



Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

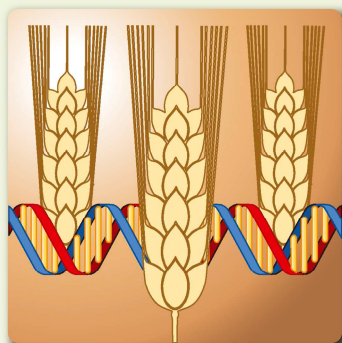
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Contents

- To Our Readers 1
- Staff 3
- Forthcoming Events 5
- Past Events 7
- Coordinated Research Projects (CRPs) and Research Coordination Meetings (RCMs) 12
- Technical Cooperation Field Projects 16
- Success Stories 19
- News 24
- Developments at the Plant Breeding and Genetics Laboratory, Seibersdorf 26
- Publications 34



The President of Indonesia, Mr Susilo Bambang Yudhoyono and his wife, celebrating the success of mutant rice varieties (photo courtesy of BATAN, Indonesia).

To Our Readers

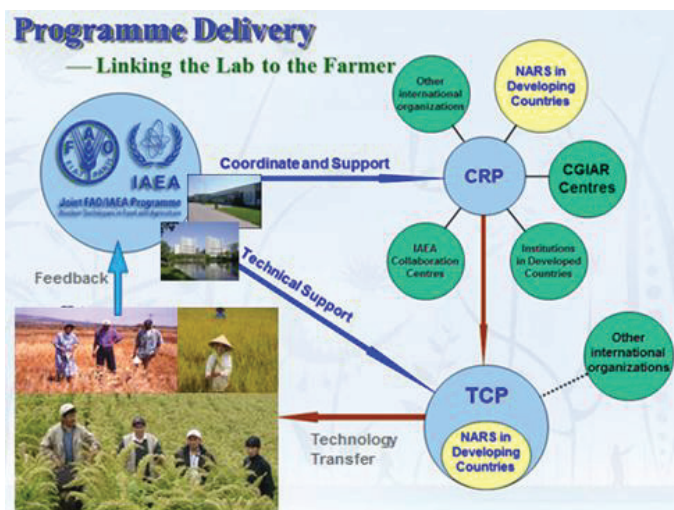
We have reached three quarters of the biennium 2012–2013. The negative effects of climate variability and change on biodiversity are becoming increasingly evident and feature more and more in our activities. The deleterious effects of climate variability and change cause devastating yield losses and threaten global food security and commodity prices. There is an urgency to develop and to produce new resilient mutant lines, to get these to farmers and to grow them on a large scale as fast as possible. We at the Plant Breeding and Genetics Section and Laboratory are adjusting our activities accordingly. We have initiated new activities for inducing and screening mutations more quickly, safely and efficiently. In this newsletter, you will find interesting news on alternatives to gamma irradiation using X rays, seed mass phenotyping using an X ray platform that we are developing and the first tests of our next generation sequencing (NGS) platform.

A milestone has been reached in meeting the challenge of wheat black stem rust disease (race Ug99). In the TC section of this newsletter, you find more information on an unfolding success story involving 18 countries and four international organisations. Inducing mutations significantly speeds up the process of plant breeding and is more cost effective and environmentally friendly than using fungicides to prevent stem rust caused by race Ug99. While spontaneous mutations occurring in nature happen over a long period of time, mutation induction is used to achieve the same results much more quickly and efficiently, providing sustainable solutions to crop production



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constraints and responding to food security threats. In fact, this success story is a good example of the pipeline from the laboratory to the farm that we implement. This pipeline is demand driven, results based and outcome oriented: technology packages are adapted and/or developed in the Plant Breeding and Genetics Laboratory; services are provided (mutation induction) and capacity built; technology packages are further tested and debugged in research networks (CRPs); and then the technology is transferred to our counterparts in Member States through Technical Cooperation projects.



Two CRPs will close in 2013. You will find more information about CRP D2.40.12, 'Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline', in this issue. This CRP proposed to address efficiency of mutation induction through the assembly, adaptation and interlacing of novel cellular and molecular biology techniques to achieve a seamless dovetailing of validated processes into a modular pipeline: cellular and molecular biology techniques addressing the bottlenecks imposed by the need to generate large mutant populations rapidly in appropriate genetic backgrounds (homozygous for the mutation events, devoid of chimeras and in contemporary breeding materials). By scrutinizing target genes for desired changes, the need for field trials of large populations will be precluded. Milestones include the development of rapid techniques for dissolution of chimeras in vegetatively propagated banana; establishment of barley TILLING for targeting genes controlling drought; microspore mutagenesis for instant production of homozygous true breeding mutant lines; reduced representation next-generation sequencing approaches to screen mutant rice populations; and development and validation of low cost methods for mutant screening.

Major milestones have been reached in CRP D2.40.23, 'Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants'. Genes encoding core proteins of the repair pathway in rice have been cloned and are being characterized. Whole genome scanning in soybean is under way for naturally mutated and selected genes. A chloroplast mutator gene and mutations caused by it have been identified in barley, and three putative DNA repair genes in pea are currently under study. Mutant populations of rice are being screened for reduced sensitivity to radiation. The assembly and publication of the complete sequence of the wild soybean (*Glycine soja*) genome is a major achievement that will aid genotypic selection (mutant variation) for crop improvement in the future. A barley EST database was established with extensive sequence alignments to Arabidopsis sequences, with hyperlinks to original data sources and to the MVGS database.

Plant mutation breeding continues to be relevant throughout the world. This is evident by the increasing number of crop species that are subject to mutagenesis (over 200) and the increasing numbers of mutant varieties (over 3000). While mutation techniques have become routine and standard in the plant breeding programmes in many countries, capacity in others is often lagging, and in some mutation breeding has yet to be established. We are therefore proud to report the initiation of national mutation breeding programmes in Oman, Palestine and Qatar.

A recent news item underlines the increasing importance of mutation breeding as a workable alternative to GMO: The world's largest producer of seeds, Monsanto, has apparently given up on attempts to spread its genetically modified (GM) plant varieties in Europe. A German media report stated that the firm would end all lobbying for approval and has dropped any plans to have farmers grow its GM plant varieties in Europe. All over the world, protesters have been rallying against GM food – in Germany, the protest movement against GM plants has been particularly strong for years. The German Agriculture Ministry said it had been highly critical of gene modification technologies – 'The promises of GM industry have not come true for European agriculture, nor have they for the agriculture in developing and emerging economies', the Ministry said in a statement.

Pierre J.L. Lagoda
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¹ Left the IAEA in April 2013

Farewells



Madeleine Spencer has served a full time at the Agency, and she is now returning to her home institute in Senegal as a professor. In recognition of her excellent work as a team member within the Plant Breeding and Genetics Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, she was presented with a Merit Award.

Since joining the Plant Breeding and Genetics subprogramme eight years ago, her performance has been exceptionally meritorious. Indeed, her work has been exemplary during her stay of duty. Madeleine has always been eager and motivated in her work, being efficiently involved in the organization and implementation of the subprogramme activities. Her no-nonsense approach to willingly and proactively taking up additional tasks, with dauntless determination and flawless motivation in all duties, and her sustained high level performance made her an outstanding staff member, and it is a privilege to have had such a dedicated professional in the team — one who is technically very competent in her field, as well as highly organized and hard working. Furthermore, she provided excellent advice, took the initiative, and was careful, considerate, precise and goal oriented in the planning and implementation of her projects. As such she was a very reliable and trusted team member. Of particular note is the large contribution she has made in backstopping the development of the different TC cycle project designs. She also has been integral in forging new collaborations with Member States and in advancing trans-sectional and trans-divisional collaborations (with Soil Water Management and Crop Nutrition and with FAO NR department). Noteworthy in this context was her ability to secure extra-budgetary funding for a training course related to a successful Coordinated Research Project, which she was managing as scientific secretary. The calibre of her scientific research and independence goes beyond the requirements of her post. As such, she became a pillar of the Section and an invaluable member of the subprogramme implementation team. From this, you all will have noted that we miss her tremendously. Everybody who knows the energy of Madeleine understands that this 'retirement' is quite theoretical, and I am sure that we will hear from her very often in the future.

Gilbert Seballos was with the Plant Breeding and Genetics Laboratory for nearly three years. During his tenure, he fit seamlessly into the team of PBGL, being highly motivated, eager and competent. Gilbert did his work thoroughly and with great care. His tasks were wide ranging and he exhibited complete competence in all undertakings. His work load included *inter alia* preparation of hydroponics, tissue culture support, tissue sample preparation and soil preparation. He greatly contributed to the



implementation of PBGL activities requiring field and glass-house work, greenhouse maintenance and field work. An excellent communicator, Gilbert was also an asset to PBGL in interacting with visitors and trainees. Photography is among Gilbert's skills, which has been in high demand by all staff. As designated photographer for the laboratory, Gilbert supported laboratory protocols, guidelines and reports, and documented research and visitors in a very professional manner. Gilbert was never phased by new and urgent challenges. He was quick to understand new situations and the need for prompt actions, which he carried out completely and reliably volunteering for out-of-hours' work and additional tasks when they arose. We miss his productivity, and his kind helpfulness in the laboratory.

Staff Success Story

Last but not least, let us hail the big success of two of our staff at the UN Interagency Games 2013, the 'UN Olympics'. Brian Peter Forster won Gold with the Badminton Team of IAEA and Luis Mauricio Alfonzo-Godoy won Silver with the IAEA Basketball Team. We are proud of both of them, and we see this as a demonstration that we are team players at heart and will offer our best to serve in collaboration to meet the challenge of sustainable global food security.



Forthcoming Events

Regional Training Course on GxE Testing, Seed Storage and Farmers' Participation, RAS/5/065, Los Baños, the Philippines, 24 June–5 July 2013

Technical Officer: P.J.L. Lagoda

In July, two nominees from each participating RAS/5/065 Member State (Bangladesh, Cambodia, Indonesia, Lao, Malaysia, Mongolia, Myanmar, the Philippines, Thailand and Vietnam) are invited to participate in a training course at IRRI (Los Baños, the Philippines). This two week training course will be organized by the International Atomic Energy Agency (IAEA) in collaboration with the International Rice Research Institute (IRRI), the Food and Agriculture Organization (FAO) and the Government of the Philippines through the Philippines Nuclear Research Institute (PNRI).

The purpose of this course is to provide a theoretical as well as a practical introduction to the management of project related activities designed to raise levels of collaboration on training, exchange of germplasm and harmonization of screening methods, especially for environmental stress tolerance.

Rice is the most important food crop contributing to food security and sufficiency in the Asia Pacific region. However, despite the advances in increasing yield, several biotic (disease and pest) and abiotic (drought) factors continue to limit productivity. It is now a matter of urgency that new varieties should be bred with higher and more stable and sustainable yield potentials, with higher adaptability to climate change and variability. The use of mutation induction for creating useful new germplasm and developing new cultivars is a profitable approach to improvement. If desired traits are to be enhanced and mutant varieties with high yield, short duration, shatter-resistance and stress tolerance are to be developed, it is important that various valuable mutant germplasm should be generated, identified and made best use of. In order to maximize the usefulness of mutant germplasm and to achieve synergy amongst the participants of this regional project, promising advanced mutant lines must be tested on multiple locations.

One key to successful utilization of mutant materials is the accurate and rapid evaluation and selection of promising germplasm for continued propagation. Properly controlled and designed phenotypic evaluation for traits such as salinity, drought and temperature stress response are key technology packages for successful implementation of mutation breeding strategies.

This training course is expected to propose guidelines to the project counterparts on:

1. Principles and methods of phenotypic measurements in plant breeding;
2. Experimental design for accurate phenotyping;
3. Use of rapid phenotyping methods for selection of heritable traits to facilitate mutation breeding;
4. How to test environmental effects on the crops (GxE), e.g.:
 - Choosing test sites;
 - Multilocation trials;
 - Statistical analyses.
5. Seed storage, e.g.:
 - Short and medium term;
 - Germination assays;
 - Seed multiplication;
 - Phytosanitarian aspects.
6. Farmer participation, e.g.:
 - Participatory rural appraisal techniques; participatory planning and monitoring;
 - On-farm participatory trials;
 - Community-based action and development activities for supporting the livelihoods;
 - Biostatistics in participatory approaches.

Under the guidance of the experts, the participants will draw a tentative roadmap for national GxE trials with farmer's participation and trans-national multilocation trials.

Regional Training Course on Mutation Induction Techniques and Supportive Breeding and Biotechnologies for Wheat and Barley, RAS/5/058, Seibersdorf, Austria, 1–5 July 2013

Technical Officer: P.J.L. Lagoda

Course Director: A.M.A. Ghanim

This training course is designed to develop capacity in methods for wheat and barley mutation induction, mutant screening and biotechnologies that accelerate the breeding process. It is organized through TC and is a regional course involving 22 participants; 17 from the RAS/5/058 project (Iraq, Jordan, Lebanon, Oman, Saudi Arabia, Syrian Arab Republic, Yemen) and five other TC fellows from Bangladesh, Eritrea (2), Palestine and Sudan. All staff of the Plant Breeding and Genetics Laboratory, with support from staff of the Plant Breeding and Genetics Section, will participate in providing lectures, presentations and demonstrations and in supervision during laboratory, glasshouse and field exercises. Training will focus on methods applicable to mutation

breeding and agronomy of wheat and barley, and will cover topics in:

- Mutation induction techniques (gamma and X ray);
- Mutation detection techniques (phenotypic and genotypic);
- Biotechnologies in accelerated breeding (rapid generation cycling, embryo culture and anther culture);
- Best fit soil and water management practices.

Regional Training Course on Molecular Marker and Biochemical Characterization, RAF/5/066, Eldoret, Kenya, 29 July–2 August 2013

Technical Officer: F. Sarsu

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

Through the RAF–AFRA TC projects, some of the participating national research institutes have been able to establish plant biotechnology laboratories including plant tissue culture and molecular biology, and train staff on the basic aspects of these technologies. The application of the laboratory and field experimental results requires the mastering of statistical data analysis in order to attain international trade harmonization to assure mutual recognition and in order to prevent financial losses through erroneous results.

The purpose of the training course is to provide participants with opportunities to familiarize themselves with three important aspects of crop breeding: (i) molecular techniques to be applied, (ii) data collection, data handling and analysis of field data as well as laboratory data generated by molecular marker technologies (SSRs, AFLP, SNPs, etc.), and (iii) biochemical characterization for crop improvement.

The training course will include lectures and hands-on experiments on: (i) DNA as the source of genetic information, (ii) introduction to molecular marker systems, (iii) principles of the polymerase chain reaction (PCR), (iv) principles of mapping (recombination, linkage data and segregation analysis, quantitative trait loci (QTL) analysis), (v) other molecular biology techniques used in crop improvement, and (vi) biochemical characterization for crop improvement. The participants should be from all participating Members States involved in the project RAF/5/066; additionally, they should be currently and actively working on mutation breeding and have basic knowledge in crop breeding. The training course will be conducted in English; participants should be capable of freely expressing themselves and following lectures.

Technical Meeting to Exchange Expertise in Mutation Breeding and Best Fit Soil and Water Management Practices, RAS/5/056, Ulaanbaatar, Mongolia, 13–16 August 2013

Technical Officers: S. Nielen and K. Sakadevan

The objective of this four day Technical Meeting is to discuss project activities, implementation strategies and scientific methodologies to enhance national capacity for the application of isotopic and nuclear techniques for developing and using improved crop varieties with best practice soil, water, crop and nutrient management for increasing the crop productivity. The specific objectives are:

- To review and discuss the regional methodologies used in plant mutation breeding and soil and water management and to share technical input provided by invited experts;
- To facilitate the discussion and cooperation between participating plant breeders and soil scientists;
- To strengthen initiatives for regional exchange of germplasm and soil, nutrient and water management practices;
- To propose soil, water and crop management technologies and strategies to increase productivity of improved crop germplasm.

The meeting is open to the National Project Coordinators of RAS/5/056 project and representatives of donor and international organizations.

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

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

Drought, disease, heat and salinity are major constraints affecting sustainable agricultural productivity in ARASIA States Parties. These Parties started a mutation breeding programme under the RAS/5/048 project in 2007 with the assistance of the International Atomic Energy Agency (IAEA). This initiative has been sustained with the project RAS/5/058 to build on the progress made under the previous TC project. Capacity has to be developed in order to use mutation induction and breeding to their most efficient levels. One key to the successful utilization of mutant materials is the accurate and rapid evaluation and selection of promising germplasm for continued propagation. Therefore, the purpose of this training course is to provide participants with:

- Scientific background in mutation induction and its application to crop breeding;
- Handling of subsequent mutated populations;
- Detection and identification of homogenous lines;
- Laboratory and/or field screening protocols for assessing responses to drought, salinity and high temperatures.

The training course will include lectures, practical sessions, round-table discussions, consultations on methodology and their application in various field situations. The course is open for 20 participants from all participating Members States involved in the project RAS/5/058.

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

Technical Officer: F. Sarsu

This training course was originally planned to be held from 8–12 April 2013 and later postponed until 2–6 December 2013.

This training course will be organized by the IAEA in cooperation with the Government of Benin, Université d'Abomey-Calavi (UAC), and Faculté des Sciences et Techniques (FAST). It is open to candidates from AFRA RAF/5/066 (Improving Crops Using Mutation Induction

and Biotechnology through a Farmer Participation Approach (AFRA)) project partners.

The purposes of the training course are to provide participants with:

- Mutation breeding basic knowledge on mutagenic agents, the establishment of dosimetry assays, determination of LD 50 doses for various crops;
- Basic statistical analysis of breeding programme and principles of experimental design;
- Identification, evaluation and screening of mutants;
- Mutation breeding techniques in vegetatively propagated crops;
- Establishment of adequate mutation induction protocols for specific crops;
- Handling of subsequent mutated populations.

The training course will include lectures, round table discussions, consultations on methodology and their application in various field situations. The participants should be from all participating Members States involved in the project RAF/5/066 additionally, they should be currently and actively working on mutation breeding and have basic knowledge in crop breeding. The training course will be conducted in English; participants should be capable of freely expressing themselves and following lectures.

Past Events

Second Research Coordination Meeting (RCM) on Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond, D2.30.29, Mexico City, Mexico, 26–30 November 2012

Aqua Crop Training Course, Mexico City, Mexico, 3–5 December 2012

Technical Officer: F. Sarsu

The RCM was organized in cooperation with the Institute of Biotechnology, Nacional Autónoma University, Mexico City. The main purposes of the second RCM were to review the progress made in the CRP for the past 18 months and to integrate the individual work plans of the selected participants as per discussions on the objectives, outputs and outcomes of the project document and as described in the country presentations. The RCM was followed by a three day training course on the use of the Aqua Crop system for exploiting data collected in the fields in terms of crop responses to increased temperatures. This system, once established and well-managed, should enable participants to understand not only the

morphological and physiological responses to heat, but most and foremost to be able to predict the most appropriate timing and weather conditions for planting crops under climate change situations.



Meeting participants.

The meeting was attended by seven participants from China, Colombia, Cuba, Mexico, the Philippines, Spain, and Zimbabwe, and one participant from the International Center for Tropical Agriculture (CIAT). Each participant presented the achievements made within the CRP, considering particularly the period after the first RCM in

May 2011. The participants presented their reports regarding the fulfillment of the expected outputs, in accordance with the guidelines previously prepared by the IAEA. The presentations were followed with great attention and in-depth discussions were engaged in order to provide clear understanding of individual project while closely pursuing the CRP objectives.

All participating countries have screened and assembled the populations of rice and/or beans to be entered in the project, including M₂ mutated generations of rice and beans provided by other countries such as China and Cuba. Several countries have worked on the establishment of physiological as well as genetic tools, using enzymes or innovative physiological compounds such as MV (Methyl Viologen) to mimic heat stress and monitor the changes via the enhanced ROS-scavenging capacity. This is a necessary first step to better understand gene expression variation under increased temperature conditions and then investigate the genes involved in such responses both in rice and beans. Advanced generations of mutant lines of rice and beans are being screened for responses to increased temperatures in China, Colombia, Cuba, the Philippines, Senegal, United Republic of Tanzania and Zimbabwe. Data obtained this year will be used for the training on the use of Aqua Crop model for monitoring prediction purposes. Significant progress has been reported in major areas of both rice and common bean:

1. Establishment of protocols for phenotyping and genotyping responses to increased temperatures;
2. Germplasm evaluation and identification of superior advanced mutant lines;
3. Identification and understanding of mechanisms of adaptation to high temperatures and drought;
4. Identification and analysis of genes involved in stress responses including heat, salt and drought.

The meeting also pointed out the excellent sense of integration between mutation breeding and molecular genetics, which emerged from discussion involving state of the art technologies, such as deep sequencing technology for RNA and genomic DNA, DGE (Digital Gene Expression Analysis).



Meeting participants.

The three day Aqua Crop training was welcomed by all participants — including four junior scientists from Mexico — as an excellent tool for learning to better collect and present field data relating to crop stress responses, and also for using their own data together with historical weather data of the selected region to predict crop performances under climate change related stress conditions.

Technical and programme management related suggestions were provided during the meeting; the key focus was to identify the achievements and outcomes and update all individual work plans, making adequate amendments in order to fully embrace the objectives of the project captured into a consolidated CRP work plan for the next cycle, 2013–2014. The meeting report, following the IAEA guidelines, was prepared and will be circulated to the Member States during the second quarter of 2013.

Interregional Training Course on Doubled Haploids and In Vitro Techniques, RAS/5/058, Amman, Jordan, 10–14 February 2013

Technical Officer: P.J.L. Lagoda

Course Directors: A.M.A. Ghanim and Y. Shakhathreh (NCARE)



Meeting participants at the National Center for Agricultural Research and Extension, Amman, Jordan.

This training course was organized through TC project RAS/5/058 in cooperation with the National Centre for Agricultural Research and Extension, Amman, Jordan. The purpose of this training course was to develop capacity in doubled haploid and in vitro techniques for accelerating and increasing the efficiency of mutation breeding and the delivery of promising mutants lines, with special emphases on wheat and barley. Nineteen participants from seven countries (Iraq, Jordan, Lebanon, Oman, Saudi Arabia, Syrian Arab Republic and Yemen) attended the course. The training course consisted of lectures, practicals, case discussions and interactive activities on the following topics:

1. Methods in doubled haploid techniques;
2. Use of doubled haploid and in vitro techniques in accelerated breeding and genetic mapping;

3. Case studies of doubled haploidy in wheat and barley mutation breeding.

ARASIA Training Course on Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley — Phase II, RAS/5/058, Muscat, the Sultanate of Oman, 14–17 April 2013

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

From 18–22 March, 19 representatives from 18 participating countries (Algeria, China, Egypt, India, Iraq, Islamic Republic of Iran, Jordan, Kenya, Lebanon, Oman, Pakistan, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, Uganda and Yemen) met at the IAEA to discuss the progress of the interregional Technical Cooperation Project. The work-plan for 2013, which included finalization of a publication and initiation of a network for further work beyond the five year duration of project, were extensively discussed.

Four coordination and steering meetings were previously conducted: 1) Vienna, Austria, May 2009, 2) Nairobi, Kenya, November 2009, 3) Ankara, Turkey, December 2010, 4) Vienna, Austria, November 2011. There were also technical meetings (Moi University, Kenya, in 2011, and Eldoret, Kenya, in October 2012) organized and training programmes conducted (October 2009 in Njoro, Kenya, June 2010 in Seibersdorf, Austria, and August 2010 in China).

Wheat black stem rust is a recurring problem in wheat growing areas, being a potential threat to world wheat output. The rust is causing damage by lowering grain yield and also increasing the cost of cultivation by necessitating the use of fungicide sprays to control the rust. In this project, 300 000 M2 and M3 generations received from several Member States were screened in Kenya. During this meeting, the success of the project was illustrated by 13 advanced mutant lines resistant to Ug99 from six participating Member States, 132 lines with moderately resistant reaction and 231 lines with moderately susceptible reaction. Two advanced resistant mutant lines successfully passed the national performance trials in Kenya, with higher yields than the controls, and could be released as varieties in Kenya by Chipkoilel University. Currently the two lines are regrown on three acres for seed multiplication, with a target of producing six tonnes distribution to farmers for commercial production during an official ceremony in August.

The further continuation of the project includes in general:

- a) Dissemination of the mutant germplasm;
- b) Development and release of further resistant varieties;

- c) Identification and characterization of genes/alleles in the resistant mutants;
- d) Accelerated breeding for quick development of resistant varieties.

Specifically, this translates into an action plan containing the following activities:

- a) Member States maintain procedures to obtain mutant varieties from their parental lines and/or mutant varieties from other Member States for their breeding programmes;
- b) Crosses to be made among the mutant varieties/advanced lines and parental lines for the study of inheritance, to test allelism and crosses with other varieties for introgression of resistance into other desirable genotypes/varieties;
- c) Member States screen for phenotype in their location if possible, and also send M2 material to Kenya for phenotyping;
- d) To carry the benefits of the project further and to bring more traits under its scope, a consortium funded by national and private sector funding is to be formed. The IAEA will function as a secretariat for the consortium;
- e) Member States will visit Eldoret for screening of the material in August and will also attend the ceremony which will be organized at the time of release of the Ug99 resistant varieties developed under the project;
- f) The primary screening site in Kenya is to be supplemented with screening at secondary sites in Algeria, Sudan, Uganda and Yemen. The secondary sites were chosen to confirm the phenotype or test the phenotype in another environment;
- g) A one week workshop on accelerated breeding is to be held in October 2013 at Seibersdorf;
- h) Results to be published include the edition of a manual of mutation breeding for stem rust resistance. It was agreed that a draft will be prepared by August 2013.

The work of evaluating mutants to develop them as varieties, the study of inheritance of mutant traits (resistance) and the introgression into desirable genetic background will go beyond the period of the project which is ending in 2013. The need for continuation of the project for two more years followed by the formation of a Global Wheat Mutation Breeding Consortium (GWMBC) to take the work further was thus emphasized.

A visit to the Plant Biotechnology Institute, Tulln, (BOKU) was arranged. Prof. Hermann Buerstmayr gave a presentation on cereal breeding and biotechnology work being carried out at BOKU. Prof. Hans Vollmer gave a presentation on genetic improvement of pumpkin and soybean. A visit to the local Austrian laboratory and greenhouse facilities concluded this fruitful meeting.



INT/5/150 participants at Tulln with Prof. Hermann Buerstmayr (photo courtesy of Prof. Vollmer, BOKU).

ARASIA Training Course on Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley — Phase II, RAS/5/058, Muscat, Oman, 14–17 April 2013

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



Meeting participants.

The meeting was organized by the Project Coordinator of RAS/5/058, Mr Al-Ghaliya Humaid Khamis Al-Mamari, at the Directorate General of Agricultural and Livestock Research, Ministry of Agriculture and Fisheries. The main purposes of the seventh coordination meeting were to report on the progress made over the last four years, review the work plan of the project, agree on national plans for the activities to be implemented in 2013–2014 at the national level, and prepare the draft consolidated national reports according to the template agreed upon during the last coordination meeting.

The meeting was attended by participants from Iraq, Jordan, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic and Yemen. Qatar has newly joined the project and the meeting participants welcomed the national coordinator from Qatar and were readily available to provide the necessary guidance and advice. The country presenta-

tions performed by the participants included progress achieved and results obtained under the project RAS/5/058. Further country work plans and arrangements for future project activities in 2013–2014 were discussed. The meeting presented the progress made and the national activities implemented during the last growing season. Iraq, Jordan, Lebanon, Syrian Arab Republic and Yemen have advanced in their mutation breeding work for wheat and barley: advanced mutant lines have been obtained in these countries. Discussions made after each presentation were, very useful and areas for improvement were suggested to enhance and speed up the acquisition and results in mutation induction. Training course topics were discussed and updated according to the needs of participating countries. Adoption of the SMTA protocol and germplasm exchange was encouraged in participating countries (<http://mvgs.iaea.org/>). Lebanon is conducting regional trails for seeds multiplications, which were sent by Iraq, Jordan and Syrian Arab Republic earlier. The material is being exchanged between these countries through a Memorandum of Understanding (MoU) that was signed at the onset of this programme in 2007.

The objectives of the meeting were fully accomplished. National work plans were updated for RAS/5/058 and achievements extracted. All national counterparts present at the meeting agreed to the work plan and committed to achieve their roles.

Third Research Coordination Meeting (RCM) on Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants, D2.40.13, Jeju Island, Republic of Korea, 16–19 April 2013

Technical Officer: P.J.L. Lagoda

The third RCM was held in conjunction with the third International Symposium on Genomics of Plant Genetic Resources (GPGR3), hosted at the International Convention Center in Jeju Island, South Korea, from 16–19 April 2013. Twelve research and agreement holders from 10 Member States (Argentina, Bulgaria, China, Germany, India, Republic of Korea, Poland, Portugal, the United States of America and Switzerland) met for one week to discuss the progress of the CRP.

The GPGR3 organizers invited the IAEA to organize Session VI: Plant Mutation Genomics/Third RCM on Isolation and Characterization of Genes Involved in Mutagenesis in Crop Plants, co-chaired by the reporting Technical Officer (TO) and Prof. Si-Yong Kang (Seoul, Republic of Korea). The CRP contract holders from the FAO and IAEA gave talks on their recent research activities and discussed genome stability and its interactions.

The conference was a great success. GPGR3 had 325 participants from over 24 countries. The conference offered knowledge exchange and outstanding networking opportunities. It was an excellent platform to showcase the work of the IAEA through CRPs.

The reporting TO gave a talk on Mutation Induction in a Genomics Era. In addition, he was also invited to the roundtable discussion session XI (Symposium Wrap-up) — Collaboration and Sharing between Public and Private Sectors — International Corporation and Sharing Genetic Resources and Information. During GPGR3, the TO attended the GPGR3's International Organizing Committee Meeting to discuss the next conference site of GPGR4, to be held in Brazil in 2016.

The CRP contract holders recommended to extend the CRP for an additional year (with no cost to the IAEA) in order to wrap up ongoing activities and produce protocols and guidelines.

Regional Training Course on Plant Mutation Breeding: Mutation Induction, Mutation Detection, Pre-Breeding, INS/5/039 and BGD/5/028, Seibersdorf, Austria, 3–14 June 2013

Course Director: B.P. Forster

The purpose of this training course was to provide basic knowledge and skills in mutation breeding, i.e. 1) mutation induction, 2) mutation detection and 3) pre-breeding of mutant lines. The course was designed for plant breeders in Member States embarking on mutation breeding to provide mutant variation for various desired traits, such as greater yield, salt and drought tolerance, and resistance to pests and diseases, particularly in areas threatened by

climate change. The training course aimed to provide knowledge and skills to participants of INS/5/039 (Indonesia) and BGD/5/028 (Bangladesh), and to other related TC projects with active programmes in mutation breeding. Methods were taught on how to induce and detect desired mutant traits in these projects and how selected mutant lines could be developed using accelerated breeding methods, thus speeding up the development of improved mutant varieties.

The course focused on methods pertinent to the crops and traits that are of interest to the participating countries, for example, demonstrations were provided in screening for salt tolerance in rice and drought tolerance in wheat. Lectures were given in mutation induction, radio-sensitivity testing, mutant detection and pre-breeding. The course also provided an opportunity for networking among participating countries. A major objective was to provide practical training so that the techniques taught may be applied when the participants returned to their home countries, and therefore laboratory practicals and hands-on experience (tissue culture, doubled haploidy, embryo rescue, DNA isolation and genotyping) were a major feature of the course.

There were a total of 16 participants: seven from Bangladesh, two from Botswana, six from Indonesia, and one from Palestine.

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

Project Number	Ongoing CRPs	Scientific Secretary
D2.30.28	Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops	S. Nielen
D2.30.29	Climate Proofing of Food Crops: Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond	F. Sarsu
D2.40.12	Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline	B. Till
D2.30.13	Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants	P.J.L. Lagoda
D1.50.13	Approaches to Improvement of Crop Genotypes to High Water and Nutrient Use Efficiency for Water Scarce Environment	K. Sakadevan and P.J.L. Lagoda
D2.30.30	Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System	B.P. Forster

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

Technical Officer: S. Nielen

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

The project started in early 2009 and had its first RCM in Vienna, Austria, 29 June–3 July 2009. The second RCM took place on 11–15 April 2011 in Pretoria, South Africa, and the third RCM was held 15–19 October 2012 in Hangzhou, China. Currently, 15 research groups from 13 countries (Botswana, Bulgaria, China, Denmark, Germany, Ghana, India, Kenya, Peru, South Africa, Ukraine, the United Kingdom, and the United States of America) participate in the project, of whom 10 are under research contracts, three under research agreements, and two are under technical contracts. In the course of the project, new mutant germplasm collections from elite varieties of the target crops of wheat, barley, sorghum, soybean, groundnut, sweet potato and tomato have been developed. Efficient phenotypic screening methods for resistant starch, increased carotenoids and increased tocopherols were developed. These include colorimetric

assays for phosphate and phytate for barley and wheat flour and for starch composition in maize and wheat and a method for HPLC analysis of some carotenoids (lutein, zeaxanthin, lycopene, beta-carotene). Various molecular marker techniques have been developed or adapted to local conditions and are being used to screen for genes affecting synthesis of resistant starch (RS), increased carotenoids, decreased oxalate, decreased phytate and increased tocopherols. For example, sequencing of the *SSIIIa* gene from wild type rice and a high RS mutant showed the presence of one single SNP and of a four bp deletion causing a truncated protein. A CAPs marker was developed based on this mutation, which co-segregates with the high RS trait. Other molecular studies, such as expression analysis of genes involved in synthesis of phytic acid in soybean or screening of a tomato TILLING population for mutations in *SSIIIa* gene and beta genes, are currently being conducted.

The final RCM, where the results of this CRP will be summarized, its outputs and outcome assessed, and manuscripts for publication finalized, is planned to be held in April 2014 in Cusco, Peru.

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

Technical Officer: F. Sarsu

This CRP was initiated in 2010. The first RCM was held in Vienna, Austria, 2–6 May 2011. Ten research contract holders (China, Colombia, Cuba, India, Mexico, Pakistan, the Philippines, Senegal, the United Republic of Tanzania and Zimbabwe) and five agreement holders (China, International Rice Research Institute (IRRI), Japan, Spain and the UK) attended the RCM.

The overall objective of this CRP is to develop new high yielding mutant varieties with improved quality under low input cultivation in a range of agro-ecologies through broadening adaptability. Many regions already weighed down with drought, flooding or resurgence/occurrence of disease may see the spread of such food security-threatening situations to unforeseen regions, given climate change and variability. Therefore, food security crops need to be 'climate proofed'. The specific objectives of the CRP include:

1. Development of modern nuclear technology enhanced breeding protocols to enable improved responses to abiotic and biotic stresses, providing sustainable food security under increasingly adverse and variable conditions;
2. Adaptation and application of modern and high throughput biotechnology packages to nuclear applications in soil, water and crop nutrition management for enhanced crop adaptation and flexibility.

This CRP is being steadily implemented in all participating countries. The M₂ generations of rice and common bean are being screened in laboratories, in screen houses and in the fields. Even though it is quite early to account for solid achievement, it can be noted that most efforts have been placed in establishing reliable and solid screening protocols, which in turn should later ensure the selection of the most suitable mutated genotypes. On the other hand, the efforts in the analysis of the genomic responses have also been substantial. Thanks to the release of the common bean genome sequence early this year, we expect to see a wealth of genes and other genomics involvement in tolerance to heat being clarified and documented.

The second RCM was held in Mexico City, Mexico, 26–30 November 2012 (See 'Past Events' section). The third and final RCM is planned to be held in Dakar, Senegal, during the third quarter of 2014.

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

Technical Officer: B. Till

This CRP was initiated in 2008. The first RCM was held in Vienna, Austria, 25–29 May 2009, the second RCM was held in Vienna, 13–17 December 2010, and the third RCM was held in Vienna, 18–22 June 2012. This CRP has six research contract holders from China, Cuba, Ghana, Poland, Sierra Leone and Vietnam and four agreement holders from Austria, Germany, and USA (2). To address the global need for sustainable intensification of crop productivity, this CRP focused on the assemblage, adaptation and interlacing of novel cellular and molecular biology techniques to achieve a seamless dovetailing of validated processes into a modular pipeline. Modules include optimization of mutation induction, optimized approaches for vegetatively propagated species, efficient

phenotypic screening, effective genotypic screening, and the development and utilization of reverse genetics for trait improvement.

Effective and efficient integration of induced mutations into breeding programmes for the development of improved crop varieties consists of a series of modules. These modules include optimized mutation induction to produce a population of plants harboring a mutation spectrum and density that increases the chance of recovering useful alleles controlling targeted traits. Mutation screenings at the phenotypic and genotypic level are two more important modules in a pipeline of steps to producing an improved mutant variety. Reverse genetic strategies and special optimizations for vegetatively propagated crops are also modules to enhance efficiency in what might be considered pre-breeding steps for mutant varietal development. This CRP focuses on these modules for enhancing the efficiency of induction and screening for induced mutations. The focus is on four target crops to serve as models for seed and vegetative propagation: barley, rice, banana, and cassava. Counterparts continue with their work plans and progress was reported in all areas at the third RCM, held in Vienna in June of this year. Highlights include barley microspore mutagenesis that can be used to create instantly true breeding lines, next generation sequencing approaches being applied to rice and cassava for rapid mutation discovery, methods for rapid dissolution of chimeric sectors in banana, TILLING in barley for abiotic stress, and FEC mutagenesis techniques developed for cassava. In the past six months, work has been initiated to develop low cost methods for rapid genotypic evaluation of putative doubled haploid barley plants in order to confirm plants are truly homozygous and not escaped diploids. To expand data sets of mutation density and spectrum in cassava and to prepare a small pilot population for reverse genetics by TILLING, a technical contract has recently been awarded to Mr Hua-Bing Yan of the Guangxi Academy of Agricultural Sciences in Guangxi, China. The work from this contract will produce approximately 800 mutagenized lines, from which DNA will be extracted and sent to the Plant Breeding and Genetics Laboratory in Seibersdorf for evaluation. The major outputs of this CRP will be protocols and guidelines aimed at supporting Member States in the efficient use of induced mutations for plant improvement.

Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants, D2.30.13

Technical Officer: P.J.L. Lagoda

For 40 years, mutation induction and chemical agents have proved extremely for successfully improving crop varieties. The Food and Agriculture Organization of the United Nations (FAO) and the International Atomic Energy Agency (IAEA), through their Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture, efficiently supported, both financially and scientifically, research around the world in the field of mutation

induction and breeding. As a result of these research activities, many developing countries experienced growing economic benefits through mutation induction and achieved enhanced genetic diversity in many crop germplasm. However, the molecular basis of the mutation process is still a black box. In order to investigate the different parameters, a previous CRP looked into the effects of mutagens on the DNA in plants. The second component is the repair mechanisms on the genomic level. CRP D2.40.13 was created five years ago to investigate this second component of mutation induction.

The objective was to isolate and characterize genes involved in mutagenesis and find out types of mutations induced by various physical mutagens in studied crop plants, and to generate mutants deficient in DNA repair pathways in crops and assess their usefulness for efficiency enhancement of mutation induction.

Major milestones have been reached in this CRP. Genes encoding core proteins of the repair pathway in rice have been cloned and are being characterized. Whole genome scanning in soybean is underway for naturally mutated and selected genes. A chloroplast mutator gene and mutations caused by it have been identified in barley, and three putative DNA repair genes in pea are being studied. Mutant populations of rice are being screened for reduced sensitivity to radiation. The assembly and publication of the complete sequence of the wild soybean (*Glycine soja*) genome is a major achievement. A barley EST database has been established with extensive sequence alignments to *Arabidopsis* sequences, with hyperlinks to original data sources and to the MVGS database. This database is a valuable knowledge platform on repair mechanism genes, and will go online publically in 2014, after upgrading and updating.

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

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

This CRP is in its second year. All research contract holders have submitted a project progress report for the first year and the contracts have been renewed. The CRP aims to increase crop productivity and water and nutrient use efficiencies in agro-ecological zones affected by abiotic stresses such as drought, salinity and high temperatures by using best fit soil and water management practices and improved crop varieties through demonstrations in small farmers' fields. A total of 12 research contract holders from Bangladesh, China, Indonesia, Kenya, Malaysia (two contracts), Mexico, Pakistan, Peru (two contracts), Uganda and Vietnam and one agreement holder from South Africa are participating in this project. The overall objective of this CRP is to increase crop productivity and food security by developing and extending to farmers technology packages which include information about improved crop varieties and best-fit soil, water,

nutrient and crop management practices that make cropping systems resilient to environmental stresses. The specific objectives are: 1) to increase the productivity of improved mutant varieties of crops tolerant to environmental stresses under existing soil and climatic conditions, and 2) to enhance nitrogen and water use efficiencies of crops tolerant to environmental stresses through best practice involving soil, water, crop and fertilizer management.

Field studies implemented in all countries for evaluating improved varieties of rice (aerobic, ratooning and saline tolerant varieties in Bangladesh, China and Malaysia), sorghum (tolerant to acidity and drought), soybean (tolerant to extreme temperatures and water stress), banana and potato (disease resistance), amaranthus (high yielding), wheat (disease, water and nutrient use efficiencies), barley (early maturity) and quinoa (adapted highlands) for yield, water and nutrient use efficiencies.

The second RCM of the CRP was held from 24–28 June 2013 in Kuala Lumpur, Malaysia. During the second RCM the project work plan for third and subsequent years was discussed, gaps identified and work plan fine-tuned.

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

Technical Officer: B.P. Forster

This CRP began in the third quarter of 2012 and will be concluded in the third quarter of 2017. The objectives are:

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

In December 2012, we held our first RCM, in which all contract holders participated (Austria, China, Indonesia, Kuwait, the Former Yugoslav Republic of Macedonia, Malaysia, Mongolia and Peru). This was set up primarily

to consider the activities of each participant and group activities, both in the long term (five years) and in the short term (first two years of the project):

1. To develop dual purpose (food and feed) mutant cereal crops in developing countries;
2. To develop cropping systems that maximise yield by the application of appropriate soil and water management practices and develop guidelines for crop management systems;
3. Test mutant varieties and advanced lines in on-farm trials;
4. Evaluate agronomic performance and nutritive value of mutant varieties and advanced lines;
5. Develop locally adapted breeding material;
6. Determine fodder and feed value of mutant varieties and advanced lines in animal production systems;
7. Deliver useful mutant genetic stocks to interested Member States, including those not participating directly in the CRP;
8. Develop protocols/screening methods for crop mutant induction, mutation detection and mutant line development;
9. Publish and disseminate results.

Technical Cooperation Field Projects

Project Number	Country/Region	Title and Objective(s)	Technical Officer
ALG/5/026	Algeria	Increasing the Genetic Variability for the Improvement of Strategic Crops (Wheat, Barley, Chickpeas and Dates) for Enhanced Tolerance to Biotic and Abiotic Stresses and the Development of Biotechnology Capacities	P.J.L. Lagoda
ANG/5/008	Angola	Using Nuclear Technology to Select Mutants of Cassava Resistant to the African Cassava Mosaic Virus and Various Diseases Affecting this Crop	S. Nielen
BGD/5/028	Bangladesh	Assessing Crop Mutant Varieties in Saline and Drought Prone Areas Using Nuclear Techniques	S. Nielen
BKF/5/009	Burkina Faso	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques for Food Security and Poverty Alleviation	P.J.L. Lagoda
BOT/5/009	Botswana	Using Radiation Technology and Biotechnology to Develop Mutant Lines of Important Crops with Increased Yield and Improved Nutritional and Hygienic Qualities	A.M.A. Ghanim/S. Nielen
CAF/5/006	Central African Republic	Improving Cassava Production through High-Yielding Varieties and Sustainable Soil Fertility Management by Using Isotopic and Nuclear Techniques to Ensure Sustainable Farming	B. Till in collaboration with Soil and Water Management and Crop Nutrition Section
COL/5/024	Colombia	Supporting Mutagenesis and Functional Genomics Applied to the Improvement of Rice	B. Till/S. Nielen
ERI/5/024	Eritrea	Supporting the Livelihood of Barley Farmers through Mutation Techniques and N15 Technology to Improve Malting, Food and Feed Barley Production	A.M.A. Ghanim/S. Nielen
INS/5/039	Indonesia	Enhancing Food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Adaptation	B.P. Forster/B. Till
INT/5/150	Interregional	Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99)	P.J.L. Lagoda/B.P. Forster
INT/5/152	Interregional	Supporting Mutation Breeding Impact Assessment	P.J.L. Lagoda/B.P. Forster
IVC/5/031	Cote d'Ivoire	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
KAZ/5/003	Kazakhstan	Increasing Micronutrient Content and Bioavailability in Wheat Germplasm by Means of an Integrated Approach	F. Sarsu/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
KEN/5/032	Kenya	Characterising and Improving Germplasm of Selected Crops at the Molecular Level Using Nuclear and Biotechnology Techniques	F. Sarsu/P.J.L. Lagoda
LES/5/001	Lesotho	Improving Crop Yield, Quality and Stress Tolerance for Sustainable Crop Production to Alleviate Hunger, Poverty and Environmental Degradation	S. Nielen/A.M.A. Ghanim
MAG/5/022	Madagascar	Strengthening Food Security	F. Sarsu/B.P. Forster
MAL/5/029	Malaysia	Applying Mutation Breeding and Optimized Soil, Nutrient and Water Management for Enhanced and Sustainable Rice Production	S. Nielen

Project Number	Country/Region	Title and Objective(s)	Technical Officer
MAR/5/020	Mauritius	Developing Stress Tolerant Banana and Tomato Varieties by Enhancing the National Capacity in Mutation Induction and Biotechnology	B. Till/S. Nielen
MON/5/021	Mongolia	Improving the Productivity and Sustainability of Farms Using Nuclear Techniques in Combination with Molecular Marker Technology	B.P. Forster/P.J.L. Lagoda in collaboration with Animal Procution and Health Section
MOR/5/033	Morocco	Using Nuclear Techniques to Support the National Programme for the Genetic Improvement of Annual and Perennial Plants and to Develop Agricultural Production	F. Sarsu/A.M.A. Ghanim
MYA/5/020	Myanmar	Strengthening Food Security through Yield Improvement of Local Rice Varieties with Induced Mutation (Phase II)	S. Nielen/P.J.L. Lagoda
NAM/5/010	Namibia	Developing High Yielding and Drought Resistant Pearl Millet (<i>Pennisetum glaucum</i> L), Sorghum Bicolor (L) Moench, Bambara Groundnut (<i>Vigna subterranea</i>) and Cowpea (<i>Vigna unguiculata</i> (L) Walp) Following Up a Previous Project (PHASE II)	F. Sarsu/S. Nielen
NER/5/015	Niger	Improving Productivity of the Millet-Cowpea Cropping System through Development and Dissemination of Improved Varieties and New Water and Fertiliser Management Techniques	S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
OMA/5/002	Oman	Assessing the Suitability of Sterile Insect Technique (SIT) and Related Techniques for Combating Date Palm Insect Pests	P.J.L. Lagoda in collaboration with Insect Pest Control Section
PAK/5/047	Pakistan	Developing Germplasm through TILLING in Crop Plants Using Mutation and Genomic Approaches	B. Till/S. Nielen
PAL/5/005	Palestine	Improving local Palestinian wheat and barley varieties for salt and drought resistance through mutation breeding and biotechnology	B.P. Forster/P.J.L. Lagoda
RAF/5/066	Regional Africa	Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA)	F. Sarsu/B. Till
RAS/5/056	Regional Asia	Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change	S. Nielen/P.J.L. Lagoda
RAS/5/058	Regional Asia	Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change	P.J.L. Lagoda/F. Sarsu
RAS/5/064	Regional Asia	Enhancing Productivity of Locally-underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices	P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
RAS/5/065	Regional Asia	Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications	P.J.L. Lagoda/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
RLA/5/056	Regional Latin America	Improving Food Crops in Latin America Through Induced Mutation (ARCAL CV)	S. Nielen/B. Till
RLA/5/063	Regional Latin America	Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI)	S. Nielen/B. Till

Project Number	Country/Region	Title and Objective(s)	Technical Officer
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
SUD/5/033	Sudan	Enhancing Productivity of Major Food Crops (Sorghum, Wheat, Groundnut and Tomato) under Stress Environment Using Nuclear Techniques and Related Biotechnologies to Ensure Sustainable Food Security and Well-Being of Farmers	F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
UZB/5/004	Uzbekistan	Development of Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity	F. Sarsu/S. Nielen
UZB/5/005	Uzbekistan	Developing Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity (Phase II)	F. Sarsu/S. Nielen
YEM/5/008	Yemen	Introduction of Gamma Ray Irradiation Techniques for Agriculture Purposes	F. Sarsu/S. Nielen
YEM/5/010	Yemen	Using Induced Mutations and Efficiency Enhancing Bio-Molecular Techniques for Sustainable Crop Production	S. Nielen/P.J.L. Lagoda
ZAI/5/019	Democratic Rep. of Congo	Developing Mutations, In Vitro and Molecular Techniques for Further Dissemination to Breeders and Pharmaceutical Plant Producers to Enhance the Livelihood of Target Populations	B. Till/F. Sarsu
ZAM/5/027	Zambia	Developing Maize Genotypes for Drought and Low Soil Fertility Tolerance	F. Sarsu in collaboration with Soil and Water Management and Crop Nutrition Section
ZIM/5/015	Zimbabwe	Developing Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content Using Mutation Breeding and Novel Techniques, Phase II	F. Sarsu/S. Nielen

Success Stories

Enhancing Food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Agriculture, INS/5/039

Technical Officer: B.P. Forster

Indonesia is an archipelago made up of over 17 500 islands located in the tropical zone of South East Asia. The population exceeds 238 million people, making Indonesia the fourth most populous country in the world. The population is growing at a rate of about 2% per year and is expected to reach 265 million people by 2020 and 306 million by 2050. Indonesia (along with Malaysia, the Philippines, Singapore and Thailand) is a founding member of ASEAN (Association of Southeast Asian Nations, which now includes Brunei, Cambodia, Laos, Myanmar, and Vietnam). Indonesia is a member of the G-20 major economies.

The national motto, 'Bhinneka Tunggal Ika' means 'Many, yet one', which reflects the array of ethnic groups and religions in the country. Indonesia has abundant natural resources, but suffers from natural disasters (mainly seismic activities), and poverty is widespread.

Agriculture — Current Situation and Problems

Agriculture plays a key role in the economy of Indonesia and accounts for 43% of total employment and contributes to 15% of the GDP. National food production does not meet the country's food security needs and Indonesia is a net importer of many staple foods, including: rice, soybean, wheat and beef. Rural and semi-rural communities, which account for about 172 million people, are particularly vulnerable to food shortages; 60% of the poorest people live on small farms. Improved agricultural production is therefore a major national objective.

Indonesia is tropical and crops can be grown all year round. Major crops include rice, cassava, groundnuts, oil palm, rubber, cocoa, coffee and copra. Agricultural development is limited by sub-optimal soil conditions in many parts of the country, which include acidic and saline soils. Indonesia has a long coastline and agricultural production is low in coastal areas where soil salinity can be problematic. Climate change is also affecting agricultural production and Indonesia has experienced recent episodes of prolonged droughts, salinity and flooding. Further perturbations in weather are anticipated. As a consequence, breeding crops to combat climate change is essential to safeguard food security and the Indonesian economy. 'Climate smart agriculture' has multiple components. There is no doubt that agronomic practices, such as soil, water and fertiliser management, will play key roles, but an essential and basic ingredient is that crops must have the genetic potential to produce high and stable yields in fields subject to adverse conditions.

Enhancing the genetic diversity of crop plants is therefore essential.

Two major strategies have been implemented to increase national food crop production in Indonesia: (1) extending food crop growing areas, and (2) increasing production on existing agricultural land. In extending the growing areas, marginal and forested areas have been brought under cultivation. Due to growing awareness of the environmental problems caused by this policy, there is increased pressure to improve productivity on existing farmlands. Crop intensification can be achieved by growing short season and high yielding crops. There is an urgent demand for early maturing varieties of food crop so that the time between harvest and planting the next crop is minimized. In addition, varieties adapted to sub-optimal conditions such as salinity will help address the effects of climate change.

Past and Present Successes in Mutation Breeding

Indonesia was the first country in the world to cultivate a mutant crop variety. This pioneering success was achieved by the release of the tobacco mutant variety 'Vorstenland' in 1934. This mutant was induced by X ray irradiation which resulted in a superior mutant plant with pale green leaves and high leaf quality. The application of plant mutation induction was intensified in 1972 at the Centre for the Application of Isotope and Radiation Technology (PATIR) at the National Nuclear Energy Agency (BATAN), Jakarta, with technical support from the IAEA. The focus was on increasing crop productivity, with an emphasis on rice. The first mutant rice variety produced by PATIR-BATAN was 'Atomita 1', in 1982. The strategy continued to be successful, and in 2003 the Chairman of BATAN announced the planting of superior, high yielding mutant varieties of rice and soybean in farmer's fields in 23 agricultural regions of Indonesia. The yield potential of rice mutant varieties was more than nine tonnes per hectare, and four tonnes per hectare for soybean.



Professor Mugiono, rice breeder (PATIR-BATAN), with one of his mutant rice varieties. 'Bestari', released in 2008, is a high yielding variety, resistant to disease, early maturing and with nutritional grain quality. Prof. Mugiono was a founding father of mutation breeding in Indonesia and was responsible for the release of 20 rice mutant varieties (photo courtesy of BATAN, Indonesia).

Successful Mutant Varieties

Plant breeders at PATIR-BATAN have produced many mutant varieties. The first was 'Atomita 1', released in 1982, and others include:

- Paddy rice: 'Atomita 1' (1982), 'Atomita 2' (1983), 'Atomita 3' (1990), 'Atomita 4' (1991), 'Cilosari' (1996), 'Meraoke' (2001), 'Pandan Putri', 'Woyla' (2001), 'Kahayan' (2003), 'Winongo' (2003), 'Diah suci' (2003), 'Yuwono' (2004), 'Mayang' (2004), 'Mira-1' (2006), 'Bestari' (2008), 'Inpari Sidenuk' (2011), 'Inpari Mugibat' (2012), 'Suluttan Unserat 1' (2012), 'Suluttan Unsrat 2' (2012).
- Upland rice: 'Situgintung' (1992).
- Soybean: 'Muria' (1987), 'Tengger' (1991), 'Mera-tus' (1998), 'Rajabasa' (2004), 'Mitani' (2008), 'Mutiara 1' (2010).
- Mungbean: 'Camar' (1991).
- Cotton: 'Karisma 1' (2008).



Official testing of mutant rice lines by Mr Sobrizal and colleagues (Photo credit: B.P. Forster, FAO/IAEA).

A major success in mutation breeding has been the development of rice lines that complete their cropping cycle within 100 days. This is hugely significant as it provides an opportunity to produce three (rather than two) harvests of rice per year. The success is doubly significant as these rapidly maturing rice lines have also been bred to be high yielding and have a yield potential of up to nine tonnes/hectare. A further success has been the development of 'super-fast' bean mutant lines (Q-298 and 4-Psj) which can be grown in a three-crop rotation scheme with rice without losing valuable time. The new mutant bean lines are very early maturing with a growth duration of less than 70 days from sowing to harvest. These lines are currently undergoing official testing for varietal status.

A major mandate for PATIR-BATAN is to improve rice varieties for high yield, early maturity, grain quality, resistance to the main pests and diseases and tolerance to drought and salinity. However, the mutation breeding effort has been extended to include more crops, soybean, banana and sorghum. Plant breeders at PATIR-BATAN aim to release, on average, two mutant varieties every year. Currently PATIR-BATAN has seven promising rice lines, two soybean lines and two sorghum mutant lines in official tests to achieve varietal status, and more are in the pipeline.



Mutant varieties for the future: Mr Human (BATAN) with his brown mid-rib mutant of sorghum with the potential to increase feed quality, and Ms Yuliasti (BATAN) with her 'super-fast' bean.

Impact of BATAN Mutant Varieties

In order to improve the quality of life, Indonesia has been active in promoting the development of small and medium sized enterprises. To support this programme, BATAN is engaged in a programme on 'Utilization of Research and Development Result in Nuclear Science and Technology (PHLIN)'. The PHLIN programme has been conducted for 13 years and covers 24 provinces in Indonesia (Aceh, North Sumatra, West Sumatra, Jambi, Bengkulu, Riau, Bangka Belitung, South Sumatra, Lampung, Banten, West Java, Central Java, Yogyakarta, East Java, Bali, West Nusa Tenggara, East Nusa Tenggara, North Sulawesi, Gorontalo, South Sulawesi, South East Sulawesi, West Kalimantan, South Kalimantan and Central Kalimantan). The objectives of this programme are to

(1) facilitate technology transfer in order to promote self-supporting public economic activities in local areas, (2) to promote the use of local resources and (3) to promote active participation of local governments, enterprises and local community in utilizing BATAN's R&D products, such as mutant varieties for agriculture. Activities include demonstration plots and demonstration farming, seed breeding and an easy method for distribution of various mutant crop varieties (especially rice and soybean) to farmers. The programme is successful, for example mutant paddy rice varieties are made available to farmers through small enterprises and these varieties are cultivated in several areas, such as Subang, Jepara, Lampung, Blitar, Banyuwangi, Lombok and Aceh.

Impact of Mutant Varieties from BATAN in Agriculture, 1999–2011

Classification	Indonesia	BATAN	Percentage Contribution
Rice productivity	5.0 t/ha (Statistics Indonesia 2011)	7.0 t/ha	140%
Harvested area of rice cultivation	13 566 600 t/ha (Statistics Indonesia 2011)	2 250 000 t/ha (2000–2011)	16.5% (1.4% / a)
Paddy varieties	190 varieties (up to 2010)	17 varieties (up to 2011)	9%
Soybean varieties	71 varieties (up to 2008)	6 varieties (up to 2011)	8.5%
Location of cultivation	33 provinces	24 provinces	72%



President Susilo Bambang Yudhoyono of Indonesia and his wife celebrating the success of mutant rice varieties (photo courtesy of BATAN, Indonesia).

Future Strategies

Mutation breeding will continue as a standard method for crop improvement, and there are plans to extend this to a wider range of plants: food security crops, plantation crops, fibre crops, medicinal plants and ornamentals.

Mutation breeding has certain advantages that make it ideal for the rapid improvement of traditional and farmer-preferred varieties, without altering the key favoured characteristics. Thus traditional tall aromatic rice may be converted to semi-dwarf stature or to having improved earliness or disease resistance without altering aroma.

A new area being pursued by PATIR-BATAN is the development of F1 hybrid rice. Currently, F1 hybrid varie-

ties produced in China are undergoing trials in Indonesia. F1 hybrid crops have the potential to produce higher yields than conventional varieties and have greater yield stability. Thus the ability to produce F1 hybrid rice in Indonesia is of interest. F1 hybrid production requires male sterile and fertility restorer lines, and work has been initiated at PATIR-BATAN to develop cytoplasmic male sterile lines by back-crossing cultivated rice to its wild relative, and developing fertility restorer lines through induced mutation of locally adapted breeding materials. Breeding materials for F1 hybrid rice have also been developed through Indica X Japonica and Indica X Japonica crosses.



Plant breeders of the future: students at the field testing station of the Indonesian Center for Rice Research.



Collaboration with Hasanuddin University.

Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99), INT/5/150

Technical Officer: P.J.L. Lagoda

Under the project INT/5/150 on Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99), scientists are accelerating research into new varieties of wheat to identify those resistant to an aggressive fungus, called wheat black stem rust disease (race Ug99), which is destroying harvests in African and Middle Eastern countries.

Wheat provides 20% of the world's calories, and Ug99 is capable of cutting wheat yields by 20–80%, with isolated incidents of 100% destruction. About 90% of commercial high-yielding wheat is vulnerable to Ug99. Scientists from 18 IAEA Member States under INT/5/150 joined the rest of the world on working to produce new wheat varieties that are impervious to the fungus, through mutation breeding.

Under INT/5/150, stem rust research participating countries have been committed to breeding for stem rust resistant wheat and barley at Chepkoilel University College over the four years of this project's implementation period. Thirteen wheat mutant germplasms from six participating Member States have so far been selected and advanced, and four were submitted for National Performance Trials in Kenya. All four were validated, being resistant to the three most virulent strains of Ug99. Two of these, in addition to out-yielding the control lines, have been planted on three acres for seed multiplication (with a target of six tonnes) to be released to the farmers for commercial production. An official ceremony will take place on that occasion in August this year. Currently over 25 wheat mutant germplasm materials from INT/5/150 participating countries are being re-examined for their response to stem rust infection. These were planted at various agroecological zones.



Participants from different Member States came for screening and viewing of material in Eldoret, Kenya.



This picture depicts the success of this project: Performance of mutant selections (green uninfected by stem rust) compared with other selections (highly infected) in national performance trials in Kenya.

The official release of two new varieties in the four year period since the inception of the project in 2009 is a high achievement and showcases the potent contribution of the IAEA to global food security.

News

Information Sheets for Visitors


In our last newsletter we introduced our 'Information sheets for visitors'. These are fact sheets for individual countries that described the main issues in crop production with respect to local conditions and crops. Interactions with the Joint FAO/IAEA Division are included, along with success stories such as the release of improved mutant varieties. These hand-outs give us greater visibility and are very popular with our visitors, as they provide basic information on our work with Member States. We ask our fellows to prepare these information sheets (for their respective countries) because these fellows have the pertinent knowledge and hands-on experience with critical issues facing crop production in their home countries. We currently have 14 'Information sheets for visitors':

- Afghanistan
- Bangladesh
- Burkina Faso
- China
- Indonesia

- Kenya
- Mongolia
- Nigeria
- Palestine
- Peru
- Sudan
- Thailand
- Turkey
- USA

The information sheets from Burkina Faso, Kenya, Palestine and Sudan are new for 2013 those from Bangladesh, Indonesia and Turkey have been revised in 2013. An example of an information sheet is given for Kenya below. If you would like to prepare an information sheet, please contact us.

Capacity building



Mr Amos Ego on a fellowship at the PBGL working on validation of Ug99 wheat mutants

Recent trainees from Kenya

Stephen Kipchirchir, Kimno (2010)

IAEA coordinated research project on Artemisia

- ♦ Mutation induction in Artemisia and germplasm characterization.
- ♦ Irradiation services: Barley and Artemisia

EGO Amos Kibiwott (2013)

IAEA coordinated (INT/5/150) Research project







- ♦ Tissue culture techniques
- ♦ DNA purification and molecular marker techniques
- ♦ Mutation induction and radio-sensitivity tests

PLANT BREEDING AND GENETICS LABORATORY

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


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AMOS EGO

Kenya

Applying mutation techniques in breeding for tolerance to biotic and abiotic stresses



Plant Breeding and Genetics Laboratory

The PBGL supports capacity in Member States for the use of induced mutations to develop superior crop varieties through R&D, Services and Capacity

Success story

Semi-arid lands cover 83% of the land area (56.0 million ha) in Kenya. Hot and barren lands have long been unfit for agriculture and traditionally used for grazing. Kenya experiences periodic food shortages which are partly due to intermittent, but severe, droughts. Emergence of new virulent pathotypes in the high potential areas have also caused severe yield losses, a good example is race Ug99 of wheat stem rust which has become a devastating disease.

Wheat is the second most important cereal crop in Kenya, after maize. But the country produces just one third of its requirement. The rest is imported and commodity prices are rising. Kenya therefore has a challenge to produce crops that are tolerant to the biotic and abiotic stresses.



Field screening for Ug99 resistance by participants of INT/5/150 at Eldoret

The Kenya Agricultural Research Institute (KARI), the University of Eldoret and other research institutions have developed their capacity in mutation breeding with support from the AFRA programme and the IAEA.

One outcome is the mutant wheat variety 'Njoro-BW1' developed by mutation induction using gamma rays with selection for drought tolerance, high yield, baking quality and resistance to diseases. This variety was officially released in 2001, and has been grown successfully in the highlands and in areas with acidic soils. Farmers from diverse regions (dry lowlands and highlands) are therefore able to grow this variety.

Currently, mutant lines resistant to Ug99 have been produced and field tested under the IAEA inter-regional INT/5/150 project, at the University of Eldoret, Kenya. Mutations were induced at the PBGL in Seibersdorf and the advanced lines developed are being characterised using molecular markers.

Mutant barley lines have also been developed that are resistant to lodging.

Mutant varieties



Officially released in Kenya

Wheat: 'Njoro- Bw1'

Njoro-BW1 was officially approved in 2001. Main improved attributes are tolerance to drought and use in limited rainfall conditions. It is high yielding, moderately resistant to wheat rust and has good baking quality.

Cowpea: ICV 11, ICV 12

ICV 11 was officially approved in 1985. It was developed by gamma irradiation of seeds. Main improved attributes are semi-erect stature, large leaves, green stem, green pods, early maturity (65 days), high yield (1100 kg/ha) and resistance to cowpea aphids.

ICV 12 was officially approved in 1985. It was developed by gamma irradiation of seeds. Main improved attributes are higher yielding than ICV 11 and resistance to cowpea aphids.

For more information please visit:
<http://mvgs.iaea.org/>

New Gamma Irradiator in Malaysia

The Malaysian Nuclear Agency has recently received a new gamma irradiator for its plant mutation breeding programme. The machine is a Biobeam GM 8 000 from Gamma-Service Medical GmbH in Leibzig, Germany, and is equipped with a Cs-137 chloride source, which confers a much longer lifetime than a Co-60 source. A special feature of this irradiator is a rotating sample cylinder with adjustable speed in order to enable uniform exposure of the material inside the container. With the acquisition of this modern gamma irradiator and the continuous operation of their well established gamma greenhouse for chronic irradiation, Malaysia demonstrates its ongoing strong commitment to the application of nuclear techniques for crop improvement. Irradiation services at the Malaysian Nuclear Agency are also offered to other countries on a cost recovery basis. For more information regarding irradiation service requests please con-

tact Mr Ibrahim (Malaysian Nuclear Agency; Ministry of Science, Technology and Innovation; Bangi, 43 000 Kajang, Selangor, Malaysia; email: rusli_ibrahim@nuclearmalaysia.gov.my).



Scientists at Malaysian Nuclear Agency demonstrating the new gamma irradiator.

Developments at the Plant Breeding and Genetics Laboratory, Seibersdorf

A major item of excitement at the PBGL is the planned laboratory modernization starting in 2015, to be accomplished in 2017. The principle of modernizing the IAEA Laboratories at Seibersdorf was approved at the 2012 General Conference, and now each laboratory is being asked for details of what is needed. Our guide in all of this is 'relevance': how best can the PBGL serve the Member States? Our core activities will remain the same: research and development (R&D), and training and service. For R&D it is imperative that we have laboratories and equipment that are modern and can be exploited in developing more efficient protocols in mutation induction, mutation detection and mutant line development. For training we need better teaching laboratories and lecture rooms that can handle small and large numbers of trainees throughout the year; and for services we need to invest in developing alternatives to gamma irradiation for plant mutagenesis. Funding for laboratory modernization will be met by the Member States, who are now asking questions about 'relevance'. For those of us in the Plant Breeding and Genetics Laboratory, this is easy to answer. You only need look at the mutant variety database, where you will find over 3 000 mutant varieties in over 200 crop species. But the impact of plant mutant varieties is not just a matter of numbers (>3 000 varieties); varieties that carry mutant genes dominate agriculture. Once a desired mutant is produced, it is perpetuated by plant breeders and the mutant trait is passed on to future successful varieties for example, the semi-dwarf mutant (*sdw1*) induced by X rays in the barley variety Diamant in 1965 is present in over 90% of contemporary spring barleys in western Europe. Examples of mutant foundation varieties such as Diamant can be found in many crops.

'Relevance' to Member States also drives us to develop more efficient methods in plant mutation breeding. Plant mutation breeding can be divided into: mutation induction, mutation detection and mutant line development. Mutation induction is fast and takes seconds/minutes in an irradiator. Mutation detection has been a bottleneck, as this can take months, even years, but is now being accelerated through the development of high-throughput phenotyping and genotyping. We are currently seeing a renaissance in plant mutation breeding — more countries are building capacity. Oman, Palestine and Qatar initiated national mutation breeding programmes this biennium, Kuwait is in the starting blocks and more countries are asking for training. The interest is founded on basic science in the 'sequencing revolution'. As a consequence we can expect more and more information on genes that control important traits and the development of rapid DNA diagnostics to screen for desired mutants more effectively. The future is bright, and there has been no better time

to be involved in plant mutation breeding. A major challenge for us is the time it takes from mutation induction to mutant variety development; this can take several years even for a short-lived annual crop. However, new methods are emerging that accelerate the breeding process, including rapid generation cycling whereby 4–8 generations can be generated in a year, and the application of doubled haploidy, which, in conjunction with marker assisted selection, can shorten the breeding process. We have just embarked on developing methods in accelerated mutation breeding in barley and sorghum, and hope to have some positive data to report for the next newsletter.

At the time of writing, the Danube River that flows by Vienna is at record high levels not seen for 400–500 years. The flood waters are now wreaking havoc in Hungary. Also the Elbe River in Germany has breached its banks and is causing widespread flooding in eastern Germany, causing thousands of people to flee their homes. At the same time the USA is experiencing a heat wave with temperatures 10°C above normal. These catastrophes underline the need to develop crop plants resilient to perturbations in the environment. The speed at which climate changes are affecting crop plants is alarming, and there needs to be a rapid response to safeguard food security. Plant mutation breeding has potential in this respect, as it offers a rapid means of increasing biodiversity in crop plants and a rapid means of producing new varieties.

X Ray Protocol for Plant Mutagenesis

Gamma sources have been popular for plant mutagenesis; however, since they involve the use of radioactivity, they have become security risks. Strict international regulations are imposed on their shipment and production as well as on the refurbishment of old gamma irradiators. These restrictions now limit gamma irradiation for plant mutagenesis; therefore, the Plant Breeding and Genetics Laboratory has embarked on a series of investigations aimed at optimizing X rays for plant mutagenesis. Initially a protocol was developed using an existing X ray machine (RS 2 400) which has been used extensively in the Insect Pest Control Laboratory to produce sterile male insects. The protocol is posted on our web site and will be prepared for publication and distribution to Member States. Our aim is to develop more X ray mutagenesis protocols for other, simple and commercially available X ray machines. Our preliminary evaluations indicate that an X ray machine with a static system and horizontally rotating platform (sample tray) will be efficient in mutation induction and may facilitate wide adoption of X ray mutagenesis as an alternative to gamma irradiation.

Molecular Methods for Screening Mutant Plants

Underlying the successes of over 3 200 registered mutant plant varieties are induced and heritable changes in the genomic DNA due to treatment of plant materials with mutagens. Thus, efficient ways to identify induced variation that is either linked to, or causative for, the resulting improved crop trait can improve the efficiency of breeding. A variety of new high-throughput 'omics' technologies are emerging in this area, and the PBGL is engaged in activities and collaborations to evaluate how suitable these methods will be for supporting mutant plant breeding capacities in developing Member States. The majority of the efforts in evaluating and adapting new technologies are linked to IAEA CRP D2.40.12, Enhancing the Efficiency of Mutagenesis through an Integrated Biotechnology Pipeline. The PBGL has established a next generation sequencing facility based on the Illumina platform. This allows rapid acquisition of billions of base pairs in a single run. Pilot experiments have been performed using DNA extracted from advanced mutant lines of *Sorghum bicolor* that are exhibiting potentially interesting phenotypes such as early flowering. While new DNA sequencing methods provide orders of magnitude improvement over traditional Sanger methods, the large size of plant genomes still limits the use of bench-top sequencers for whole genome approaches. As such, the PBGL has been performing experiments on restriction-phased reduced representation genome libraries. This work is in collaboration with the University of California-Davis. To date, molecular assays have been validated at PBGL, and efforts are now ongoing to build the appropriate bioinformatics pipelines. Future studies will be aimed at evaluating other approaches for reduced representation genome sequencing, with the ultimate goal of developing a low cost method for rapid evaluation of the spectrum and density of mutations in populations and for targeted recovery of specific mutations in genes (TILLING by Sequencing, Tbs).

The focus of adaptive R&D activities at the PBGL spans seed and vegetatively propagated crops. Efforts in next generation sequencing also include the development of methods for evaluation of mutant cassava populations. Cassava is a facultative vegetatively propagated crop, and little information is available on the density and spectrum of mutations that can be induced in the genome of cassava. Knowledge of this will provide useful guidelines for the development, propagation, management and screening of mutant cassava populations. Most edible bananas are obligate vegetatively propagated species. The PBGL recently completed work on inheritance and stability of induced mutations in banana, and on the dissolution of chimerism in tissue culture. The PBGL is happy to announce that this work was published in December of 2012, and it was selected for the cover of the Plant Biotechnology Journal.

Efforts are also ongoing to evaluate near infrared reflectance spectroscopy (NIRS) for rapid qualitative evaluation of mutant rice seed characteristics in collaboration with Bodenkultur University (BOKU) in Austria. NIRS is a rapid analytical method based on reflection/absorption from functional chemical groups in the near-infrared region of light, which can be used to predict organic components in seed or any other solid organic tissue. A mutant population was generated using a Malagasy *japonica* rice accession and two physical agents, gamma rays and X rays. Plants were propagated in a glasshouse and general phenotyping for morphological traits was performed on M₂, M₃ and M₄ generations. M₄ seed was collected for evaluation using NIRS. A qualitative and non-destructive NIRS approach was developed and applied on the M₄ mutant lines. Spectroscopic outliers were defined, reducing the number of lines requiring further characterization by about 50-fold. With these methods established, the PBGL is now focusing on validating this qualitative approach through the use of quantitative NIRS standards coupled with a proteomics approach to further characterize the differences in mutant seed. Preliminary experiments in collaboration with BOKU suggest measurable variability within the proteomes of different mutant lines.

While technological advances in the field of genomics and phenomics in the past decade are cause for great optimism that the global challenge of sustainable food security can be met through agricultural improvements, there is a risk that these methodologies may not be easily transferred to developing countries where they are most needed. The PBGL has been working towards developing low cost and accurate methods to enable researchers in developing countries to adopt molecular screening strategies and reverse-genetics (TILLING) for characterization of mutant populations. When developing protocols, considerations include: laboratory infrastructure (access to liquid nitrogen and other materials, access to safe toxic waste disposal, availability of constant electricity), ease of application of protocols, assay costs and maintenance of equipment. The PBGL has developed and validated a series of protocols that are now being delivered to Member States. Highlights include methods for tissue collection and storage that do not require electricity, cold storage or liquid nitrogen, DNA extraction protocols that use low cost materials but produce high quality genomic DNA from crops at a tenth of the cost of commercial kits, enzyme purification methods for TILLING and Ecotilling assays that use common weeds as a starting material, and low cost mutation discovery methods using these self-extracted enzymes and standard gel platforms. These methods have been incorporated into a three day training module and were taught at the 3–14 June training course held in Seibersdorf.

Visitors to the PBGL

February

A delegation from the Bangladesh Institute of Nuclear Agriculture (BINA) came to discuss human resource development to support plant breeding in Bangladesh. An outcome of this visit was that six trainees from Bangladesh were accepted for the training course: Plant Mutation Breeding, 3–14 June 2013, at the PBGL, Seibersdorf.

A visit of 23 Technical Cooperation National Liaison Officers and Assistants was hosted to provide information on the activities of the PBGL and other laboratories at Seibersdorf.

As part of an 'Introduction to the IAEA: Seminar for journalists', the PBGL received journalists, reporters and camera crews and provided a general introduction to the activities of the laboratory.

Prof. K. Zachmann (historian) from the Munich Centre for Technology in Society visited to gather information on the impact of mutation breeding on food security and world agriculture.

March

Mr T. Kanek (First Secretary/Special Assistant for Nuclear Issues, Permanent Mission of Japan to the International Organizations in Vienna) and Mr C. Shimizu (Principal Deputy Director, Non-proliferation, Science and Nuclear Energy Division, Ministry of Foreign Affairs, Japan) visited the PBGL. A focal point for discussion was the development nuclear technologies for plant mutagenesis that did not involve radioactive materials.

The National Liaison Officer for Panama, Mr R.E. Herrera Guerra, visited the PBGL to view facilities with respect to potential fellowships, meetings and procurement in agency supported activities in Panama.

April

Officials of the Government of Myanmar, including Mr Khin Maung Latt (Deputy Director General, Department of Atomic Energy), accompanied by the DDG-NA Mr Daud Mohamad, visited the PBGL as part of a general tour of activities at the Seibersdorf Laboratories.

May

Mr Ren Wang (ADG-AG, FAO Rome) and Mr R. Guei (Secretary of the Committee on Agriculture and Senior Technical Officer, ADGO-AG, FAO Rome), accompanied by DIR-NA Mr Qu Liang, visited the PBGL as part of a general tour of the research, development, training and services carried out at the Seibersdorf Laboratories.

Mr I.B. Abdulrazzaq (Director General, Agriculture Research Directorate, Ministry of Science & Technology, Iraq) visited the PBGL to discuss projects in plant mutation breeding, the development of X ray mutagenesis and successes in mutation breeding in Iraq.

His Excellency, Mr Joseph Macmanus (Resident Representative of the USA to the IAEA, and Members of Delegation) along with Mr K. Kessler (Deputy Counselor) and Ms J. Amos (Attaché), accompanied by DIR-NAPC Ms Meera Venkatesh, visited the PBGL to view our activities.

Heads of the Mission of European Union Member States, Candidate Country Croatia and the EU Delegation, accompanied by DDG-NA Mr Daud Mohamad and DIR-NAFA Mr Qu Liang, visited the PBGL as part of a tour of the Seibersdorf Laboratories.

June

The 15th meeting of the Standing Advisory Group on Nuclear Applications (SAGNA) visited the laboratory on 11 June. A priority was to discuss laboratory modernization.

Irradiation Services

In 2012 we conducted our 1300th service request for Member States with respect to irradiation of plant materials for mutation induction and radiosensitivity responses. The figure now stands at 1326 requests from countries since records began in 1977. Irradiation services are provided for both gamma and X ray irradiation. Most of these mutagenic treatments are carried out on seed samples, but requests for irradiation treatments of plant samples including in vitro micro-propagated samples are also received. The table below summarizes the requests received in the first six months of 2013 (18 requests for over 30 species).

Request number	Country	Species
1309	Madagascar	Bambara ground nut
1310	Indonesia	Rice
1311	Turkey	Wheat, chickpea
1312	Germany	Ornamental plants
1313	Turkey	Pepper, tomato, eggplant
1314	UK	Barley
1315	Austria	Barley
1316	Kenya	Potato

Request number	Country	Species
1317	United Republic of Tanzania	Rice
1318	Germany	Ornamental plants
1319	Mongolia	Wheat
1320	Poland	Sugar beet
1321	The Netherlands	Ornamental plants
1322	Kenya	Chickpea, finger millet, sorghum, wheat
1323	Botswana	Maize, groundnut, bean, bambara groundnut
1324	Indonesia	Rice, cotton, soybean, orchid
1325	Palestine	Durum wheat
1326	Bangladesh	Rice, jute, rapeseed, mustard, groundnut, sesame, mung bean, chickpea, lentil, plackgram, grass-pea, tomato, soybean

Human Capacity Development

Fellowship training – Individual training

Name	Country	Area of training	Period
Ms Mayada BESHIR	Sudan	<ul style="list-style-type: none"> Mutation induction and detection using molecular techniques such as TILLING 	19 November 2012–19 February 2013
Mr Amos EGO	Kenya	<ul style="list-style-type: none"> Induced mutation, molecular screening and Ug99 resistance 	12 April 2013–14 July 2013
Mr Md. Rafiqul ISLAM	Bangladesh	<ul style="list-style-type: none"> Mutation induction for vegetatively and seed propagated crops. Drought phenotyping 	3 June 2013–30 November 2013

Fellowship training – Group training

Regional training course on Plant Mutation Breeding : Mutation Induction, Mutation Detection and Pre-Breeding, 3–14 June 2013:

Participants	Country
Mr Mohammad Abdul Kalam AZAD	Bangladesh
Ms Hosne-Ara BEGUM	Bandladesh
Ms Shamsun Nahar BEGUM	Bandladesh
Mr Md. Rafiqul ISLAM	Bandladesh
Mr Md Abdul KASHEM	Bandladesh
Mr Mohammad Ibrahim KHALIL	Bandladesh
Mr Mohammad Lutfar Rahman MOLLAH	Bandladesh
Mr Lekgari Aatshwaelwe LEKGARI	Botswana
Mr Odireleng MOLOSIWA	Botswana
Mr Wijaya Murti INDRIATAMA	Indonesia
Ms Nurlina KASIM	Indonesia
Mr Muhamad SAMULLAH	Indonesia
Mr Rinaldi SJAHRIL	Indonesia

Participants	Country
Mr Untung SUSANTO	Indonesia
Ms Sasanti WIDIARSIH	Indonesia
Mr Aziz Abdelkarim SALAMEH	Palestine



Fellows and IAEA staff on the first day of the training course in plant mutation breeding.

Scientific visitor

Name	Country	Areas of training	Period
Mr Hohammad JOUHAR	Syrian Arab Republic	<ul style="list-style-type: none"> Molecular screening of mutations (TILLING and Ecotilling) 	6–10 May 2013

Cost-free Interns

Name	Country	Topic (University)	Period
Ms Farzaneh TAASSOB-SHIRAZI	Islamic Republic of Iran	<ul style="list-style-type: none"> Rapic introgression of mutant genes 	January 2012–December 2014
Ms Ayşe SEN	Turkey	<ul style="list-style-type: none"> Molecular characterization of mutant plants 	8 May 2013–7 May 2014

Conferences

Various members of the PBGS and PBGL participated in the Vienna International Plant Conferences in February 2013, specifically the ‘Plant Genetics and Breeding Technologies’ and ‘Plant Disease & Resistance Mechanism’ conferences. Each of these conferences had over 250 participants and a significant number of our collaborators were in attendance. In addition to giving two oral presentations and five posters, many meetings were possible and collaborations were initiated and reinforced, such as developing protocols for X ray mutagenesis, mutation detection and accelerated breeding.

Oral presentations

- Wheat Black Stem Rust (race Ug99): Mutation Assisted Breeding Meets the Challenge (Pierre J.L. Lagoda, et al.)
- Do-it-yourself Molecular Biology for Plant Breeding: Low-cost Tools for Developing Countries (Owen A. Huynh, Bernhard J. Hofinger, Mayada M. Beshir, Joanna Jankowicz-Cieslak, Huijun Guo, Brian P. Forster and Bradley J. Till)

Poster presentations

- Rapid introgression of mutant traits for fodder quality in barley (Farzaneh Taassob-Shirazi, Brian P. Forster, Biguang Huang, Heinrich Grausgruber and Jerome Franckowiak)
- Impact of induced mutations in plant breeding (Mirta Matijevic, Souleymane Bado, Pierre J.L. Lagoda, and Brian P. Forster)
- Doubled haploid production in spring wheats of hot irrigated environments (Abdelbagi M. Ali, H.M. Elamein, I.S.A. Tahir, M. Baum and Brian P. Forster)
- Resurgence of X rays in plant mutation breeding (S. Bado, K. Kozak-Stankiewicz, H. Sekander, N. Alhajaj, A.M.A. Ghanim, B.P. Forster and M. Laimer)
- Application of Soft X ray and Near-Infrared Reflectance Spectroscopy for rapid phenotyping of mutant seed. (J. Jankowicz-Cieslak, L. Razafinirina, J. Rabefiraisana, N. Rakotoarisoa, G. Seballos, B.P. Forster, B.J. Till and J. Vollmann)



Mr A.M.A. Ghanim discussing his poster (on doubled haploid technologies in plant mutation breeding programmes) to conference delegates.

Plant Breeding and Genetic Laboratory staff travels to Member States

Mr B.P. Forster

San Diego, United States of America, 12–16 January 2013

- Attended the Plant and Animal Genome (PAG) conference and gave an oral presentation on introgression of mutant traits in plant breeding.
- Attended the Musa Genomics and Cassava workshops at PAG.
- Attended a Bill and Melinda Gates Convening on mutation induction for herbicide resistance in cassava.

Makassar, Jakarta and Subang, Indonesia, 3–8 February 2013

- Visited three institutes in Indonesia: Hasanuddin University (Sulawesi), National Nuclear Energy Agency, BATAN (Java) and Rice Research Centre (West Java) with respect to ongoing work on and implementation of the TC project Enhancing food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Adaptation (INS/5/039). One outcome of the visit was the identification of trainees who took part in the June training course on 'Plant mutation breeding', Seibersdorf.

Mr B.J. Till

Olomouc, Czech Republic, 30 May 2013

- Visited the Institute of Experimental Botany in Olomouc, Czech Republic, to give a seminar on the activities of the PBGL in genotypic screening of induced mutations in seed and vegetatively propagated crops. Meetings were held with all research groups and possibilities for collaborative research were discussed.

Mr A.M.A. Ghanim

Amman, Jordan, 10–14 February 2013

- Visited Amman, Jordan to conduct an interregional training course on 'Doubled Haploids and In Vitro Techniques' in connection to the implementation of the RAS/5/058 project. The training was attended by participants from seven countries (Iraq, Jordan, Lebanon, Oman, Saudi Arabia, Syrian Arab Republic and Yemen).

Gaborone, Botswana, 18–22 March 2013

- Visited Gaborone, Botswana, to review and provide technical advice on the implementation of the TC project BOT/5/009 'Using Radiation Technology and Biotechnology to Develop Mutant Lines of Important Crops with Increased Yield and Improved Nutritional and Hygienic Qualities'.



MI population of Maize (left) and Cow pea (right) in Gaborone Botswana. Mr E. Peloewee (the counterpart for TC project BOT/5/009) inspecting his material during the duty travel of the technical officer (A.M.A. Ghanim) in March 2013.

Asmara, Eritrea, 13–17 May 2013

- Visited Asmara, Eritrea, to review and provide technical support for implementation of the TC project ERI/5/008, ‘Supporting the Livelihood of Barley Farmers through Mutation Techniques and N15 Technology to Improve Malting, Food and Feed Barley Production’.



Mr Ghanim and Mr Asmorom (the counterpart for TC project ERI/5/008) inspecting M2 population of barley during duty travel to Eritrea in May 2013.

Ljubljana, Slovenia, 19–21 June 2013

Visited Ljubljana, to follow and document procedures in seed irradiation using the X ray facility in the University of Slovenia as part of the PBGL effort to expand the development of X ray mutagenesis protocols. Seeds of some cereal samples were irradiated at different doses and brought back for evaluation at the PBGL facility. The development of X ray protocols for mutation induction is a major goal for the PBGL as this seen as a viable replacement for gamma irradiation.

Hellos and goodbyes

The PBGL is happy to announce the addition of a new cost-free intern to the laboratory. Ms A. Şen from Istanbul University joins the PBGL for a one year post-doctoral research fellowship funded by the Government of Turkey. Ms Şen will be assisting the PBGL team in developing methods for mutation discovery using enzymatic cleavage and next generation sequencing strategies. She is also participating in a collaborative project between the PBGL and the John Innes Centre in the UK to establish a grass pea (*Lathyrus sativus*) TILLING platform.



Ms A. Şen from Turkey working on DNA characterization of plant mutants

Sadly, we said goodbye to Bernhard Hofinger and Gilbert Seballos. Bernhard stood in to take on the duties of Ms J. Jankowicz-Cieslak while she was off on maternity leave. Bernhard produced some excellent data which have been the subject of papers prepared for publication. He was instrumental in PBGL activities to develop and validate a range of low-cost assays that are suited for developing countries. These assays have become part of the curricula of the PBGL training courses. We wish him well. Bernhard's departure is of course linked to the return of Joanna and we are very pleased to see Joanna back at work. Gilbert Seballos worked with the PBGL for almost three years. In this time he mastered many techniques and became the go-to photographer for everything from macro shots of plant pollination to group shots of visiting dignitaries. His horticultural skills enabled staff to expand many different research horizons. Gilbert and Bernhard were not only excellent in their duties, they were excellent members of the PBGL family. We have many fond memories and will miss them greatly.



G. Seballos (foreground) helping PBGL staff member O. Huynh (background) prepare the research field.



B. Hofinger (seated, with glasses) teaches a group of visiting fellows and experts on low cost molecular methods for mutation screening.

Glasshouse refurbishments

Our glasshouses have been refurbished, and we have literally raised the roof. Our glasshouses were donated by the USA 30 years ago and have been used for radio-sensitivity testing screening for mutant traits, raising plants for our R&D work and for training (we estimate that over 1000 fellows have been trained in these glasshouses). However, time has left its toll, and in 2012 we

secured funding for refurbishment, especially to meet health and safety issues. To date €450 000 has been spent. Work started in March 2013 and on 30 May 2013, a completion certificate was signed. As part of the refurbishment we adapted one compartment for temperate crops, which is now stocked with wheat and barley experiments (drought and salt tolerance screening) and demonstrations for training courses in June and July this year.



Workers refurbishing PBGL glasshouses.

Publications

Staff Publications in the Field of Plant Breeding and Genetics

Journal Publications/Book Chapters and Published Abstracts

JANKOWICZ-CIESLAK, J., HUYNH, O.A., BROZYNKA, M., NAKITANDWE, J., TILL, B.J., Induction, rapid fixation, and retention of mutations in vegetatively propagated banana, *Plant Biotechnology Journal* Dec. 10(9) (2012) 1056–66.

JANKOWICZ-CIESLAK, J., HUYNH, O.A., DUSSORUTH, B., SARAYE, B., TILL, B.J., Low cost mutation discovery methods suitable for developing countries, *ScienceMED* 3(3) (2012) 245–249.

COOPER, J.L., HENIKOFF, S., COMAI, L., TILL, B.J., TILLING and Ecotilling for Rice, *Methods in Molecular Biology: Rice Protocols*, Springer (2012) 39–56.

MEHLO, L., MBAMBO, Z., BADO, S., LIN, J., MOAGI, S.M., BUTHELEZI, S., STOYCHEV, S., Induced protein polymorphisms and nutritional quality of gamma irradiation mutants of sorghum, *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis* (2013). On line:

<http://dx.doi.org/10.1016/j.mrfmmm.2013.05.003>

Conference abstracts

JANKOWICZ-CIESLAK, J., KOZAK-STANKIEWICZ, K., RAZAFINIRINA, L., RABEFIRAISANA, J., RAKOTOARISOA, N.V., FORSTER, B.P., TILL, B.J., VOLLMANN, J., Application of Near-Infrared Reflectance Spectroscopy for rapid phenotyping of mutant seed germplasm, 2013.

Book of Abstracts: International Conference on Plant Genetics and Breeding Technologies, Vienna, Austria, 18–20 February 2013.

HUYNH, O.A., HOFINGER, B., JANKOWICZ-CIESLAK, J., GUO, H., BESHIR, M., FORSTER, B.P., TILL, B.J. Do-it-yourself molecular biology for plant breeding: low-cost tools for developing countries, *Book of Abstracts: International Conference on Plant Genetics and Breeding Technologies*, Vienna, Austria, 18–20 February 2013.

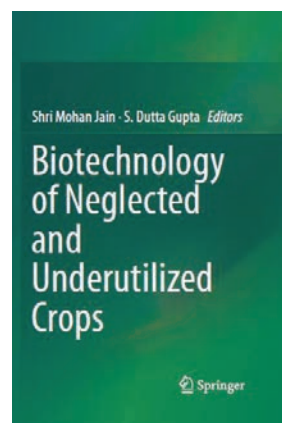
HOFINGER, B., HUYNH, O.A., JANKOWICZ-CIESLAK, J., HUANG, B., COMAI, L., MUELLER, A., OTTO, I., KUMLEHN, J., FORSTER, B.P., TILL, B.J.,

Choose your throughput: Recovery of induced and natural nucleotide variation in plants, *Book of Abstracts: International Conference on Plant Genetics and Breeding Technologies*, Vienna, Austria, 18–20 February 2013.

Non-IAEA Publications in the Field of Plant Breeding and Genetics

Biotechnology of Neglected and Underutilized Crops

S.M. Jain, S. Dutta Gupta (Eds)



About this book

The world food supply depends on a few crop species, known as ‘major crops’. Almost 95% of the world food requirements are met by 30 plant species. There is a great need to broaden the exploitation of plant genetic diversity in order to avoid dependence on few food crops. The neglected crops categorized as ‘minor crops’ have lesser importance globally in terms of production and market value. They could become an excellent source of useful gene. Several factors such as physical appearance, taste, nutritional properties, cultivation methods, processing qualities and economic gains are responsible for the promotion and acceptance of ‘major crops’ worldwide. However, some crop species may be distributed worldwide but tend to be preferred in local ecologies and local production and consumption systems. They are traditionally grown in their centres of origin or in local farmers’ fields, important for the subsistence of local communities and constituting an important part of the local dietary nutrition. Their genetic improvement is often hampered due to narrow genetic diversity.

This is the first comprehensive resource worldwide that reflects research achievements in neglected and underutilized crop biotechnology, documenting research events

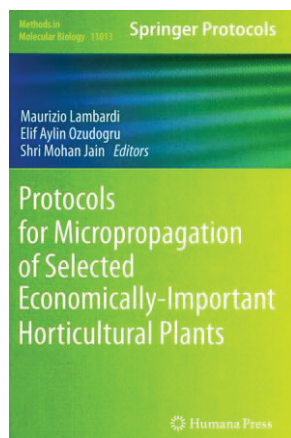
during the past three decades, current status and outlook. The book has 16 chapters and is divided into four sections, providing information on: *Chenopodium* as a potential food source, thin cell layer technology in micropropagation of *Jatropha*, and *Panax vietnamensis*; molecular biology and physiology of *Haberlea rhodopensis*, cell trait prediction of legumes, in vitro and in vivo, and application of TILLING in orphan crops; biotechnology of neglected oil crops, Quinoa, *Erucia sativa*, *Stylosanthes*; and *Miscanthus*; genetic transformation of Safflower, *Jatropha*, Bael, Taro; and genetic engineering of Mangroves. This book will be useful for researchers, students, policy makers and people with commercial interests.

2013

ISBN 978-94-007-5500-0

Protocols for Micropropagation of Selected Economically Important Horticultural Plants

M. Lambardi, E.A. Ozudogru, S.M. Jain (Eds.)



About this book

- A concise and comprehensive guidance on rapid in vitro plant propagation of economically important horticultural species;

- Written by well recognized researchers in the field;
- Features lavishly illustrated photos and drawings.

Micropropagation is a reliable technology applied commercially worldwide for large-scale plant multiplication, germplasm conservation, pathogen elimination, genetic manipulation and supply of selected plants. In *Protocols for Micropropagation of Selected Economically-Important Horticultural Plants*, well recognized researchers in the field compile step-wise protocols for rapid plant multiplication of economically important horticultural species. The book contains 35 chapters, divided into four major sections. The first three sections A, B and C contain 29 micropropagation protocols of selected fruit and nut species, indoor and outdoor ornamental plants, cut flowers, and vegetables. In addition to the detailed protocols of in vitro shoot initiation, proliferation, root induction and acclimatization, chapters also include detailed information on medium preparation, explant selection and preparation. The six chapters of Section D cover specific reviews on pivotal topics, such as in vitro rejuvenation, synthetic seed technology, thermotherapy and meristem culture in banana, genetic transformation of pineapple, flower colour somaclonal variation in torenia, and cryotherapy of horticultural crops. Moreover, as a part of the highly successful *Methods in Molecular Biology* series, chapters include introductions to the respective topic, lists of necessary materials, notes and illustrative photographs.

Comprehensive and well written, *Protocols for Micropropagation of Selected Economically-Important Horticultural Plants* is a useful resource for horticulturists, researchers, commercial companies, plant propagators, biotechnologists and students interested in micropropagation.

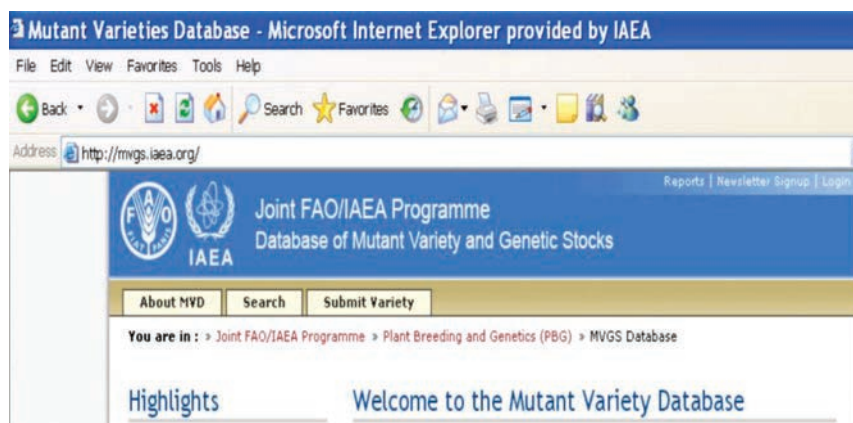
2013

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FAO/IAEA Database of Mutant Varieties and Genetic Stocks

Welcome to our FAO/IAEA Database of Mutant Varieties and Genetic Stocks! At the moment, we have just completed construction of the part for the Mutant Variety Database, which is still in the process of information updating. We will add the part for Mutant Genetic Stocks in due time. The database is an improvement over

the former FAO/IAEA Mutant Variety Database in many ways. We are working to make the new database the global information source of mutant varieties and mutant genetic stocks, as well as of activities and events related to plant mutation breeding and research.



The key feature of the database is that you can register your mutant varieties from your desktop. For this purpose, you need to first register an account; then you will be authorized to submit or edit a mutant variety.

We would greatly appreciate your support by registering your mutant varieties in our database. Once the variety is registered, it will have its own 'homepage' (see below). Therefore, you can use it as an important platform to

showcase your new varieties (the introduction of each variety may also be shown in a local language).

Please visit the web site <http://mvgs.iaea.org> and send us your suggestions and comments regarding the structure and content of this database. Please also send us other information related to plant mutation breeding, mutant varieties and genetic stocks; we may post it on the web site.



YOU MAY STILL SEND US INFORMATION ON YOUR MUTANT VARIETY AND WE WILL UPLOAD IT INTO THE SYSTEM, IF IT IS DIFFICULT FOR YOU TO DO SO.

Impressum

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