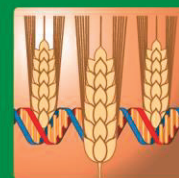




Joint FAO/IAEA Programme  
Nuclear Techniques in Food and Agriculture

# Plant Breeding & Genetics Newsletter



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## To Our Readers



Plant Breeding and Genetics (PBG) stand at Vienna International Centre (VIC) during the celebration of the 2016 International Year of Pulses.  
a) Released pulse mutant varieties; b) Visitors at the PBG booth.

On 28 and 29 September 2016, the IAEA Scientific Forum – *Nuclear Technology for the Sustainable Development Goals* – brought together experts and scientists to showcase how nuclear techniques contribute to health, food security, energy and the environment. Several keynote speakers, including HSH Prince Albert of Monaco, joined IAEA Director General Yukiya Amano in recognizing the important contribution of nuclear science and technology in helping countries to meet the Sustainable Development Goals. In one of the five thematic sessions, *Zero Hunger: Atoms for Food, Agriculture and Nutrition*, the keynote speaker was Mr Mohammad Shamsher Ali, Director General, Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh, who addressed how nuclear technology is successfully deployed to boost food security and tackle agricultural challenges and how nuclear techniques for crop improvement contribute to food security.

An event to celebrate the International Year of Pulses (2016) took place on 20 September 2016 at the Vienna International Centre. The year 2016 was declared the International Year of Pulses by the 68th UN General Assembly to help raise public awareness of the nutritional benefits and the role of pulses in sustainable food production. The Plant Breeding and Genetics Subprogramme (PBGS) jointly with the Soil and Water Management and Crop Nutrition Subprogramme organized a Side Event on Enhancing Pulses for Food Security by Nuclear Applications. This event was organized to highlight the role of pulses in their contribution to food security, human health and wealth and how enhancing the sustainability of agricultural cropping systems and nuclear techniques are helping to improve yield, enhance food security and broaden the genetic diversity of pulses. A variety of pulses and pulse plants were displayed with their

nitrogen-fixing roots and nodules visible. Also presented were mutant pulse varieties that have been officially released in Member States (MSs). A slide show and infographic materials summarised the important role of pulses.

The PBG Subprogramme is currently coordinating and supporting five Coordinated Research projects (CRPs) and providing technical support to a total of approximately 40 Technical Cooperation Projects (TCPs), with about 30 new TCP proposals received for the 2018–2019 cycle from all over the world, focusing on crop improvement through mutation breeding techniques. All these projects will contribute to ensure food security in Member States.

We are pleased to announce that we published a book of protocols developed through the CRP on Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline. This book offers 19 detailed protocols for increasing the efficiency of mutation breeding. These protocols provide techniques for mutation breeding or functional genomics study using both forward and reverse genetic approaches.

Another protocol on pre-field screening for heat tolerant mutants in rice was developed under the CRP on Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond. It will be published in early 2017. This protocol will help breeders to screen heat tolerance mutants in rice and to develop rice varieties adaptable to temperature variations and climate change.

The PBGS continuously assists MSs in the development and improvement of mutation breeding technologies and provides technical support and services in crop improvement programmes in MSs. This year during the Regional Training Course organized by the Bangladesh Institute of Nuclear Agriculture (BINA), the work of PBGS was recognized by Mr Mohammad Shamsheer Ali, Director General of BINA providing a token to FAO and IAEA for continuous support for agriculture development in Bangladesh.

In response to Member States' requests to consider the possibilities of developing and applying mutation breeding techniques on tolerance to abiotic stress in crops, we held a Consultants Meeting to develop a new CRP on Improving Crop Resistance to Abiotic Stresses through Mutation Breeding for Sustainable Agriculture. Considering the effects of climate change, the new CRP will focus on crop improvement for drought tolerance through mutation breeding techniques. During the meeting, project objectives, activities and workplan were discussed in detail.

The call for proposals will be announced on our website in the beginning of 2017. More information and the announcement can be found on (<http://www-naweb.iaea.org/nafa/pbg/>).

As for the Plant Breeding and Genetics Laboratory (PBGL), we can report on the publication of a protocol book on 'Biotechnologies for Plant Mutation Breeding', which offers a wide range of protocols on the use of induced mutations in crop breeding and functional genomics, and the preparation of a Training Manual on 'Mutation Induction in Coffee', which compiles protocols developed at the PBGL.

This year significant progress was made on the discovery of mutations using next generation sequencing for different crops, including rice and banana. Also, a program for the development of molecular markers for important traits has been initiated to translate the molecular knowledge on mutant traits into applications for plant breeding and to enable wider utilization of available useful mutant germplasm by Member States. A semi-dwarf mutant trait in sorghum was chosen in the pilot phase (see Developments at the Plant Breeding and Genetics Laboratory, page 25).

In October 2016, a film crew visited the Agency's Laboratories in Seibersdorf, including PBGL, in the context of a National Geographics project on the application of nuclear technologies to help address global challenges such as food, agriculture and climate change. In December 2016 a 22-minute documentary was aired on the National Geographics Channel in Belgium, the Netherlands and France highlighting the work at PBGL and the contribution of plant mutation breeding to food security and climate-smart agriculture.

Finally, I would like to thank all our collaborators and counterparts for their support and significant inputs to our joint activities, as well as staff of the Plant Breeding and Genetics Subprogramme for their dedication and competence in supporting Member States by developing and transferring sustainable plant mutation breeding techniques to them. As 2016 comes to an end, our best seasonal greetings on behalf of all of us at the Subprogramme. We look forward to another fruitful year and wish you a very successful 2017.

*Ljupcho Jankuloski*  
*Acting Head*  
*Plant Breeding and Genetics Section*





# 60 Years

**IAEA**

*Atoms for Peace and Development*

Set up in 1957 as the world's centre for cooperation in the nuclear field, the International Atomic Energy Agency (IAEA) works with its Member States and multiple partners worldwide, especially in the developing world, to promote the safe, secure and peaceful use of nuclear technologies. In September 2016, the IAEA held its sixtieth regular session of the General Conference, and in recognition thereof, the Secretariat will commemorate its sixtieth anniversary throughout the coming year.

Nuclear technologies continue to provide competitive and often unique solutions to help fight hunger and malnutrition, combat plant and animal diseases and pests, improve agricultural productivity and environmental sustainability and ensure that food is safe. Since 1964, the IAEA and the Food and Agriculture Organization of the United Nations (FAO) have worked in partnership through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture to help Member States use these

technologies safely and appropriately. Throughout this time the programme of the Joint FAO/IAEA Division, with its unique laboratories at Seibersdorf, has continuously evolved to meet the world's changing needs. In doing so, it has focused on expanding its ongoing contribution to agricultural development and global food security, and proactively embraced and added its expertise to efforts to adapt to and mitigate the effects of climate change, respond to globalization, conserve ecosystem services and broaden biodiversity. Today, it strives to mobilize commitment and concerted action towards meeting the Sustainable Development Goals of the United Nations through the appropriate integration of nuclear and related technologies for sustainable agriculture development and food security.

We take this opportunity to thank our numerous partners worldwide, whether institutions or individuals, for their dedication and continuous support to our mission since 1964.



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## Forthcoming Events

### **Project Coordination Meeting on Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA), RAS/5/077, Nay Pyi Taw, Myanmar, 20–24 February 2017**

Technical Officer: S. Nielen

The new regional project RAS/5/077, which starts its activities in 2017, will held a Project Coordination Meeting in Nay Pyi Taw, Myanmar. National project coordinators and representatives of donor and international organizations will review the current status of mutation breeding approaches and crop varieties in RCA Government Parties, to identify and address gaps and needs for advanced mutation breeding approaches and techniques to develop new crop varieties targeted for improved and environmentally friendly crop productivity, and to discuss and amend the regional and national workplans to be implemented under the project. This project is targeted to address the challenges of climate change on crop production by the most economic, effective and ecological approaches. New types of crop varieties referred to as Green Crop with high quality traits such as high yield, high photosynthetic efficiency, ideal plant type, resistance to abiotic and biotic stresses and less agricultural inputs (pesticides and fertilizer) under environmental-friendly conditions should be developed. The purpose of this project is to strengthen research collaboration on mutational development of green crop varieties among participating countries through application of advanced mutagenesis and molecular-physiological assisted screening approaches for the improvement of new plant type, yield component, growth duration and adaptation, to resulting in increase of crop productivity and supporting food security in this region.

### **Regional Training Course on Biotic Resistance and Plant Pathology (Latin America and the Caribbean), RLA/5/068, San Jose, Costa Rica, 6–10 March 2017**

Technical Officer: S. Nielen

This course is part of the regional TC project RLA/5/068 on Improving Yield and Commercial Potential of Crops of Economic Importance (ARCAL CL).

Many of the countries of Latin America and the Caribbean have a deficit in food production, leading to serious problems of poverty and malnutrition, especially in rural areas. This situation is compounded by the effects of climate change and population growth in the region. The productivity of the fields of small farmers are affected by adverse weather conditions (drought, floods, extreme temperatures), soil impoverishment caused by inappropriate agricultural practices (salinization, acidification, loss of nutrients) and by using the inadequate technology and growing old underperforming cultivars often susceptible to pests and diseases. The project is based on the use of induced mutation, mutation detection and pre-breeding technologies to develop new crop varieties with the required characteristics. The purpose of this training course is capacity building on the implementation of screening techniques to identify plants with qualitative and quantitative resistance to diseases caused by fungi, bacteria, viruses and other pathogens. Additionally basic training on the mechanisms of plant defence will be provided, as well as the criteria to apply the most appropriate improvement method.

### **Regional AFRA Training Course on Improving Resilience to Drought through Mutation Breeding, RAF/5/076, Tsumeb, Namibia, 24–28 April 2017**

Technical Officer: F. Sarsu

Course Director: L. Ndinela Horn

This training course will be organized in cooperation with the Government of the United Republic of Namibia, Ministry of Agriculture, Water and Forestry. It is open to project partners/candidates in the project RAF/5/076 (AFRA) on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach.

The purpose of this course is to provide participants with theoretical as well as practical information on mutation induction, mutation screening and breeding drought tolerance in crop breeding.

The course will include lectures and practical sessions on:

- Mutation breeding procedures/methodologies and handling of mutated population;
- Identification, evaluation and selection of breeding lines;

- Genetics of drought stress tolerance;
- Physiology of drought tolerance;
- Pre field/field screening methodologies for drought stress tolerance;
- Breeding for drought tolerance, mutation breeding, conventional breeding and utilization of appropriate biotechnologies;
- Field demonstration and practical sessions.

The participants will be from participating Member States involved in the TC project RAF/5/076, and actively working in mutation breeding. The course aims to enrich scientists with at least a M.Sc. degree involved in plant breeding/genetics and with a strong affinity and interest in modern plant breeding methods involving induced mutation, mutation screening (high-throughput phenotyping and genotyping) and techniques that can facilitate the breeding process.

### **Workshop on Improving Selected Seed Propagated Crops Using Mutation Breeding in Africa, RAF/5/076, Vienna, Austria, 3–5 May 2017**

Technical Officer: F. Sarsu  
Workshop Director: I. Ingelbrecht

This workshop will be organized under the project RAF/5/076 on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA).

The purpose of this workshop is:

1. To discuss with the project participants selected crops (cowpea, rice and sorghum), to learn their needs in terms of capacity building (human and infrastructural) and transfer of technology involving assistance of the PBGL for successful implementation of the project RAF/5/076;
2. To explore and exchange experience and organize possible synergistic R&D approaches for strengthening ongoing or planned improvement of food crops for enhanced food security in the region;
3. To initiate, facilitate and strengthen collaboration in research and development of these crops through common agreements such as germplasm exchange and collaborative research;
4. To identify any specific and common needs of the countries to transfer technology from PBGL to the region or between different countries of the region for successful implementation of the project.

The meeting is open to participating Member States through their designated national project coordinators working on cowpea, rice and sorghum improvement. The participants will be national plant breeder counterparts, working on cowpea, rice and sorghum improvement, responsible for planning the activities carried out within RAF/5/076 in the respective Member States and knowledgeable about crop productivity constraints in their respective countries.

### **Regional Training Course on Induced Mutations and Supportive Biotechnologies for Cereal Breeding, RAS/5/074, Seibersdorf, Austria, 8–9 May 2017**

Technical Officer: F. Sarsu  
Course Director: A.M.A. Ghanim

This training course is open to candidates from the project RAS/5/74 on Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley.

The purpose of this course is to provide participants with theoretical as well as practical information on mutation breeding and related biotechnologies to accelerate crop improvement and enhance the efficiency of plant breeding.

The two-week training course consists of lectures, demonstrations (laboratory and greenhouse) and laboratory exercises on:

- Mutation breeding procedures/methodologies and handling of mutated populations;
- Rapid generation cycling;
- Doubled haploid techniques;
- Phenotyping for abiotic stress (drought, heat stress and salinity);
- Marker assisted selection;
- Utilization of appropriate technologies for mutant phenotyping and genotyping.

This course is intended for participants with an academic background equivalent to a Bachelor's degree in plant breeding and genetics. The candidates should have experience and be actively involved in cereal breeding. An understanding of crop genetics, tissue culture and/or crop physiology is desirable. It is expected that participants will introduce and apply the techniques taught in their respective breeding programmes.

Participants should have a strong affinity and interest in modern plant breeding methods involving induced mutation, mutation screening (high-throughput



phenotyping and genotyping) and technologies that can facilitate the breeding process.

The training course will be conducted in English and participants should be capable of free expression, have an enquiring mind (ask questions) and be able to follow the lectures.

## **Regional Training Course on Methodologies and Mechanisms for Screening against Abiotic Stresses Using Mutation Breeding and Molecular Markers, RAS/5/070, Bangkok, Thailand, 22–26 May 2017**

Technical Officer: F. Sarsu  
Course Director: W. Ponrakdee

This training course will be organized in cooperation with the Government of Thailand, Ministry of Agriculture and Cooperatives. It is open to project partners/candidates from RAS/5/070 on Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques.

The purpose of the training course is to provide participants with theoretical as well as practical information on

application of molecular markers in mutation breeding including screening of target traits for bioenergy crops.

The one-week training course consists of lectures and hands-on experiments on:

- Basis of plant biotechnology and mutation induction; DNA as the source of genetic information;
- Introduction to molecular marker systems;
- Principles of the polymerase chain reaction (PCR);
- Principles of mapping, recombination, linkage data and segregation analysis, quantitative trait loci (QTL) analysis;
- Other molecular biology techniques used in crop improvement;
- Establishment of adequate screening protocols *in vitro* and/or *in vivo* integrating to mutation breeding programmes;
- Utilization of appropriate technologies for mutation screening for abiotic stress in bioenergy crops.

The participants will be from participating Members States involved in the TC project RAS/5/070 and actively working in mutation breeding. Candidates should also be currently actively involved in bioenergy crop programmes and should have at least a M.Sc. degree involved in plant breeding/genetics.

## **Past Events**

### **National Training Course on Phenotyping and Genotyping Mutants for Abiotic Stress, SRL/5/045, Peradeniya, Sri Lanka, 18–22 July 2016**

Technical Officer: F. Sarsu  
Course Director: P. Weerasinghe

The national training course was part of the TC project SRL/5/045 on Establishing a National Centre for Nuclear Agriculture. The training course was held at the Department of Agriculture Field Crops Research & Development Institute Peradeniya, Sri Lanka. Twenty five scientists participated and Mr Mirza Mofazzal Islam from Bangladesh Institute of Nuclear Agriculture (BINA) and Mr Muhammad Ashraf from Pakistan Nuclear Institute for Agriculture and Biology (NIAB) were invited as lecturers. The training course included lectures and practical sessions on:

1. Mutation Breeding for crop improvements;

2. Screening of mutant lines for desired traits in the field/greenhouse/laboratory conditions;
3. Utilization of plant tissue culture techniques (e.g. Doubled Haploid (DH) techniques) for mutation breeding and screening for biotic/abiotic stresses;
4. Practical works; Heat stress screening protocol for rice, field screening in rice/mung bean, mutagenic effects in first generation in lab (recording seedling data at different doses);
5. Mutagenic effects in first generation in lab (Calculations of LD<sub>50</sub> dose), mutagenic effects in M<sub>2</sub> generation in lab;
6. Preparation of medium for embryo/anther culture, culturing methods for embryo and anther /microspore;
7. Development of molecular markers and their use in the mutation breeding programmes related to crops;
8. Use of QTL mapping for mutation breeding, isolation and characterization of genes involved in mutagenesis of crop plants;

9. Practical works; Extraction of DNA: different methods, DNA quantification, gel electrophoresis, preparation of PCR, molecular markers.

The participants were very much enthusiastic and interested in induced mutations particularly on combined biotechnology such as marker technology and DH techniques in mutation breeding. The participants gained experience and knowledge to apply these techniques in their ongoing breeding programmes.



*Practical session on genotyping mutants.*



*Participants discussing on screening of mutant lines in field conditions.*

### **Third Research Coordination Meeting (RCM) on Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production Systems for Climate Smart Agriculture, Darkhan, Mongolia, 1–5 August 2016**

Technical Officer: L. Jankuloski

The third RCM was held in collaboration with the institute of Plant and Agriculture Science (IPAS) in Darkhan, Mongolia.

Seven research contract holders (Austria, China, the Former Yugoslav Republic of Macedonia, Malaysia, Mongolia and Peru) and one agreement holder (United Kingdom) participated in the meeting. The contract holders from Indonesia, Kuwait could not attend the meeting, but they sent their presentations and progress reports. All participants contributed to the success of the third RCM. The project was reviewed and discussions with Chief Scientific Investigators (CSIs) were successful.

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

The major objectives of this CRP were to maximize the yields of mutant varieties. The crops chosen (sorghum, rice, barley and wheat) were those that can be used for both human food and animal fodder. Each participant presented the achievements made within the CRP, particularly during the period after the last RCM in August 2014. The reports highlighted the methods used and results obtained in developing new mutant germplasm with improved nutrient quality traits.

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

The CRP was successful in regard to the following achievements:

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

From the second RCM in 2014, four research/review articles were published in citation indexed journals, and two research papers were presented in conferences.

The network among CRP participants is strong, and already exchanged seed material from mutant varieties/lines is under evaluation in respective countries under their environmental condition. As an example mutant barley varieties/lines developed in Peru were exhibited in the experimental field at IPAS in Mongolia.

The RCM participants visited the experimental field at IPAS, where wheat breeding material, including recently released mutant variety, Darkhan 141, and other advanced mutant lines, as well as M<sub>2</sub>, M<sub>3</sub>, M<sub>4</sub> generations were exhibited. Subsequently, participants visited facilities at



IPAS, where Ms Yadamsuren gave detailed information on current research programmes at IPAS.

The wheat mutation breeding programme in Mongolia, managed by Ms Yadamsuren, is progressing very well. Released mutant variety, Darkhan 141, is under seed multiplication and is expected to be disseminated to farmers next year. Another success of wheat mutation breeding programme at IPAS is the development of a new advanced wheat mutant line that is expected to be released in the next years.



*Demonstration of wheat mutant plants in the experimental field at IPAS, Darkhan, Mongolia.*



*Wheat varieties and breeding lines at IPAS, Darkhan, Mongolia.*

## National Training Course on Mutation Breeding and Supportive Biotechnologies for Improvement of Vegetables in Mauritius, MAR/5/023, Quatre Bornes, Mauritius, 8–19 August 2016

Technical Officer: F. Sarsu  
Course Director: R.D. Nowbuth

The training was held at the Food and Agricultural Research and Extension Institute Mauritius, Quatre Bornes,

Mauritius under the ongoing TC project MAR/5/023 on Improving Landraces of Crucifers (Cauliflower and Cabbage) and Carrot through the Use of Nuclear Techniques for Mutation Breeding and Biotechnology. Twenty-three scientists participated and Dr Pritam Kalia from the Indian Agriculture Research Institute, New Delhi, was invited as lecturer. The aim of this training course was to provide participants with theoretical as well as practical information on the use of mutation breeding and supportive biotechnologies for improvement of vegetables in Mauritius – mostly focusing on carrot, cauliflower and cabbage.

The training course included lectures and practical sessions on:

1. Breeding methodologies for self or cross pollinated plants;
2. Factors affecting the choice of breeding methods;
3. Classical breeding/mutation breeding/and combined biotechnologies;
4. Strategies for setting breeding objectives and maximizing selection and improvement of key traits;
5. Alternative approaches through hybridization and selection;
6. Lab and field techniques used in breeding and maintaining economic crops;
7. Evaluation lines/hybrids in the field for breeding variety(ies);
8. Crucifer (cauliflower and cabbage) and carrot breeding;
9. Crossing in crucifer/carrot and selection/screening for biotic/abiotic stresses and end-use quality;
10. Handling mutated population's management in the field;
11. Data analyses experimental results and prepare publication with results.

Practical sessions:

1. Floral biology and hybridization techniques in self-pollinated vegetable crops (e.g. tomato, brinjal, chilli);
2. Floral biology, pollination behavior and hybridization techniques in cross-pollinated vegetable crops (e.g. crucifers, carrot);
3. Handling of cross breeding and mutant populations in field
4. Microspore/anther culture technique for doubled haploid production in crucifers;
5. Embryo rescue *in vitro* technique for introgression trait of interest from alien *Brassica* species into *Brassica oleracea*;
6. Use of chemical mutagens and gamma rays in treating seeds to induce mutation.





*Practical sessions on phenotyping of mutants in field conditions.*



*Training course participants with Mr Pritam Kali.*

## **Consultants Meeting on Improving Crop Resistance to Abiotic Stresses through Mutation Breeding for Sustainable Agriculture, Vienna, Austria, 5–9 September 2016**

Technical Officer: F. Sarsu

A consultants meeting was organized to discuss and formulate a new Coordinated Research Project (CRP) on Improving Crop Resistance to Abiotic Stresses through Mutation Breeding for Sustainable Agriculture. Six invited experts Ms Huijun Guo, Institute of Crop Science, Chinese Academy of Agricultural Sciences (CAAS), Mr Are Ashok Kumar, International Crops Research Institute for the Semi-arid Tropics (ICRISAT), Mr Hiroyoshi Iwata, Graduate School of Agricultural Life Sciences, Ms Suchismita Mondal, International Maize and Wheat Improvement Center (CIMMYT), Mr Michel E. Ghanem, International Center for Agricultural Research in the Dry Areas (ICARDA), and Mr Chikelu Mba, Food and Agriculture Organization of the United Nations (FAO) participated in the meeting and contributed with their expertise. The consultants agreed that drought is the most

devastating abiotic stress factor worldwide and projected to worsen with anticipated climate change. The consultants strongly support the idea of developing a proposal aimed at resolving the bottlenecks for improving drought tolerance in crop plants through mutation breeding. Detailed announcement of the project and how to participate will be announced early in 2017.



*Consultants, staff of the Plant Breeding and Genetics Section (PBGS) and fellows from the Plant Breeding and Genetics Laboratory.*

## **Regional Training Course on Handling of Mutation Rice Production in Selection through Advanced Marker Added Technique on Biotic and Abiotic Traits, RAS/5/073, Mymensingh, Bangladesh, 2–11 October 2016**

Technical Officer: L. Jankuloski

Course Director: M. Islam



*Training course participants.*

The regional training course was held under TC project RAS/5/073 on Supporting Climate-Proofing Rice

Production Systems (CRiPS) Based on Nuclear Applications-Phase II. It was organized in cooperation with the Bangladesh Institute of Nuclear Agriculture and attended by 11 participants involved in the project (Cambodia, China, Indonesia, Lao P.D.R, Malaysia, Mongolia, Myanmar, Nepal, the Philippines, Thailand and Viet Nam) and five local participants from Bangladesh.

This two-week training course was officially opened by the Secretary of the Bangladesh Ministry of Agriculture, Mr Mohammad Mainuddin Abdullah.

The purpose of this training course was to provide participants with theoretical as well as practical information on modern techniques in mutation breeding combined with efficiency enhancing biotechnologies to improve the capacity to generate and develop rice mutants tolerant to abiotic and biotic stresses. The training course included lectures, roundtable discussions and practical sessions (laboratory, greenhouse and field). Lectures were given by the invited expert Dr Yuwei She, and local experts from BINA. The Technical Officer provided lectures on mutation breeding, mutation induction techniques and handling of mutant populations.

The training course included lectures and practical sessions on:

- Basic concepts and knowledge on mutagenic agents;
- Physical and chemical mutagen treatment;
- Establishment of the proper starting material for specific objectives;
- Mutation breeding, types of mutation breeding and advantages of mutation breeding;
- Radio-sensitivity test and growing of  $M_1$  generation of rice;
- Mutagenic effects in the first generation, mutation types, injury, sterility and chimeras;
- Growing of  $M_2$  population of rice, assessing mutation frequency and mutation rate, and phenotypic selection of plants/progenies for desirable traits;
- Pre-breeding ( $M_3$ – $M_4$ ) and yield trials;
- Experimental design, data collection, data compilation and data analysis;
- Population management for selecting mutants in self-pollinated crops;
- Basic concepts of molecular breeding (DNA structure, PCR, marker type and applications);
- Development of molecular markers and their use in mutation breeding programmes related to rice.

- Isolation and characterization of genes involved in mutagenesis of crop plants and QTL mapping;
- Marker assisted backcrossing;
- T-DNA insertion mutagenesis;
- Actual protocols for improving rice through mutation breeding from seed irradiation to release of new commercial varieties;
- Phenotyping and genotyping mutants to screen in field/lab/greenhouse conditions;
- Application of next-generation sequencing (NGS) in molecular mutation breeding;
- Marker-assisted breeding for development of salinity/submergence/drought tolerant rice varieties;
- Application of molecular markers in crop improvement with special emphasis on submergence stress.

Participants showed great interest in the training course and participated actively during the lectures and practical sessions and in the roundtable discussions. They obtained experience in the screening techniques and molecular techniques applied in rice breeding. The practical demonstrations and hands-on experience were of particular value and positively acknowledged by all participants. Participants acknowledged that the knowledge and skills, gained during this training course are relevant for their future work in their home countries.

During the two-week training course participants visited the experimental field at BINA and appreciated the rice mutation breeding programme, particularly rice mutant varieties tolerant to salinity, submergence and drought. The training course strengthened collaboration and partnerships between participating countries.



*Training course participants.*



## Training Course on Mutation Induction in Coffee, Seibersdorf, Austria, 3–14 October 2016

Technical Officer and Course Director: S. Nielsen

This training course was held jointly at the FAO/IAEA Plant Breeding and Genetics Laboratory (PBGL), Seibersdorf, Austria and the Plant Biotechnology Unit, Department of Biotechnology, BOKU University, Vienna, Austria. The course was organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture under the project Capacity Building Programme for Latin American Countries against Coffee Leaf Rust, supported by a grant of the OPEC Fund for International Development (OFID).

As reported in the last Plant Breeding and Genetics Newsletter (No. 37, July issue), the Coffee Mutation Network (CMN) was established at its initial meeting in Vienna in April 2016. It consisted of six institutes in coffee growing countries in Latin America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Peru) and the Joint FAO/IAEA Division with participation of Promecafe/IICA, CIFC, BOKU University Vienna, and World Coffee Research (WCR).

This network is specifically dedicated to the use of induced mutations to overcome the narrow genetic base of coffee to provide new avenues for enhanced disease resistance. As mutation breeding in coffee is a new technology, complementary activities are necessary to efficiently establish it in the coffee growing countries. This training course was one of the activities planned for the first phase of the project. Eleven participants from the CMN member countries plus Panama and Jamaica attended the course, which consisted of lectures, demonstrations and practical exercises on the following topics:

- Mutation induction techniques (physical and chemical) in coffee;
- Development of mutant populations;
- Genotypic screening of mutants;
- Next-generation sequencing approaches for mutation discovery and marker development in coffee;
- Tissue culture techniques in coffee: shoot cultures, callus and suspension cultures, anther culture, somatic embryogenesis;
- Host-pathogen interactions: control strategies for coffee leaf rust disease.

The participants partly came with good experience in tissue culture techniques and this training enabled them to improve their skills and to adapt these techniques for the application of mutation induction. Some participants brought seeds from the target varieties to the PBGL seed irradiation service. These seeds, after determination of the appropriate irradiation dose, will be irradiated and sent

back for development of mutant populations. It is expected that this course signifies an important step towards establishing mutation techniques in coffee in the region.

Apart from the PBGL team and BOKU scientists, Mr Alfredo Zamarripa Colmenero from the Programa Integral de Atencion al Cafe de la Secretaria de Agricultura de Mexico (SAGARPA) provided lectures and expertise. The course was enthusiastically evaluated by the participants. Through visits of the EFE News Agency and the IAEA's own press office, awareness was made internationally on the background of the course, e.g. an EFE article was widely published in newspapers and online news outlets in Spain and Latin America and the IAEA has published a video on its Website:

(<https://www.iaea.org/newscenter/multimedia/videos/tackling-coffee-disease-with-nuclear-science>).



Training course participants.

## First RCM on Mutation Breeding for Resistance to the Parasitic Weed (*Striga* spp) in Cereal Crops, D2.50.02, Vienna, Austria, 10–14 October 2016

Technical Officers: A.M.A. Ghanim and L. Jankuloski

The parasitic weeds *Striga asiatica* and *Striga hermonthica* are major biological constraints to cereal production in most of sub-Saharan Africa and semi-arid tropical regions of Asia. The main objective of CRP D2.50.05 is to develop laboratory, screen-house and field screening protocols of mutant populations of sorghum and upland rice for resistance to these weeds. Allelism and mechanisms of resistance will be analyzed to classify different mechanism of resistance. Accelerating techniques such as rapid cycling of crop generation and efficiency enhancing technologies of doubled haploid, genomics and molecular markers will be adapted to speed up the delivery of durable resistance. The meeting objectives were to review the workplan and consolidate the team and coordinate the work to maximize the use of resources to achieve the targeted objectives. The meeting was attended by 11 participants, contract and agreement holders from developing and developed countries from Africa (5), Asia (4), Europe (1) and USA (1). Each participant presented highlights on his/her related

areas of expertise and a workplan for the project activities during the first year of the CRP. The team was divided into subgroups to work jointly on the main research themes to develop laboratory, glass-house and field screening protocols for resistance to *Striga asiatica* and *Striga hermonthica* in sorghum and upland rice, and protocols for efficiency enhancing technologies, such as doubled haploid production, histology, genomic and marker technologies to enhance efficiency of selecting targeted mutants and speed up the process of delivery of *Striga* resistant varieties. A common set of resistant and susceptible germplasm and source of *Striga* seeds is planned to be shared among the team members to facilitate comparisons of results, validation and wide use of the screening protocols by Member States. During the meeting participants visited the PBGL, toured the facilities, were introduced to the lab activities and discussed the possible Lab contribution to the workplan of the CRP. The second RCM is planned for 2018 to review the progress made in the workplan.



Group photo of the first RCM meeting at the IAEA Vienna International Centre (VIC), Vienna, Austria.

## Technical Workshop on Remediation of Radioactive Contamination in Agriculture, Vienna, Austria, 17–18 October 2016

Technical Officers: C. Blackburn, G. Dercon, I. Naletoski, S. Nielen and Z. Ye

The year 2016 marks the fifth anniversary of the incident at the Fukushima Daiichi nuclear power plant (NPP) and the 30th anniversary of the accident at the Chernobyl NPP. The technical workshop was co-organised by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the National Agriculture and Food Research Organization of Japan (NARO). Over 100 experts from around the world participated in the event and all of

the presentations and discussions focused on research results and practical experience from Japan and from countries affected by the Chernobyl NPP accident. This was a great success in promoting and sharing knowledge and experience related to remediation of radioactive contamination in food and agriculture. Copies of the presentations are now available online at <http://www-naweb.iaea.org/nafa/news/2016-FAO-IAEA-NARO.html>.

The two day event commenced with opening statements from representatives of the host organizations: Mr Aldo Malavasi, Deputy Director General of the IAEA; Mr Qu Liang, Director of the Joint FAO/IAEA Division in representation of FAO and Mr Imbe Tokio, President of the National Agriculture and Food Research Organization (NARO) of Japan.

The meeting was planned in collaboration with NARO and comprised technical officers from four different Sections within the Joint Division, coordinated by the Food and Environmental Protection Section. An appreciation of ongoing developments and activities in this area will greatly improve emergency preparedness related to food and agricultural production in Member States. It will also support efforts to re-establish agricultural trade from areas currently affected by residual levels of radionuclides.

## Regional AFRA Training Course on Basic Mutation Breeding Techniques for Crop Improvement, RAF/5/076, Morogoro, United Republic of Tanzania, 24–28 October 2016

Technical Officer: F. Sarsu

Course Director: P. Kusolwa



Training course participants.

This training course was organized in cooperation with the Government of the United Republic of Tanzania through Sokoine University of Agriculture, Department of Crop Science and Production, Morogoro. It was open to project partners/candidates from TC project RAF/5/076 on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach.



The training course was attended by 29 participants from 18 countries, including Burkina Faso, Burundi, Côte d'Ivoire, Democratic Republic of Congo, Ethiopia, Ghana, Libya, Madagascar, Namibia, Senegal, Sierra Leone, Sudan, United Republic of Tanzania, Zambia, and Zimbabwe.

The training course provided participants with theoretical and practical information on mutation induction, mutation breeding and mutation-related biotechnologies, as well as phenotyping mutants and screening of mutant lines for desired traits under field, greenhouse, and laboratory conditions. The training course included lectures, roundtable discussions and practical sessions (laboratory, greenhouse and field) on these topics. A roundtable discussion was held on: How will the participants use this workshop/training course experience - mutation breeding and appropriate *in vitro* and *in vivo* technologies - in their national breeding programmes to release improved varieties to the farmers.

Dr Mehboob-ur-Rahman, National Institute for Biotechnology & Genetic Engineering (NIBGE), Faisalabad, Pakistan, Dr Paul M. Kusolwa, Sokoine University of Agriculture, Morogoro, and Prof Rajbir S. Sangwan, Université de Picardie Jules Verne, France, were the lecturers in this training course. The participants were delighted with the achievements, showed great interest in the training course, participated actively in the roundtable discussions and asked many questions about the applications of *in vitro* techniques in mutation breeding. They also gained good experience in phenotyping mutants – screening of mutant lines for desired traits of crops in the field/greenhouse/laboratories conditions, the establishment of the proper screening protocols (*in vitro* and/or *in vivo*) to be used in field conditions. The training course was well appreciated and was highly evaluated by the participants, who acknowledged that the knowledge and skills gained during this training course are highly relevant for their future work in their home countries.



Laboratory experiments by the participants: Pollen stage determination, sampling of flowers-anthers, identification of anther/pollen stages of development.



Laboratory experiments by the participants: Anther culture on media.

## Regional Training Course on Mutation Breeding and other Related Techniques for the Development of Heat Tolerant Cotton Mutants, RAS/5/075, Faisalabad, Pakistan, 7–18 November 2016

Technical Officer: L. Jankuloski

Course director: Dr Hussain Manzoor



Training course participants.

The two-week regional training course was organized in cooperation with the Government of Pakistan through the Nuclear Institute of Agriculture and Biotechnology in Faisalabad, Pakistan. The purpose of this training course was to introduce participants of RAS/5/075 to mutation breeding in cotton for abiotic stress tolerance, particularly heat tolerance.

The training course was attended by nine participants from participating Member States, including Bangladesh, Islamic Republic of Iran, Myanmar, Syrian Arab Republic and Viet Nam, and four local participants from Pakistan.





*Training course participants in the experimental field.*

The training course was officially opened by Prof Dr Muhammad Ali, Vice Chancellor, Government College University, Faisalabad.

The training course provided participants with theoretical as well as practical information on cotton mutation breeding combined with efficiency enhancing biotechnologies to improve the capacity to generate and develop cotton mutants tolerant to abiotic and biotic stresses. It included lectures, practical sessions in the field and roundtable discussions. Lectures related to the topic were given by local experts, from NIAB, NIBGE and PAEC. The Technical Officer provided lectures on mutation induction techniques, mutation breeding and handling of mutant populations.

The training course included lectures and practical sessions on:

- Physio-biochemical and molecular indices for heat tolerance in cotton;
- Data recording on various morphological traits conferring heat tolerance in cotton;
- Use of DNA-based tools for identification of mutants;
- Reverse genetic approach in molecular mutation breeding;
- Molecular plant breeding with specific reference to cotton;
- Developing adaptation strategies for cotton production;
- Hands-on training on DSSAT/Aqua crop models for cotton genotypes resilience evaluation;
- Physiological parameters for screening cotton genotypes under thermal stress conditions;
- Recording of physiological parameters: anther dehiscence, pollen viability, relative cell injury level, electrical conductivity, sympodial node numbers bearing effective bolls, gas exchange characteristics, stomatal conductance, transpiration rate, net photosynthetic rate, etc.;
- Evaluation of cotton mutants against CLCuD;

- Role of carbon isotope discrimination technique to increase water use efficiency;
- CWSI and CTD techniques for selection against drought/heat tolerant cotton mutants;
- Role of biotechnology in the improvement of cotton.

The participants showed great interest in the training course and participated actively during the lectures, practical sessions and in the roundtable discussions. The focus of the training course was on practical demonstrations and hands-on experience. Training course participants were able to work in the experimental field at NIAB with M<sub>1</sub>, M<sub>2</sub>, M<sub>3</sub> and M<sub>4</sub> mutant generations. Dr Manzoor explained in detail how to handle mutant populations. These practical sessions were of particular interest to the participants, which they very positively acknowledged. Participants confirmed that the knowledge and skills gained during this training course were highly relevant to their future work in their home countries and that these will be able to establish cotton mutation breeding in their countries.

The training course was also successful in strengthening collaboration and partnerships between participating countries. Mutant lines and varieties developed at NIAB were shared with participants in order to evaluate adaptability of cotton mutant lines in their countries and to use them in their cotton breeding programmes.



*Hands on practice in the experimental field.*



*Hands on practice in the experimental field.*



*Practical lectures in the field.*

## **IAEA/BATAN Group Fellowship Training Course on Plant Mutation Breeding, RAS/0/073, Jakarta, Indonesia, 14 November–9 December 2016**

Technical Officers: S. Nielen and A.M.A. Ghanim  
Course Director: Soeranto Human, CIRA-BATAN

A group fellowship training course on plant mutation breeding was organized under TC project RAS/0/073 at BATAN, Jakarta, Indonesia. This course was a pilot activity of the Regional Capacity Building Initiative (RCBI) of Indonesia. In cooperation with the IAEA, RCBI is aimed at technology transfer to less developed countries in the Asian region. Besides the local participant, the course was attended by 12 participants from the region, two each from Cambodia, Lao P.D.R, Mongolia, Myanmar Nepal, and one from United Republic of Tanzania. Stephan Nielen (PBGS) and Abdelbagi M.A. Ghanim (PBGL) represented the Agency and provided technical presentations and advice in the first and the second week of the training, respectively. Local experts also contributed as lecturers and assisted in the preparation of the practical sessions. The first week was mainly focused on the theory and practical aspects of mutation induction, the effect of mutagens on plants of the first mutant generation ( $M_1$ ) and the possible causative factors of mutations. Also, examples of the socio-economic impact of mutation breeding were presented and the FAO/IAEA Mutant Variety Database was introduced to the participants. During the second week,

theory and practice of development and screening of mutant populations for seed and vegetatively propagated crops, and efficiency enhancing technologies for mutation breeding with emphasis on doubled haploid and crop rapid-cycling technologies were the main topics. Participants were trained on protocols developed at the PBGL such as development of mutant populations for seed and vegetative propagated crop plants and screening for resistance/tolerance to biotic and abiotic stresses, *in vitro* mutation induction and doubled haploid production techniques. In the second week, a study tour to the Horticultural Research Institute was organized to expose participants to the institute's experience in mutation breeding of ornamental crops. The participation of staff from PBGS and PBGL was a good opportunity to contribute to capacity building in Member States and disseminate protocols developed or adapted at the PBGL to enhance mutation breeding efficiency and improve the skills of young researchers. In the third week participants were thought by BATAN staff in the sorghum and banana mutation breeding programme in Indonesia and in performance of yield trials and multi-location trials for mutant variety release. Practical Work on molecular markers was done at the Center for Agricultural Biotechnology (BB-Biogen), Bogor, West Java. An introduction into use of nuclear and isotopic techniques in soil, water and nutrient management was provided by Mr Roland Rallos (PNRI, Philippines) in the last week.



*Participants sowing irradiated seeds for a radio-sensitivity test.*



## Coordinated Research Projects

Project Number	Ongoing CRPs	Scientific Secretaries
D2.30.29	Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond	F. Sarsu
D2.30.30	Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System	L. Jankuloski/ I. Ingelbrecht
D1.50.13	Approaches to Improvement of Crop Genotypes to High Water and Nutrient Use Efficiency for Water Scarce Environment	J. Adu-Gyamfi/ L. Jankuloski
D2.20.05	Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana	B. Till/S. Nielen
D2.50.05	Mutation Breeding for Resistance to <i>Striga</i> Parasitic Weeds in Cereals for Food Security	A.M.A. Ghanim/ L. Jankuloski

### Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security, D2.50.05

Scientific Secretaries: A.M.A. Ghanim and L. Jankuloski

The new CRP D2.50.05 on Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security has effectively started with eight research contracts from Burkina Faso, China, Ethiopia, Islamic Republic of Iran, Kenya, Madagascar, Sudan, and Turkey, two technical contacts from Japan and USA, and four agreement holders from FAO, Rome, Japan, the Netherlands, and USA. The main objective is to develop effective screening protocols to identify and advance resistant mutants. Screening packages will be optimized for laboratory, screen house and field to *Striga asiatica* and *S. hermonthica*. Allelism and mechanisms of resistance will be analyzed to classify different source of resistance, which can be combined to produce durable resistance. Efficiency enhancing technologies of doubled haploid, genomics and molecular markers will be adapted (for more information, see Past Events in this issue).

### Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana, D2.20.05

Scientific Secretaries: B. Till and S. Nielen

The main objective of this CRP is to adapt and develop screening protocols that are suitable for mass screening of mutant lines to identify rare plants showing enhanced

resistance to disease. The target crops for this CRP are banana and coffee. Cavendish bananas are clones and susceptible to diseases, including Fusarium wilt caused by tropical race four (TR4). In recent years TR4 has been identified in nine countries suggesting that it is spreading geographically and threatening global banana production. Coffee is the second most traded commodity behind crude oil and derivatives. Coffee leaf rust is devastating to plantations. Global climate change and variation threaten to increase the negative impact of this disease.

Many challenges need to be addressed for successful coffee and banana mutation breeding. Polyploid bananas are vegetatively propagated and therefore require *in vitro* propagation pre- and post-mutagenesis. In addition to disease screening methods, low-cost tissue culture and efficient methods to dissolve chimeric sectors that result from mutagenesis of multicellular tissues are needed. Very little work on mutation breeding has been done on coffee. We therefore expect to focus some efforts of this CRP on developing and validating mutation induction techniques in the perennial tetraploid Arabica coffee. The results from the first year of the CRP will be reviewed at the RCM planned for 2017. The PBGL has been adapting next generation sequencing techniques to identify mutations caused by treating triploid Cavendish bananas with gamma irradiation. Preliminary results are promising, suggesting similar methods can be adapted for tetraploid coffee (see the section on Developments at the PBGL in this newsletter for more information). In addition, funding provided by the OPEC Fund for International Development (OFID) was used to hold a training course on coffee mutation induction in October 2016, thus further expanding and strengthening the network started within this CRP (for more information, see Past Events in this issue).



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

Scientific Secretary: 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 three agreement holders from Spain, the United Kingdom and the International Center for Tropical Agriculture (CIAT), Colombia.

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

The project focuses on improving the grain yields of rice grown in harsh conditions, such as high temperature stress. One aim is to improve rice yields in harsh conditions by screening and selecting induced mutants for high temperature stress tolerance. The seedling and flowering stages were identified as key growth stages that are sensitive to heat stress in rice. Therefore, screening methodologies were developed for high temperature to identify valuable mutant populations in the greenhouse, growth chamber and under field conditions. These protocols will provide users with the screening techniques to select rice mutants with tolerance to heat. Simple and quick methods are also provided to screen seedlings for heat tolerance in hydroponics and pots in growth chamber/greenhouse conditions. The seedling test takes 3–4 weeks and allows the screening of several hundred seedlings. The test can be used to screen mutant lines and cultivars as well as M<sub>3</sub> generations to advanced mutant generations.

Each participating country has been establishing at least one or two protocols for whole plant, physiological, genetic and molecular studies. Mutant line screening protocols for rice and common beans have been developed under growth chamber and field conditions for confirmation of heat tolerance. In the particular case of beans, responses to nodulation and nitrogen fixation are closely monitored in order to identify the best symbiosis: plant/rhizobium is performing satisfactorily under heat conditions. Additionally, gene expression was investigated under increased temperature conditions. Some genes involved in high temperature response, both in rice and beans, showed

a significant change in expression patterns, which may play a role in stress tolerance. A detailed characterization of those genes under heat stress has to be carried out yet.

All participating countries generated new mutant populations in rice and beans. Screening has been done for heat tolerance in growth chamber and field conditions. Also, some countries used characterized mutant lines from previous projects. All of them have mutant lines at least at the M<sub>4</sub> generation, which tested tolerant for their responses to increased temperatures. Cuba released a new rice mutant variety ‘Guillemar’, which has good yield under heat stress conditions and low water supplies. Some participants have advanced/pre-released mutant lines in rice and bean, which will be released to farmers by 2018.

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

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

Scientific Secretary: L. Jankuloski

This CRP began in the third quarter of 2012 and will be concluded in the third quarter of 2017. In December 2012, we held our first RCM in Vienna, Austria, the second RCM was held in August 2014 in Bogor, Indonesia and the third and final RCM was held in 2016 in Darkhan, Mongolia.

The objectives of this CRP are:

1. To identify cereal mutant varieties or advanced mutant lines for food and feed;
2. To evaluate mutant cereal varieties/lines for agronomic performance and feed quality;
3. To develop crop management systems for cereal mutant varieties with respect to improved yield and quality;
4. To determine biomass, harvest index and nitrogen use efficiency of mutant varieties and advanced lines;
5. To validate and publish protocols and guidelines for speeding up the establishment of useful mutants in desirable genetic backgrounds;
6. To perform pilot tests of superior mutant varieties/lines on-farm through participatory farmer approaches.

The crops chosen are those that can be used for both human food and animal fodder. The project involves nine participating countries and four major crops, namely wheat (the Former Yugoslav Republic of Macedonia, Mongolia), rice (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 MSs.

All participants have identified promising 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 there are already impressive outcomes, particularly in Indonesia where mutant varieties are now grown in several regions on an increasing area. In barley, relevant germplasm with natural variation for reduced lignin content trait has been identified and progress is made to identify the underlying sequence variations in several barley lines.

All project participants have submitted project progress reports and all contracts have been renewed for 2017.

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

Scientific Secretaries: J. Adu-Gyamfi and L. Jankuloski

This CRP is in its final year. Ten research contract holders (Bangladesh, China, Kenya, Malaysia (two), Mexico, Pakistan, Peru, South Africa, Uganda and Vietnam), one technical contract holder (Peru) and one agreement holder (South Africa) are participating. The research project was started in December 2011 and three RCMs have been carried out so far to review project progress and present preliminary results. The overall objective of this CRP is to increase crop productivity and food security by developing improved crop varieties and soil, water, nutrient and crop management technologies and making them available to farmers, and ensure their cropping systems are resilient to biotic and abiotic stresses in water scarce environments.

Key outputs of the CRP to date include:

1. The total area covered by ratooning rice cultivars (one planting and two harvests) from 2012–2015 is 42,000

ha in China with yield up to 14,500 kg/ha over two harvests.

2. 20–30% yield increase of two elite potatoes with high fertilizer use efficiency at four locations (Njoro, Kabiana, Marigat and Molo) using a combination of animal manure and nitrogen fertilizer have been recorded by farmers.
3. Three genotypes of wheat with high water and nutrient use efficiencies are being tested in 25 farmers field (0.5 ha per farmer) in six districts (Peshawar, Nowshera, Charsadda, Lakki- Marwat, Swabi and Dir) in Pakistan.
4. Three varieties and one advanced mutant line of barley, and five improved genotypes of quinoa suitable for high altitude have been identified and are being tested in the high altitude mountains and coastal areas of Peru.

## **General information applicable to all coordinated research projects**

### **Submission of Proposals**

Research contract proposal forms can be obtained from the IAEA, the National Atomic Energy Commissions, UNDP offices or by contacting the Technical Officer. The form can also be downloaded from the URL:

<http://www-crp.iaea.org/html/forms.html>.

### **Complementary FAO/IAEA Support**

IAEA has a programme of support through national Technical Cooperation (TC) projects. Such support is available to IAEA Member States and can include additional support such as equipment, specialized training through IAEA training fellowships and the provision of technical assistance through visits by IAEA experts for periods of up to one month. Full details of the TC Programme and information on how to prepare a project proposal are available at the URL:

<http://pcmf.iaea.org/>.

## Technical Cooperation Field Projects

Project Number	Country/Region	Title	Technical Officer(s)
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	L. Jankuloski
BGD/5/029	Bangladesh	Evaluating Promising Abiotic Stress Tolerant Crop Mutants/Varieties and Measuring the Suitable Management Practices for the Promotion of Sustainable Production at Saline, Submergence and Drought Prone Areas	L. Jankuloski in collaboration with the Soil and Water Management and Crop Nutrition Section
BUL/5/014	Bulgaria	Screening of Cereal Germplasm Stress Response and Adaptation Potential by Advanced Nuclear, Omics and Physiological Approaches	L. Jankuloski/S. Nielen
BKF/5/016	Burkina Faso	Using Nuclear Techniques for Improving Rice Yield and Quality	L. Jankuloski/ I. Ingelbrecht
BDI/5/001	Burundi	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	S. Nielen/I. Ingelbrecht in collaboration with the Soil and Water Management and Crop Nutrition Section
CAF/5/008	Central African Republic	Improving Cassava Yield through Improved Crop Variety and Best Soil Management Practices Using Nuclear Techniques	I. Ingelbrecht/A.M.A. Ghanim in collaboration with the 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
ZAI/5/025	Congo, Democratic Rep. of the	Increasing Genetic Variability in Cassava and Maize for Enhanced Tolerance to Biotic and Nitrogen Stresses	L. Jankuloski/F. Sarsu
IVC/5/039	Cote d'Ivoire	Improving Maize Production in Savannah Areas with Severe Pedoclimatic Degradation in the North of Cote d'Ivoire through the Cultivation of Induced Mutants Adapted to these Areas	F. Sarsu/I. Ingelbrecht
GHA/5/036	Ghana	Screening Oil Palm M2 Population for Useful Mutants	L. Jankuloski/F. Sarsu
IRA/5/014	Iran, Islamic Republic of	Improving Wheat Yield and Stress Tolerance for Sustainable Production	B. Till/L. Jankuloski
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
KEN/5/037	Kenya	Using Climate Smart Brachiaria Mutants to Develop Integrated Farm Model Technologies for Improved Livelihood Among Smallholder Farmers	S. Nielen/F. Sarsu
KUW/5/002	Kuwait	Implementing Mutation Induction to Improve Barley Production under Harsh Environmental Conditions	L. Jankuloski/A.M.A. Ghanim



Project Number	Country/Region	Title	Technical Officer(s)
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
LAO/5/002	Lao, P.D.R.	Improving Soil Fertility and Water Use Efficiency in the Cassava-Rice-Soybean Production System under Smallholder Farming Systems	L. Jankuloski in collaboration with the Soil and Water Management and Crop Nutrition Section
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
LES/5/005	Lesotho	Improving Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production, Phase II	S. Nielen/A.M.A. Ghanim
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
MAU/5/006	Mauritania	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques to Water Management and Soil Fertility	L. Jankuloski/F. Sarsu in collaboration with the Soil and Water Management and Crop Nutrition Section
MAR/5/023	Mauritius	Improving Landraces of Crucifers (Cauliflower and Cabbage) and Carrot through the Use of Nuclear Techniques for Mutation Breeding and Biotechnology	F. Sarsu/L. Jankuloski
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 the Animal Production and Health Section
MOZ/5/007	Mozambique	Enhancing Mutation Breeding of Sorghum and Pearl Millet to Develop High Yield, Disease Resistance and Drought Tolerance	S. Nielen/A.M.A. Ghanim
MYA/5/020	Myanmar	Strengthening Food Security through Yield Improvement of Local Rice Varieties with Induced Mutation (Phase II)	S. Nielen/L. Jankuloski in collaboration with the Soil and Water Management and Crop Nutrition Section
NAM/5/012	Namibia	Developing High Yielding and Drought Tolerant Crops through Mutation Breeding	F. Sarsu/S. Nielen
NAM/5/014	Namibia	Evaluating Efficient Water and Nutrient Use, Molecular Characterization and Nutritional Composition of Mutant Germplasm Populations	F. Sarsu/S. Nielen in collaboration with the Soil and Water Management and Crop Nutrition Section
NEP/5/003	Nepal	Improving Crop Yield for Food Security and Economic Growth by Using Nuclear and Molecular Techniques	S. Nielen/L. Jankuloski
NER/5/019	Niger	Improving Sesame Plant Productivity by Obtaining High-Yielding Induced Mutants Adapted to Semi-Arid Conditions	I. Ingelbrecht/A.M.A. Ghanim
OMA/5/004	Oman	Building Capacity for the Improvement of Major Crops through Induced Mutation Using Nuclear and Related Techniques	A.M.A. Ghanim/I. Ingelbrecht

Project Number	Country/Region	Title	Technical Officer(s)
PAL/5/009	T.T.U.T.J. of the Palestinian A.	Enhancing the Performance of Durum Wheat Landraces by Induced Mutation (Phase II)	L. Jankuloski/A.M.A. Ghanim
QAT/5/006	Qatar	Enriching Genetic Diversity and Conserving Plant Genetic Resources Using Nuclear Techniques and Related Technologies	A.M.A. Ghanim/ L. Jankuloski
RAF/5/076	Regional Africa	Improving Crops by Using Mutation Induction and Biotechnology through a Farmer Participatory Approach	F. Sarsu/S. Nielen
RAS/5/069	Regional Asia	Complementing Conventional Approaches with Nuclear Techniques towards Food Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	L. Jankuloski/S. Nielen
RAS/5/070	Regional Asia	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	F. Sarsu/S. Nielen
RAS/5/073	Regional Asia	Supporting Climate-proofing Rice Production Systems (CRiPS) Based on Nuclear Applications-Phase II	L. Jankuloski/S. Nielen
RAS/5/074	Regional Asia	Enhancing Wheat and Barley Productivity through Induced Mutation with Supportive Breeding and Related Biotechnology Techniques (Phase III) (ARASIA)	F. Sarsu/L. Jankuloski
RAS/5/075	Regional Asia	Improving Sustainable Cotton Production through Enhanced Resilience to Climate Change	L. Jankuloski/F. Sarsu in collaboration with the Soil and Water Management and Crop Nutrition Section
RAS/5/077	Regional Asia	Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA)	S. Nielen/F. Sarsu
RLA/5/068	Regional Latin America	Improving Yield and Commercial Potential of Crops of Economic Importance (ARCAL CL)	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 in collaboration with the Soil and Water Management and Crop Nutrition Section
SIL/5/014	Sierra Leone	Enhancing Nutritional and Other End-User Postharvest Qualities of Rice and Cassava through Mutation Breeding	S. Nielen/L. Jankuloski
SIL/5/017	Sierra Leone	Selecting and Analyzing Bio-Enriched and Bio-Fortified Rice and Cassava Lines and their Efficient Postharvest Transformation to Popular Food Products	S. Nielen/I. Ingelbrecht
SRL/5/045	Sri Lanka	Establishing a National Centre for Nuclear Agriculture	F. Sarsu
SUD/5/037	Sudan	Applying Nuclear Techniques to Improve Crop Productivity and Livelihood of Small-scale Farmers in Drought Prone Areas	F. Sarsu/S. Nielen in collaboration with the Soil and Water Management and Crop Nutrition Section
URT/5/030	Tanzania, United Rep. of	Improving Rice and Barley Production through Application of Mutation Breeding with Marker Assisted Selection	L. Jankuloski/F. Sarsu
URT/5/032	Tanzania, United Rep. of	Developing Maize Cultivars for Improved Yield and Resistance to Viral Disease	F. Sarsu/L. Jankuloski



Project Number	Country/Region	Title	Technical Officer(s)
THA/5/054	Thailand	Increasing Adaptability for Adverse Environment Tolerance in Rice Germplasm Using Nuclear Techniques	F. Sarsu/S. Nielsen
VIE/5/018	Viet Nam	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
ZIM/5/021	Zimbabwe	Assessing and Promoting Sustainable Agricultural Production in Communal and Newly Resettled Farms	F. Sarsu/A.M.A. Ghanim in collaboration with the Soil and Water Management and Crop Nutrition Section

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

In 2016, significant progress was made in the area of mutation discovery using PBGL's MiSeq Sequencing platform. Several mutant crop genomes have been sequenced in-house, including rice, banana and tomato. Protocols are being developed and optimized to identify different types of mutations, including single nucleotide polymorphisms (SNPs) and small or large insertions or deletions (indels).

During 2016, PBGL has started to translate the knowledge on molecular trait discovery into practical applications for field breeding. A program for the development of molecular markers for mutant traits has been initiated to enable wider utilization of available useful mutant germplasm by Member States and enhance local agrobiodiversity.

In this starting phase, two pilot projects have been initiated; one is focused on a semi-dwarf mutant trait in sorghum and a second on a reduced-lignin content trait in barley. The former is a gamma-induced mutation and a whole genome sequencing approach is being followed, while in the case of barley natural variation is being identified following a candidate gene approach. In both cases, the mutant traits are recessive. Hence, breeding programs would greatly benefit from marker technology to rapidly introduce these traits into farmer-preferred varieties.

In terms of capacity building, the workshop on coffee mutation induction involving some six Latin American countries proved a great success. The workshop also presented an excellent opportunity to interact with key actors from the participating countries involved in coffee improvement and has triggered new opportunities for joint R&D under the CRP 'Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana'. In the context of this workshop, the PBGL team produced a training manual to share protocols of R&D conducted at the PBGL on coffee mutation induction with the workshop participants.

To streamline international germplasm exchange in the context of TCP and CRPs, the list of crops registered for import into Austria, particularly from non-EU countries, has been expanded from four to 22 with supporting guidelines and Standard Operating Procedures updated to ensure timely delivery of germplasm.

With regards to outreach, a new PBGL folder, presenting an overview of our R&D, training, services and networking activities, has been prepared along with leaflets on PBGL's flagship R&D projects on coffee leaf rust, banana Fusarium wilt TR4 and resistance breeding for Striga in sorghum and rice.

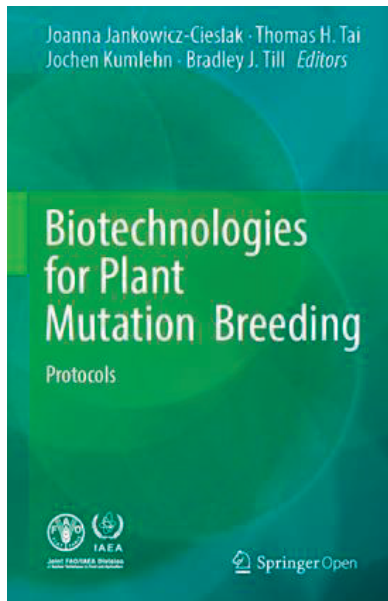
PBGL's country info sheets always attract a lot of interest from our many visitors and are currently being updated.

In due time, this information will be placed on the new IAEA website that is being constructed.

More details on PBGL R&D, crop irradiation services and capacity building efforts is given below.

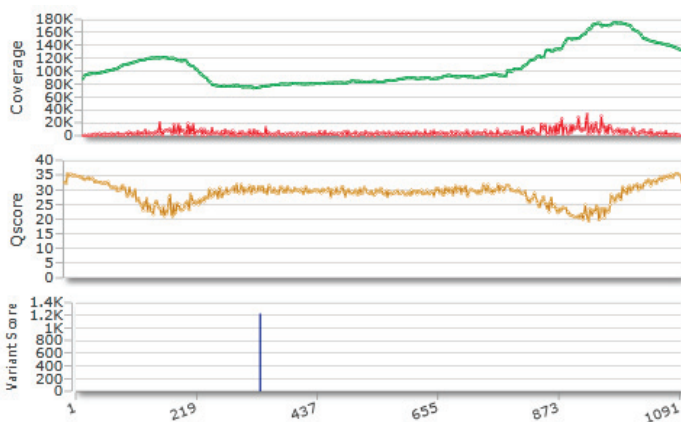
## Improving Methods for the Characterization of Mutant Plants

The continual development of new technologies for the discovery and characterization of natural and induced plant mutations makes the PBGL an exciting place to work. What we have learned in recent years is that the act of inducing mutations, screening mutant populations and introgressing mutant alleles controlling important traits can be made much more efficient. We are pleased to announce that we have just published a book of protocols developed through CRP D2.40.12 on 'Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline'. This book offers 19 detailed protocols on the use of induced mutations in crop breeding and functional genomics studies, which cover topics including chemical and physical mutagenesis, phenotypic screening methods, traditional TILLING and TILLING by sequencing, doubled haploidy, targeted genome editing and low-cost methods for the molecular characterization of mutant plants that are suitable for laboratories in developing countries. The collection of protocols equips users with the techniques they need in order to start a program on mutation breeding or functional genomics using both forward and reverse genetic approaches. Methods are provided for seed and vegetatively propagated crops (e.g. banana, barley, cassava, jatropha, rice) and can be adapted for use in other species.



*The new book on biotechnologies for plant mutation breeding is open access and free to download.*

While we are happy with the development of many new protocols to facilitate plant mutation breeding, there is still more work to be done at the PBGL. Since the last newsletter we have established in-house bioinformatics pipelines for the discovery of natural and induced SNPs, small and large indels. Our work has focused on banana, barley, cassava, rice and tomato. Our focus has been on developing efficient methods for both whole genome and amplicon based sequencing. We have recently optimized methods for amplicon sequencing of products above 600 bp using sonication methods. Pooling experiments are underway to maximize throughput while maintaining accurate mutation discovery. We are currently exploring how different three dimensional pooling schemes can be best implemented. Bioinformatics analysis is being modified accordingly.



*Data on the coverage (top), quality (middle) and nucleotide variant (bottom) from a 1091 bp fragmented PCR product.*

With these methods optimized, the PBGL now has validated platforms for whole genome sequencing for indel discovery in small to medium genome size crops (such as sorghum, rice, banana and coffee) and amplicon based approaches that can be applied to any crop. Experiments are planned for 2017 to continue this work.

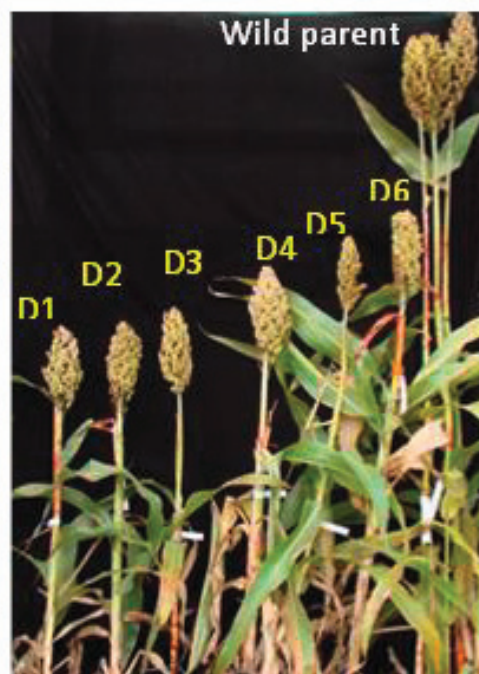
## **Towards Marker Development for a Semi-Dwarf Mutant Trait in Sorghum**

The PBGL has initiated a programme for development of molecular markers for important mutant traits to facilitate their wider utilization by Member States. The initiative started with pilot examples in food security crops such as cereals and legumes to establish the protocols and then gradually expand to other crops. The approach is expected to enable wider utilization of available useful mutant germplasm by Member States and avoid the need for redoing mutation induction program for the same traits. A semi-dwarf mutant trait in sorghum was chosen in the pilot phase of marker development at the PBGL. The mutation was induced by gamma irradiation in a tall farmer-preferred sorghum variety, Wad Ahmed, from Sudan. The trait is recessive and assumed to be controlled by a single gene. The mutant is useful as an agronomically important trait for semi-dwarf plant height, which reduces loss in yield due to lodging, enhances response to fertilizer application, facilitates mechanized combine harvesting in large scale farming systems and is a critical trait in hybrid sorghum breeding. The mutant is also associated with early maturity and enhances stay-green at maturity, which is useful for tolerance to terminal drought and in forage sorghum production. The mutant is expected to improve yield, maximize crop potential and secure production in terminal drought prone areas. Since the semi-dwarf trait is recessive, development of a functional marker will facilitate rapid introgression of the mutant trait widely into farmer's preferred open pollinated varieties and inbred lines for hybrid production. This season (June–October 2016), six sisters, fairly homogenous,  $M_6$  lines were planted together with the wild parent Wad Ahmed in the field of the PBGL. The material was phenotyped for the mutant trait and associated agronomic characteristic, such as plant height, flowering/maturity period, biomass, etc. Sample DNA was collected from each line and the wild parent for sequencing. Inter-crossing is planned for allelism test and development of population for marker-phenotype linkage analysis. The availability of a marker would allow reducing the time for introgression of the trait in a backcross breeding program as it would obviate the need for selfing after each backcross to enable identification of individuals carrying the recessive gene to be further backcrossed to the recurrent parent. Thus, in a typical



backcross scheme of 8–10 generations of crossing and selfing, the number of generations can be reduced by half to 4–5 generations. Furthermore, combining marker selection with our developed rapid cycling cultivation protocol in sorghum (four cycles per year) this can be

achieved in 1–2 years, a significant gain in time. The mutant trait may link with the ongoing CRP on animal feeding and the planned CRP on drought and the material might also be useful in the context of the *Striga* CRP for screening.



*Mutant lines and wild parent in the field of PBGL, Sept 2016, used for training of fellows from Member State on mutant line development, selfing and phenotyping of the different dwarf mutant lines and wild parent, and development of molecular marker for the mutant trait.*

## Kits

The PBGL has developed positive control kits to assist Member States in optimizing PBGL protocols in their own laboratories for their own species. Each kit contains a detailed protocol along with the material needed to successfully complete the protocol. Kits are available upon request.

Kits distributed since the last newsletter:

- Low cost DNA extraction kits: Iran, Costa Rica.
- Low cost enzyme extraction for mutation discovery: Iran, Costa Rica.

## Professional Networking

The PBGL thanks all of you who have connected with us on LinkedIn. If you haven't done so already, please feel free to connect (<http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3>).

## Human Capacity Development

### Group Training on Low Cost Methods for Mutant Plant Characterization

An *ad hoc* training course on low cost methods for mutant plant characterization, including DNA extraction and enzymatic mismatch cleavage, was held in Karaj, Islamic Republic of Iran on July 26 and 27.



*Training was carried out in the molecular biology laboratories in Karaj.*

## Crop Irradiation Services

During 2016, 50 requests for crop irradiation have been handled with the total number of requests reaching 1490. Crops or plant species not previously irradiated include chia, horse gram (one of the lesser known beans), common liverwort and *Boechera divaricarpa* (spreadingpod rockcress).

Request number	Country	Species
1441	Cambodia	Cassava
1442	Tanzania, United Rep. of	Maize, Barley
1443	Uzbekistan	Paulownia
1444	Germany	Various ornamental plants
1445	Côte d'Ivoire	Maize
1446	Sri Lanka	Onion
1447	Nepal	Rice
1448	Germany	<i>Salvia hispanica</i> (chia)
1449	Burkina Faso	Rice
1450	Oman	Date palm, Banana
1451	Cambodia	Cassava
1452	Sudan	Pearl Millet, Sorghum, Groundnut
1453	Sierra Leone	Cassava, Cowpea, Maize, Soybean
1454	Czech Republic	Barley
1455	Mongolia	Wheat, Oat, Rye, Barley, Soybean, Pea, Flax
1456	UK/India	Watermelon
1457	Germany	Various ornamental plants
1458	Niger	Sesame
1459	Spain	Citrus clementine
1460	Burkina Faso	Rice, Cowpea
1461	Sri Lanka	Mung bean, Soybean, Millet, Cowpea, Chilly, Onion, Sorghum, Horse gram
1462	Bulgaria	Wheat
1463	Eritrea	Barley
1464	Mauritania	Rice

Request number	Country	Species
1465	Germany	Various ornamental plants
1466	Libya	Barley
1467	Hungary	Ornamental plants
1468	Italy	Strawberry
1469	Iraq	Cowpea
1470	Austria	Wheat
1471	Germany	Ornamental plants
1472	Spain	<i>Marachantia polymorpha</i> (common liverwort)
1473	Namibia	Maize
1474	Tanzania, United Rep. of	Wheat, Barley
1475	Congo, Democratic Republic of	Maize
1476	Mozambique	Sorghum, Pearl millet
1477	Romania	Pea
1478	T.T.U.T.J. of the Palestinian A.	Durum wheat, Barley
1479	Cameroon	Maize
1480	Tanzania, United Rep. of	Sorghum, Rice
1481	Netherlands	Dahlia
1482	Guatemala	<i>Coffea arabica</i>
1483	Honduras	<i>Coffea arabica</i>
1484	Nigeria	<i>Vigna unguiculata</i> (cowpea)
1485	Costa Rica	<i>Coffea arabica</i>
1486	El Salvador	<i>Coffea Arabica</i>
1487	Burundi	Cassava
1488	UK	Hosta
1489	Sri Lanka	<i>Eleusine coracana</i> (finger millet), <i>Zea mays</i> , <i>Vigna radiata</i> (mung bean)
1490	Germany	<i>Boechera divaricarpa</i> (spreadingpod rockcress)

## Individual Training Activities

Name	Country	Status	Topic / Areas of Training	Period
Mr Yassier Anwar	Indonesia	Scientific Visitor	Mutation induction in barley, screening and accelerated breeding	April 2016
Mr Mohammed Jouhar	Syrian Arab Republic	Scientific Visitor	Development of low cost method for disease diagnostic	May 2016
Ms Sneha Datta	India	Intern	Plant mutation detection	October 2015–October 2016
*Ms Lina Kafuri	Colombia	Intern	Discovery of natural mutations in cassava	August 2015–February 2016
*Mr Daniel Tello	Colombia	Intern	Discovery of natural mutations in cassava	August 2015–February 2016
**Ms Prateek Gupta	India	Intern	Plant mutation detection	June–July 2016
Mr Luka Jarc	Slovenia	Intern	Plant mutation detection	October 2016–March 2017
Mr Harimialimalala Jhonny Rabefiraisana	Madagascar	Individual Fellow	Mutation detection in maize and rice	October 2015–February 2016
Ms Reunreudee Kaewcheenchai	Thailand	Individual Fellow	Mutation detection in rice	October 2015–February 2016
Mr Romaric Nzoumbou-Boko	Central African Republic	Individual Fellow	Mutation detection in cassava	September–February 2015
Ms Geralde Gado Yamba Kassa	Central African Republic	Individual Fellow	Mutation detection in cassava	September 2015–February 2016
Ms Junatsu V. Sesay	Sierra Leone	Individual Fellow	Mutation induction	January–March 2016
Mr Farooq Azam	Pakistan	Individual Fellow	Mutation detection in wheat	March–May 2016
Mr Hamid Bachiri	Algeria	Individual Fellow	Mutation detection/phenotyping	March–May 2016
Mr Vichai Purupunyavanich	Thailand	Individual Fellow	Mutation detection/genotyping in rice	March–June 2016
Mr Zeremariam G. Mosazghi	Eritrea	Individual Fellow	Mutation detection/phenotyping	March–May 2016
Mr Alfred Ubalus	Nigeria	Individual Fellow	Mutation induction	April–May 2016
Ms Dina Aker	Palestine	Individual Fellow	Mutation induction and detection	September–October 2016
Mr Omar Hassan	Sudan	Individual Fellow	Mutation induction and detection	September–December 2016
Mr Nafeti Mheni	Tanzania, United Republic of	Individual Fellow	Mutation induction and detection	September 2016–February 2017
Ms Habibah Al-Menai	Kuwait	Individual Fellow	Mutation induction and detection	September–November 2016
Ms Munasingha J.P. Kumararathna	Sri Lanka	Individual Fellow	Mutation induction and detection	October–December 2016
Ms Ala Lahlouh	Palestine	Individual Fellow	Mutation induction and detection	September–October 2016
Mr Cheikh Ahmed El Moctar	Mauritania	Individual Fellow	Mutation induction and detection	September–December 2016
Mr Abiud Ujama Mbunguha	Namibia	Individual Fellow	Mutation induction and detection	August 2016

\*Funded by CIAT (Centro Internacional de Agricultura Tropical), Cali, Colombia; \*\*Funded by the University of Hyderabad, India.



## Visitors to the PBGL

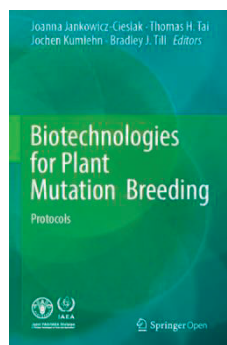
In 2016 until the time of writing, we have welcomed about 38 visitor groups representing some 53 different Member States from all continents.

In September 2016, on the occasion of the IAEA Annual General Conference, HSH Prince of Monaco visited the Agency's Laboratories in Seibersdorf, Austria. Among the many visitors to PBGL were delegates to the General Conference, government officials, representatives from R&D organizations and charitable foundations, students and fellows from IAEA or universities from various FAO or IAEA Member States such as: Austria, Bahrain, Belgium, Benin, Bulgaria, Cyprus, Denmark, Estonia, a

large delegation from the Small Island Developing States covering islands in the Pacific and Caribbean region, Brazil, Bulgaria, Canada, China, Costa Rica, Democratic Republic of Congo, Ethiopia, the EU, France, Germany, Greece, Hungary, Indonesia, Iraq, Japan, Kenya, Latvia, Malaysia, Namibia, Nepal, the Netherlands, the Philippines, Poland, Portugal, Republic of Korea, Slovenia, Spain, the San Marino, South Africa Sudan, Sweden, Tunisia, United States of America and Uruguay. The visitors showed great interest in PBGL's research on crop mutation breeding and related capacity building initiatives, and especially how these activities could help address some of the crop improvement challenges in their home countries.

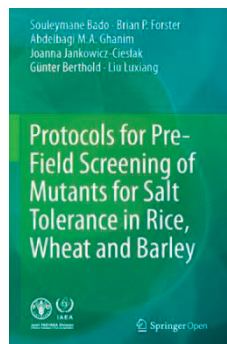
## Publications

### Books



JANKOWICZ-CIESLAK, J., TH.H. TAI, J. KUMLEHN, B.J. TILL, (2016) *Biotechnologies for Plant Mutation Breeding*. Springer ISBN: ISBN 978-3-319-45019-3 (Print) 978-3-319-45021-6 (Online).

<http://www.springer.com/book/9783319450193>.



BADO, S., B.P. FORSTER, A.M.A. GHANIM, J. JANKOWICZ-CIESLAK, J. BERTHOLD, L. LUXIANG (2016) *Protocols for Pre-Field Screening of Mutants for Salt Tolerance in Rice, Wheat and Barley*. Springer ISBN: 978-3-319-26588-9 (Print) 978-3-319-26590-2 (Online).

<http://www.springer.com/us/book/9783319265889>.

### Book Chapters

JANKOWICZ-CIESLAK, J., TILL, B.J. (2016). Chemical Mutagenesis of Seed and Vegetatively Propagated Plants using EMS. *Curr. Protoc. Plant Biol.*, 1: 617-635.

HOFINGER, B.J., HUYNH, O.A., JANKOWICZ-CIESLAK, J., TILL, B.J. (2016). A Protocol for Benchtop Extraction of Single-Strand-Specific Nucleases for Mutation Discovery. Chapter 15 in: *Biotechnologies for*

*Plant Mutation Breeding*. Jankowicz-Cieslak et al. (eds), Springer, pp. 241-251.

HUYNH, O.A., JANKOWICZ-CIESLAK, J., SARAYE, B., HOFINGER, B., TILL, B.J. (2016). Low-Cost Methods for DNA Extraction and Quantification. Chapter 14 in: *Biotechnologies for Plant Mutation Breeding*. Jankowicz-Cieslak et al. (eds), Springer, pp. 227-239.

JANKOWICZ-CIESLAK, J., MBA, C., TILL, J.B. (2016). Mutagenesis for Crop Breeding and Functional Genomics. Chapter 1 in: *Biotechnologies for Plant Mutation Breeding*. Jankowicz-Cieslak et al. (eds), Springer, pp. 3-18.

JANKOWICZ-CIESLAK, J., TILL, B.J. (2016). Chemical Mutagenesis and Chimera Dissolution in Vegetatively Propagated Banana. Chapter 3 in: *Biotechnologies for Plant Mutation Breeding*. Jankowicz-Cieslak et al. (eds), Springer, pp. 39-54.

JANKOWICZ-CIESLAK, J., B.J. TILL (2016). Forward and Reverse Genetics in Crop Breeding. Chapter 8 in: *Advances in Plant Breeding Strategies Volume In: Breeding, Biotechnology and Molecular Tools*. J.M. Al-Khayri et al. (eds.), Springer, pp. 215-240.

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MAGHULY, F., BADO, S., JANKOWICZ-CIESLAK, J., LAIMER, M. (2016). Chemical and Physical Mutagenesis in *Jatropha curcas*. Chapter 2 in: *Biotechnologies for Plant Mutation Breeding*. Jankowicz-Cieslak et al. (eds), Springer, pp. 21-38.

TILL, B.J., HOFINGER, B.J., SEN, A., HUYNH, O.A., JANKOWICZ-CIESLAK, J., GUGSA, L., KUMLEHN, J. (2016). A Protocol for Validation of Doubled Haploid Plants by Enzymatic Mismatch Cleavage. Chapter 16 in: Biotechnologies for Plant Mutation Breeding. Jankowicz-Cieslak et al. (eds), Springer, pp. 253-262.

TILL, B.J., S. DATTA, J. JANKOWICZ-CIESLAK. TILLING: The Next Generation. In: Advances in Biochemical Engineering/Biotechnology. Rajeev K. Varshney et al. (eds.), Springer (*in press*).

VOLLMANN, J., JANKOWICZ-CIESLAK, J. (2016). Utilising NIRS for Qualitative and Non-destructive Identification of Seed Mutants in Large Populations. Chapter 12 in: Biotechnologies for Plant Mutation Breeding. Jankowicz-Cieslak et al. (eds), Springer, pp. 193-202.

## Peer-reviewed Journal Articles

BADO, S., RAFIRI, M.A., EL-ACHOURI, K., SAPEY, E., NIELEN, S., MUKTHAR, A.A., FORSTER, B.P., LAIMER, M. (2016). *In vitro* methods for mutation induction in potato (*Solanum tuberosum* L.). African Journal of Biotechnology. Vol. 15(39): 2132-2145.

BADO, S., LAIMER, M., GUEYE, N., DEME, N.F., SAPEY, E., MUKTHAR, A.A., BLOK, V.C., FORSTER, B.P. (2016). Micro-Tuber Production in Diploid and Tetraploid Potato after Gamma Irradiation of *in Vitro* Cuttings for Mutation Induction. American Journal of Plant Sciences, 7: 1871-1887.

BADO, S., FORSTER, B.P., PADILLA-ALVAREZ, R., RESCH, C., MIGLIORI, A., DIAWARA, Y., JAKSIC, M., MUKTHAR, A.A., NIELEN, S., LAIMER, M. (2016). Prediction of Salt Tolerance in Rice (*Oryza sativa*) Based on Shoot Ion Content under Non-Stressed Conditions. Journal of Materials Science and Engineering A 6 (1-2): 1-16.

BESHIR M.M., A.M. ALI, P. RUBAIHAYO, N.E. AHMED, P. OKORI (2016). Simple Sequence Repeat Markers Associated with Anthracnose and Turicum Leaf Blight Resistance in Sorghum. African Crop Science Journal, Vol. 24, No.1: 97–107, ISSN 1021-9730/2016.

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JANKOWICZ-CIESLAK J., B.J. TILL. Chemical Mutagenesis of Seed and Vegetatively Propagated Plants using EMS. Current Protocols in Plant Biology (*in press*).

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Cost SNPs Detection Technology. Acta Horticultura 1114. ISHS 2016. DOI 10.17660/ActaHortic.2016.1114.6 XXIX IHC – Proc. Int. Symp. Banana: ISHS-ProMusa Symposium on Unravelling the Banana's Genomic Potential Eds.: I. Van den Bergh et al.

MASHEVA, S., V. YANKOVA, D. MARKOVA, T.S. LAZAROVA, M. NAYDENOV, N. TOMLEKOVA, F. SARSU, T.S. DINCHEVABADO (2016). Use of Microbioagents to Reduce Soil Pathogens and Root-knot Nematodes in Greenhouse-grown Tomatoes. Bulgarian Journal of Agricultural Science 22(1): 91–97.

NANDKANGRE, H., OUEDRAOGO, M., SAWADOGO, M., BADO, S., SAWADOGO, N., OUOBA, A., KONATE, M.N. (2016). Morphometric and agronomic characterization of 56 ginger landraces in Burkina Faso. Journal of Applied Biosciences 100:9545 – 9556.

NANDKANGRE, H., OUEDRAOGO, M., NANEMA, R.K., BADO, S., OUEDRAOGO, N., SAWADOGO, M. (2016). Variability, Correlations, Heritability and Genetic Advance of Rhizome Yield and Yield Related Traits in Ginger (*Zingiberofficinale* Rosc.) Landraces from Burkina Faso. Journal of Applied Environmental and Biological Sciences 6(8): 54-60.

OLASUPO, F.O., ILORI, C.O., FORSTER, B.P., BADO, S. (2016). Mutagenic Effects of Gamma Radiation on Eight Accessions of Cowpea (*Vigna unguiculata* [L.] Walp.). American Journal of Plant Sciences, 7: 339-351.

TOMLEKOVA, N. SOFKOVA-BOBCHEVA, S.Y., SARSU, F. AND BAUDIN, J.-P. (2016). Genetic diversity of Bulgarian *Phaseolus vulgaris* L. Based On phaseolin type and seed-coat colour. Bulgarian Journal of Agricultural Science, Agricultural Academy. 22 (No 3): 447–451.

TOMLEKOVA N., YANCHEVA S., SARSU F., CHUPOV A., PENCHEV E., MASHEVA S. (2016). Adaptation of HPLC analysis for quantification of main carotenes in tomato. Comptes rendus de l'Académie Bulgare des sciences, 69(7): 869–876.

VELKOV, N., N. TOMLEKOVA, F. SARSU (2016). Sensitivity of Watermelon Variety Bojura to Mutant Agents 60Co and EMS. Journal of BioSci Biotech. 5: 105–110.

## Conference Abstracts

DATTA, S., J. JANKOWICZ-CIESLAK, B.J. HOFINGER, S. BADO, S. NIELEN, I. HENRY, L. COMAI, B.J. TILL (2016). TILLING by Sequencing. International Conference on Plant Genetics & Breeding Technologies II, Vienna, Austria, 1–2 February 2016, Abstract Book pp.15.

GHANIM, A.M.A., N.S. MUSTAFA, N.M.K. OMER, S. BADO, F. SARSU, S. NIELEN (2016). Optimization of Doubled Haploid Production for Enhancing Efficiency of Wheat Mutation Breeding. International Conference on Plant Genetics & Breeding Technologies II, Vienna, Austria, 1–2 February 2016, Abstract Book pp. 30.

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## Websites and Links

- Plant Breeding and Genetics Section:

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

<https://www.iaea.org/about/plant-breeding-and-genetics-section>

- InfoGraphic on Mutation Breeding:

<http://www-naweb.iaea.org/nafa/resources-nafa/Plant-Mutation-breeding.mp4>

- Mutant Variety Database:

<http://mvd.iaea.org>

- IAEA Plant Breeding and Genetics LinkedIn:

<http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3>

- Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture:

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

<http://www.iaea.org/topics/food-and-agriculture>

- Joint FAO/IAEA Publications

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

- Food and Agriculture Organization of the United Nations (FAO):

<http://www.fao.org/home/en/>

- FAO Agriculture and Consumer Protection Department:

[http://www.fao.org/ag/portal/index\\_en/en/](http://www.fao.org/ag/portal/index_en/en/)

### Impressum

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