Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

# Plant Breeding & Genetics Newsletter

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## To Our Readers

*Coffee Leaf Rust – Photo by The American Phytopathological Society.*

Major challenges facing humanity include climate variability and change with an impact on food security and agricultural development, health, elimination of poverty and management of water resources, together with the need for a cleaner and safer environment. In this regard, nuclear technologies have proven efficient to help meet these challenges. New crop varieties are bred with higher and more stable and sustainable yield potentials, with higher adaptability and resilience to climate variability and change. The use of mutation induction for creating useful new germplasm and developing new cultivars is a profitable approach to improvement.

In 2015, we supported 52 national and regional TC projects. The major focus of these projects, especially the regional ones, is on adaptability and resilience to the negative effects of climate variability and change on agronomic productivity. For Latin America and sub-Saharan Africa, drought and heat are major constraints of crop production. Breeding drought tolerant varieties of staple crops providing the preferred consumer quality and market traits is a challenge for breeders. Floods are the most frequent calamities amongst all natural disasters and East Asia and the Pacific region, along with South Asia, are particularly vulnerable. Climate change and variability are

expected to bring about increased typhoon activity, rising sea levels and out-of-phase monsoon seasons in South East Asia and other regions. Mitigating this situation requires an integrated approach to develop technology packages of mutant lines (broader adaptability to warrant sustainable high yield under variable climatic conditions) with proper water and nutrient utilization practices. In this context, mutation induction techniques have shown potential as a valuable tool in developing improved crop cultivars tolerant to flood/submergence.

In 2015, we organized a number of successful workshops, regional and national training courses, focusing inter alia on Nutrient Management and Farm Management Strategies to Improve Crop-Water Productivity Using AquaCrop Model (RAS/5/065), Mutation Breeding Techniques for Crop Improvement (SRL/5/045), Phenotyping and Genotyping of Mutants for Abiotic Stresses (RAS/5/058), Mutation Detection Methods Applied to Floods (RAS/5/069) Induced Mutation in Seed Propagated Crops for Crop Improvement (RAF/5/066) (which you can read about in this newsletter).

In 2016, we will start two new Coordinated Research Projects (CRPs). One will be on Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security. The aim of this CRP will be to support the generation of novel sources of variation, using mutation breeding, by developing efficient screening protocols for *Striga* resistance in cereals for research capacity building and improvement of food security in Member States.

Another CRP will be on Efficient Screening Techniques for Mutants with Disease Resistance for Coffee and Banana. Globally 10% of crop yield is lost due to disease. Local damages can be up to 100%, which means losses of billions of dollars annually. Pathogens are rapidly evolving and suitable genetic diversity is lacking in many crops, e.g. in coffee and banana. Mutation induction is a safe and effective method to enhance disease resilience by creating genetic resistance as a proven approach. The threat of yield loss due to disease is ever-present and will remain a breeding goal in future endeavors.

Coffee is the second most traded commodity in the world after crude oil. Coffee leaf rust (CLR, *Hemileia vastatrix*, also known as 'Roya') disease kills coffee plants by withering the leaves. Further, a new project on Capacity Building for Latin American Countries against Coffee Leaf Rust, sponsored by a grant of the OPIC Fund for International Development (OFID) will be implemented from Plant Breeding and Genetics Subprogramme of the Joint FAO/IAEA Division. The objective of this project is to establish a global R&D network, centered in Latin America, based on resistance to CLR mutation breeding and efficiency enhancing biotechnologies, to increase capabilities to fight CLR effectively in coffee producing Member States. The project aims at drawing participation from national agricultural research systems, which have existing programs and expertise, in coffee breeding, propagation, biotechnologies and pathology. The Joint FAO/IAEA Plant Breeding and Genetics Laboratory (PBGL) is spearheading the development of suitable technologies.

As the importance of Agriculture for Development is paramount (World Bank Report 2008), we will facilitate the use of nuclear technologies in Member States to contribute to global food security. We will further develop integrated technology packages, protocols and guidelines to enhance crop tolerance to environmental stress, adaptation to climate change, quality breeding, and crop/biomass productivity.

In this spirit, we are eager to collaborate with you for generating plenty of success stories in 2016. Please accept my best wishes of Peace, Health and Prosperity for a brilliant 2016.

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

# Staff

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

| Name | Title | Email | Extension |
|---|---|---|---|
| Qu Liang | Director | q.liang@iaea.org | 21610 |

## Plant Breeding and Genetics Subprogramme

| Name | Title | Email | Extension |
|---|---|---|---|
| Pierre J.L. Lagoda | Section Head | p.lagoda@iaea.org | 21626 |
| Stephan Nielen[1] | Plant Breeder/Geneticist | s.nielen@iaea.org | 21617 |
| Ljupcho Jankuloski[2] | Plant Breeder/Geneticist | l.jankuloski@iaea.org | 21623 |
| Fatma Sarsu | Plant Breeder/Geneticist | f.sarsu@iaea.org | 21618 |
| Madeleine Spencer[3] | Consultant | m.spencer@iaea.org | 26844 |
| Katayoun Allaf | Programme Assistant | k.allaf@iaea.org | 21621 |
| Luis Mauricio Alfonzo Godoy | Team Assistant | l.m.alfonzo-godoy@iaea.org | 21620 |
| | | | |
| Vacant | Laboratory Head | | |
| Bradley J. Till | Plant Breeder/Geneticist | b.till@iaea.org | 28260 |
| Adelbagi Mukhtar Ali Ghanim | Plant Breeder/Geneticist | a.mukhtar-ali-ghanim@iaea.org | 28268 |
| Mirta Matijevic | Technician | m.matijevic@iaea.org | 28317 |
| Joanna Beata Jankowicz-Cieslak | Technician | j.jankowicz@iaea.org | 28275 |
| Bernhard Hofinger | Technician | b.hofinger@iaea.org | 28279 |
| Guenter Berthold | Technician | g.berthold@iaea.org | 28418 |
| Andreas Draganitsch | Technician | a.draganitsch@iaea.org | 28418 |
| Souleymane Bado | Technician | s.bado@iaea.org | 28208 |
| Joanna Malgorzata Mletzko | Team Assistant | j.mletzko@iaea.org | 28362 |

**Plant Breeding and Genetics Section**
Vienna International Centre, Wagramer Strasse 5, P.O. Box 100, 1400 Vienna
Phone: +431 2600 + extension; Fax: +431 26007; Email: Official.Mail@iaea.org

**Plant Breeding and Genetics Laboratory**
FAO/IAEA Agriculture and Biotechnology Laboratories, 2444 Seibersdorf, Austria
Phone: +431 2600 + extension; Fax: +431 26007; Email: Official.Mail@iaea.org

[1] Acting Laboratory Head
[2] Acting Section Head
[3] Started in October 2015

# Staff News

## Consultant

I have the pleasure to introduce Ms Madeleine Spencer who will accompany the Plant Breeding and Genetics subprogramme as a consultant for six months.

Ms Spencer had served eight years at the IAEA as a Technical Officer and Research Coordinator, being efficiently involved in the organization and implementation of the Plant Breeding and Genetics subprogramme activities. She based her job on her research and teaching expertise to ensure the efficient and effective development and implementation of research projects, trainings and scientific as well as technical knowledge dissemination, and assisting in the evaluation and implementation of technical cooperation for IAEA and FAO.

Ms Spencer is Associate Professor at the Université Cheikh Anta DIOP in Dakar, Senegal with 20 years of experience in teaching. Her research is mostly related to plant tissue culture, plant genome analysis, and plant mutation breeding with a focus on cowpea and soybean at the Université Cheikh Anta DIOP, Dakar, Senegal and University of Tennessee, Knoxville (USA).

As a consultant she will support PBG subprogramme in the preparation of internal and public relations' documents and assist in formulation of coordinated research project related to nuclear and other advanced technologies in plant breeding.

# Forthcoming Events

## Regional AFRA Training Course on Farmer Participatory Plant Breeding Approach for Dissemination of Mutant Varieties, RAF/5/066, Harare, Zimbabwe, 29 February–4 March 2016

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

This training course will be organized by the International Atomic Energy Agency in cooperation with the Government of Zimbabwe through Crop Breeding Institute (CBI), Department of Research and Specialist Services (DR&SS), Ministry of Agriculture, Mechanisation and Irrigation Development (MAMID). It is open to project partners/candidates from the project RAF/5/066 (AFRA) on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA).

The purpose of this course is to provide participants with theoretical as well as practical information on 1) Mutation breeding for crop improvement; 2) Learning the methodologies of participatory plant breeding from invited experts; and 3) The chance to consult with experts for developing and improving the workplan of participatory plant breeding at their home institute.

The course will include lectures and practical sessions on:

- Mutation breeding for crop improvement;
- Statistical analysis of on-farm participatory varietal selection (PVS);
- Participatory varietal selection;
- Identifying farmers' needs;
- Searching for suitable material to test with farmers;
- Experimentation on farmers' fields.

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

# Regional Training Course on Mutation Detection Methods Applied to Floods, RAS/5/069, Putrajaya, Malaysia, April 2016 (exact date to be decided)

Technical Officers: L. Jankukoski and P.J.L. Lagoda

Floods are the most frequent disaster amongst all natural disasters and East Asia and the Pacific region, along with South Asia are particularly vulnerable. Climate change and variability are expected to bring about increased typhoon activity, rising sea levels and out-of-phase monsoon seasons in South East Asia and other regions. Mitigating this situation requires an integrated approach to develop technology packages of mutant lines (broader adaptability to warrant sustainable high yield under variable climatic conditions) with proper water and nutrient utilization practices. In this context, mutation induction techniques have shown potential as a valuable tool in developing improved crop cultivars tolerant to flood/submergence.

The purpose of this training course is to introduce participants of TC project RAS/5/069 on Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia to modern techniques in mutation breeding combined with efficiency enhancing biotechnologies in theoretical as well as practical information to improve the capacity to develop resilience/adaptation of agricultural production systems to flooding events in generating flood/submergence tolerant crops using nuclear techniques.

The training course will include lectures on:

- Modern techniques in mutation breeding and detection methods for submergence tolerance;
- Marker Assisted Selection (MAS) for submergence target traits;
- Collaborative networks for advanced mutation breeding, agronomic evaluation and molecular screening.

Participants will be able to discuss specific breeding issues and learn about the most suitable mutagenesis approach for their target towards flood risk mitigation and post-flood rehabilitation.

The training course is organized by the International Atomic Energy Agency (IAEA) in collaboration with the Malaysian Nuclear Agency and the Government of Malaysia.

Participants will be plant breeders and geneticists from participating Member States involved in project RAS/5/069.

# First Regional (AFRA) Coordination Meeting on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach, RAF/5/076, Dakar, Senegal, 18–22 April 2016

Technical Officer: F. Sarsu

After the initial meeting in 2014 in Windhoek, Namibia and the second coordination meeting of the project in 2014 in Mombasa, Kenya, this will be the third coordination meeting of the TC project RAF/5/066 and also the first coordination meeting of the upcoming project (RAF/5/076). During the previous cycles the regional project has quite efficiently assisted Members Sates in improving their own crop breeding programmes through the use of radiation induced mutations in crops improvement, first by establishing strong and reliable capacity in the use of mutation induction, and also by creating the conditions for the association of modern and advanced plant biotechnologies to such programmes.

Member States focus in many instances on dissemination and promotion of mutant crop varieties that have already been produced. Member States also focus on strengthening of regional capability for developing and promoting drought tolerant varieties as well as varieties of traditional and neglected African crops. The genetic improvement of underutilized/neglected crops such as bambara groundnut, amaranth, safflower and cocoyam through mutation and *in vitro* techniques have also been included in previous programmes and most of these are still on-going and require further assistance. In addition, to meet the growing needs of food processing industries such as grains for beer companies and cassava for starch production, there will be a focus on market-oriented crops which will be developed to meet specific requirements.

The objectives of this meeting are:

- To review and analyze the results achieved at regional level within project RAF/5/066;
- To develop the Project's Completion Report;
- To prepare the achievements at the regional and national level of TC project RAF/5/066 to be highlighted in the project completion report;
- To review workplan of the new TC project RAF/5/076 on Improving Crops by Using Mutation Induction and Biotechnology through a Farmer Participatory Approach and agree on regional and national plans for the activities to be implemented during 2016–2019.

## Regional (AFRA) Training Course on Field Experimental Design and Data Analysis in Mutation Breeding, RAF/5/066, Cotonou, Benin, 9–14 May 2016

Technical Officer: F. Sarsu
Course Director: C.B. Gandonou

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

The purpose of this course is to provide participants with theoretical as well as practical information on 1) Learning the statistical methods used for designing field and laboratory trials and for accurate and efficient analysis of data from those trials; 2) Improving breeding efficiency through application of appropriate experimental designs and analysis models; and 3) Application of mutation breeding for crop improvement.

The course will include lectures and practical sessions on:

- Application of mutation breeding for crop improvement;
- Establishment of the proper starting material for specific project objectives;
- Breeding procedures, methodologies and handling of mutated population;
- Experimental Designs for Accurate data collection, analysis and interpretations;
- Design and analysis of experiments;
- Randomization/replication/control of experimental error;
- Computer applications to agricultural experiments using statistical packages;
- Statistical analysis for breeding;
- Analysis of variance for plant breeding;
- Analysis of multiple locations and years;
- Interpretations of statistical data for crop improvement;
- Stability and its importance in plant breeding;
- Using molecular marker data to detect mutations and use of markers in breeding.

The participants should be from all participating Member States involved in project RAF/5/066. Additionally, they should be currently and actively working on mutation breeding and have basic knowledge in crop breeding. The course will surely enrich scientists with at least a M.Sc. degree involved in plant breeding/genetics. Participants should have a strong affinity and interest in modern plant breeding methods involving induced mutation, mutation screening (high-throughput phenotyping and genotyping) and techniques that can facilitate the breeding process.

## IAEA/RCA Training Course on The Applications of *In Vitro* Techniques in Mutation Breeding of Bioenergy Crops, RAS/5/070, Jakarta, Indonesia, 23–27 May 2016

Technical Officer: F. Sarsu
Course Director: S. Human

This training course will be organized by the International Atomic Energy Agency in cooperation with the Government of the Republic of Indonesia through the Centre for Isotopes and Radiation Application (CIRA), National Nuclear Energy Agency (BATAN). It is open to project partners/candidates from the TC project RAS/5/070 (RCA) on Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques.

The purpose of the training course is to provide participants with theoretical and practical information on the application of *in vitro* techniques in mutation breeding including screening of target traits for bioenergy crops.

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

- Basis of plant biotechnology and mutation induction;
- Use of *in vitro* techniques in mutation breeding;
- Handling of sub-sequent *in vitro* derived mutated populations;
- Establishment of adequate screening protocols *in vitro* and/or *in vivo*;
- Utilization of appropriate technologies for mutation screening for target traits in bioenergy crops.

The participants should be from all participating Members States involved in project RAF/5/070. Additionally, they should be currently and actively working on mutation breeding in particular bioenergy crops and should be scientists with at least a M.Sc. degree involved in plant breeding/genetics. Participants should have a strong affinity and interest in modern plant breeding methods involving induced mutation, mutation screening (high-throughput phenotyping and genotyping) and techniques that can facilitate the breeding process.

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

Technical Officer: C.M. Blackburn

(Food Irradiation Specialist, Food and Environmental Protection Section, Joint FAO/IAEA Division, Email: c.blackburn@iaea.org)

**Breaking News:** Just as this Newsletter was being finalized, the National Agriculture and Food Research Organization (NARO) of Japan and the Joint FAO/IAEA Division initiated a joint project to hold a Technical Workshop on Remediation of Radioactive Contamination in Agriculture. A two day meeting at IAEA headquarters in Vienna is being planned for 17 and 18 October 2016. Recovery from the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Plant accident is an important cornerstone of NARO's R&D mission and it has been contributing to the development of decontamination technologies for farmland soil, and radionuclide transfer-control technologies for agricultural production. It is envisaged that the Technical Workshop will also include results of agricultural remediation activities from areas affected by the accident at the Chernobyl Power Plant. This year marks the fifth and thirtieth anniversary of both events respectively and there is considerable interest from our member countries on limiting the impact of radio caesium on agricultural production. We will announce more details on the Joint Divisions website in due course.

# Past Events

## Regional Training Course on Nutrient Management and Farm Management Strategies to Improve Crop-Water Productivity Using AquaCrop Model, RAS/5/065, Los Baños, the Philippines, 6–24 July 2015

Technical Officers: L. Jankuloski and P.J.L. Lagoda

The training course was organized jointly by the IAEA and the International Rice Research Institute (IRRI). The local coordinator was Dr Abdelbagi M. Ismail, Principal Scientist and Coordinator.

Rice is the most important food crop contributing to food security and sufficiency in the Asia Pacific region. However, despite the advances in increasing yields, several biotic (disease and pest) and abiotic (drought, flood) factors continue to limit productivity.

The purpose of this training course was to introduce the national collaborators of RAS/5/065 participating Member States to modern techniques in mutation breeding and in the use of integrated technology packages based on best fit soil and water management practices and mutation induction combined with efficiency enhancing biotechnologies. Researchers from Bangladesh, Cambodia, China, Indonesia, Lao, People's Democratic Republic, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, Viet Nam participated in this training course which focused on:

- Mutation breeding;
- Rice breeding and screening methodologies for abiotic stress tolerance;
- Nutrient management using isotopic techniques (N-15);
- Nitrous oxide emission under flooded rice field;
- FAO's AquaCrop model for improving crop-water productivity.

The training course was held in three-week modules:

**Module 1:**

a) AquaCrop model for predicting crop production under different water-management conditions (rain fed and irrigated) under present and future climate change conditions and under different management strategies.

b) Mutation breeding for crop improvement (concept and use of mutation induction in plant breeding, screening techniques for selecting mutant lines, techniques for detection of mutated genes).

**Module 2:**

a) Plant biotechnologies applied in rice breeding.

b) The use of nitrogen-15 technique for determining fertilizer use efficiency under flooded rice conditions.

**Module 3:**

a) Nitrous oxide emission under flooded rice conditions.

b) Rice breeding for abiotic stress tolerance.

The training course is part of the regional project RAS/5/065 on Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications. The TC project RAS/5/065 builds on the progress made under different national and regional TC projects, which already produced some segregating mutant lines with improved agronomic characters.

*Training course participants.*

## National Training Course on Basic Mutation Breeding Techniques for Crop Improvement, SRL/5/045, Peredeniya, Sri Lanka, 20–24 July 2015

Technical Officer: F. Sarsu
Course Director: W.M.A.D.B. Wickramasinghe

The national training course was part of the TC project SRL/5/045 on Establishing a National Centre for Nuclear Agriculture in Sri Lanka. It was implemented in the Department of Agriculture. Mr Mirza Mofazzal Islam from the Bangladesh Institute of Nuclear Agriculture (BINA) and Mr Muhammad Ashraf from the Pakistan Atomic Nuclear Institute for Agriculture and Biology (NIAB) were invited as lecturers. The training course focused on basic information on mutation breeding, pre-mutation breeding studies, preparations of the mutation breeding project, screening procedures, selections and evaluation of mutants in rice and mungbean resistance to major abiotic and biotic stresses in the field as well as under controlled conditions (greenhouse, *in vitro*), and identification of the best mutant lines and steps to be followed for release.

The training course included lectures and practical sessions on:

- Mutation induction for crop breeding;
- Establishment of the proper starting material for specific project objectives;
- Basic concepts knowledge on mutagenic agent;
- Application of mutation breeding in self-pollinated and cross pollinated crops — Handling of mutated population;
- Basic statistical analysis for plant breeding programme;
- Actual protocols for improving rice through mutation breeding from seed irradiation of three new rice and mungbean varieties;
- Phenotyping and genotyping mutants to screen in field/lab/greenhouse conditions;
- Statistical analysis and evaluation of various radio sensitivity tests.

At the end of the course, round table discussions were conducted and groups were organized to discuss and prepare projects on mutation breeding from irradiation to release of mutant varieties. Also the course participants prepared different mutation breeding programmes on different crops starting from irradiation to the release of new variety. Each of the groups presented a short PowerPoint presentation about the project. The discussions were made through cross-questioning which helped them to fine-tune their projects.

*Training course Participants.*

*Participants evaluating mutant mungbean lines in the field.*

# IAEA/RCA Training Course on Application of Mutation Breeding and Screening of Target Traits in Bioenergy Crops, RAS/5/070, Beijing, China, 24–28 August 2015

Technical Officer: F. Sarsu
Course Director: L. Liu

This training course was organized by the International Atomic Energy Agency in cooperation with the Government of China, Space Breeding Research Center, Department of Mutational Genetics & Crop Breeding, Institute of Crop Sciences (ICS), and Chinese Academy of Agricultural Sciences (CAAS). It was open to project partners/candidates from TC project RAS/5/070 (RCA) on Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques. The training course was attended by 26 participants from Bangladesh (2), China (4), India, Indonesia, Cambodia, Republic of Korea, Malaysia (2), Mongolia (2), Myanmar (2), New Zealand, Pakistan, the Philippines (2), Sri Lanka (2), and Vietnam (2).

The purpose of the training course was to provide participants with theoretical as well as practical information on mutation induction, mutation breeding and related biotechnologies, and screening of target traits for bioenergy crops.

The one-week training course consisted of lectures, demonstrations (laboratory, greenhouse and field), and exercises on;

- Scientific background of mutation induction and its application to crop breeding;
- Handling of sub-sequent mutated populations and identification, evaluation and selection of breeding lines;
- Utilization of appropriate technologies for mutation screening for target traits in bioenergy crops;
- Screening of mutant lines for desired traits of bioenergy crops in the field;

Participants were also able to discuss their specific breeding problems and learn about the most suitable mutagenesis approach for their target bioenergy crops.


*Training course participants.*

# Regional Training Course on Phenotyping and Genotyping of Mutants for Abiotic Stresses in Cereals, RAS/5/058, Seibersdorf, Austria, 5–16 October 2015

Technical Officer: F. Sarsu
Course Director: S. Nielen

This two-week training course was organized in the framework of the regional ARASIA TC project RAS/5/058 entitled Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barely — Phase II. The purpose of this course was to provide participants theoretical background and technical skills in mutation induction, mutation screening and — discovery for breeding crops with improved abiotic stress tolerance. The training course consisted of lectures, demonstrations (laboratory and greenhouse), practical exercises, and discussions of case studies on the following topics:

- Mutation breeding procedures/methodologies and handling of mutated populations and related techniques including tissue culture techniques;
- Genetics and physiology of abiotic stress resistance/tolerance;
- Methodologies for screening of mutant population, identification and detection of mutants for abiotic stress tolerance;
- Utilization of appropriate technologies for mutant phenotyping and genotyping ;
- Low cost genomic DNA extraction and mutation discovery.

Lectures and exercises were provided and supported by PBGL staff. In addition, Mr Michel Ghanim, crop physiologists at ICARDA, Morocco, was invited to teach on the physiological aspects of draught tolerance and to demonstrate and discuss various screening technologies. This was enriched by a lecture on Carbon Isotope Discrimination by Mr Gerd Dercon, Head of the Soil and Water Management and Crop Nutrition Laboratory. The training course thereby not only covered the various aspects of mutation breeding and mutation discovery, it also clearly showed the participants the necessity to consider various perspectives including crop physiology when approaching complex traits such as stress tolerance. In order to create awareness on other nuclear techniques used in the Joint FAO/IAEA programme, a tour through the other four laboratories of the Joint FAO/IAEA Division (Soil and Water Management and Crop Nutrition, Animal Production and Health, Insect Pest Control, and Food and Environmental Protection) was organized.

*Training course Participants.*

The training course was attended by 20 participants, thereof 11 from the ARASIA project, coming from Iraq, Jordan, Oman, Saudi Arabia, Syrian Arab Republic, and Palestine. Three scientific visitors from national TC project in Cote d'Ivoire, Kenya, and Laos, as well as six PBGL fellowship trainees from Albania, Bangladesh, Eritrea, Madagascar, Sudan, and Syrian Arab Republic participated in this course.

## Regional Training Course on Induced Mutation in Seed Propagated Crops for Crop Improvement, RAF/5/066, Accra, Ghana, 12–16 October 2015

Technical Officer: F. Sarsu
Course Director: K. Danso

This training course was organized by the International Atomic Energy Agency in cooperation with the Government of Ghana and Ghana Atomic Energy Commissions (GAEC). The training course was attended by 22 participants from 17 African countries (Algeria, Benin, Burkina Faso, Cameroon, Central African Republic, Democratic Republic of the Congo, Egypt, Madagascar, Mauritius, Morocco, Namibia, Nigeria, Senegal, Sudan, Uganda, United Republic of Tanzania, and Zimbabwe).

The purpose of this course was to provide participants with theoretical as well as practical information on mutation induction, application in seed propagated crops, accelerated breeding techniques (such as doubled haploid, anther/embryo culture etc.) and mutant line screening for biotic and abiotic stress tolerance in crop breeding.

The course included lectures and practical sessions on:

- Induced mutation in seed propagated crops;
- Establishment of the proper starting material for specific project objectives;
- Handling of mutated populations to develop new varieties;
- Basics of plant biotechniques;
- Doubled haploid, anther/embryo culture techniques to support mutation breeding;
- Theoretical and practical application of biotechniques in mutation breeding for crop improvement;
- Phenotyping and genotyping screening for mutants in the laboratory and in the field.

Practical sessions comprised radio sensitivity tests for cassava seeds including the establishment of LD50. Additionally, anther cultures of tomato and maize and embryo rescue of cassava seeds were demonstrated to speed up the plant mutation breeding cycle.

*Training course participants.*

*Participants visiting cassava experiment field.*

## Consultants Meeting on Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security, Vienna, Austria, 19–23 October 2015

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

A consultants meeting was organized in order to formulate the proposal for the new CRP on Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security. Five invited experts from Japan, the Netherlands, Sudan, the United States of America (USA) and the Food and Agriculture Organization of the United Nations (FAO) participated in the meeting and contributed with their expertise. The consultants strongly support the concept of the CRP proposal and agreed to the bottlenecks to be addressed by the CRP for mutation breeding for *Striga* resistance in cereals. They recognize a general lack of known resistance among the cereal hosts of *Striga* and consider mutagenesis a viable option for broadening the genetic base of host plant resistance, particularly because this can be done in varietal backgrounds already preferred by farmers but only lacking *Striga* resistance. The consultants proposed different potential mechanisms for *Striga* resistance based on the current understanding of host/parasite biology liable to mutation induction and agreed that a key challenge will be in developing efficient screening technologies to handle the large populations required for mutagenesis based improvement. The CRP is seen as strongly linked to Strategic Objective 2 (SO2) of the FAO and this gives the CRP the opportunity to be more visible and provide an avenue for possible extra-budgetary funding for training through this linkage. (For more information, see CRPs on page 14).

*Consultants and the staff of the Plant Breeding and Genetics Section.*

## First Project Coordination Meeting of Regional Project on Improving Yield and Commercial Potential of Crops of Economic Importance, RLA/5/068, Asunción, Paraguay, 2–6 November 2015

Technical Officer: S. Nielen

The new regional Latin America project ARCAL RLA/5/068 is scheduled to start in 2016 for duration of four years. The overall objective of this project, which is a follow up of the two previous projects ARCAL RLA/5/056 and RLA/5/063, is to improve crop productivity for food security and economic growth by generating new mutants of high quality and adapted to biotic and abiotic stresses. Within the previous projects various levels of progress in genetic improvement of crops using mutation breeding of basic food crops and native species have been achieved. Mutant lines in earlier and advanced stages are available in various crops such as quinoa, amaranth, native potato, wheat, beans, tomato, chipilin, avocado and banana. One of the successes was the release of the rice mutant variety SCS 118 Marques in Brazil in 2013. This variety was developed after gamma ray mutation induction and has excellent industrial performance and good consumer acceptance. In order to achieve a real impact on the life of farmer families and on food security, there is an urgent need of further developing these advanced mutant lines into released cultivars. Besides testing agronomic performances, intensive quality analysis including nutritional quality of the seeds and fruits are necessary to ensure market success of the products. Also, it is important to identify the mutated genes, so that they can be

transferred by marker assisted breeding to other genotypes of interest. New technologies for high throughput DNA- and RNA sequencing are available in the region that will facilitate reaching this goal. There is also a demand in the region for developing new mutant lines with improved tolerance to abiotic stresses and disease resistance for native crops such as papa, yucca, ginger, avocado, papaya, citrus, banana, and coffee. Among the outputs expected from the project are advanced mutant lines and released mutant varieties of various economic and sub utilized crops, with tolerance to abiotic and resistance to biotic stresses, as well as established protocols for screening techniques and molecular characterized advanced mutant lines.

The purpose of the meeting was to coordinate and setup a workplan with clearly defined activities, goals and indicators that will enable the project outputs to be reached. Fifteen project coordinators from the 18 participating countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, and Venezuela) presented the current status of their projects and future plans. On the basis of this information, the activities for the next four years (training courses, workshops, expert visits, fellowships and limited provision of equipment and consumables) were discussed and agreed upon. A very interesting field visit was arranged to the Centro de Investigación Hernando Bertoni (CIHB) of the Instituto Paraguayo de Tecnología Agraria (IPTA) in Caacupé where the experimental station of the *Stevia rebaudiania* (Ka'a He'e in Guaraní) breeding programme is located. The meeting was organized in cooperation with the National University of Asunción, Paraguay.

*Project coordination meeting participants.*

## Final Review Meeting of the Regional RCA Project on Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate, RAS/5/056, Nay Pyi Taw, Myanmar, 17–20 November 2015

Technical Officer: S. Nielen

The meeting was organized in collaboration with the Department of Atomic Energy, Ministry of Science and Technology (MOST), Myanmar, in the new capital of Myanmar. The objectives of the meeting were to 1) Review the results that have been achieved with regard to implementation of the individual country workplans and regional project outcomes and outputs since January 2012, 2) Review and discuss the implementation of the project activities (technical meetings, workshops, training courses and national field studies), evaluate the results achieved, and 3) Discuss workplan of activities of the new RCA project RAS/5/070, which will start in the second year of the next cycle (2017).

The national project coordinators from Australia, Bangladesh, China (Lead Country Coordinator (LCC) Prof Luxiang Liu), India, Indonesia, Malaysia, Myanmar, Mongolia, Nepal, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam, national counterparts in Myanmar and the project Technical Officer attended the meeting. Within the four-year life cycle of the project, 28 new mutant varieties with climate change related traits were officially released and disseminated to the farmers. This includes four mutant varieties of rice from Bangladesh, Republic of Korea, Myanmar, Pakistan; nine of wheat from China (8) and Mongolia (1); one of barley (Australia); six of Sorghum (Indonesia); one each of black gram and pigeon pea (both from India), one of mungbean (Thailand); one each of cotton and sugarcane (Pakistan); and three of Kenaf (Republic of Korea). Furthermore, hundreds of advanced mutant lines have been developed and many are in the pipeline for national yield trials and for being released. Among them are two advanced rice mutant lines in Malaysia that are high yielding under minimal water conditions and are suitable as 'Aerobic Rice'. A technology package consisting of these mutants plus bio fertiliser with oligochitosan as the key ingredient has been developed and attained doubled yield of rice in two experimental sites. Through such success stories the importance of collaborative efforts in integrating plant mutation breeding with soil and water management practices was emphasized. The meeting was also used to

strengthen the Asia and Oceania Association of Plant Mutagenesis (AOAPM). Through a newly developed webpage (www.plantmutagenesis.net) that was presented by the LCC the association now has a platform to exchange information on crop mutation breeding related topics. A technical visit to the Department of Agricultural Research (DAR), Ministry of Agriculture and Irrigation (MOAI), Yezin, was organized and the meeting participants had the chance to get an overview on DAR activities and specific insight into the work on biotechnology research and the seed bank.

The excellent organization of this successful meeting by the host country Myanmar was highly appreciated by all participants.


*Meeting participants.*

## First RCM on Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana, D2.20.05, Vienna, Austria, 7–17 December 2015

Technical Officers: B. Till and S. Nielen

This first meeting was planned to bring together agreement holders and contract holders in order to discuss the project objectives and to fine-tune workplans. The project aimed, among other things, to increase the efficiency of screening mutant coffee and banana populations to identify enhanced resistance to coffee leaf rust and fusarium wilt in bananas. (For more information, see Coordinated Research Projects on page 15).

# 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 |
| D1.50.13 | Approaches to Improvement of Crop Genotypes to High Water and Nutrient Use Efficiency for Water Scarce Environment | K. Sakadevan and P.J.L. Lagoda |
| D2.20.05 | Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana | B. Till and S. Nielen |

| | New CRPs | Scientific Secretaries |
|---|---|---|
| D2.50.05 | Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security | A.M.A. Ghanim and L. Jankuloski |

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

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

The parasitic weeds *Striga asiatica* and *S. hermonthica* are major biological constraints to cereal production in most of sub-Saharan Africa and semi-arid tropical regions of Asia. Yield losses are mainly in maize, millet, upland rice and sorghum and most severe on marginal lands of subsistence farmers. The unique biology of *Striga*, tightly adapted to its crop hosts, limits control options. Because subsistence farmers either cannot afford or do not have access to inputs, host plant resistance is a vital part of *Striga* control. Resistance traits, however, are lacking in most cereal varieties sown in *Striga* prone areas. This CRP proposes the use of physical mutagenesis and associated screening technologies to broaden the genetic base of resistance. The project seeks to combine expertise in field and laboratory screening to enhance mutation breeding to timely develop or adapt screening packages to generate novel sources of *Striga* resistance. Initial focus will be on sorghum and rice because of their importance to food security and amenability to mutation breeding techniques. Screening packages will be optimized for laboratory, screen-house and field to identify resistant mutants to *Striga asiatica* and *S. hermonthica*. The mechanisms of discovered resistance reactions among the mutagenized populations will be determined through laboratory co-culture of the cereal with *Striga*. This will allow pyramiding of different mutations containing incompatible alleles into single varieties with durable resistance. Accelerating techniques such as rapid cycling of crop generation and efficiency enhancing technologies of doubled haploid, genomics and molecular markers will be adapted in the CRP as appropriate. Up to ten research contracts are expected to be awarded and five no-cost agreement holders from advanced laboratories and research institutes with recognized expertise in the targeted technologies will be invited to share their experience with the contract holders and contribute to the development and validation of the planned technical packages. In addition, it is foreseen that two technical contracts will be awarded for services in advanced areas such as marker development and advanced efficiency enhancing technologies and mutant characterization.

Detailed announcement on the project and how to participate will be published in due course.

*Completely damaged sorghum field by heavy Striga hermonthica infestation.*

## 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 Coordinated Research Project (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. Exported 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 petroleum. Coffee leaf rust is devastating to plantations. Global climate change and variation threaten to increase the negative impact of each disease. There are many challenges that 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.

## 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 International Center for Tropical Agriculture (CIAT).

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

All participating countries generated new mutant populations in rice and beans. Also, some countries used characterized mutant lines from previous projects. All of them have mutant lines at least at the $M_4$ generation, which tested tolerant for their responses to increased temperatures. Cuba released a new 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 beans which is planned to be released to farmers by 2018.

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

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

The third RCM took place in Vienna, Austria, 22–26 June 2015. The purpose of this meeting was to evaluate the progress made so far and evaluate data including advanced mutant lines with improved heat stress tolerance. Screening protocols and dissemination of the results will be published and accessible to all MSs.

## 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 and the second RCM was held in August 2014 in Bogor, Indonesia.

The objectives of this CRP are:

1. To identify 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 (China, Malaysia), barley (Austria, China, Kuwait and Peru) and sorghum (Indonesia). The project aims to improve the agronomy of the crop especially in respect to soil and water management, improve nutritional value and improve the knowledge and skills base of participating MSs.

All participants have identified mutant varieties and/or advanced mutant lines that are now subject to farming management practices to maximize yields in challenging conditions. Success in tailoring agronomy for mutant varieties will be judged by take up by farmers but there are already impressive outcomes, particularly in Indonesia where a mutant line is now grown in several regions on an increasing area.

All project participants have submitted project progress report and all contracts have been renewed for 2015–2016. The mid-term review was positively evaluated by the Committees for Coordinated Research Activities (CCRA), thus the project will continue as planned.

The Third RCM is planned to be held 1–5 August 2016 in Darkhan, Mongolia.

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

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

This CRP is in its final year. Ten research contract holders (Bangladesh, China, Kenya, Malaysia (two participants), Mexico, Pakistan, Peru, South Africa, Uganda and Viet Nam), one technical contract holder (Peru) and one agreement holder (South Africa) are participating in the CRP. 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 environment. The specific objectives are to:

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

The final renewals for the national projects are completed and the final project closure will be in the fourth quarter 2016.

Key outputs of the CRP until December 2014 include:

- Ratooning rice cultivars (one planting and two harvests) have been introduced in more than 40 000 ha in China with yield up to 14 500 kg/ha over two harvests.
- Three mutant sorghum varieties with yield increase up to 7% were implemented in farmer's field under rainfed conditions.
- Elite potato varieties were successively evaluated for yield and fertilizer use efficiency.
- Three varieties and one advanced mutant line of barley, and five improved genotypes of quinoa that are suitable for high altitude were evaluated for yield and water and nutrient use efficiencies.
- A series of field studies have been carried out to evaluate and select two improved rice varieties MR219-4 and MR219-9 which are tolerant to aerobic conditions.
- Genotypes of quinoa, Huauzontle and Chia were evaluated for yield performance for drought and salinity tolerance in Mexico.
- Three gynotypes of wheat for water and nutrient use efficiencies and two varieties of wheat tolerant to UG99 were evaluated for different levels of nitrogen and phosphorus fertilizer application under rainfed conditions.
- Three mutant soybean varieties have been evaluated for water and nutrient use efficiencies during spring and summer periods.

# 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 | P.J.L. Lagoda/A.M.A. Ghanim |
| BGD/5/028 | Bangladesh | Assessing Crop Mutant Varieties in Saline and Drought Prone Areas Using Nuclear Techniques | 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 Soil and Water Management and Crop Nutrition Section |
| BOT/5/009 | Botswana | Using Radiation Technology and Biotechnology to Develop Mutant Lines of Important Crops with Increased Yield and Improved Nutritional and Hygienic Qualities | A.M.A. Ghanim/S. Nielen |
| BOT/5/012 | Botswana | Improving Soil and Water Management Options to Optimize Yields of Selected Crops | P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section |
| BUL/5/013 | Bulgaria | Supporting Laboratory Upgrade for Improved Food Crops through Nuclear and Molecular Techniques | F. Sarsu/L. Jankuloski |
| BKF/5/009 | Burkina Faso | Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques for Food Security and Poverty Alleviation | P.J.L. Lagoda/L. Jankuloski |
| BKF/5/013 | Burkina Faso | Enhancing Sorghum Productivity by Breeding Resistant Varieties to Striga Hermonthica Strains in Agro-Ecological Zones | L. Jankuloski/P.J.L. Lagoda |
| BDI/0/001 | Burundi | Supporting Human Resource Development and Nuclear Technology Support Including Radiation Safety | F. Sarsu |
| CAF/5/006 | Central African Republic | Improving Cassava Production through High-Yielding Varieties and Sustainable Soil Fertility Management by Using Isotopic and Nuclear Techniques to Ensure Sustainable Farming | P.J.L. Lagoda/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section |
| COL/5/024 | Colombia | Supporting Mutagenesis and Functional Genomics Applied to the Improvement of Rice | S. Nielen/B. Till |
| ZAI/5/022 | Congo, Democratic Rep. of the | Using Nuclear and Biotechnology Techniques for Genetic Adaptation and Improvement of Staple Crops for High Temperatures and Water Stress | L. Jankuloski/B. Till |
| IVC/5/031 | Cote d'Ivoire | Improving Plantain and Cassava Yields through the Use of Legume Cover Crops | P.J.L. Lagoda/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section |

| Project Number | Country/Region | Title | Technical Officer(s) |
|---|---|---|---|
| IVC/5/035 | Cote d'Ivoire | Improving Maize Crops Subject to Severe Soil and Climate Degradation through Induced Mutants Adapted to these Areas | P.J.L. Lagoda/F. Sarsu |
| ERI/5/008 | Eritrea | Supporting the Livelihood of Barley Farmers through Mutation Techniques and N15 Technology to Improve Malting, Food and Feed Barley Production | A.M.A. Ghanim |
| GHA/5/034 | Ghana | Screening of M2 Population for Useful Mutants for Oil Palm Mutation Breeding | L. Jankuloski/S. Nielen |
| INS/5/039 | Indonesia | Enhancing Food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Adaptation | L. Jankuloski/B. Till |
| KAZ/5/003 | Kazakhstan | Increasing Micronutrient Content and Bioavailability in Wheat Germplasm by Means of an Integrated Approach | F. Sarsu/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section |
| KEN/5/034 | Kenya | Using Irradiated Improved Brachiaria Grass and Dolichos Lablab Species for Increasing Quantity and Quality of Milk Production and Reproduction for Smallholder Dairy Farms in Drought Prone Areas | S. Nielen/F. Sarsu |
| LAO/5/001 | Lao, P.D.R. | Enhancing Food Security through Best Fit Soil-Water Nutrient Management Practices with Mutation Induction for Drought Resistant Rice | L. Jankuloski |
| LES/5/004 | Lesotho | Using Nuclear Techniques for Improvement of Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production (Continuation of the on-going project) | S. Nielen/A.M.A. Ghanim |
| MAK/5/008 | Macedonia, The Former Yug. Rep. of | Using Nuclear and Molecular Techniques for Improved Feed and Malt Quality and Safety in Barley | P.J.L. Lagoda |
| 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 |
| MAR/5/020 | Mauritius | Developing Stress Tolerant Banana and Tomato Varieties by Enhancing the National Capacity in Mutation Induction and Biotechnology | B.Till/S. Nielen |
| MON/5/021 | Mongolia | Improving the Productivity and Sustainability of Farms Using Nuclear Techniques in Combination with Molecular Marker Technology | L. Jankuloski/S. Nielen in collaboration with Animal Production and Health Section |
| MOR/5/033 | Morocco | Using Nuclear Techniques to Support the National Programme for the Genetic Improvement of Annual and Perennial Plants and to Develop Agricultural Production | P.J.L. Lagoda/A.M.A. Ghanim |
| MYA/5/023 | Myanmar | Evaluating Nitrogen Use Efficiency Using Low Nitrogen Tolerant Rice Varieties | P.J.L. Lagoda |
| NAM/5/012 | Namibia | Developing High Yielding and Drought Tolerant Crops through Mutation Breeding | F. Sarsu/S. Nielen |
| NEP/5/003 | Nepal | Improving Crop Yield for Food Security and Economic Growth by Using Nuclear and Molecular Techniques | S. Nielen/L. Jankuloski |

| Project Number | Country/Region | Title | Technical Officer(s) |
|---|---|---|---|
| NER/5/015 | Niger | Improving Productivity of the Millet-Cowpea Cropping System through Development and Dissemination of Improved Varieties and New Water and Fertilizer Management Techniques | P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section |
| OMA/5/002 | Oman | Assessing the Suitability of Sterile Insect Technique (SIT) and Related Techniques for Combating Date Palm Insect Pests | A.M.A. Ghanim/P.J.L. Lagoda in collaboration with Insect Pest Control Section |
| PAK/5/047 | Pakistan | Developing Germplasm through TILLING in Crop Plants Using Mutation and Genomic Approaches | B. Till/S. Nielen |
| PAL/5/006 | Palestine | Enhancing the Performance of Durum Wheat Landraces by Induced Mutation | L. Jankuloski |
| RAF/5/066 | Regional Africa | Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA) | F. Sarsu/A.M.A. Ghanim |
| RAF/6/042 | Regional Africa | Applying Nuclear Techniques to Design and Evaluate Interventions to Reduce Obesity and Related Health Risks | F. Sarsu/A.M.A. Ghanim |
| RAS/5/058 | Regional Asia | Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change | F. Sarsu/P.J.L. Lagoda |
| RAS/5/064 | Regional Asia | Enhancing Productivity of Locally-underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices | L. Jankuloski in collaboration with Soil and Water Management and Crop Nutrition Section |
| RAS/5/065 | Regional Asia | Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications | P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section |
| RAS/5/069 | Regional Asia | Complementing Conventional Approaches with Nuclear Techniques towards Food Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia | P.J.L. Lagoda/L. Jankuloski |
| RAS/5/070 | Regional Asia | Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA) | F. Sarsu/P.J.L. Lagoda |
| SEN/5/034 | Senegal | Using an Integrated Approach to Develop Sustainable Agriculture in a Context of Degrading Soil Fertility, Climate Change and Crop Diversification | F. Sarsu/P.J.L. Lagoda |
| SIL/5/014 | Sierra Leone | Enhancing Nutritional and Other End-User Postharvest Qualities of Rice and Cassava through Mutation Breeding | S. Nielen/L. Jankuloski |
| SRL/5/045 | Sri Lanka | Establishing a National Centre for Nuclear Agriculture | F. Sarsu |
| SUD/5/033 | Sudan | Enhancing Productivity of Major Food Crops (Sorghum, Wheat, Groundnut and Tomato) under Stress Environment Using Nuclear Techniques and Related Biotechnologies to Ensure Sustainable Food Security and Well-Being of Farmers | F. Sarsu/A.M.A. Ghanim in collaboration with Soil and Water Management and Crop Nutrition Section |
| URT/5/029 | Tanzania, United Rep. of | Improving Rice and Barley Production through the Application of Mutation Breeding with Marker Assisted Selection | L. Jankuloski/S. Nielen |

| Project Number | Country/Region | Title | Technical Officer(s) |
|---|---|---|---|
| THA/0/014 | Thailand | Developing Applications of Ion Beam and Plasma Technology for the Induction of Crop Mutation, Gene Transfection and Biomedical/Biochemical Material Modification | S. Nielen/B. Till |
| THA/5/054 | Thailand | Increasing Adaptability for Adverse Environment Tolerance in Rice Germplasm Using Nuclear Techniques | F. Sarsu/S. Nielen |
| UZB/5/005 | Uzbekistan | Developing Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity (Phase II) | F. Sarsu/S. Nielen |
| VIE/5/018 | 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/P.J.L. Lagoda |
| ZAM/5/029 | Zambia | Evaluating the Impact of Nitrogen and Water Use Efficiency in Upland Rice | L. Jankuloski/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section |
| ZIM/5/015 | Zimbabwe | Developing Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content Using Mutation Breeding and Novel Techniques, Phase II | F. Sarsu/L. Jankuloski |

# Announcements

## Capacity Building Programme for Latin American Countries against Coffee Leaf Rust

A new project of the Plant Breeding and Genetics subprogramme of the Joint FAO/IAEA Division, sponsored by a grant of the OPEC Fund for International Development (OFID).

### The Problem

*Coffee Leaf Rust.*

Coffee is the second most traded commodity in the world after crude oil. Coffee leaf rust (CLR, *Hemileia vastatrix*, also known as 'Roya') disease kills coffee plants by withering the leaves. First reported in 1861 in Kenya, by the 1920s CLR was widely found across much of Africa and Asia. In the 1970's, CLR became widespread in Brazil, which was its first appearance in the western hemisphere. Today CLR is found worldwide in virtually all coffee-producing countries, and is now seriously affecting yields.

### Impact of CLR

In Central America, changes in temperature have increased on average by two degrees Celsius, conditions that favour the rapid dissemination of this disease.

**Guatemala** has declared a state of agricultural emergency after CLR affected approximately 193 000 ha of coffee, equating to 70% of the national crop. 100 000 direct jobs have already been lost and it is projected that this will affect the livelihoods of millions of people. As a result of the outbreak, Guatemala is releasing US$13.7 million in emergency aid to help farmers buy pesticides and to inform farmers on ways to manage the disease. Guatemala expects coffee yields to drop by 40% in 2014 due to CLR.

**Honduras** and **Costa Rica** also declared national emergencies over CLR. According to the Institute of

Coffee in Costa Rica (ICAFE), the 2013–2014 harvest was the smallest in 37 years. It was estimated that the latest CLR outbreak contributed to the decrease of the 2013–2014 harvest by 50% or more. Honduras is seeking methods to curb the disease epidemic and save its coffee industry (worth about US$1.4 billion in sales in 2012).

In **El Salvador**, the Salvadoran Coffee Council said the impact of coffee rust is the worst in thirty years. The council estimates the disease has affected 100% of the country's coffee plantations.

In **Peru**, CLR became a big problem in coffee plantations, and the Peruvian government declared a sanitary emergency (Decreto Supremo N° 082–2013–PCM).

In **Nicaragua** due to CLR coffee exports dropped 21% in 2013, representing losses of $170 million. Overall, coffee went from being Nicaragua's top export product in 2012 to third (behind gold and beef) in 2013.

## A Solution: Using Mutation Breeding to Address Coffee Rust

Mutation breeding offers a potential solution to the problem. This technology has been a successful approach in crop improvement for over 70 years and has generated several tree crops similar to coffee (http://mvd.iaea.org). Advantages of mutation breeding are:

- Faster than conventional breeding;
- Used to improve a favoured variety in order to circumvent a specific deficiency, such as e.g. disease resistance;
- Tested, proven and robust technology applicable to a wide range of crops;
- Environmentally friendly, cost effective and non-regulated technology;
- Non-GM technology;
- Resultant mutant varieties are accepted worldwide by authorities, growers and end-users.

Cultivated coffee has already benefitted from naturally occurring spontaneous mutants. Although these are rare, several have been selected and grown as varieties, including 'Caturra' (a short, compact and high-yielding mutant of 'Bourbon' primarily grown in Brazil); 'Pacas' (a mutant of 'Bourbon' grown in El Salvador); and 'Maragogype' (a large bean size mutant of 'Typica' coffee discovered in Brazil.).

Induced mutations in existing 'preferred' varieties can be generated with the aim of producing CLR resistance with minimal disruption of the characteristics of the 'favoured' variety.

## Support to Member States

A request was made to the Agency by Guatemala for assistance in addressing coffee leaf rust. The Joint FAO/IAEA Division has sought extra-budgetary funding to support this work and requests assistance from countries in identifying the most appropriate candidates to participate in an upcoming project. The Joint FAO/IAEA Division has received an OPEC OFID-Grant on 'Capacity Building Program for Latin American Countries against Coffee Leaf Rust'. Target countries include Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Peru, and the following elements are being planned for 2016:

### Planning Workshop

In March 2016 in Vienna, Austria, there will be a one-week workshop to establish the network for collaboration on using mutation breeding in coffee and to define technical/scientific approaches.

### Procurement of Equipment for Six Participating Institutes (Seed Money)

The purpose is to provide seed money for basic equipment to initiate the local coffee mutation breeding activities (e.g. purchase of laminar flow hood for tissue culture work).

### Training Course on Mutation Induction in Coffee

In October 2016 (tentative date), there will be a two-week course with to provide an introduction on various concepts of mutation induction in coffee and specific tissue culture techniques involved, as well as screening in-greenhouse. Participants will be invited for a two-week course at the Plant Breeding and Genetics Laboratory (PBGL) in Seibersdorf, Austria.

Scientists from the target countries with relevant backgrounds are encouraged to participate, and to contact the Plant Breeding and Genetic Section for more detailed information.

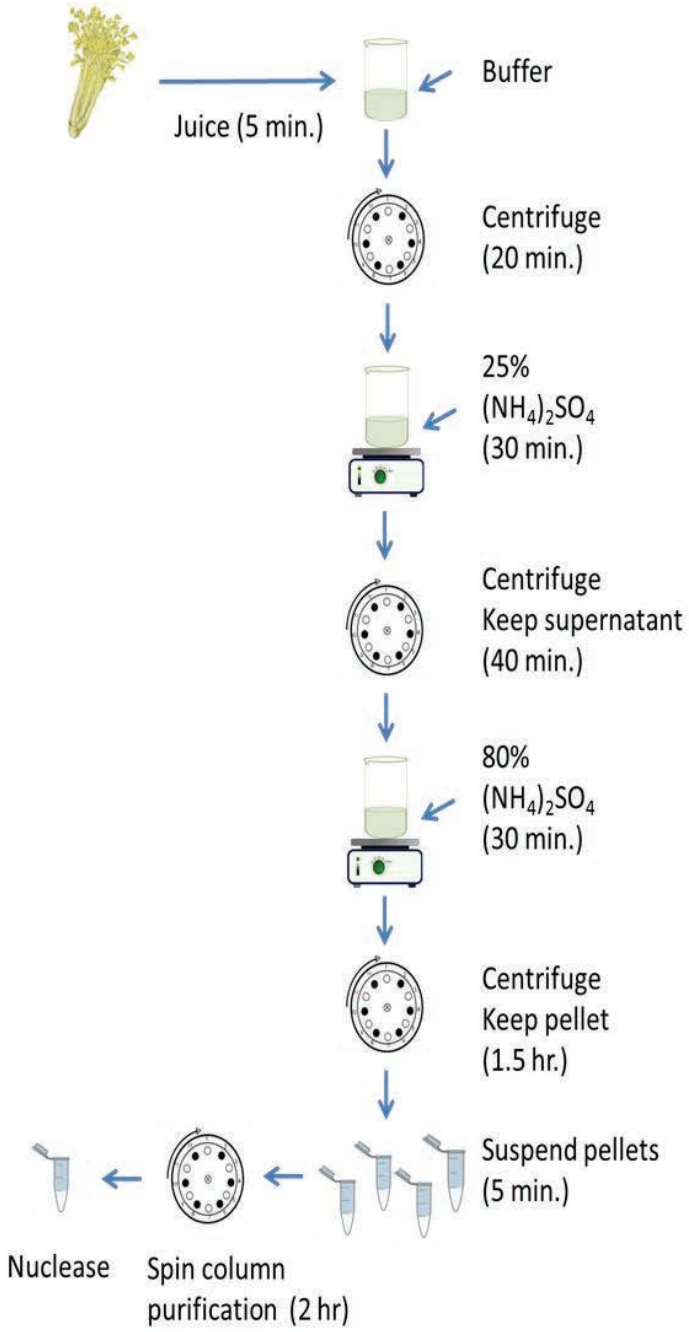
**Scientists from the target countries with relevant backgrounds are encouraged to participate, and to contact the Plant Breeding and Genetic Section for more detailed information.**

**Plant Breeding and Genetics Section**
Vienna International Centre, Wagramer Strasse 5
P.O. Box 100, 1400 Vienna
Phone: +431 2600-21626
Email: Official.Mail@iaea.org

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

## Improving Methods for the Molecular Characterization of Mutant Plants

The act of mutagenizing seed or tissues can have a profound and varying effect on DNA sequence of plants. Depending on the dosage and mutagen used, plant may accumulate thousands of single base pair changes, or just a handful of insertions and deletions of perhaps a million base pairs. A newly released mutant crop variety will harbour one or several induced mutations that cause the improved trait. While a stable trait is sufficient for the farmer, there are many advantages for the breeder knowing what mutation is causing the trait. Knowledge of gene function enables more precise breeding. Identification of the causative mutant allele allows development of perfect markers for rapid introgression and pyramiding of traits. The PBGL continues in its efforts to develop low-cost and where possible non-toxic methods for characterization of natural and induced mutations in plants. Single Nucleotide Polymorphisms (SNPs) are the most common type of nucleotide variation found in nature and the predominant type of variation induced by some mutagens. The PBGL recently published an open access book with Springer describing methods from tissue desiccation to SNP and small indel discovery (http://rd.springer.com/book/10.1007%2F978-3-319-16259-1). The methods have already been used to train over 100 scientists from 30 Member States. While we consider this a good step in the right direction, there is always room for improvement. We continue to optimize and improve the procedures from molecular characterization of mutant plants. For example, the PBGL has further optimized its protocol for purification of single strand specific nucleases used for mutation detection. This new methods avoids the use of toxic chemicals or expensive preparatory centrifuges. All steps can be performed at room temperature using standard equipment found in most molecular biology labs and the entire process can be completed in a single day. The result is a nuclease that costs less than one cent per reaction (see figure). Two *ad hoc* training courses have been carried out to teach researchers these methods (see previous newsletter and human capacity building below).

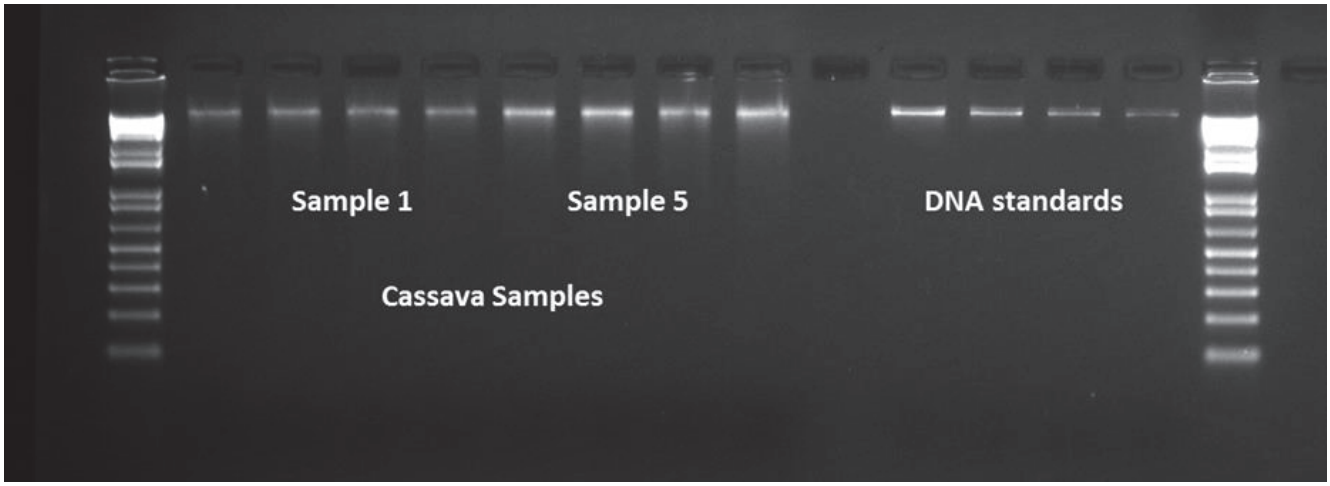



*Overview of the steps involved in preparation of crude enzyme extracts from celery containing single-strand-specific nuclease activity. Approximate time for each step is indicated.*

Much effort has gone towards the discovery of SNP mutations. However, it can be argued that the discovery of larger genomic aberrations is much more challenging. This is because plants accumulate larger mutations at a much lower frequency than smaller ones. The fewer the mutations there are, the harder they are to discover. Further, special techniques are often required for discovery of such mutations and the optimal technique can change depending on the type of mutation that is induced. Improvements to DNA sequencing technologies are promising to change that. In collaboration with partners from the University of California, Davis, the PBGL is developing methods for whole genome analysis for the recovery of mutations induced by treatment with gamma irradiation. We began this work in September as part of an *ad hoc* group training course where we sequenced 17 mutant rice lines (see human capacity development section). Analysis of this data is currently in progress.

## Extra Budgetary Funding to Support Improvement of Cassava

Since the last newsletter, the PBGL began work on a collaborate effort with CIAT (International Center for Tropical Agriculture) for the genotyping of cassava accessions held at CIAT. Financial support for this work is provided by the Colombian granting agency COLCIENCIAS. Cassava (*Manihot esculenta*) is an important staple crop for over 500 million people in the tropics. Working with Professor Hernan Ceballos the goal is to characterize cassava for nucleotide variation in genes important for starch quality and herbicide tolerance. DNA is being shipped from Colombia to Seibersdorf where it is being quantified and pooled prior to screening using an amplicon based next generation sequencing approach. In addition to learning more about genetic variation in cassava, the Seibersdorf team is developing streamlined methods for processing thousands of samples. Pilot experiments show rapid quantification of cassava genomic DNA using paramagnetic beads (see figure).




*Agarose gel image showing the concentration of cassava genomic DNA can be rapidly normalized with the use of limited capacity binding paramagnetic beads.*

## Kits

The Plant Breeding and Genetics Laboratory 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 distributed to Austria, Jordan.
- Low cost enzyme extraction for mutation discovery: South Africa, Jordan, Iraq, Oman, Syrian Arab Republic, Austria.

# Professional Networking

The PBGL thanks all of you who have connected with us on LinkedIN If you haven't already linked with us, please feel free to connect (http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3). We are now linked with307 researchers and are happy to continue to expand our connections to the broader plant sciences and agricultural community.

# Human Capacity Development

## Group Training on Next Generation for the Discovery of Gamma Induced Mutations in Rice

An *ad hoc* training course on whole genome sequencing of rice was held at the PBGL from 24 to 28 August 2015. Course topics included genomic DNA fragmentation, library preparation and next generation sequencing. Visitors from Colombia, Jordan, India and Poland attended the course.

*The Illumina MiSeq reagent cartridge is explained. From left to right: Anna Sochacka, Sana'a Khraisat, Sneha Datta, Daniel Tello, Lina Kafuri, Bernhard Hofinger and Bradley Till.*

## Group Training on EMS Mutagenesis of Barley

An *ad hoc* training course on chemical mutagenesis of barley seed was organized by Mr B. Till from 28 to 30 September 2015. The training covered a standard protocol for treatment of seed with EMS and post-treatment handling. Visitors from Germany, Syrian Arab Republic and Colombia attended the course.

*Training was carried out in the newly upgraded chemical mutagenesis laboratory. From left to right: Rana Elias of Syria, Priyanka Kumari of Germany, Bradley Till (trainer) and Lina Kafuri of Colombia.*

## Group Training on Low-Cost Purification of Single-Strand-Specific Nucleases for Mutation Discovery

An *ad hoc* training course was organized by Mr. B. Till from 11 to 12 November 2015 covering low-cost protocols developed at the PBGL for bench-top enzyme purification and mutation discovery. Visitors from Albania, Madagascar, Thailand, Pakistan, Syrian Arab Republic and Colombia attended this course.

*Group training on methods for purifying enzyme for plant mutation discovery. From left to right: Gledjan Caka, Jhonny Rabefiraisana, Mehboob-ur-Rahman, Dana Jawdat, Reunreudee Kaewcheenchai, Bradley Till and Rana Elias.*

## Screening for Salt Tolerance in Soybean Using Hydroponic Culture

By 2050, about half of the world's population is at risk of being undernourished as a result of rising food demand and a potentially compromised supply affected by climate

change. By 2100, up to 40% of the world's land surface will have to adapt to altered climates. Being the most populated country in the world Bangladesh is to grow rice for food security in the good soils. Thus, non-cereals are mostly grown in the marginal soils including southern coastal part affected by varying degrees of soil salinity causing serious limitations to crop production. Hence, most of the cultivable land remains fallow during January to May in the coastal belt after rain-fed rice cultivation where soybean may be a potential crop to increase cropping intensity. Recently, in Bangladesh, soybean has become an important crop for its increasing demand as an ingredient of poultry and fish meal as well as for the consciousness of its healthy nutrition as human food.

In the context of climate change, there is a great challenge to maintain sustainable food production to feed growing world population. The PBGL has been involved actively in developing efficient and reliable screening methods for development of salt tolerant mutant varieties. Screening packages against salinity stress is being designed and evaluated to suit different crops under different conditions in the laboratory, glasshouse and open field. During the reporting period an experiment was conducted for salinity screening in soybean genotypes from Bangladesh.

Twenty soybean genotypes were used for salinity screening using hydroponic culture. Sodium chloride (NaCl) was used at 0, 5, 10 and 15 dS/m concentrations for salinity induction in hydroponic system with modified Ishida's nutrient solution. Salinity stress was imposed at early vegetative stage (after nine days from transplanting of seedlings in hydroponic) and continued for more than six weeks (see figure). Measures were taken for plant growth traits like plant height and leaf number, chlorophyll fluorescence etc. Genotypes had shown variation in sensitivity to salinity stress along the intensity gradient and time of exposure to stress.

Combined differential scoring of these parameters enabled classification of the 20 soybean genotypes into five classes; highly sensitive, sensitive, moderately sensitive, tolerant and highly tolerant to salinity (see table). Tolerant genotypes will be further validated under field condition in Bangladesh. The extended treatment with different levels of salinity enables the classification of the genotypes based on their tolerance threshold level that can be adapted to screening of mutant populations for salt tolerance.


*Screening of 20 soybean genotypes for salt tolerance in hydroponic solution with four level of salt stress (0, 5, 10 and 15 dS/m NaCl in modified Ishida nutrient solution) after six weeks of salt treatments.*

| | Number of genotypes in each salt sensitivity class | | | | |
|---|---|---|---|---|---|
| **Salt treatment** | **I** | **II** | **III** | **IV** | **V** |
| **15 dS/m** for 2 weeks | 9 | 7 | 2 | 2 | - |
| **15 dS/m** for 3 weeks | 3 | 9 | 6 | 1 | 1 |
| **15 dS/m** for 4 weeks | 2 | 3 | 6 | 7 | 2 |
| **15 dS/m** for 5 weeks | 2 | - | 3 | 5 | 10 |
| **15 dS/m** for 6 weeks | 2 | - | - | 1 | 17 |
| **10 dS/m** for 4 weeks | 8 | 7 | 4 | 1 | - |
| **10 dS/m** for 5 weeks | 5 | 3 | 5 | 5 | 2 |
| **10 dS/m** for 6 weeks | 2 | 2 | 7 | 4 | 5 |
| **5 dS/m** for 6 weeks | 7 | 11 | 2 | - | - |

*Classification of the 20 soybean genotypes depending on salt sensitivity into highly tolerant (I), tolerant (II), moderately sensitive (III), sensitive (IV) and highly sensitive (V).*

## Irradiation Services

At the time of writing the PBGL has received in 2015 at total of 29 requests for plant irradiation services from 20 Member States (MSs). These are listed below and included 27 crop species. The total number of irradiation requests since records began now stands at 1439. For each request (unless otherwise stated), we carry out radio-sensitivity tests to determine the optimal irradiation dose for mutation induction. Therefore, we normally request that MSs send us sufficient seed for this initial test (usually 100–300 seeds). Once the optimal dose is determined, this is applied to the rest of the seed samples and the $M_1$ seeds will be returned to the Member State.

| Request number | Country | Species |
|---|---|---|
| 1411 | USA | *Pisum sativum*, *Phaseolus vugaris* |
| 1412 | UK | *Rudbeckia fulgida* |
| 1413 | Germany | Aster, *Dendranthema* |
| 1414 | Madagascar | Cassava |
| 1415 | Botswana | Maize |
| 1416 | Spain | Euphorbia |
| 1417 | UK | Wheat |
| 1418 | Lao P.D.R. | Rice, Soybean, Mungbean, Maize |
| 1419 | Nepal | Rice |
| 1420 | Mongolia | Wheat, Rapeseed |
| 1421 | Namibia | Rice |
| 1422 | Palestine | Durum Wheat |
| 1423 | Nigeria | Sesame |
| 1424 | Nigeria | Coffee |
| 1425 | Sri Lanka | *Vigna radiate*, *Glicine max*, *Allium cepa*, *Capsicum annum* |
| 1426 | Cote D'Ivoire | Maize |
| 1427 | Spain | Rice |
| 1428 | UK | Wheat |
| 1429 | UK | Rapeseed |
| 1430 | Nigeria | *Digitania exilis* (Fono) |
| 1431 | Kenya | *Dolichos lablab*, *Brachiara ruzzizensis* |
| 1432 | Nigeria | *Vigna vexillata* |
| 1433 | Sierra Leone | Cassava, Cocoa, Peanut |
| 1434 | Oman | Wheat, Barley |
| 1435 | Iraq | Hot Pepper |
| 1436 | Oman | Wheat, Barley |
| 1437 | Austria | Wheat |
| 1438 | Cote D'Ivoire | Barley |
| 1439 | Morocco | Lentil |

## Individual Training Activities

| Name | Country | Status | Topic / Areas of Training | Period |
|---|---|---|---|---|
| *Mr Zhiwei Chen | China | Cost-free Expert | Mutation detection in rice | August 2014–July 2015 |
| Ms Farzaneh Taassob Shirazi | Islamic Republic of Iran | Scientific Visitor | Mutation induction in barley, screening and accelerated breeding | Until 30 April 2015 |
| Mr Mohammed Jouhar | Syrian Arab Republic | Scientific Visitor | Development of low cost method for mutant characterization | 1–12 June 2015 |
| **Ms Miriam Szurman-Zubrzycka | Poland | Scientific Visitor | Group training on 'Low-cost purification of single-strand-specific nucleases for mutation discovery' | May 2015 |
| Ms Stephanie Bannister | Austria | Scientific Visitor | Group training on 'Low-cost purification of single-strand-specific nucleases for mutation discovery' | May 2015 |
| ***Mr Amin Kihara | Japan | Scientific Visitor | Screening methods for drought and salt tolerance | November 2015 |
| Mr Mehboob-Ur Rahman | Pakistan | Scientific Visitor | Mutation detection technologies | September 2015 |
| Ms Ziani Eps Abed Fadila | Algeria | Scientific Visitor | ARASIA regional training course on 'Phenotyping and genotyping of mutants for abiotic stresses in cereals | October 2015 |
| Ms Chanthakhone Boualaphanh | Lao P.D.R. | Scientific Visitor | ARASIA regional training course on 'Phenotyping and genotyping of mutants for abiotic stresses in cereals | October 2015 |
| Mr Justing Yatty Kouadio | Cote D'Ivoire | Scientific Visitor | ARASIA regional training course on 'Phenotyping and genotyping of mutants for abiotic stresses in cereals | October 2015 |
| Mr Albert Nyongesa | Kenya | Scientific Visitor | ARASIA regional training course on 'Phenotyping and genotyping of mutants for abiotic stresses in cereals | October 2015 |
| Ms Anna Sochacka | Poland | Intern | Plant mutation induction, *in vitro* propagation and screening techniques | March–September 2015 |
| Ms Sneha Datta | India | Intern | Plant mutation induction, *in vitro* propagation and screening techniques | October 2015–March 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 |
| Mr Abdel Barakat | Egypt | Intern | Mutation detection | June–September 2015 |
| Ms Sana'a H. Khraisat | Jordan | Intern | Mutation detection using retrotransposon based markers | June–September 2015 |
| Ms Banumaty Saraye | Mauritius | Individual Fellow | Heat stress screening of tomato mutants | November 2014–March 2015 |

| Name | Country | Status | Topic / Areas of Training | Period |
|---|---|---|---|---|
| Mr Ndiogou Gueye | Senegal | Individual Fellow | Mutation induction in sesame and cowpea, drought screening *in vivo* and *in vitro* | January–April 2015 |
| Ms Ndeye Fatou Deme | Senegal | Individual Fellow | Mutation screening in cowpea | February–June 2015 |
| Mr Milton Kabbia | Sierra Leone | Individual Fellow | Cassava mutation breeding | February–August 2015 |
| Mr Udompan Promnart | Thailand | Individual Fellow | Mutation breeding in rice, screening for abiotic stress tolerance | May–August 2015 |
| Mr Harimialimalala Jhonny Rabefiraisana | Madagascar | Individual Fellow | Mutation detection in maize and rice | October 2015–January 2016 |
| Ms Reunreudee Kaewcheenchai | Thailand | Individual Fellow | Mutation detection in rice | October 2015–January 2016 |
| Mr Gledjan Caka | Albania | Individual Fellow | Heterozygosity tests in tomato | October–November 2015 |
| Mr Romaric Nzoumbou-Boko | Central African Republic | Individual Fellow | Mutation detection in cassava | September–December 2015 |
| Ms Geralde Gado Yamba Kassa | Central African Republic | Individual Fellow | Mutation detection in cassava | September–December 2015 |
| Mr Md Abdul Malek | Bangladesh | Individual Fellow | Mutation induction in soybean and screening for salt tolerance | September–December 2015 |
| Mr A.K. Tecleghiorghis | Eritrea | Individual Fellow | Mutation induction in barley and screening for salt tolerance | October–December 2015 |
| Ms Kamal Omer | Sudan | Individual Fellow | Mutation induction in wheat and sorghum. DH methods | August–November 2015 |
| Ms Rana Elias | Syrian Arab Republic | Individual Fellow | Mutation induction and detection in barley | September–November 2015 |
| Ms Dana Jawdat | Syrian Arab Republic | Individual Fellow | Mutation detection in barley and cotton | November–December 2015 |

*Funded and supported by the Fujian Agriculture and Forestry University and the Chines Government, respectively; **Funded by University of Silesia, Katowice, Poland; ***Funded by Arid Land Research Center, Japan; ****Funded by CIAT (Centro Internacional de Agricultura Tropical) Cali, Colombia.

## Visitors to the PBGL

The PBGL continues to host a high flux of visitors. In 2015 until the time of writing we have received over 50 visitors groups from various MSs, including delegations and High Level visits from 18 MSs. Visitors groups also included internal groups, students from Austrian and and international Universities, as well as representatives of other international organizations. Visitors are keen to understand the principles of plant mutation breeding, the role of the PBGL, our impact and ongoing and future projects.

# Publications

## Books

TILL, B.J., J. JANKOWICZ-CIESLAK, O.A. HUYNH, M.M. BESHIR, R.G. LAPORT, B.J. HOFINGER (2015) Low-Cost Methods for Molecular Characterization of Mutant Plants: Tissue Desiccation, DNA Extraction and Mutation Discovery, A Protocol. Springer ISBN: 978-3-319-16258-4 (Print) 978-3-319-16259-1 (Online), ISBN: 978-3-319-16258-4 (Print) 978-3-319-16259-1 (Online) http://rd.springer.com/book/10.1007%2F978-3-319-16259-1.

BADO, S., B.P. FORSTER, A. GHANIM, J. JANKOWICZ-CIESLAK, G. BERTHOLD, L. LUXIANG. Protocols for Pre-Field Screening of Mutants for Salt Tolerance in Rice, Wheat and Barley. ISBN 978-3-319-26588-9 *(in press, to be published in 2016).*

## Peer-reviewed Book Chapters

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

BADO, S., B.P. FORSTER, B.J. TILL, S. NIELEN, P.J.L. LAGODA, M. LAIMER (2015). Plant Mutation Breeding: Current Progress and Future Assessment. J. Janick (editor), In: Plant Breeding Reviews, Volume 39, pp 23–88.

## Peer-reviewed Journal Articles

BADO, S., R. PADILLA-ALVAREZ, A. MIGLIORI, B.P. FORSTER, M. JAKSIC, Y. DIAWARA, R. KAISER, M. LAIMER (2015). The Application of XRF and PIXE in the Analysis of Rice Shoot and Compositional Screening of Genotypes. Nuclear Instruments and Methods in Physics Research Section B Beam Interactions with Materials and Atoms 09/2015; DOI:10.1016/j.nimb.2015.08.081.

JHURREE-DUSSORUTH, B., J. JANKOWICZ-CIESLAK, B.J. TILL. Genetic Diversity Study of Dessert-type Banana Accessions in Mauritius using Low-Cost SNPs Detection Technology. Acta Horticulturae *(in press).*

BADO, S., P. BAZONGO, G. SON, A.M. LYKKE, T.K. MOE, B.P. FORSTER, S. NIELEN, A. OUEDRAOGO, I.H.N. BASSOLÉ (2015). Physicochemical Characteristics and Composition of Three Morphotypes of *Cyperus esculentus* Tubers and Tuber Oils. Journal of Analytical Methods in Chemistry, http://www.hindawi.com/journals/jamc/aa/673547/.

MAGHULY, F., J. JANKOWICZ-CIESLAK, S. PABINGER, B.J. TILL, M. LAIMER (2015). Geographic origin is not supported by the genetic variability found in a large living collection of Jatropha curcas with accessions from three continents. Biotechnology Journal 10, pp 536–551.

FORSTER, B.P., B.J. TILL, A.M.A. GHANIM, H.O.A. HUYNH, H. BURSTMAYR, P.D.S. CALIGARI (2015). Accelerated Plant Breeding. CAB International 2015 (Online ISSN 1749-8848).

LEAL-BERTIOLI, S.C.M., S.P. SANTOS, K.M. DANTAS, P.W. INGLIS, S. NIELEN, A.C.G. ARAUJO, J.P. SILVA, U. CAVALCANTE, P. GUIMARÃES, A.C. BRASILEIRO, N. CARRASQUILLA-GARCIA, R.V. PENMETSA, D. COOK, M.C. MORETZSOHN, D. BERTIOLI (2015). Arachis batizocoi: a study of its relationship to cultivated peanut (A. hypogaea) and its potential for introgression of wild genes into the peanut crop using induced allotetraploids. Ann Bot 115, p. 237–49.

## Referred Journals

BESHIR, M.M., A.M.A. GHANIM, N.E. AHMED, I.H, BABIKER, P. RUBAIHAYO and P. OKORI (2015). Prevalence and severity of sorghum leaf blight in sorghum growing areas of central Sudan. Wudpecker Journal of Agricultural Research 4(6).

BESHIR, M.M., A.M.A. GHANIM, P. RUBAIHAYO, N.A. AHMED, P. OKORI (2016). Simple sequence repeat markers associated with anthracnose and turcicum leaf blight resistance in sorghum. African Crop Science Journal. Accepted for publication.

## Conference Abstracts

SARSU, F., M. CARIDAD, C. MUÑOZ (2015). Development of Heat Tolerance Screening Techniques of Common and Tepary Beans Mutants for Adaptation to High Temperature in Drought Prone Areas. Plant Abiotic Stress III. 29 June–1 July 2015, Vienna, Austria. Book of Abstract page 48.

SARSU, F., M. ASHRAF, M. CARIDAD, P. KUSOLWA, L. KIHUPI, M. RAJAB, N. YONA (2015). Rapid Screening Methods for Heat Stress Tolerance of Mutant Rice in the face of Climate Change. Plant Abiotic Stress III. 29 June–1 July 2015, Vienna, Austria. Book of Abstract page 48.

J. JANKOWICZ-CIESLAK, S. BADO, A. SOCHACKA, S. DATTA, A. DAVSON, J. ROBINSON, C.-P. CHAO, S.-H. HUANG, A. VILJOEN, B.J. TILL (2015). A pipeline for generating bananas resistant to Fusarium wilt TR4. Plant Biotic Stresses & Resistance Mechanism II Conference, 2–3 July 2015, Vienna, Austria.

B. SARAYE, J. JANKOWICZ-CIESLAK, A. SOCHACKA, S. DATTA, B.J. TILL (2015). Improvement of heat stress response in tomatoes through induced mutations. Plant Abiotic Stress Tolerance III Conference, 29 June–1 July 2015, Vienna, Austria.

J. JANKOWICZ-CIESLAK, L. FRAGNER, J. SZABLINSKA, W. WECKWERTH, B.J. TILL (2015). A climate ready banana: studies of the effects of drought stress. Plant Abiotic Stress Tolerance III Conference, 29 June–1 July 2015, Vienna, Austria.

J. JANKOWICZ-CIESLAK, K. KOLLOCH, O.A. HUYNH, J. ZALE, B.J. TILL (2015). TILLING and Ecotilling for disease resistance in citrus. Plant Biotic Stresses & Resistance Mechanism II Conference, 2–3 July 2015, Vienna, Austria.

Z. CHEN, B.J. TILL, T. LAN, B.J. HOFINGER, J. JANKOWICZ-CIESLAK, O.A. HUYNH, S. BADO, S. NIELEN (2015). Reverse Genetics for Discovery of New Alleles Conferring Resistance to Rice Pathogens. Plant Biotic Stresses & Resistance Mechanism II Conference, 2–3 July 2015, Vienna, Austria.

S. BADO, R. PADILLA-ALVAREZ, A.M.A. GHANIM, S. NIELEN, M.A. MIGLIORI, M. JAKSIC, Y. DIAWARA, M. LAIMER (2015). Early prediction of rice tolerance to salinity based on intake of essential elements. IBA June 2015, Opatija, Croatia.

A.M.A. GHANIM, N.M. KAMAL, S. NIELEN (2015). Overview of marker-assisted introgression of stay-green in sorghum for terminal drought tolerance. Plants Abiotic Stress Tolerance III, 29 June–1 July 2015, Vienna, Austria.

R.B. SNIGDHA, N. WONDER, A.M.A. GHANIM, S. NIELEN (2015). Pre-field phenotyping of lentil mutants for drought tolerance using polythylene glycol. Plants Abiotic Stress Tolerance III. 29 June–1 July 2015, Vienna, Austria.

K. KOŠMRLJ, E. SAPEY, A.M.A. GHANIM, B. BOHANEC, B.P. FORSTER, S. NIELEN (2015). Haploid induction *via* pseudo-fertilization with irradiated pollen in cucurbits. Plants Abiotic Stress Tolerance III, 29 June–1 July 2015, Vienna, Austria.

T. BELACHEW, A.M.A. GHANIM, S. NIELEN, Y. DIAWARA (2015). Optimization of Ion Beam as an efficient alternative for mutation induction in crop plants. Plants Abiotic Stress Tolerance III. 29 June–1 July 2015, Vienna, Austria.

# Websites and Links

- Plant Breeding and Genetics Section:

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

- InfoGraphic for 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 Division of Nuclear Techniques in Food and Agriculture:

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

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

- 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/about/en/

- FAO Agriculture and Consumer Protection Department:

  http://www.fao.org/ag/portal/index_en/en/

## Impressum

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