Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Plant Breeding & Genetics Newsletter

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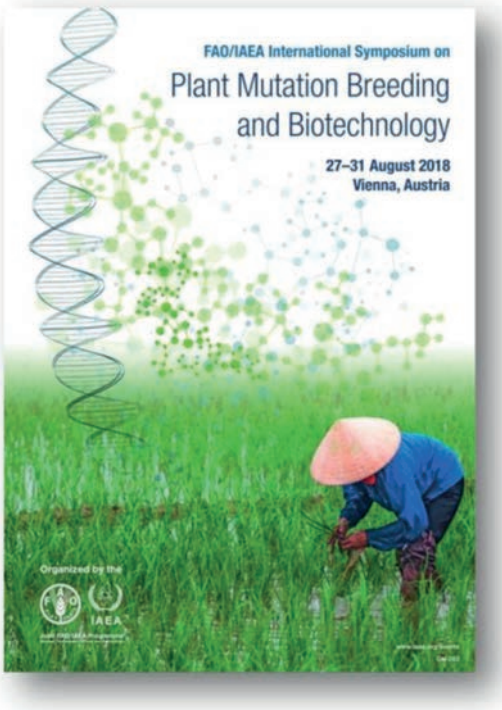
To Our Readers

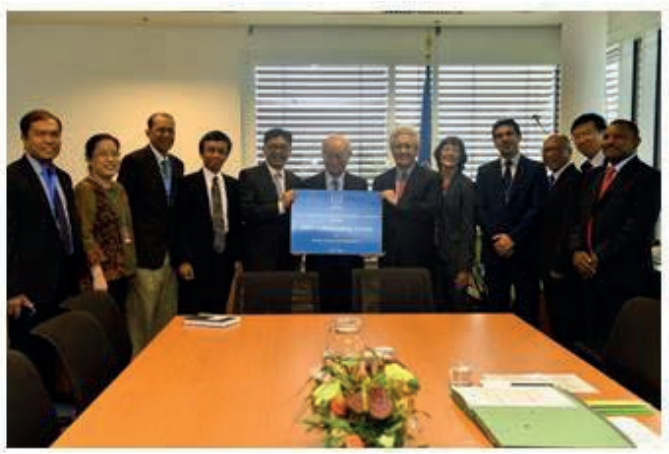
Dear colleagues,



I am proud to announce the FAO/IAEA International Symposium on Plant Mutation Breeding and Biotechnology, to be held in Vienna, Austria, from 27 to 31 August 2018. Since our last International Symposium ten years ago, this event will highlight specific challenges faced by Member States, including emerging transboundary threats to crop production, and will assess the overall importance of mutation breeding to food security. It will highlight new developments, trends and challenges in the field of plant mutation breeding and biotechnology, and foster a broad exchange of information within the scientific community as well as with the private sector. The Call for Papers as well as more information on the Symposium is included in this newsletter and can be found on the dedicated website of this Symposium.

As we come to the end of 2017, let me reflect on some of the achievements of the Plant Breeding and Genetics (PBG) Subprogramme, to which so many of you have contributed, and inform you about some of the planned activities for 2018.

A new agreement was signed between Indonesia's National Nuclear Energy Agency (BATAN) and the IAEA, designating the Center for Isotopes and Radiation Application (CIRA/BATAN) as an IAEA Collaborating Centre. Nuclear applications in crop improvement have long been making significant contribution to food security in Indonesia. CIRA/BATAN has successfully developed many mutant varieties in different crops; indeed, it received an outstanding achievement award for this work during the celebration of the 50th anniversary of Joint FAO/IAEA Division in 2014. The Collaborating Centre agreement will further strengthen collaboration between the PBG and CIRA/BATAN on the development of plant mutation breeding and related nuclear technologies aimed at enhancing capabilities in crop improvement for climate change adaptation. One of the centre's contributions will be to validate and co-develop protocols for mutation breeding of rice, sorghum and soybean.



Left photo: Aldo Malavasi, IAEA Deputy Director General and Head of the Department of Nuclear Sciences and Applications, and Djarot Sulistio Wisnbroto, Chairman, National Nuclear Energy Agency of the Republic of Indonesia (BATAN) sign the Collaborating Centre Agreement in the presence of IAEA Director General Amano with BATAN Chairman Wisnubroto and Darmansjah Djumala, Ambassador and Resident Representative of Indonesia to the IAEA during the 61st IAEA General Conference in Vienna, Austria on 22 September 2017

Right photo: IAEA Director General Amano with BATAN Chairman Wisnubroto and Darmansjah Djumala, Ambassador and Resident Representative of Indonesia to the IAEA, at the Collaborating Centre Agreement signing ceremony (Photos courtesy of D. Calma/IAEA)

During the 61st IAEA General Conference, PBG, jointly with the Soil and Water Management & Crop Nutrition (SWMCN) Section and the Technical Cooperation Division for Asia and Pacific, organized a side event on *Climate-Proofing Rice Production Systems: Nuclear Techniques for Climate Change Adaptation*. This event showcased how nuclear techniques are helping Member States to broaden the genetic diversity of rice, improve yield and enhance food security. Four speakers, from Indonesia, Malaysia, the Philippines and Viet Nam, showcased sustainable successes in using nuclear techniques to mitigate the impacts of climate change, the importance of mutation breeding for developing improved rice varieties and the impacts they have had on food security. The side event was attended by 60 participants, including Ambassadors from Viet Nam, Malaysia, Myanmar and the Philippines. See also https://www.iaea.org/newscenter/news/nuclear-technology-helps-southeast-asia-boost-climate-proof-rice-experts-demonstrate the associated news release.

Audience at the IAEA General Conference Side Event

Invited speakers of the IAEA General Conference Side Event and Joint FAO/IAEA Division staff

The PBG currently provides technical support to five Coordinated Research Projects (CRPs) and 69 active Technical Cooperation Projects (TCPs), focusing on crop improvement through mutation breeding techniques. These projects contribute to developing crop mutant varieties adaptable to climate change and to ensuring food security in Member States.

A new CRP on 'Improving Resilience to Drought in Rice and Sorghum through Mutation Breeding' was launched this year, with the first research coordination meeting (RCM) held in October 2017. This CRP aims at improving drought resilience of rice and sorghum germplasm through mutation induction and the development/adaptation of robust screening protocols for rapid generation advancement and developing molecular markers linked to drought tolerance genes.

Currently we are in the process of developing a new CRP on Disease Resistance in Cereals for Better Adaptation to Climate Change, which will focus on disease resistance in

rice. Following a Consultants Meeting in Vienna, Austria, in December 2017 to discuss project objectives, activities and work plan, a call for research proposals will be announced on our website (https://www.iaea.org/about/plant-breeding-and-genetics-section) in early 2018. We invite you to look out for this Call and to submit your proposals if you would like to participate.

A Technical Meeting on Mutation Breeding was organized in Bali, Indonesia, from 4 to 7 September to discuss a regional approach, strategy and socio-economic impacts of plant mutation breeding for national and regional development in Asia. The meeting underlined the importance of mutation breeding for crop improvement and urged PBG to continue to provide technical support, advice and services in plant mutation breeding to assist countries in the region to further enhance the adaptability of crops to climate changes. The meeting stressed the need to strengthen cooperation in the region through the establishment of a Regional Mutation Breeding Network to facilitate the exchange of mutant varieties/lines for breeding purposes with the aim of accelerating mutant trait discovery and molecular marker development for agronomically important traits to improve the efficiency of mutation breeding.

Through eleven training courses organized in Members States as well as through training opportunities at our Plant Breeding and Genetics Laboratory (PBGL) at Seibersdorf, we support Members States' needs to strengthen capacity building and to transfer technology for crop improvement. As a direct result, eleven mutant varieties were released in 2017 and 10 mutant lines are in the pipeline to be released. In Pakistan, the sesame mutant variety NIAB-Pearl, released in 2017, has a 20-25% higher yield compared to the previously preferred sesame varieties. It has been widely accepted by farmers and is already cultivated on 10 000 ha. In Bangladesh, where nuclear techniques have been the mainstream in rice breeding for many years, rice production increased three-fold in the last few decades; also here, new varieties of rice have now been developed. Its history of rice mutation breeding has enabled Bangladesh to stay one step ahead of its rapid population growth. In Zimbabwe, a recently released cowpea mutant variety (named Crop Breeding Cowpea 5) with improved yield and large seeds has the potential to replace the existing small-seeds cowpea varieties and to increase the cultivated area in Zimbabwe.

In 2017, the PBGL made substantial progress towards developing greenhouse protocols for pre-field screening for resistance to the parasitic weed *Striga* in both sorghum and rice. Building on the progress made in mutation discovery during previous years, the PBGL has initiated several R&D projects in 2017 aimed at developing molecular marker technology and protocols to speed up the breeding and pyramiding of key mutant traits of high value to Member States. Two pilot projects have been set up and are at advanced stages: one project focuses on the development of allele-specific markers for a low-lignin trait in barley useful for feed applications, while the second project focuses on the development of markers for semi-dwarfism and early maturing traits in sorghum. The latter project is utilizing next-generation sequencing technologies for whole genome sequencing of mutants and their parental lines. Laboratory operations and management systems have been updated to facilitate a multidisciplinary R&D approach that integrates genetics and biotechnology with breeding. Networks are currently being developed to help set up new R&D cooperation with Member States intended to address major crop improvement challenges using mutation breeding and related technologies.

In future, we plan to distribute the PBG Newsletter only electronically. If you would like to continue receiving it, please send your email address to K.Allaf@iaea.org. You will of course still find it also on our website.

Finally, I would like to thank all our collaborators and counterparts for your support and significant inputs to our joint activities and to express my appreciation for your dedication and enthusiasm in helping to support our Member States by developing and transferring sustainable plant mutation breeding techniques to them.

Ljupcho Jankuloski
Acting Head
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Staff News

Technician

Florian Goessnitzer

We are pleased to welcome Mr Florian Goessnitzer who joined the PBGL in August 2017. Florian studied Biology and Botany with specialization in plant physiology and plant chemistry at the University of Vienna, Austria, and finished his diploma thesis at the Department of Pharmacognosy in 2012. In his thesis, he dealt with the establishment of *in vitro* plant tissue cultures of *Peucedanum ostruthium* (a medicinal plant used in traditional Austrian medicine) using the soil bacterium *Rhizobium rhizogenes* that induces the hairy-root disease in dicotyledonous plants. Following this, he performed HPLC analysis of the secondary metabolites produced by these hairy roots. During his diploma thesis, he was employed at the department's Pharmaceutical Biotechnology Laboratory. For more than six years he acquired extensive knowledge through several projects dealing with the discovery of natural products from plants and microorganisms using state-of-the-art *in vitro* tissue culture, microbiological, molecular and analytical methods. In his most recent project, he was involved with the cultivation and identification of microorganisms from marine sediments of the deep sea. He also served as a lecturer at the Department of Botany and Biodiversity Research of the University of Vienna, teaching and training students in various techniques and methods of *in vitro* plant tissue culture. Florian's scientific background, his broad knowledge in several research fields and his extensive experience in laboratory management make him a valuable contribution to the PBGL team.

Forthcoming Events

Experts Meeting on Compiling of Screening Protocols for Target Green Traits in Selected Crops, RAS/5/077, Faisalabad, Pakistan, 12–16 March 2018

Technical Officer: S. Nielen

This meeting is part of the regional TCP RAS/5/077 on Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA). This project has the objective to develop new types of crop varieties referred to as 'Green Crop' with high quality, traits such as high yield, high photosynthetic efficiency, ideal plant type, resistance to abiotic and biotic stresses and less agricultural inputs (pesticides and fertilizer) under environmental-friendly manner.

The purpose of the meeting is to draft a protocol book with focus on both screening techniques and physiological analysis for abiotic stresses and nutrient uptake. The protocols will serve as guidance for project participants in screening their mutant populations for abiotic stresses, including drought tolerance, as well as for high nutrient efficiency with the aim of selecting high yielding mutant plants with significantly reduced consumption of chemical fertilizers and water. A group of invited experts will present and discuss various screening techniques, elaborate a suitable format of protocols and prepare drafts of the protocols that, after further editing, will be printed and made available to all project participants.

Training Course on Mutation Breeding of Agricultural Crops Focused on Tolerance to Various Types of Abiotic Stress RLA/5/068, Ciudad Obregón, Sonora, México, 12–16 March 2018

Technical Officer: S. Nielen

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

Many countries in Latin America and the Caribbean have a deficit in food production, leading to serious problems of poverty and malnutrition, especially in rural areas. This situation is further compounded by the effects of climate change and population growth. The productivity of small farmers are also affected by adverse weather conditions (drought, floods, extreme temperatures), soil impoverishment caused by inappropriate agricultural practices (salinization, acidification, loss of nutrients), inadequate technology and use of underperforming cultivars often susceptible to pests and diseases. The project focusses on the use of mutation induction, mutation detection and pre-breeding technologies to develop new crop varieties with improved characteristics.

The purpose of this course is the formation of the necessary skills for the application of selection techniques that will allow the identification of plants with characteristics of tolerance to various types of abiotic stress, as well as their metabolic and molecular bases, which significantly impact the productivity of agricultural crops of socio-economic interest in each country. The participants will be trained in the use of equipment and methodologies for the quantification of stress impacts in regard to characters of productivity and quality that allow the evaluation of a large number of genotypes. Special emphasis will be placed on tolerance to drought and salinity and to counting techniques (greenhouse and field) for the selection of large mutant populations in a mutation breeding programme.

The course is organized for the countries that participate in RLA/5/068 (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru and Venezuela) and specifically for scientists directly involved in the mutation breeding programme of the participating institutes.

Workshop on Mutation Breeding and Supportive Biotechnologies for Crop Improvement in Pacific Islands, RAS/5/079, Vienna and Seibersdorf, Austria, 2018 (exact date to be decided soon)

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

Sustainable food, nutrition and livelihood security is a necessity for every nation, as is international trade. Some key challenges contributing to food insecurity include increased population, urbanization, reliance on imported foods, changes in eating habits and diets, impacts of climate change, frequent occurrence of natural disasters and emerging plant and pest diseases, all of which also contribute to poor health of communities. A number of Pacific Island Countries (PICs) were greatly impacted by El Niño and have been experiencing prolonged impacts of drought over the past five years. The PICs are becoming vulnerable to the outbreaks of new pests and diseases and their possible spread across the borders. However, limited capacity in terms of human, finances and scientific infrastructure have discouraged much innovative research in the region. Crop mutation breeding has the potential as a valuable tool to develop biotic/abiotic stress resistant/tolerant crop varieties. So far, the use of safe nuclear science technology and related biotechnologies for generating crops that are tolerant varieties to drought, strong winds, and certain pest and diseases has not been explored by the PICs. Thereby the new regional TCP RAS/5/079 is focused on Improving Crops Resilience to Climate Change through Mutation Breeding in Pacific Islands and is planned to start in January 2018.

The purpose of this workshop is to launch the project and discuss the specific needs of each country and finalize the details of the activities under the project work plan, and to provide participants with basic theoretical and practical knowledge on crop mutation breeding with special attention to vegetatively propagated crops which will be the basis for future training events.

The first, advisory segment of this workshop (12–14 March 2018 in Vienna International Centre (VIC), Vienna) will focus on the following topics:

- Status of information resources and surveys undertaken to inform the development of this project;
- A description of existing infrastructure (facilities, laboratories);
- Related work on plant breeding currently being conducted by counterpart institutions;
- National limitations and restrictions;
- The needs identified at the first project meeting and any further considerations identified subsequently;
- National/regional needs to successful implementation of the project.

The second, technical segment (14–23 March 2018, Seibersdorf) will be organized by the Plant Breeding and Genetics Laboratory, Seibersdorf. This training part will include lectures, practical experiments, demonstrations and interactive exercises. For the practical experiments, banana/and or other appropriate vegetatively propagated material will be used as an example of a vegetatively propagated crop. The following main topics will be covered:

- General principles of mutation induction and development of mutant populations;
- Mutation induction in vegetatively propagated plants;
- Radio-sensitivity testing and dose optimization for *in vitro*/*in vivo* explants;
- Handling of mutant populations (phenotyping/genotyping) for mutant identification;
- Utilization of appropriate technologies for efficiency enhancing of mutation breeding.

Training Course on Advanced Tissue Culture Techniques Combined with Mutagenesis for Crop Improvement, RAF/5/076, Accra, Ghana, 7–11 May 2018

Technical Officer: F. Sarsu

This training course will be organized in cooperation with the Ghana Atomic Energy Commissions (GAEC). It is open to candidates and project partners in the project RAF/5/076 (AFRA) on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach.

The purpose of this training course is to provide participants with theoretical as well as practical information on tissue culture techniques applied in mutation breeding.

The course will include lectures and practical sessions on:

- Plant tissue culture for mutation breeding;
- Handling mutant plant populations;
- *In vitro* mutation screening methods;
- Using haploid techniques in breeding;
- Practical examples of *in vitro* mutagenesis;
- Security and safety in the laboratory.

The participants should be from participating Members States involved in the project RAF/5/076 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 in plant breeding and 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.

Second Coordination Meeting on Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach, RAF/5/076, Tangier, Morocco, 26–30 June 2018

Technical Officer: F. Sarsu

Most African countries grow similar food crops and hence they share common problems on climatic conditions, diseases, pests, soil fertility, flooding and poor yield. The effects of climate change have affected food production in most of African countries in equal measure. There is a limited financial, human and technical capacity of many African countries to enhance research and adaptation of new technologies for food security. Regional collaborations help to share available resources to solve these challenges. Regional collaborations also facilitate efficient sharing of funds from AFRA and other funding agencies, sharing of best practices, expertise, equipment, and trainings. Collaborations also increase the chances of success in managing common problem such as drought, transboundary pests and diseases, e.g. the East African strain of cassava mosaic virus. Therefore, a regional approach on solving issues of food security, malnutrition and poverty can be more efficient and cost effective.

This project focuses on strengthening of regional capability of Member States for developing and disseminating mutant varieties as well as varieties of traditional and neglected African crops. During the previous cycle, 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, 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.

After the initial meeting in Dakar, Senegal in 2016, this will be the second coordination meeting, which will be organized by the PBG in collaboration with the Morocco National Institute of Agricultural Research.

The purpose of this coordination meeting is to:

1. Review and discuss the details of the activities stated in the work plan to be implemented under the project RAF/5/076;
2. Report on the progress made over the last two years under the project RAF/5/076 by participating countries at national level;
3. Review the progress made over the last period;
4. Review the work plan of the project and agree on national plans for the activities to be implemented at the national level;
5. Identify and discuss measures to ensure sustainable continuation of work after completion of project including exchange of material and information.

The meeting will discuss the progress made and the achievements reached at each participating Member State since the last meeting and will discuss future actions related to the next phase of the project. It will detail the regional work plan and activities for facilitating its implementation, including:

- Individual country presentations on the status of work on the project and related activities;
- Presentation and discussion of country work plans;

- Group discussions on strategies for completion of the current project including modalities for exchange of germplasm and protocols for screening.

The meeting will discuss, review, and update a regional work plan and national work plans for implementation of the new project RAF/5/076 including the training needs of AFRA Member States regarding plant mutation breeding techniques and biotechnology.

Past Events

Coordination Meeting on Improving Sustainable Cotton Production through Enhanced Resilience to Climate Change, RAS/5/075, Hangzhou, People's Republic of China, 3–7 July 2017

Technical Officer: L. Jankuloski

Cotton has a special significance and plays an important role in the economies of Australia, Bangladesh, People's Republic of China, India, Islamic Republic of Iran, Myanmar, Pakistan and Viet Nam. This leading fibre crop is grown on 20.5 million hectares in the three main cotton producing countries of the Asia and Pacific region i.e. People's Republic of China, India and Pakistan, with their annual contribution of about 60–65% in total world cotton production. Emerging demands from Viet Nam and Bangladesh for their cotton mill use signifies the increased role of cotton production in the economy of regional countries.

The purpose of the coordination meeting was to review current status of cotton mutation breeding in participating countries, and fine-tune the work plan/activities for next years.

Counterparts from Bangladesh, People's Republic of China, Myanmar, Pakistan and Syrian Arab Republic attended this meeting, and provided presentations on their current status of cotton breeding in their respective countries, expected roles of nuclear techniques and related biotechnologies in the project, as well as gaps and needs for the application of mutation breeding techniques.

Meeting participants

After reviewing national cotton breeding programmes and discussion with participants, it was concluded that:

- Existing cotton varieties grown in the region are highly sensitive to extreme periods of heat stress resulting in decreasing yield and deteriorated fibre quality; and
- Development of high yielding, heat/drought tolerant and nutrient use efficient germplasm is necessary for sustainable cotton production in the region.

People's Republic of China and Pakistan are leading countries among participating countries with already established mutation breeding programme and released mutant varieties. The current achievements from the project are:

Pakistan has released one cotton mutant variety, NIAB878, with tolerance to heat and fine fibre quality and developed number of advanced mutant lines.

Cotton mutation breeding programmes in Bangladesh and Myanmar have been established within this project and are progressing very well. Development of M_2 is in progress and selection in M_2 generation will be made by end of 2017.

Mutation breeding programmes in Islamic Republic of Iran, Syrian Arab Republic and Viet Nam is in initial phase, at the stage of M_1 generation, with expectation of M_2 generation in 2018.

During the first coordination meeting in 2016, network among participants was established. Seed material of two promising heat tolerant cotton mutant lines, developed in Pakistan were disseminated to the participants. Seed material of these two mutant lines was multiplied and adaptation trial will be performed in participating countries in 2018.

During the coordination meeting, participants had the opportunity to visit greenhouses and experimental field with cotton germplasm in Zhejiang University. Participants appreciated the capacity of cotton breeding programme, as well as breeding programmes in other crops. In the field, cotton breeding material, includes diverse germplasm used for breeding as well as for genomic analysis in cotton for identification of loci associated with quality and yield traits.

In order to increase awareness on cotton mutation breeding in the region, it was recommended to invite new Member States (Afghanistan, Cambodia, Indonesia, Malaysia, Sri Lanka and Thailand) to participate in RAS/5/075.

The third coordination meeting will be held in Myanmar in June 2018. Based on needs of participating countries, it was proposed to organize training course on *in vitro* tissue culture techniques applied in cotton mutation breeding and pre-filed screening techniques for abiotic stress tolerance.

Coordination Meeting to Review the Progress of the Field Trials, Developing Bioenergy Crops to Optimize Marginal Land, Productivity through Mutation Breeding and Related Techniques, RAS/5/070, Hanoi, Viet Nam, 3–7 July 2017

Technical Officers: F. Sarsu and M. Zaman

The project coordination meeting was held in collaboration with the Viet Nam Institute of Agricultural Genetic. The purposes of the meeting were:

- To review the project progress and update the project work plan in line with activities implemented so far and emerging needs of the government parties;
- To identify the current status of soil, nutrient and water management and plant mutation breeding practices of marginal land using nuclear and isotopic techniques;
- To address the gaps and needs for the application of soil and water management techniques and mutation breeding activities for increasing soil fertility and productivity of bioenergy crops on marginal land.

Thirty national project coordinators (NPCs) (two NPCs per country – one plant breeder and one soil scientist) from 15 different Asian and Pacific countries (Bangladesh, Cambodia, People's Republic of China, India, Indonesia, Republic of Korea, Lao P.D.R., Malaysia, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, Viet Nam and national observers from Viet Nam and Technical Officers, Ms Fatma Sarsu and Mr Mohammad Zaman attended the meeting.

The current national project activities were presented, as well as the national work plans which were discussed and amended to contribute to the overall objective of the project. The meeting was successful and the expected outputs were fully achieved, national and regional work plans were discussed in detail, needs were identified and guidance provided as appropriate. In addition, the regional work plan was adapted to the identified needs and the activities were specified accordingly.

The following recommendations were made:

- Counterparts were advised to keep track of the work plan and report any changes in timely manner;
- CPs are highly encouraged to provide updated information on existing and new mutant varieties to the FAO/IAEA Mutant Variety Database (MVD) by using the MVD submission form to be downloaded from the MVD website (mvd.iaea.org) or submitting information directly to the MVD administrator.

The participants acknowledged both, IAEA and the Viet Nam Institute of Agricultural Genetic, for hosting and organizing this meeting and committed to communicate regularly to ensure that project will meet its objectives.

Meeting participants

Training Course on Advanced Mutation Techniques for Induction and Screening of Green Traits in Crops, RAS/5/077, Beijing, People's Republic of China, 14–18 August 2017

Technical Officer: S. Nielen

This was the first training course under the new regional TCP RAS/5/077 on Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA) and it was organized by the IAEA in cooperation with the Government of China through the Institute of Crop Science (ICS), Chinese Academy of Agricultural Sciences (CAAS). The project has the objective to develop new types of crop varieties referred to as 'Green Crop' with high quality traits such as high yield, high photosynthetic efficiency, ideal plant type, resistance to abiotic and biotic stresses and less agricultural inputs (pesticides and fertilizer) under environmental-friendly manner.

The purpose of this training course was to create awareness and provide scientific and technical information on application of advanced mutation techniques for induction and screening of green traits in crops. Thirty-one scientists from institutes that are actively involved in the national

work teams of the project RAS/5/077 participated in the course. The participants came from Bangladesh, Cambodia, People's Republic of China, India, Indonesia, Republic of Korea, Lao P.D.R., Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand and Viet Nam. Eleven local lecturers, including the Course Director and Lead Country Coordinator of the project, Prof Luxiang Liu, and one IAEA expert, Dr Chengdao Li, Department of Agriculture and Food, Government of Western Australia, South Perth, Australia, provided lectures and prepared and guided practical exercises and demonstrations. The training course included the following topics:

- Theoretical introduction and technical demonstration of heavy ion beam and simulated cosmic ray irradiation for mutation induction and visit to the related facilities;
- Experimental demonstration of biological effects of heavy ion beams compared with gamma rays;
- Green super rice and screening techniques for target green traits;
- Mutant detection and selection using genomics approach;
- Proteomics for green trait screening in crop mutants;
- Introduction to a TILLING and proteomics platform for gene discovery and breeding;
- Application of genome editing in main food crops.

Meeting participants

Electronic collections of all lecturers' presentations and some key literature for further reading were distributed to the participants. The course has received very positive feedback from the participants, who brought the latest knowledge on mutation induction and mutation screening techniques that can be applied in their national programmes to their home institutes. As some of the technologies are advanced and not yet accessible to every country in the region, the participants and their home institutes shall make use of the existing RAS/5/077 network. Some of them for example brought seeds for irradiation to the Institute of Crop Science, which they could bring home to plant the M_1 generation or to evaluate radio sensitivity of their material.

Introduction to practical work in the molecular laboratory

Participants in front of a tandem accelerator for generating heavy ion beams that can be used to produce protons for simulating cosmic rays irradiation

Technical Meeting on Plant Mutation Breeding, Bali, Indonesia, 4–7 September 2017

Technical Officer: L. Jankuloski

Meeting participants

This meeting was organized by PBGS and Centre for Isotopes and Radiation Application (CIRA), National Nuclear Energy Agency (BATAN) in Bali, Indonesia. Representatives and senior officials, from 17 Member States in Asia (Bangladesh, Cambodia, People's Republic of China, India, Indonesia, Japan, Republic of Korea,

Lao P.D.R., Malaysia, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Viet Nam) participated in the meeting.

The purpose of the meeting was to discuss regional approach, strategy and the role of plant mutation breeding on socio-economic effects on national and regional development and supporting the Sustainable Development Goals (SDGs) for the Asia region.

During the meeting, discussions were held on challenges and needs for the region, promoting and strengthening application of mutation breeding techniques in the region, establishing regional network to stimulate and facilitate capacity building and R&D, enhancing number of irradiation facilities in least developing countries in the region and strengthening collaboration in plant mutation breeding.

After discussions, the meeting adopted recommendations and proposals.

It was concluded that climate change has negative impact on food security in Asia and it was emphasized the comparative advantages and importance of mutation breeding for development of new crop varieties with better adaptation to climate change, particularly tolerant to drought, salinity, submergence and disease resistance.

The meeting underlined the importance of mutation breeding for crop improvement and requested the Joint FAO/IAEA Division to continue to provide technical support, advice and services in plant mutation breeding for the countries in the region towards enhancing the adaptability of crops to climate changes. Particularly support is needed to least developing countries in the region towards capacity building, infrastructure development and upgrading of facilities for mutation induction (machine source irradiation and availability of ion beam for mutation induction).

The meeting urged the need to strengthen cooperation in the region through establishing Regional Mutation Breeding Network that will focus on facilitating the exchange of mutant varieties/lines for breeding purposes, accelerating mutant trait discovery and molecular marker development for agronomically important traits to improve the efficiency of mutation breeding.

Considering the importance of mutant germplasm, as a source for breeding and developing improved crop varieties, it was recommended to establish regional mutant germplasm repository for efficient conservation, utilization and use by countries in the Asia/Pacific Region and worldwide for breeding purposes.

During the meeting, the participants had the opportunity for one day technical field visit. They visited farmers' fields grown with rice mutant varieties, adaptation trials with rice mutant varieties and experimental field with sorghum mutant lines. Participants appreciated the capacity of mutation breeding programme at BATAN and collaboration with farmers and agricultural agencies on participatory approach for developing and realising new mutant varieties. The field visit provided a good opportunity to have a full picture on the success in mutation breeding in Indonesia. Mutation breeding is one of the most successful fields of application of nuclear techniques in food and agriculture in Indonesia. Number of released rice, sorghum and soybean mutant varieties have been released to farmers and contributed to food security in Indonesia. Countries in the region, that have already established mutation breeding programmes, shared their experiences, challenges through mutant varieties contributing to food security in their countries and region.

The participants acknowledged the technical meeting and proposed to hold next meeting in Vienna during the International Symposium on Plant Mutation Breeding and Biotechnology (27–31 August 2018) for further coordination and strengthening collaboration in the region.

Some achievements include development of new advanced mutant lines in Bangladesh, Indonesia, Malaysia, Pakistan and Thailand tolerant to submergence, drought and diseases, and number of mutant lines developed in other participating countries with improved agronomic performance. Based on request and needs for participating countries, the next training course will be in drought tolerance screening in rice and IRRI was suggested as a potential host for this training.

The project has been successfully promoting collaboration between developing and least developing countries for exchange of expertise and networking within the region.

The meeting was also successful in strengthening collaboration and partnerships between developing and least developing countries for exchange of expertise and networking within the region. Mutant lines and varieties developed were shared among participating countries in order to evaluate adaptability of rice mutant varieties/lines in their countries and to use in their rice breeding programmes.

Participants visiting adaptation trials with rice mutant lines and varieties

Participants visiting experimental filed with sorghum mutant lines

First Research Coordination Meeting on Improving Resilience to Drought in Rice and Sorghum through Mutation Breeding, D2.30.31, Vienna, Austria, 9–13 October 2017

Technical Officer: F. Sarsu

The main objective of CRP D2.30.31 is to improve drought resilience of rice and sorghum germplasm through induced mutation and development/adaptation of screening techniques for sustainable food security. The project combined expertise in field, green house and laboratory to enhance mutation breeding and to develop robust protocols for rapid advancement of generations, and efficient screening packages of mutant populations for drought tolerance. Screening packages will be optimized for phenotyping and genotyping for drought tolerance to develop/adapt technology for accelerated identification of drought tolerant rice and sorghum mutants. 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.

Meeting participants

The main objective of this meeting was to integrate the individual work plans of the selected participants as per discussions on the objectives, outputs and outcomes of the project document and country presentations. The meeting was attended by 12 participants from Bangladesh, People's Republic of China (2), India (2), Indonesia, Japan, Mali, Pakistan, Sudan and Viet Nam.

The participants presented very well-structured projects aiming at better understanding the adaptation of climate change specifically drought tolerance on the two selected crops, but also aiming at developing advanced mutant lines with improved tolerance to drought tolerance using mutation breeding together with the use of phenotyping and molecular techniques. From the numerous questions and comments emerging after each presentation it was clear that the audience was well prepared and quite knowledgeable of the situation facing the crops in their own countries. Even though the approaches presented were various, the meeting found a fertile ground for further discussion.

Scientists and breeders were presented with strong and reliable techniques for asserting the positive mutations and also for shortening the screening procedures in order to more quickly attain the objectives and develop advanced mutant lines for multi-location trails. Bi- and multi-lateral collaborations were established among participants for advanced lines as well as genomics. The participants expressed their gratefulness for appreciation of the IAEA Coordinated Research Project (CRP) approach for cooperative research, which definitely appears as an effective mechanism for initiating and further strengthening collaborations amongst scientists and breeders from all Members States. Bringing together around the table scientists form developed institutions and those form less advanced ones, gives them extra possibilities for testing and screening larger number of populations and to the latter it is an opening to more advanced technologies and also additional contacts and scientific cooperation.

This first RCM brings together contract and agreement holders as well as Agency staff and official observers to review the proposed objectives, activities and outputs of the CRP as well as those of individual contracts. Technical issues were discussed, modifications were made to work plans and important gaps that need to be addressed were identified throughout the course of this RCM meeting. The Second RCM is planned for first quarter of 2019 to review the progress made in the work plan.

Training Course on Genetic Improvement to Enhance the Quality of Crops through Mutation Induction (Latin American and the Caribbean), RLA/5/068, Lima, Peru, 16–20 October 2017

Technical Officer: S. Nielen

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

The project is based on the use of induced mutations, mutation detection and pre-breeding technologies to develop new crop varieties with the characteristics required in the region. These include tolerance and resistance to various abiotic and biotic stresses. Crop quality, however, is also of utmost importance when it comes to commercialization of new developed varieties. Therefore this training course was focused on the analysis and evaluation of crop quality related to nutritive, sanitary and organoleptic characteristics.

The course was implemented at the Universidad Nacional Agraria La Molina (UNALM). Fifteen researchers from Argentina, Bolivia, Brazil, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru and Venezuela participated in the course. Apart from local lecturers of the University, Dr Carlos Guzmán García from CIMMYT, Mexico, was invited as external lecturer to the course.

Regional Training Course on Genetic Improvement to Enhance the Quality of Crops through Mutation Induction

The course included lectures and practical sessions on breeding for quality characters in wheat, rice, root and tuber crops and vegetables. Seeds of cereal mutants and native grains were used for laboratory tests to demonstrate the variability and improvement originated from gamma ray treatments. In practical exercises participants learned various methods to evaluate the physical and chemical quality in mutant populations of cereals and native grains. The included for example the use of mixography to test of the mixing properties of a dough, the analysis of gluten and the use of near infrared spectroscopy that allows assessing various quality parameters in a large number of genotypes and in non-destructive way. One of the lessons learned is how quality traits can be made an integral part of the breeding process aimed at the development of commercially successful varieties. The participants considered that the course was very useful to prepare them for the next step related with the evaluation of the quality of the advanced mutant lines developed in the different projects. The success of this course also will contribute to strengthening the regional collaboration in this project.

Course participants preparing samples for quality analysis

Training Course on Methodologies and Mechanisms for Screening of Mutants against Biotic Stresses, RAF/5/076, Yaoundé, Cameroon, 23–26 October 2017

Technical Officer: F. Sarsu

This training course was organized by the PBG in cooperation with the Government of Cameroon Ministry of Agriculture and Rural Development (MINADER). Seventeen scientists (four national) from 12 different African countries (Burundi, Burkina Faso, Central Africa, Cameroon, Ghana, Ivory Coast, Libya, Madagascar, Namibia, Sierra Leone, Tunisia and Zimbabwe) were selected to participate in the course.

Africa faces major challenges in food security, malnutrition and poverty. Increased population in most African countries have increased demand for food, and also increased need for diversified food sources. Climate change has affected food production in most of African countries in equal measure. Most African countries cultivate similar food crops and hence they share common problems on climatic conditions such as diseases and pests. Thereby, the purpose of this course was to provide participants with theoretical as well as practical information to mutation induction, mutation screening and breeding for biotic stress resistance in crop breeding.

The course included lectures and practical sessions on:

- Mutation breeding procedures/methodologies and handling of mutated population;
- Identification, evaluation and selection of breeding lines;
- Genetics/mechanisms of biotic stress resistance;
- Pre field, laboratory, screen house/field screening methodologies for biotic stress resistance;
- Breeding for biotic stress resistance, mutation breeding, classical breeding and utilization of appropriate biotechnologies;
- Field demonstration and practical screening of selected crop (in maize).

The majority of participants positively evaluated the course and they acknowledged that the knowledge and skills gained are greatly relevant for their future work.

Participants discussing on radio sensitivity tests during the practical session

Participants listening to the lecture on breeding for biotic stress resistance

National Training Course on Mutation Breeding and Efficiency Enhancing Technologies, QAT/5/006, Doha, Qatar, 5–16 November 2017

Technical Officer: A.M.A. Ghanim

The training course was attended by 23 national researchers and technicians of the national TCP QAT/5/006. In addition to the Technical Officer from the PBGL, two experts in plant *in vitro*, molecular and phenotyping technologies in different plant species provided lectures on theory and practical bases of the technologies. The course covered the following main areas:

1. Introduction to mutation induction and development of mutant populations;
2. Overview of efficiency enhancing techniques for mutation breeding;
3. Protocols of doubled haploid production and its application in mutation breeding;

4. Protocols of mutation induction in vegetatively propagated plants including *in vivo* and *in vitro* techniques;
5. Protocols of screening mutant populations for resistance to abiotic stresses with emphasis on salinity and drought.

The PBGL provided adapted protocols and material for the practical sessions on mutation induction using gamma and X ray irradiation, as well as protocols for doubled haploid and salt tolerance screening. The opening session was attended by the Assistant of the Director of Agricultural Research Department, the Assistant of the National Liaison Officer, the National Counterpart of the TCP QAT/5/006, other officials, press representatives and the participants. The training course was the first of its kind in Qatar and laid the foundation for mutation breeding in this country. The participants and the officials were very satisfied and appreciative to the course contents and conduction. This course also created an opportunity to stimulate local funding support to strengthen mutation breeding of priority crops in Qatar for food security.

Practical session on radio-sensitivity test of wheat, barley and wild plants from Qatar using gamma and X rays

National Training Course on Methods for Mutation Detection in Plants, BUL/5/014, Sofia, Bulgaria, 21–24 November 2017

Technical Officer: L. Jankuloski

The training course was held under TCP BUL/5/014 and was organized in cooperation with the institute of Plant Physiology and Genetics. It was attended by 17 participants from 11 different national institutions and one from Macedonia.

The purpose of this course was to provide participants with theoretical as well as practical information on techniques for mutation detection in plants. The training course included theoretical lectures, practical sessions and roundtable discussions. Theoretical lectures and practicals related to the topics were given by the invited expert, Prof J.S. (Pat) Heslop-Harrison from the Department of Genetics and Genome Biology, University of Leicester, UK, and scientists from Bulgarian Academy of Agricultural Sciences.

Training course participants

The training course included lectures and practical sessions on:

- The plant genome and its components;
- Chromosomes, genomes and gene organization;
- Identification of DNA polymorphisms in loci related to abiotic stress response in barley and wheat genomes;
- Using genetic approaches: Identifying, creating and using variability for crop breeding;
- From DNA data to the farmers field: super-domestication and reaching the Sustainable Development Goals.

Training programme was directed towards obtaining theoretical knowledge and practical skills in diverse areas of forward and reverse genetics.

Guidance and specific practical knowledge on the identification of DNA polymorphisms in loci related to abiotic stress response in barley and wheat genomes as well as on the principles and applications of the High Resolution Melting analyses for mutation detection in plants have been provided to the course participants.

Participants showed great interest in the training course and participated actively during the theoretical lectures, practical sessions and in the roundtable discussions. Trainees obtained practical knowledge and experience in genes detection in wheat and barley. The practical demonstrations and hands-on experience were of particular value for the success of this course, which was very positively acknowledged by participants.

Final Coordination Meeting on Enhancing Wheat and Barley Productivity through Induced Mutation with Supportive Breeding and Related Biotechnology Techniques, RAS/5/074, Safat, Kuwait, 27–29 November 2017

Technical Officer: F. Sarsu

Cereals are the most important food crops contributing to food security and sufficiency in the Arab countries.

However, Arab countries are the largest net importers of cereal in the world. Also, 35 percent of daily calories consumed in Arab countries come from wheat and this alone is driving the region's heavy dependence on cereal imports. One of the solutions is improvement of agricultural productivity through investments in research and development; therefore, improved technology will boost cereal yields in the region. Water shortage problem is very important and much of the land in the region too dry for cultivation and grazing. Introducing new drought-tolerant crops combined with water-use efficiency in the area could be an alternative. In addition to water and land constraints, cereal-yield growth has been slower in Arab countries than the rest of the world.

Meeting participants

This situation requires an integrated approach to develop technology packages of mutant lines having (resistance to diseases, tolerance to salinity and heat traits, and sustainable high yield under variable climatic conditions) with proper water, soil and nutrient resources utilization practices. In this context, mutation induction technique has shown potential as a valuable tool in developing drought/salinity tolerant and disease resistant mutant lines of wheat and barley. In order to address these agricultural constraints, a regional mutation breeding programme was implemented under TCPs RAS/5/048 and RAS/5/058. Under these projects, some segregating lines with the targeted agronomic characters were developed as wheat and barley mutant varieties with drought tolerance and some advanced mutant lines are in the pipeline.

The last coordination meeting was organized by the national project coordinator, Ms Habibah Al-Menai, in Kuwait with the following objectives:

- Review the national project progress according to the work plans in line with activities implemented in 2016/2017 of the government parties;
- Report on the progress made under RAS/5/048, RAS/5/058 and two years of RAS/5/074;
- Discuss and decide on exchange/preservation arrangements of genetic plant material, which is generated under the project;
- Discuss the use of techniques/protocols provided during regional training courses;
- Agree on exchange mutant lines/pre-released varieties and decide on continuation of established collaboration/network;
- Discuss and identify needs of the region for another crop and/or agricultural projects which could be assisted through IAEA technical programme;
- Prepare completion report of the TCP RAS/5/074.

The Technical Officer and Kuwaiti officials addressed a warm welcome to the participants, stated importance of the project, implemented activities under the project and emphasized the objectives of the meeting. The following countries were represented in the meeting: Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Syrian Arab Republic and Yemen.

Participants made presentations showing progress achieved and results obtained under the TCPs RAS/5/048 and RAS/5/074 (from 2007 to 2014), as well as the results of the activities planned in support of the project. The details of these achievements were discussed and technical feedback was provided to the counterparts to further emphasize the individual project results in order to achieve the overall objective of the project.

Implementation of the project enhanced the regional capacity for development of new drought tolerant varieties using mutation breeding and biotechnology techniques, and field evaluation and dissemination of improved crop varieties, thereby, assisted the ARASIA Member States in the development and dissemination of improved wheat and barley by induced mutations.

These are the major achievements of this project:

- Availability of research capability, basic infrastructure and trained manpower in most participating countries, (at least one regional training course as well as expert missions are organized each year);
- Some countries such as Yemen have already released drought tolerant wheat and barley varieties, which are contributing towards food security in the Country. Other countries have advanced mutant lines in the pipeline; Jordan already applied two years ago for release of barley mutant lines, which is expected to be released soon. Early generation and advanced induced mutant lines are available in all participating countries;
- More people trained in mutation induction, screening of mutant lines for biotic/abiotic stress, and combined biotechnologies such as tissue culture techniques and molecular techniques;
- Increased official and public awareness of the benefits of nuclear techniques in crop improvement;
- Introduction of new methodologies (such as drought tolerance screening) and biotechnologies (double haploid, molecular markers) in most countries;

- The SMTA (Standard Material Transfer Agreement) adopted and signed in participating countries. Thereby, more germplasm and protocols collected and maintained; developed mutant varieties and advanced mutant lines exchanged between participated countries;
- Very strong collaborations established in plant mutation breeding between participated countries and IAEA.

Training Course on Drought Tolerant Rice: Experimental Design, Phenotyping and Breeding Approaches, RAS/5/073, Los Baños, Philippines, 4–8 December 2017

Technical Officer: L. Jankuloski

The regional training course was held under TCP RAS/5/073 on Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications – Phase II. It was organized in cooperation with the International Rice Research Institute (IRRI) and attended by 19 participants involved in the project from Bangladesh, Cambodia, Indonesia, Lao P.D.R, Malaysia, Mongolia, Myanmar, the Philippines, Thailand and Viet Nam.

The purpose of this training course was to provide trainees with theoretical as well as practical lectures on techniques in mutation breeding combined with conventional breeding techniques and efficiency enhancing biotechnologies to improve the capacity to improve and develop rice mutants tolerant to drought.

Training course participants

The training course included lectures, roundtable discussions and practical sessions (laboratory, greenhouse and field). Lectures were given by the experts from IRRI. The Technical Officer provided lectures on mutation induction and mutation breeding techniques and handling of mutant populations.

The training course included lectures and practical sessions on:

- Overview of components for successful drought research programme;
- Breeding schemes, selection criteria, population structure and suitable traits;
- Donor identification and population development;
- Breeding scheme, selection criteria and material flow;
- QTL mapping basics and introduction to QTL cartographer;
- Physiological aspects of drought tolerance;
- Mutation induction. Basic concepts and knowledge on mutagenic agents. Physical and chemical mutagen treatment;
- Mutation breeding, handling of mutant population, selection;
- Grain yield QTLs for drought tolerance;
- QTLs for traits related to adaptation to direct seeding in rice;
- Identification of candidate genes for drought tolerance.

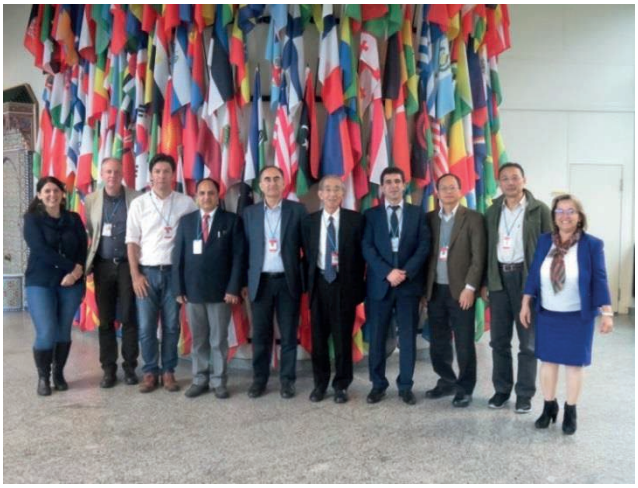
Participants showed great interest in the training course and participated actively during the lectures, practical sessions and in the roundtable discussions. The practical demonstrations and were of particular value and positively acknowledged by all participants. Especially roundtable discussion and design of experimental plans were highly appreciated among trainees. Participants acknowledged that the knowledge and skills, gained during this training course are relevant for their future work in their home countries.

Visit of plant genotyping facilities at IRRI

Practical lecture in plant physiology lab at IRRI

Consultants Meeting on Disease Resistance in Cereals for Better Adaptation to Climate Change, Vienna, Austria, 18–22 December 2017

Technical Officer: L. Jankuloski



PBG staff and consultants

A consultants meeting was organized in order to formulate the proposal for the new CRP on Disease Resistance in Cereals for Better Adaptation to Climate Change (working title). Six invited scientists from China, India, Japan, USA and International Organizations FAO and IRRI, contributed with their expertise and technical advice to the design of a project, which aims at increasing the potential of mutation induction in crop breeding. This CRP should identify new and improved ways on the use of nuclear technology, which will help our counterparts to meet their local breeding challenges.

The consultants met and strongly supported the idea of developing a CRP proposal. They agreed on the need to address the challenges in mutation breeding to improve disease resistance in cereals, particularly rice. Consultants recognized the lack of reliable and efficient screening methods for resistance to sheath blight and false smut in rice and lack of known resistance in wheat blast and consider mutagenesis a viable option for broadening the genetic base of host plant resistance. Consultants proposed that the CRP focuses on generation of germplasm with novel disease resistance using different mutagenesis tools and approaches. The new alleles identified should be mapped using DNA markers to facilitate marker-assisted breeding in different national programmes.

The CRP is seen as strongly linked to Strategic Objectives 2 (SO2) of the FAO which were identified as priorities by the member states. This provides the CRP with the opportunity to be more visible and an avenue for possible extra-budgetary funding for capacity building.

Consultant's visit to PBGL

More news on this new CRP, as well as call for proposal, will be published in the following months on our website.

Coordinated Research Projects

Project Number	Ongoing CRPs	Scientific Secretaries
D2.30.30	Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System	L. Jankuloski I. Ingelbrecht
D2.20.05	Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana	S. Nielen I. Ingelbrecht
D2.50.05	Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security	A.M.A. Ghanim L. Jankuloski
D2.30.31	Improving Resilience to Drought in Rice and Sorghum through Mutation Breeding	F. Sarsu
	CRP in Planning	
	Disease Resistance in Cereals for Better Adaptation to Climate Change	L. Jankuloski

Improving Resilience to Drought in Rice and Sorghum through Mutation Breeding, D2.30.31

Scientific Secretary: F. Sarsu

Drought is the most devastating abiotic stress factor worldwide affecting crop production and is projected to worsen with anticipated climate change. It severely limits plant growth and development as well as agricultural characteristics resulting in reduction of crop yields. Improving drought tolerance in crops to increase the efficiency of water use and to enhance agricultural water productivity under rain-fed conditions is among top priority for most countries. Among various agro-ecologies, Africa and South Asia are considered to be the most vulnerable to climate change and both have large numbers of poor populations constrained with meagre access to basic resources of water and productive land.

The breeding of hardy, input use-efficient, 'smart crop varieties' that are inter alia drought tolerant, which produce more yields with fewer inputs, would constitute part of the solution to the envisaged abiotic stresses arising from climate change.

The main objective of this CRP is to adapt and develop robust protocols for efficient screening of mutant populations for drought tolerance. The target crops are improved rice and sorghum tolerant to drought for current and future climate change scenarios. These two crops are essential staples in the diets of millions of impoverish and vulnerable populations and, therefore, any attempt in increasing their yields under drought stress could have a major and positive impact in terms of food security and improved health and income generation. Eight research contracts and two technical contracts have been awarded and three agreement holders from advanced laboratories and research institutes with recognized expertise in the targeted technologies to share their experience with the contract holders and contribute to the development and validation of the planned technical packages. The results from the first year of the CRP will be reviewed at the CRP planned for first quarter of 2019 (for more information, see Past Events on page 12).

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

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

The CRP D2.50.05 on Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security has effectively started with eight research contracts from Burkina Faso, People's Republic of China, Ethiopia, Islamic Republic of Iran, Kenya, Madagascar, Sudan, and Turkey, two technical contacts from Japan and USA, and four agreement holders from FAO, Rome, Japan, the Netherlands, and USA. The main objective is to develop effective screening protocols to identify and advance resistant mutants and to adapt efficiency enhancing technologies such as doubled haploid, rapid cycling and molecular markers.

During the reporting period, all contract holders initiated the work related to respective activities related to the CRP. Screening packages are being optimized for laboratory,

screen house and field to *Striga asiatica* and/*or S. hermonthica*. in Burkina Faso, Ethiopia, Kenya Madagascar, Sudan, while the remaining contract holders engaged in optimizing one or more of the efficiency enhancing technologies. The Plant Breeding and Genetic Laboratory (PBGL) is optimizing protocols related to laboratory screening using soil, gel and rizotron assay for resistance to *Striga,* and established platform for histological analysis of mechanisms of resistance which will be used to classify different sources and mechanisms of resistance (see more under PBGL activities in this Newsletter). Detailed reports from the contract holders will be received by the end of the first year of the contract mostly during June to September 2017 to be reviewed for extension to the send year of the CRP.

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

Scientific Secretaries: S. Nielen and I. Ingelbrecht

The CRP officially started in November 2015 and had its first RCM 7–11 December 2015 in Vienna, Austria, and the second RCM was held 29 May–2 June 2017 in Lisbon, Portugal. The project started with 12 participating institutes from ten countries (Austria, China, Iran, Malaysia, Nigeria, Peru, the Philippines, Portugal, South Africa and United Kingdom) and one International Organization (Bioversity International). Within the first year, two more research contract holders from Costa Rica and Mauritius joined the project and two research agreements (Austria and Portugal) were transferred to Technical Contracts. The main objective of this CRP is to adapt and develop screening protocols that are suitable for mass screening of mutant lines to identify rare plants showing enhanced resistance to disease. The target crops for this CRP are banana and coffee. Cavendish bananas are clones and susceptible to diseases, including Fusarium wilt caused by *Fusarium oxysporum* f.sp. cubense (Foc) tropical race four (TR4). In recent years TR4 has been identified in nine countries suggesting that it is spreading geographically and threatening global banana production. Coffee is the second most traded commodity behind crude oil and derivatives. Coffee leaf rust (CLR) caused by *Hemileia vastatrix* is devastating to plantations. Global climate change and variation threaten to increase the negative impact of this disease.

At the end of the second year of this project considerable progress has been achieved as regards to the development of screening techniques as well as for mutation induction techniques in crops, banana and coffee. In banana, a robust and fast in-vitro bioassay for TR4 resistance has been established and applied for screening of 6000 *in vitro* rooted plants derived from mutation induction experiments. Also, a technique for greenhouse screening of small plants has been optimized, as well as a hydroponic system for lab-based screening of Fusarium wilt (TR4). In line with the defined expected project outputs new methods for low cost tissue culture have been developed. As for coffee, where very little work on mutation breeding has been done before the project, we focused on developing and validating mutation induction techniques, specifically in *Coffea arabica*. Effective methods for seed irradiation were developed and the optimum dosages determined. As alternative to seed irradiation, methods for callus induction, formation and regeneration of embryogenic callus, germination of embryo and development of seedlings were established and different types of explants were irradiated with various dosages of gamma rays. Results from these experiments are expected to emerge in the third year of the project.

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

Scientific Secretary: L. Jankuloski

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

The objectives of this CRP are:

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

The crops chosen are those that can be used for both human food and animal fodder. The project involves nine participating countries and four major crops, namely wheat (the Former Yugoslav Republic of Macedonia, Mongolia), rice (Malaysia), barley (Austria, People's Republic of China, Kuwait and Peru) and sorghum (Indonesia). The project aims to improve the agronomy of the crop especially in respect to soil and water management, improve nutritional value and improve the knowledge and skills base of participating Member States.

All participants have identified promising mutant lines that are now subject to farming management practices to maximize yields in challenging conditions. Success in tailoring agronomy for mutant varieties will be judged by take up by farmers but there are already impressive outcomes, particularly in Indonesia where mutant varieties are now grown in several regions on an increasing area. In barley, relevant germplasm with natural variation for reduced lignin content trait has been identified and progress is made to identify the underlying sequence variations in several barley lines. In cooperation with technical contract holder, Mr Heinrich Grausgruber (BOKU University, Vienna, Austria), PBGL is developing molecular marker to reduce lignin in barley. Final reports are expected by end of 2017 and project will be closed in 2018.

Technical Cooperation Field Projects

Project Number	Country/Region	Title	Technical Officer(s)
ALG/5/026	Algeria	Increasing the Genetic Variability for the Improvement of Strategic Crops (Wheat, Barley, Chickpeas and Dates) for Enhanced Tolerance to Biotic and Abiotic Stresses and the Development of Biotechnology Capacities	L. Jankuloski
ANG/5/015	Angola	Achieving Drought Tolerant Plants by Inducing Mutation with Gamma Rays	S. Nielen
AZB/5/002	Azerbaijan	Developing Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity through Mutation Breeding	F. Sarsu
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
BUL/5/014	Bulgaria	Screening of Cereal Germplasm Stress Response and Adaptation Potential by Advanced Nuclear, Omics and Physiological Approaches	L. Jankuloski/S. Nielen
BUL/5/015	Bulgaria	Increasing Productivity and Quality of Basic Food Crops	F. Sarsu
BKF/5/016	Burkina Faso	Using Nuclear Techniques for Improving Rice Yield and Quality	L. Jankuloski/I. Ingelbrecht
BKF/5/019	Burkina Faso	Improving Food Crop Genotypes for Enhancing Yield and Adaptation to Climate Change Using Mutation Breeding and Isotopic Techniques	L. Jankuloski
BDI/5/001	Burundi	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	S. Nielen/I. Ingelbrecht in collaboration with Soil and Water Management and Crop Nutrition Section
CAF/5/008	Central African Republic	Improving Cassava Yield through Improved Crop Variety and Best Soil Management Practices Using Nuclear Techniques	I. Ingelbrecht/A.M.A. Ghanim in collaboration with Soil and Water Management and Crop Nutrition Section
CPR/5/024	China, People's Republic of	Enhancing the Accelerated Application of Mutant Germplasm and High-Efficiency Breeding in Crops	I. Ingelbrecht
ZAI/5/022	Congo, Democratic Republic of the	Improving Productivity and Quality of Crops (Soybean and Maize) Using Induced Mutation and Biotechnology	L. Jankuloski

Project Number	Country/Region	Title	Technical Officer(s)
ZAI/5/025	Congo, Democratic Republic of the	Increasing Genetic Variability in Cassava and Maize for Enhanced Tolerance to Biotic and Nitrogen Stresses	L. Jankuloski/F. Sarsu
PRC/5/002	Congo, Republic of the	Developing Disease Resistant Varieties of Cassava and Banana	S. Nielen
IVC/5/039	Cote d'Ivoire	Improving Maize Production in Savannah Areas with Severe Pedoclimatic Degradation in the North of Cote d'Ivoire through the Cultivation of Induced Mutants Adapted to these Areas	F. Sarsu/I. Ingelbrecht
GHA/5/036	Ghana	Screening Oil Palm M2 Population for Useful Mutants	L. Jankuloski/F. Sarsu
GHA/5/037	Ghana	Using Irradiated Pollen for the Development of Provitamin A Rich, Drought Tolerant and Cassava Mosaic Disease Resistant Cassava Mutants	I. Ingelbrecht
INS/5/043	Indonesia	Intensifying Quality Soybean Production to Achieve Self-Sufficiency	A.M.A. Ghanim
IRA/5/014	Iran, Islamic Republic of	Improving Wheat Yield and Stress Tolerance for Sustainable Production	L. Jankuloski
JAM/5/013	Jamaica	Improving Crops by Using Experimental Mutagenesis and Diagnostic Technologies	S. Nielen
KAZ/5/004	Kazakhstan	Developing Drought Tolerant and Disease Resistant Wheat Varieties with Enhanced Nutritional Content Using Mutation Breeding	F. Sarsu
KEN/5/034	Kenya	Using Irradiated Improved *Brachiaria* Grass and *Dolichos Lablab* Species for Increasing Quantity and Quality of Milk Production and Reproduction for Smallholder Dairy Farms in Drought Prone Areas	S. Nielen/F. Sarsu
KEN/5/037	Kenya	Using Climate Smart *Brachiaria* Mutants to Develop Integrated Farm Model Technologies for Improved Livelihood Among Smallholder Farmers	S. Nielen/F. Sarsu
KEN/5/038	Kenya	Using Nuclear Techniques to Evaluated and Improve the Impact of Mutated Forages on the Performance of Smallholder Dairy Cows	S. Nielen
KUW/5/002	Kuwait	Implementing Mutation Induction to Improve Barley Production under Harsh Environmental Conditions	L. Jankuloski/A.M.A. Ghanim
KUW/5/003	Kuwait	Implementing Mutation Induction to Improve Barley Production under Harsh Environmental Conditions – Phase II	L. Jankuloski

Project Number	Country/Region	Title	Technical Officer(s)
LAO/5/002	Lao, P.D.R.	Improving Soil Fertility and Water Use Efficiency in the Cassava-Rice-Soybean Production System under Smallholder Farming Systems	L. Jankuloski in collaboration with Soil and Water Management and Crop Nutrition Section
LES/5/004	Lesotho	Using Nuclear Techniques for Improvement of Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production (Continuation of the on-going project)	S. Nielen/A.M.A. Ghanim
LES/5/005	Lesotho	Improving Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production, Phase II	S. Nielen/A.M.A. Ghanim
MAG/5/023	Madagascar	Promoting Climate Smart Agriculture to Face Food Insecurity and Climate Change with Regard to Basic National Foods (Rice and Maize)	L. Jankuloski/F. Sarsu
MAG/5/025	Madagascar	Enhancing Biocontrol of *Striga asiatica* (L.) Kuntze through the Development of Tolerant Rice and Maize Lines and its Links with Microbiological and Ecological Functioning of Soil	L. Jankuloski
MLW/5/003	Malawi	Developing Drought Tolerant, High Yielding and Nutritious Crops to Combat the Adverse Effects of Climate Change	F. Sarsu
MAL/5/031	Malaysia	Establishing an Environmentally Sustainable Food and Fodder Crop Production System	L. Jankuloski
MAU/5/006	Mauritania	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques to Water Management and Soil Fertility	L. Jankuloski/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
MAR/5/023	Mauritius	Improving Landraces of Crucifers (Cauliflower and Cabbage) and Carrot through the Use of Nuclear Techniques for Mutation Breeding and Biotechnology	F. Sarsu/L. Jankuloski
MON/5/021	Mongolia	Improving the Productivity and Sustainability of Farms Using Nuclear Techniques in Combination with Molecular Marker Technology	L. Jankuloski/S. Nielen in collaboration with Animal Production and Health Section
MOZ/5/007	Mozambique	Enhancing Mutation Breeding of Sorghum and Pearl Millet to Develop High Yield, Disease Resistance and Drought Tolerance	S. Nielen/A.M.A. Ghanim

Project Number	Country/Region	Title	Technical Officer(s)
MYA/5/020	Myanmar	Strengthening Food Security through Yield Improvement of Local Rice Varieties with Induced Mutation (Phase II)	S. Nielen/L. Jankuloski in collaboration with Soil and Water Management and Crop Nutrition Section
NAM/5/016	Namibia	Developing Drought Tolerant Mutant Crop Varieties with Enhanced Nutritional Content	F. Sarsu/S. Nielen
NAM/5/014	Namibia	Evaluating Efficient Water and Nutrient Use, Molecular Characterization and Nutritional Composition of Mutant Germplasm Populations	F. Sarsu/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
NEP/5/003	Nepal	Improving Crop Yield for Food Security and Economic Growth by Using Nuclear and Molecular Techniques	S. Nielen/L. Jankuloski
NEP/5/006	Nepal	Enhancing Productivity of Corps and Fruit Employing Nuclear and Molecular Techniques	S. Nielen
NER/5/019	Niger	Improving Sesame Plant Productivity by Obtaining High-Yielding Induced Mutants Adapted to Semi-Arid Conditions	I. Ingelbrecht/A.M.A. Ghanim
NIC/5/011	Nicaragua	Broadening the Genetic Variation of Vegetative Propagated Crops Using Nuclear Techniques	S. Nielen
OMA/5/004	Oman	Building Capacity for the Improvement of Major Crops through Induced Mutation Using Nuclear and Related Techniques	A.M.A. Ghanim/I. Ingelbrecht
OMA/5/005	Oman	Enhancing the Application of Mutation Breeding and Supporting Biotechnology Techniques for the Improvement of Important Strategic Crops	A.M.A. Ghanim
PAL/5/009	Palestine	Enhancing the Performance of Durum Wheat Landraces by Induced Mutation (Phase II)	L. Jankuloski/A.M.A. Ghanim
QAT/5/006	Qatar	Enriching Genetic Diversity and Conserving Plant Genetic Resources Using Nuclear Techniques and Related Technologies	A.M.A. Ghanim/L. Jankuloski
RAF/5/076	Regional Africa	Improving Crops by Using Mutation Induction and Biotechnology through a Farmer Participatory Approach	F. Sarsu/S. Nielen
RAS/5/069	Regional Asia	Complementing Conventional Approaches with Nuclear Techniques towards Food Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	L. Jankuloski/S. Nielen

Project Number	Country/Region	Title	Technical Officer(s)
RAS/5/070	Regional Asia	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	F. Sarsu/S. Nielen
RAS/5/073	Regional Asia	Supporting Climate-proofing Rice Production Systems (CRiPS) Based on Nuclear Applications-Phase II	L. Jankuloski/S. Nielen
RAS/5/074	Regional Asia	Enhancing Wheat and Barley Productivity through Induced Mutation with Supportive Breeding and Related Biotechnology Techniques (Phase III)	F. Sarsu/L. Jankuloski
RAS/5/075	Regional Asia	Improving Sustainable Cotton Production through Enhanced Resilience to Climate Change	L. Jankuloski/F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
RAS/5/077	Regional Asia	Promoting the Application of Mutation Techniques and Related Biotechnologies for the Development of Green Crop Varieties (RCA)	S. Nielen/F. Sarsu
RAS/5/079	Regional Asia	Improving Crop Resilience to Climate Change through Mutation Breeding in Pacific Islands	F. Sarsu
RLA/5/068	Regional Latin America	Improving Yield and Commercial Potential of Crops of Economic Importance (ARCAL CL)	S. Nielen/L. Jankuloski
SEN/5/034	Senegal	Using an Integrated Approach to Develop Sustainable Agriculture in a Context of Degrading Soil Fertility, Climate Change and Crop Diversification	F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
SIL/5/014	Sierra Leone	Enhancing Nutritional and Other End-User Postharvest Qualities of Rice and Cassava through Mutation Breeding	S. Nielen/L. Jankuloski
SIL/5/017	Sierra Leone	Selecting and Analysing Bio-Enriched and Bio-Fortified Rice and Cassava Lines and their Efficient Postharvest Transformation to Popular Food Products	S. Nielen/I. Ingelbrecht
SIL/5/020	Sierra Leone	Enhancing the Concurrent Selection and Evaluation of Biofortified and Bio-enriched Varieties Derived from Mutant Rice, Cassava and other Crops	L. Jankuloski
SRL/5/045	Sri Lanka	Establishing a National Centre for Nuclear Agriculture	F. Sarsu
SUD/5/037	Sudan	Applying Nuclear Techniques to Improve Crop Productivity and Livelihood of Small-scale Farmers in Drought Prone Areas	F. Sarsu/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section

Project Number	Country/Region	Title	Technical Officer(s)
TOG/5/002	Togo	Improving Crop Productivity and Agricultural Practices through Radiation Induced Mutation Techniques	L. Jankuloski
URT/5/030	Tanzania, United Rep. of	Improving Rice and Barley Production through Application of Mutation Breeding with Marker Assisted Selection	L. Jankuloski/F. Sarsu
URT/5/032	Tanzania, United Rep. of	Developing Maize Cultivars for Improved Yield and Resistance to Viral Disease	F. Sarsu/L. Jankuloski
THA/5/054	Thailand	Increasing Adaptability for Adverse Environment Tolerance in Rice Germplasm Using Nuclear Techniques	F. Sarsu/S. Nielen
TUN/5/029	Tunisia	Developing Barley and Durum Wheat Resilience to Drought and Heat Tolerance through Mutation Breeding	F. Sarsu
UGA/5/041	Uganda	Developing Disease Resistant High Yielding Farmer Preferred Cassava Varieties in Uganda through Induced Mutation Breeding	S. Nielen
NHE/5/001	Vanuatu	Enhancing the Productivity and Quality of Crops through the Application of Mutation Breeding Techniques	L. Jankuloski
VIE/5/020	Viet Nam	Enhancing the Capacity for Research and Applications of Nuclear Techniques in Plant Breeding	L. Jankuloski
ZAM/5/031	Zambia	Improving the Yield of Selected Crops to Combat Climate Change	F. Sarsu
ZIM/5/021	Zimbabwe	Assessing and Promoting Sustainable Agricultural Production in Communal and Newly Resettled Farms	F. Sarsu/A.M.A. Ghanim in collaboration with SWMCN

Developments at the Plant Breeding and Genetics Laboratory

The Plant Breeding and Genetics Laboratory (PBGL) carries out applied R&D and provides training and irradiation services. These activities are directed at the creation of mutations and their identification through the development of efficient screening protocols. PBGL's R&D priorities are dictated in part by the ongoing CRPs, and, more generally, by the crop improvement challenges faced by FAO and IAEA Member States. In 2017, the Laboratory management and operations were restructured to support a multidisciplinary R&D approach integrating crop breeding and genetics with trait phenotyping and genotyping. To strengthen linkages with field breeding in Member States two networking events were held, one at the Austria focusing on countries in Southern Africa and a second in Indonesia with focus on Asian countries. These efforts have focused on seed-propagated crops, including rice and sorghum. Accordingly, PBGL's field and greenhouse activities have significantly expanded in 2017. The PBGL greenhouses are being refurbished and fitted to meet increasing demands from Member States for R&D cooperation and technical backstopping. Below you will find a brief overview of our activities since the last Newsletter.

Accelerating Breeding of Mutant Barley for Feed Quality Using Marker Technology

Barley is an important feed crop for a wide range of animals. It is consumed by animals as seed, green forage, hay or silage. Barley mutants such as low lignin types (*rob1*) increase feed quality due to higher digestibility. To introduce or combine the low lignin trait with other useful barley mutant traits we have set out to develop an allele-specific marker to accelerate breeding of this recessive trait. This work is carried out in cooperation with Prof H. Grausgruber (BOKU University, Austria) in the context of the CRP on barley (D2.30.30). Prof Grausgruber is introducing the *rob1* mutant trait into a hooded (*Kap*1) cultivar to improve feed quality traits in barley through the pyramiding of different mutant traits. The barley working collection established at the PBGL includes some 14 spring barley types, including natural variants, induced mutants with reduced lignin and their parental lines. We produced F_1 crosses and advanced selected F_1 populations to F_2 stage. One low lignin mutation has been introgressed into two different barley cultivars; Optic and Bowman. Further, phenotypic analysis of the F_1 progeny confirmed that the reduced lignin trait was confirmed to be recessive. An allele-specific marker system based on the differential amplification of the wild type and mutant allele via PCR has been developed and was validated. Two F_2 segregating populations are currently growing in the greenhouse (see photo). Future efforts will focus on adapting the assay to a low cost, user-friendly and robust genotyping protocol.

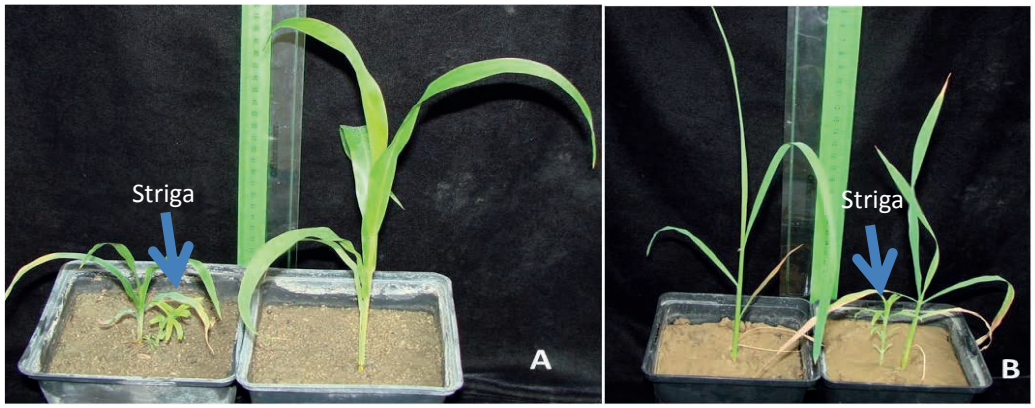
Parents and F_1 progeny of barley cultivar Optic x rob1 mutant (top); F_2 progeny of Optic x rob1 mutant (bottom)

Mutation Breeding for Resistance to *Striga* Parasitic Weeds in Cereals for Food Security

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. The main objective of the CRP on *Striga* (D2.50.05) is to develop laboratory, screen-house and field screening protocols of mutant populations of sorghum and upland rice for resistance to *S. asiatica* and *S. hermonthica*. In addition, the CRP focuses on technologies such as rapid cycling of generation of crop plants, doubled haploid techniques and molecular markers to enhance efficiency of mutant identification and accelerate delivery of resistant varieties.

During the first year of the CRP, participating contract holders have made significant progress on their planned

activities. Field screening protocols were optimized by Burkina Faso, Ethiopia, Madagascar and Sudan; laboratory screening protocols using gel-assay, rizotron and others were optimized by Japan and USA. Further confirmation and expansion of protocols are planned for the second year. The PBGL has optimized screening protocols in glasshouse condition using different size of pots (see photo) in addition to rizotron and gel-assay methods. Protocols for haploid production were optimized for upland rice in Iran and Turkey and further work is going on in sorghum.



Screening in pots for resistance to Striga in sorghum (A) and upland rice (B). Arrow point to Striga infested pot compared to healthy plant of the same variety in non-infested pot

During the second year the protocols will be verified and validated by screening of M_2 populations of sorghum and upland rice developed by some of the participating Member States. Allelism and mechanism of resistance will be analyzed to classify different mechanisms of resistance. Accelerating techniques such as rapid cycling of crop generation and efficiency enhancing technologies using genomics and molecular markers will be adapted for speeding the delivery of durable resistance. The second RCM is planned for August 2018 parallel to the Symposium on Plant Mutation Breeding and Biotechnology.

Regional Crop Mutation Breeding Networks to Catalyse Partnerships and R&D Cooperation with Member States

In the previous Newsletter we reported on a Crop Mutation Breeding Network Initiative with countries in Southern Africa through the regional project RAF/5/076. During this reporting period, a first Regional Network has been formally established in Asia, with Indonesia designated an IAEA Collaborating Centre. These Networks will greatly facilitate R&D cooperation with the PBGL and help set priorities to enhance the impact of crop mutation breeding in the Member States. A first area of cooperation concerns the development of molecular tools to speed up crop mutation breeding of agronomically important traits for Member States. In 2017, the PBGL has obtained several advanced mutant lines from different Member States in Asia and Africa, including Burkina Faso, Indonesia and Zimbabwe. During the 2017 summer, the PBGL team conducted extensive field experiments for phenotypic verification of the uniformity and stability of advanced mutant lines of sorghum, cowpea, and tomato amongst others (see figure). In particular, mutant lines were compared with their parent in observation plots to detect any off-types.

Field establishment and phenotypic evaluation of mutant crops by the PBGL team

Irradiation Services Provided to Member States in 2017

At the time of writing (30 November 2017), the PBGL has received a total of 40 irradiation service requests this year (see table). As before, the majority of requests are conducted in the context of TCPs. Under the new TC project cycle 2018–2019, we expect requests to irradiate several new crop species. Therefore, PBGL has expanded the crop registry for import into Austria following consultations with the Austrian Agency for Health and Food Safety (AGES) to facilitate the smooth international exchange of germplasm with the Member States.

Request number	Country	Request type	Crop
1495	Germany		Ornamental
1496	Burkina Faso	CRP	Sorghum, Rice
1497	Germany		Cassava
1498	Romania	TCP	Pea
1499	UK		*Brassica napus* (rape)
1500	Sierra Leone		Rice
1502	Uzbekistan		Paulownia
1502	Sudan	F	Pearl millet, Sorghum, Tomato, Onion, Cowpea
1503	Uzbekistan		Cotton
1504	Tanzania, United Rep. of	F	Maize
1505	Hungary		Ornamental
1506	Poland		Conifers
1507	Austria		Chamomile
1508	Cote d'Ivoire	TCP	Maize
1509	Austria		*Cannabis sativa*
1510	Iraq	TCP	Rice
1511	Iraq	TCP	Watermelon, Squash, Cucumber, Okra, Eggplant
1512	Senegal	TCP	Cowpea
1513	Namibia	TCP	Cassava, Sorghum
1514	Germany		Wheat
1515	The Netherlands		Ornamental
1516	Germany		Ornamental
1517	Lesotho	F	Beans
1518	Sudan	F	Sorghum
1519	The Netherlands		Ornamental
1520	Oman	F	Garlic
1521	Ghana	F	Oil palm
1522	Bulgaria	TCP	Wheat
1523	Iraq	TCP	Cowpea
1524	Cameroon	CRP	Maize, Okra
1525	Germany		Ornamental
1526	Romania	TCP	Barley
1527	The Netherlands		Ornamental
1528	UK		Hosta
1529	Austria	CRP	Coffee
1530	Germany		Ornamental
1531	Qatar	TCP	Wheat, Barley, *Stipa capensis, Cenchrus ciliaris*
1532	Mali	CRP	Rice, Sorghum
1533	Zimbabwe	CRP	Maize
1534	UK		*Brassica napus*
1535	The Netherlands		Ornamentals

Request type indicated in this table: CRP: in context of Coordinated Research Project; F: by fellow request; TCP: in context of Technical Cooperation Project

Individual Training Activities at the PBGL

Name	Country	Status	Topic	Period
Mr N. Mheni	Tanzania, United Rep. of	F	Doubled haploid, *Striga* screening	2 months
Mr O. Hassan	Sudan	F	*Striga* screening	7 weeks
Mr N. Kabore	Burkina Faso	F	Mutation induction, marker-assisted selection	3 months
Mr A. Doubro Bombi	Central African Republic	F	Mutation induction, marker-assisted selection	3 months
Mr L.D. Sefume	Lesotho	F	Mutation induction bean, marker assisted selection	3 months
Ms M.S.M. Al Hinai	Oman	F	Doubled haploid, marker assisted selection	3 months
Mr P.M. Matova	Zimbabwe	F	Mutation discovery, efficiency enhancing techniques, cowpea	2 weeks
Mr W. Nunekpeku	Ghana	F	Mutation induction and chromosome doubling in oilpalm	6 months
Mr M.H.M. Adam	Sudan	F	Mutation induction, marker assisted selection	3 months
Ms A.H.K. Al-Mamari	Oman	F	Mutation induction, marker assisted selection	2 months
Mr S. Boureima	Niger	F	*Striga* screening, protocol, marker assisted selection	3 months
Mr H. Zangui	Niger	F	Marker development and marker assisted selection	3 months
Mr L. Jarc	Slovenia	I	Mutation discovery, marker development	8 months
Ms A. Akgun	Turkey	I	Mutation discovery, marker development in barley	6 months
Ms S. Shoukat	Pakistan	I	*Striga* screening	6 months
Ms A.M. Landau	Argentina	SV	Mutation discovery	1 week
Mr I.H.N. Bassole	Burkina Faso	SV	Induced mutations and supportive biotechnologies	1 week
Mr E.M. Elazazi	Qatar	SV	Induced mutations and supportive biotechnologies	2 weeks

F: Fellowship; I: Intern; SV: Scientific Visit

Visitors to the PBGL

In 2017, the PBGL has welcomed visitor groups and delegations from over 30 Member States, including Algeria, Australia, Bangladesh, Belize, Bolivia, Botswana, Cambodia, Chile, China, Dominican Republic, Guatemala, Iran, Iraq, Jordan, Lao P.D.R., Malaysia, Nepal, the Netherlands, Niger, Namibia, Palau, Panama, Papua New Guinea, Russia, Thailand, Turkey, Uganda, UK, USA and Zimbabwe. We also welcomed fellows and colleagues from the United Nations Vienna - Nuclear Young Generation (UN-NYG), United Nations Office for Disarmament Affairs (UNODA), as well as the United Nations Industrial Development Organization (UNIDO).

A delegation from the Chinese Academy of Agricultural Sciences (CAAS) was given a tour to the facilities and fields by Mr Liang, Director Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (see photo).

Delegation from CAAS visiting PBGL facilities and fields

Announcements

FAO/IAEA International Symposium on Plant Mutation Breeding and Biotechnology, 27–31 August 2018

Background

Over the last fifty years, the Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA) have played a critical role in supporting their Member States in the use of induced mutations to develop improved crop varieties.

The successful application of gamma rays and other physical and chemical mutagens in plant breeding over the past 90 years has increased crop biodiversity and productivity across the world.

Induced mutation offers many benefits with regard to crop improvement, especially when there is no reliable source of traits (variation) in nature that could be introduced to varieties by conventional breeding techniques such as hybridization. The induced mutation technique is becoming increasingly important to bring about heritable changes in plants and offer new genetic variation to plant breeders.

Plant biotechnologies are crucial to the effective application of mutation breeding techniques, and they are increasingly being considered for crop improvement to ensure that crops are better adapted to climate change. The application of mutation induction coupled with biotechnologies, genomics and molecular marker techniques can speed up all the main stages of breeding programmes, from the generation of variability, through selection to rapid multiplication of the desired genotypes.

Objectives

The purpose of the symposium is to review achievements, uncover new developments, trends and challenges in the field of plant mutation breeding, and to foster a broad exchange of information within the scientific community, as well as between the scientific community and the private sector. The symposium will highlight specific challenges faced by Member States, such as emerging transboundary threats to crop production, and will also assess the overall importance of mutation breeding to food security.

The symposium and its deliberations and conclusions will also provide useful feedback to the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture which will help it to address Member States' needs in future programming.

List of Topics

The scope of the symposium is meant to cover, but is not limited to, the following topical areas:

1. Contribution and impact of mutant varieties to food security
   - 1.1. Socio-economic impact of mutant varieties
   - 1.2. Released mutant varieties and their dissemination and adoption by farmers
2. Mutation breeding for adaptation to climate change in seed propagated crops
   - 2.1. Breeding for abiotic stress tolerance
   - 2.2. Breeding for biotic stress resistance
   - 2.3. Breeding for yield and quality improvement in crops
   - 2.4. Advances in *in vitro* techniques applied in seed propagated crops
   - 2.5. Breeding for enhanced resource use efficiency (land, water, NUE, etc.)
3. Mutation breeding for ornamental and vegetatively propagated crops
   - 3.1. Breeding in vegetatively propagated crop and trees
   - 3.2. Breeding in ornamental plants
   - 3.3. Advances in *in vitro* techniques applied in vegetatively propagated plants
4. Enhancing agro biodiversity through new mutation induction techniques
   - 4.1. Advances in mutation induction technologies (chemical, physical: ion beam, x ray, gamma ray etc.)
   - 4.2. Harnessing endogenous DNA elements for inducing mutations
   - 4.3. Enhancing crop genetic diversity through mutation induction (pre-breeding)
5. New challenges and technologies in plant genomics and breeding
   - 5.1. High throughput techniques for genotyping and phenotyping
   - 5.2. Mutation discovery and functional genomics
   - 5.3. Genomic and marker assisted selection
   - 5.4. Plant genome editing technologies (emerging trends and new opportunities)

Key Deadlines

31 January 2018: Submission of abstract through INDICO (including submission of Forms A and B through a competent national authority – see Section G of the Announcement http://www-pub.iaea.org/iaeameetings/56061/FAO-IAEA-International-Symposium-on-Plant-Mutation-Breeding-and-Biotechnology)

31 January 2018: Submission of grant application (Forms A and C through a competent national authority – see Section G of the Announcement)

30 April 2018: Notification of acceptance of abstract Registration only (Submission of Form A through a competent national authority) is not subject to a deadline.

Abstract Submission

Abstracts must be submitted in electronic format through the IAEA browser-based fi le submission system INDICO available at the conference web page. Additionally, Forms A and B have to be submitted as explained in the announcement on the conference web page. Submission of abstracts only (without submission of Forms A and B) will not be considered.

Registration and Funds

No registration fee is charged to participants.

Limited funds are available to assist certain participants.

Approved grants will usually cover only part of the cost of attendance. Please see the conference web page for further details.

Language

The conference will be held in English.

Exhibition

A limited amount of space will be available for commercial vendors' display/exhibits during the conference. Interested parties should contact the Scientific Secretariat by email at ismbb2018@iaea.org by 31 January 2018.

Symposium Secretariat

Scientific matters and paper submissions:

Mr Ljupcho Jankuloski and Mr Ivan Ingelbrecht

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Email: ismbb2018@iaea.org

Participation, grants and administrative matters:

Ms Martina Khaelss

Division of Conference and Document Services
Email: m.khaelss@iaea.org

Conference Web Page

Detailed information on administrative matters, including registration, paper submission and grants, is provided on the conference web page:

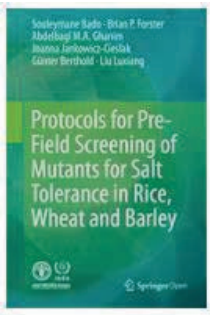
https://www.iaea.org/events/plant-mutation-breedingsymposium-2018

Please include reference number IAEA-CN-263 in all communications.

Publications

Books

JANKOWICZ-CIESLAK, J., Th.H. TAI, J. KUMLEHN, B.J. TILL, (2016) Biotechnologies for Plant Mutation Breeding. Springer ISBN: ISBN 978-3-319-45019-3 (Print) 978-3-319-45021-6 (Online). http://www.springer.com/book/9783319450193.



BADO, S., B.P. FORSTER, A.M.A. GHANIM, J. JANKOWICZ-CIESLAK, J. BERTHOLD, L. LUXIANG (2016) Protocols for Pre-Field Screening of Mutants for Salt Tolerance in Rice, Wheat and Barley. Springer ISBN: 978-3-319-26588-9 (Print) 978-3-319-26590-2 (Online). http://rd.www.springer.com/book/10.1007%2F978-3-319-26590-2.

Peer-reviewed Book Chapters

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

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

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

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

JOHNSON, S.D., TAYLOR, D.R., TAI, Th. H., JANKOWICZ-CIESLAK, J., TILL, B.J., JALLOH, A.B. (2016). Field Evaluation of Mutagenized Rice Material. Chapter 9 in: Biotechnologies for Plant Mutation Breeding. Jankowicz-Cieslak et al. (eds), Springer.

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Websites and Links

- Plant Breeding and Genetics Section:
  http://www-naweb.iaea.org/nafa/pbg/index.html
- FAO/IAEA International Symposium on Plant Mutation Breeding and Biotechnology:
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- InfoGraphic on Mutation Breeding:
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