuwait (new)
10. Lesotho
11. Madagascar
12. Mongolia
13. Morocco (new)
14. Nigeria
15. Palestine
16. Peru
17. Qatar (new)
18. Sudan
19. Thailand
20. Turkey (2nd edition)
21. USA
22. Viet Nam (new)



*New-look Information Sheets for Visitors.*

## Training on the New Flow Cytometer



Fellows using the newly installed flow cytometer at the PBGL to determine ploidy.

## Demonstration Field

The PBGL has a demonstration field used for training purposes. This is an essential part of our activities as fellows can study the effects of different irradiation treatments and follow procedures in mutant line selection. We also carry out field work to support our R&D activities.



Fellows scoring different mutant phenotypes in the barley 'Chromosome walk' demonstration in which mutant lines are arranged according to their genetic location on chromosomes (May 2014).

# Publications

## Peer-reviewed Book Chapters

J.Jankowicz-Cieslak and Bradley 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: (submitted).

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

L. Slade Lee, Bradley J. Till, Helen Hill, Owen A. Huynh, and Joanna Jankowicz-Cieslak: 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 (2014).

## Conference Abstracts

J. Jankowicz-Cieslak, M. Rapacz, S. Fluch, M. Berenyi, E. Wischnitzki, C. Mba, B.J. Till. Physiological and transcriptomic evaluation of water stress response in banana. *International Plant & Animal Genome XXII* 11–15 January 2014, San Diego, CA, USA.

Jhurree-Dussoruth, B, Jankowicz-Cieslak, J, Till, B. 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 January 2014, San Diego, CA, USA.

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.

J. Jankowicz-Cieslak, F. Maghuly, G. Marzban, L. Fagner, A. Sen, O.N. Huynh, W. Weckwerth, M. Laimer, B.J. Till, J. Vollmann. Adaptation of induced mutations and 'omics' methods for quality trait improvement in rice. *Translational Cereal Genomics*, 9–12 February 2014, Vienna, Austria.

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.N. 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 and 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.

B. Saraye and J. Jankowicz-Cieslak. Genetic diversity of chilli accessions using morphological and ISSR marker. Plant Gene Discovery & 'Omics' Technologies, 16–19 February 2014, Vienna, Austria.

B.J. Till, S. Bado, O.A. Huynh, J. Jankowicz-Cieslak, M. Beshir, I. Henry, L. Comai. Exome capture for mutation discovery in sorghum and cassava. Plant Gene Discovery & 'Omics' Technologies, 16–19 February 2014, Vienna, Austria.

B.J. Till, J. Jankowicz-Cieslak, E.K. Amos, M.G. Kinyua, O.A. Huynh, I. Henry, L. Comai, B.P. Forster, P.J.L. Lagoda. Mutation induction and discovery in cereals. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

A. Sen, P. Emmrich, O.A. Huynh, F. Robson, M. Chatterjee, C. Martin, T. Wang, B.J. Till. Development of a TILLING platform for grass pea, *Lathyrus sativus*. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

T. Lan, S. Zhang, T. Liu, B. Wang, H. Guan, B.J. Till, W. Wu. Genetic analysis, mapping and candidate identification of SST(t), a gene for seedling salt tolerance in rice. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

M. Matijevic, S. Bado, P.J.L. Lagoda, B.P. Forster. Irradiation Requests for Crop Plant Mutation Induction at the FAO/IAEA Laboratories. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

S. Bado, R. Padilla-Alvarez, A. Ghanim, B.P. Forster, M. Laimer. Nutrient Element Accumulation in Shoots as an Indicator for Salt Tolerance in rice. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

E. Amos, A. Ghanim, S. Bado, B.J. Till, B.P. Forster, P.J.L. Lagoda. Mutation Induction for Resistance to Black Stem Rust (Ug99) in Spring Wheat: An Overview of Progress Made and Prospective. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

F. Taassob-Shirazi, B. Forster, H. Grausgruber, J. Franckowiak. Development of Mutant Lines for Fodder Barley. Translational Cereal Genomics, 9–12 February 2014, Vienna, Austria.

R. Matumelo, S. Bado, D. Keji, A. Ghanim, B.P. Forster, M. Laimer. *In vitro* radio-sensitivity of potato cultivars to gamma irradiation. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.

A. Ghanim, S. Bado, A. Sen, M. Ahmed, F. Shirazi, E. Amos, M. Islam, F. Sarsu, B.P. Forster. Techniques in Accelerating Plant Mutation Breeding in Wheat and Sorghum. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.

M. Islam, A. Ghanim, S. Bado, M. Matijevic, B.P. Forster. Effects of Pollen Irradiation on Pollen Viability and Fruit Set in Cucumber. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.

M. Islam, A. Ghanim, S. Bado, M. Matijevic, B.P. Forster. Radiosensitivity for mutation induction in cucumber and tomato genotypes from Bangladesh. Applied Vegetable Genomics, 19–22 February 2014, Vienna, Austria.



## Impressum

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