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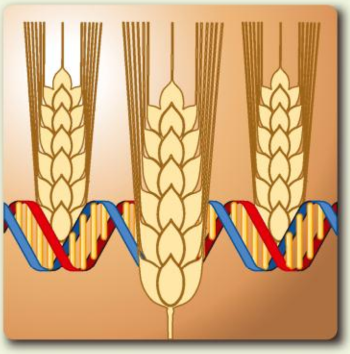

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IAEA
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Positive impact on food security in Indonesia: promotion of food diversification and sustainable agriculture development.

To Our Readers

Dear Colleagues,

Human population growth is projected to reach a staggering nine billion people by 2050. Who will feed the growing billions; how can more food be produced on less land; how can we protect crop yields from climate variability, pests and diseases? These are major issues of our generation. Thus, the theme of this year's Scientific Forum at the IAEA General Conference in September will be devoted to Food Security in all its aspects.

Mutation breeding has played a major role in improving crops and stabilizing food security concerns worldwide. Classic examples are improved yields brought about by semi-dwarf mutant varieties of wheat and rice in the mid-twentieth century, which created the 'Green Revolution'. Mutation induction via irradiation is an established method in providing useful variation for crop improvement, despite this the sought after mutant is a rare event. Today these mutants can be detected efficiently using high-throughput phenotyping and genotyping methods. Read more about the direct involvement of the Plant Breeding and Genetics Laboratory in Seibersdorf pertaining to developing technology packages, and providing training and service to tackle the abovementioned topics in this issue. Also, we are proud to announce the 50th Anniversary of the Agency's laboratories in Seibersdorf, you will find more about this event in the News section inside this issue.

In the section on Technical Cooperation Projects (TC) I want to highlight the first Coordination Meeting for the IAEA/RCA regional TC project RAS/5/056 on Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change. This regional TC project is a fully integrated endeavour between the Plant

Breeding and Genetics Section and the Soil, Water Management and Crop Nutrition Section. This new TC project RAS/5/056 is a follow-up of the recently closed project RAS/5/045. Within this previous project, well characterized mutant lines improved for important agronomic traits such as yield, resistance to diseases, protein, oil, starch and sugar content, were produced. These advanced mutant lines are now in national yield or pre-release trials. Thirty-nine mutant varieties have been officially released by the regional counterparts in the course of the life span of this project. One of the main achievements that enabled such output was the generation of enhanced capacities on mutation technique and biotechnology on both the national and regional level. But it might be arguably discussed that 40% of agronomic productivity progress is due to new varieties. In order to capture the 60% complement, this new project is based on an integrated approach based on mutant varieties and best fit soil, water and plant nutrient management practices.

On a related note, read about the Coordinated Research Project (CRP) on 'Approaches to Improvement of Crop Genotypes with High Water and Nutrient use Efficiency for Water Scarce Environments' (D1.50.13). This CRP will explore the adoption of integrated technology packages, based on best fit soil and water management practices and adapted mutant varieties by small farmers through demonstration in farmers' fields, in order to increase crop productivity and resource use efficiency in harsh environments. The overall objective of this CRP is to increase crop productivity and food security by developing and extending rapidly to farmers the improved crop varieties and soil, water, nutrient and crop management technologies 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 soil, water, crop and fertilizer management.

Further, in the TC section, you might be interested in the success of developing sorghum for supporting food security in Indonesia. Sorghum is an introduced crop to Indonesia, so there is not much genetic variability available for breeding purposes. In the past years attempts to increase genetic variation had been achieved through introduction of plant materials from ICRISAT and China. Mutation induction, using gamma irradiation of seeds, was conducted at the Center for the Application of Isotope and Radiation Technology, National Nuclear Energy Agency (BATAN). This mutation breeding programme was supported through projects RAS/5/040 and RAS/5/045 and also a national IAEA TC project INS/5/030. Sorghum (*Sorghum bicolor* L.) is considered a suitable crop for dry land farming agriculture and it is usually grown under hot and dry climates in various regions in the world. In Indonesia, sorghum is still regarded as a minor cop and its cultivation is limited, mostly grown by local farmers in a specific region for animal feed. Sorghum is a potential crop for Indonesia owing to its wide adaptability and tolerance to adverse conditions. Sorghum is also a good source of food, feed and biofuel (bioethanol). Growing sorghum can increase crop productivity in dry-land areas, thus promoting food diversification and sustainable agriculture development, providing employment and improving farmers' welfare.

Pahat variety used in food industry: Sorghum snacks with high protein and calcium.

Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops (D2.30.28), is a CRP aimed at making available new germplasm resources with improved yield and nutrient quality. It addresses the problem that most of the major staple crops are often deficient in essential vitamins and minerals and that more than 40% of the world's population suffer from malnutrition, with respect to micronutrients like vitamin A, iron and zinc. The strategies applied to reach the project's goal comprise utilizing efficient phenotypic screens and genotypic markers to identify in mutant collections individuals exhibiting traits of interest that would be incorporated into breeding programmes. Both the resulting genetic resources and the methodologies for identifying them constituted the main expected outputs from this CRP. More about the outputs of this CRP can be found inside this issue.

Pierre J.L. Lagoda
Head,
Plant Breeding and Genetics Section

Staff

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Wagramer Strasse 5, P.O. Box 100, 1400 Vienna, Austria (Phone: +431 2600 + extension; Fax: +431 2600 7; Email: Official.Mail@iaea.org)

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

Plant Breeding and Genetics Section

Name	Title	Email	Extension
Pierre J.L. Lagoda	Head of Section	p.lagoda@iaea.org	21626
Stephan Nielen	Plant Breeder/Geneticist	s.nielen@iaea.org	21617
Marie Madeleine Spencer	Plant Biotechnologist	m.m.spencer@iaea.org	21623
Fatma Sarsu[1]	Plant Breeder/Geneticist	f.sarsu@iaea.org	21618
Yamina Maksoudi	Consultant	y.maksoudi@iaea.org	21619
Katayoun Allaf	Senior Office Clerk	k.allaf@iaea.org	21621
Luis Mauricio Alfonzo Godoy[2]	Team Assistant	l.m.alfonzo-godoy@iaea.org	21620

Plant Breeding and Genetics Laboratory, FAO/IAEA Agriculture and Biotechnology Laboratories, 2444 Seibersdorf, Austria (Phone: +431 2600 + extension)

Name	Title	Email	Extension
Brian Peter Forster	Laboratory Head	b.forster@iaea.org	28285
Bradley J. Till	Plant Breeder/Geneticist	b.till@iaea.org	28260
Abdelbagi Mukhtar Ali Ghanim[3]	Plant Breeder/Geneticist	a.alighanim@iaea.org	28260
Mirta Matijevic	Technician	m.matijevic@iaea.org	28317
Joanna Beata Jankowicz-Cieslak	Technician	j.jankowicz@iaea.org	28275
Guenter Berthold	Technician	g.berthold@iaea.org	28418
Andreas Draganitsch	Technician	a.draganitsch@iaea.org	28418
Souleymane Bado	Technician	s.bado@iaea.org	28208
Owen Anthony Huynh	Technician	o.huynh@iaea.org	28279
Gilbert Seballos	Laboratory Attendant	g.seballos@iaea.org	
Joanna Malgorzata Mletzko	Team Assistant	j.mletzko@iaea.org	28362

[1] Joined the Section in June 2012
[2] Joined the Section in March 2012
[3] Joined the Laboratory in July 2012

Two new staff members joined the Plant Breeding and Genetic's team in June: Dr Abdelbagi Mukhtar Ali Ghanim joined the Plant Breeding and Genetics Laboratory, and Dr Fatma Sarsu joined the Plant Breeding and Genetics Section.

Dr Abdelbagi Mukhtar Ali Ghanim was born in Sudan and holds a BSc in Agriculture, an MSc in Plant Breeding and Genetics and a PhD in Plant Breeding and Genetics. He leads a team in plant breeding, including mutation breeding at the Agricultural Research Corporation (Wad Medani, Sudan) and before joining us, was a visiting researcher at the Arid Land Research Center (Tottori, Japan). Dr Ghanim brings a thorough understanding of plant breeding processes from parental selection to varietal release. He is a very experienced mutation breeder with a high international profile, substantiated by strong international collaborations, international exposure and an excellent publication record in pertinent (plant breeding) journals. He has been involved with the development of mutant varieties in wheat, sorghum, maize, millet, cotton, banana tomato, with drought tolerance in wheat being a major goal. We welcome Dr Ghanim as new staff member in the Seibersdorf Plant Breeding and Genetics Laboratory. If you want to contact Abdelbagi, please feel free to use the following electronic address: A.AliGhanim@iaea.org

Dr Fatma Sarsu was born in Turkey and obtained her Master and PhD degrees in field crops growing techniques, breeding methods and mutation breeding from the University of Ankara in 2003. She was employed for 19 years by the Ministry of Agriculture, Food and Livestock (MFAL) in various positions. She started her career as an extensionist on site and then continued as a researcher in the Central Research Institute of Field Crops in Ankara. Dr Sarsu worked as a plant breeder for oil crops such as sunflower, safflower, rapeseed and soybean. She moved to a position as the Coordinator of Industrial Crops Research Division in the General Directorate of Agricultural Research and Policy in 2005. She studied breeding and mutation induction as a researcher and coordinator. She coordinated various national breeding projects, conducted European Union projects and represented the MFAL in FAO projects. If you want to contact Fatma, please feel free to use the following electronic address: F.Sarsu@iaea.org

Welcome to the new colleagues and all the success in their endeavors!

Forthcoming Events

Regional Training Course on Maximization of Resources for Sustainable Increase of Wheat and Barley Productivity, RAS/5/058, Dundee, Scotland, UK, 9–13 July 2012

Technical Officer: P.J.L. Lagoda
Course Director: W. Thomas (Barley Geneticist, the James Hutton Institute, Scotland, United Kingdom)

This training course is being organized by the Joint FAO/IAEA Division in cooperation with the Government of the United Kingdom through the James Hutton Institute. It is open to 13 candidates from seven ARASIA Member States (Iraq (2), Jordan (2), Lebanon (2), Qatar, Saudi Arabia (2), Syrian Arab Republic (2) and Yemen (2)). The purpose of this training course is to develop capacities in ARASIA States Parties in the comprehensive field of maximization of resources for sustainable increase of wheat and barley productivity. The programme of the training course consists of the following main topics:

- Cereal cropping in the United Kingdom in a world context;
- Breeding methodologies in Western Europe;
- Genetic analysis of economically important traits in cereals — tools and resources;
- Understanding and exploiting host pathogen interactions to improve disease resistance;
- Root architecture and cereal nutrition;
- Cereal quality characters — requirements and analysis;
- Practice — farm and trials visit.

Regional Training Course on Mutation Induction Techniques, RAS/5/058, Muscat, Oman, 2–6 September 2012

Technical Officers: P.J.L. Lagoda and B.P. Forster
Course Director: B.P. Forster

The training course will be open to 20 participants from ARASIA Member States. The purpose of the training course is:

- Capacity development;
- Technology transfer;
- Collaborative network for advanced mutation breeding.

The ongoing ARASIA project (RAS/5/048) tackled the problem of producing good yield under harsh conditions in the two most important seed crops of the region, namely wheat and barley. To that end it employed the mutation breeding technique which has proven to cut at least two years of the normal 8–10 year cereal breeding programme duration. ARASIA Member States Oman and Saudi Arabia, with the support of PBG in the framework of RAS/5/048, have developed national mutation breeding programmes in wheat and barley. This training course will also support these activities.

Third Research Coordination Meeting (RCM) on Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops, D2.30.28, Hangzhou, China, 15–19 October 2012

Technical Officer: S. Nielen

After the initial meeting in 2009 in Vienna, Austria and a second RCM in April 2011 in Pretoria, South Africa, this will be the third RCM for this CRP, which has the overall objective to improve varieties of local crops with increased yield and crop quality, enhanced levels of micronutrient content, other nutritional factors and market-preferred traits through induced mutation techniques and supportive biotechnologies. Substantial progress has been made in the fields of mutant germplasm development and phenotypic and genotypic screening in the course of the project. The meeting will serve as a platform for exchanging the latest results achieved by all 15 participating research groups from 13 countries (Botswana, Bulgaria, China, Denmark, Germany, Ghana, India (2), Kenya, Peru, South Africa (2), Ukraine, the United Kingdom and the United States of America) and for discussing, adapting and coordinating the further steps and strategies necessary to approximate the desired project outcomes.

First Coordination Meeting on Improving Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA), RAF/5/066, Windhoek, Namibia, 15–19 October 2012

Technical Officer: F. Sarsu

In the previous cycles, the regional project has efficiently assisted Members Sates in enhancing their own crop breeding programmes through the use of radiation mutation induction in crop improvement. The new project aims to continue developing improved food crops not only for higher agricultural productivity and sustainability, but also for a better nutrition value as well as market-oriented traits.

The objectives of the meeting are to review and discuss detailed activities stated in the work plan to be implemented under the project RAF/5/066 and to assess and readjust, where necessary, the regional project activities in the project document for 2012–2016.

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

Technical Officer: M. Spencer

The progress reports sent by the participants have shown an excellent start of the research progress in all participating countries. Indeed, most of the activities planned have been initiated and in some cases even fully completed. Protocols for genetic diversity analyses in existing mutated populations, M2 and higher and/or local adapted germplasm to assess tolerance to high temperature in terms of yield and yield components have been established in several countries — both on rice and common bean germplasm including mutated populations. Some of the more advanced laboratories possessing adequate recombinant and/or backcross populations have initiated experiments on the analysis and exploitation of mutations in functional genomics using molecular tools such as positional cloning of critical genes and whole genome sequencing projects. Finally physiological and genetic characterization of physiological and biochemical responses to high temperature on nodulation/nitrogen in both rice and common beans have also been initiated. These preliminary works, together with the possibility of attending the FAO sponsored training course on AquaCrop (application to the field results on response of rice and common beans to increased temperatures, associated with water deficiency conditions), certainly enhance the enthusiasm about this forthcoming RCM.

Past Events

Sixth Coordination Meeting of RAS/5/048 Mutation Induction and Supportive Breeding and Biotechnologies for Improving Crop Productivity in ARASIA Member States, and

First Coordination Meeting of RAS/5/058 Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley — Phase II, Vienna, Austria, 27 February–2 March 2012

Technical Officer: P.J.L. Lagoda

In order to address agricultural constraints such as drought, salinity and crop diseases, ARASIA States Parties started a regional mutation breeding programme under the RAS/5/048 project in 2007 with the assistance of the Joint FAO/IAEA Divison.

Major achievements

All participated countries have now signed the Memorandum of Understanding (MoU) on germplasm exchange (Standard Material Transfer Agreement, SMTA, of the International Treaty for Plant Genetic Resources in Food and Agriculture, IT/PGRFA) and phytosanitary measures except Iraq and Oman. Iraq has been utilizing the existing bilateral agreement between Iraq and ICARDA in order to obtain and exchange genetic resources. Oman may wish to consider signing the MoU.

Two national wheat and barley mutation breeding programmes have been created in the framework of the RAS/5/048 (Saudi Arabia and Oman).The main purpose of the sixth coordination meeting was to report on the progress made over the last four years, review the work plan of the project and agree on national plans for the activities to be implemented in 2012 at the national level, prepare the draft consolidated national reports according to the template agreed upon during the fourth coordination meeting and present and review the new proposed TC project for the TC cycle 2012–2015 (first coordination meeting RAS/5/058)

Under RAS/5/048 some segregating mutant lines with the aforementioned targeted agronomic characters have been developed. These mutant genetic stocks need to be further evaluated, in order to ascertain their utility for breeding programmes (breeding a new cereal variety takes eight to ten years, mutation induction has proven to shorten this period by at least two years, but this is still beyond the biennium timeframe of TCPs). Therefore, there was a need for a second phase which builds on the progress made under the TC project RAS/5/048, whereby the selected mutant genetic stocks need to be further evaluated, under regional replicated field trials, in order to ascertain their utility for breeding programmes in the respective countries.

The meeting was attended by Iraq, Jordan, Lebanon, Saudi Arabia, Syrian Arab Republic and Yemen. The Omani national coordinator could not attend for reasons beyond her control. However, she sent a summary of the national progress report which has been incorporated into the final report.

First Coordination Meeting for the IAEA/RCA Regional TC Project on Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change, RAS/5/056, Vienna, Austria, 10–13 April 2012

Technical Officers: S. Nielen and K. Sakadevan

Major achievements

The group formulated the following outcomes of the meeting:

- The importance of integrating plant mutation breeding with soil and water management emphasized;
- Regional project work plan fine-tuned with specific time frames and host countries identified;
- National work plans developed and work teams identified;
- Current country status on mutation breeding presented;
- National priorities on mutation breeding and soil and water management identified;
- Crops and target traits identified;
- IAEA's resources to provide technical support recognized;
- Establishment of a website of Asia and Oceania Association of Plant Mutagenesis (AOAPM) agreed.

The new Regional TC project RAS/5/056 is a follow up of the recently closed project RAS/5/045, which had its final meeting in Bangkok, Thailand, 21–25 March 2011. Within this previous project, well-characterized stable mutants of a wide range of crops and for important agronomic traits such as improved yield, resistance to diseases, protein, oil, starch and sugar content were produced, which are in uniform yield trials or national pre-release trials. Thirty-nine mutant varieties have been officially released by the regional counterparts in the course of the life span of this project. One of the main achievements that enabled such output was the generation of enhanced capacities on mutation technique and biotechnology on both national and regional level.

Current concerns about the increasing global population and the impacts of climate change and climate variability on agriculture highlighted the importance of the use of improved crop varieties coupled with better soil, water and fertilizer management practices and technologies for enhancing agricultural productivity and protecting the natural resource base. This new RCA project is building on the previous achievements and aims at the development of improved crop varieties tolerant to environmental stresses and screening of the existing mutant germplasm for high yield and enhanced adaptability to climate change. Also, improved soil-water-nutrient management technology packages shall be developed and adopted by small farmers through field demonstration studies.

Representatives of 14 countries (Australia, Bangladesh, China, India, Indonesia, Malaysia, Mongolia, Myanmar, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Vietnam, Thailand) including the Project Lead Country Coordinator Prof Luxiang Liu (China) participated in this first coordination meeting in Vienna, which had the overall objective to discuss and finalize the national work plans and the details of the activities stipulated in the work plan to be implemented under the project RAS/5/056. Therefore, the current statuses of mutation breeding approaches and crop varieties and of best fit soil and water management practices were reviewed. Gaps and needs for advanced mutation breeding approaches and techniques to develop new crop varieties and for the application of integrated mutation/soil and water management technology packages to spread new crop varieties adaptable to climate change were identified.

The major concerns raised by the country representatives regarding climate change included drought, flooding, salinity and soil acidity, high and low temperature, new races of plant diseases, and deteriorating quality parameters in their regions. The crops of interest within the project are rice, wheat, sorghum, barley, greengram, cowpea, blackgram, groundnut, soybean, vegetable soybean, banana, sugarcane, pineapple, papaya, onion and kenaf. The importance of combining mutation breeding and optimized soil, nutrient and water management practices was emphasized and most of the projects consequently also comprise field studies. The work plans developed include the use of alternative strategies for mutation induction, such as aerospace induced mutation technique and ion-beam irradiation and also the integration of mutation induction, doubled haploid techniques, and marker assisted selection for improvement of the breeding efficiency. The use of high throughput approaches for phenotyping and reverse genetics and functional genomics was discussed during a visit of the Plant Breeding and Genetics Laboratory in Seibersdorf.

Regional (IAEA/AFRA) Training Course on Advanced Plant Tissue Culture Techniques Applied to Micropropation and In Vitro Mutagenesis for Cassava Improvement, RAF/5/066, Accra, Ghana, 14–18 May 2012

Technical Officer: M. Spencer

Thirteen participants from Benin (2), Cameroon, Central African Republic, Democratic Republic of Congo (2), Kenya, Nigeria, Sierra Leone and Ghana (4) attended the course. There were four lecturers, comprising three locals from Ghana and one from the Czech Republic. The practical work centred mainly on identification of the ripe stage of anthers for culture, meristem isolation and culture, ovary culture. The aim of the field trip to Bunso was to study the cassava crop.

Major achievements

The participants observed the response of about 305 cassava genotypes to mosaic diseases on the field as well as variation in flowering of the various lines (see photo). The developmental stages of the flowers suitable for anther culture to strengthen the lectures on anther culture were demonstrated. The various symptoms of the mosaic virus diseases were also observed in order to familiarize participants with the visual screening of the disease responses.

Participants observing the identification and isolation of anther in the proper stage for in vitro culture

Fields observations of cassava mosaic virus disease incidence and anther collection

Regional Training Course on Methodologies and Mechanisms for Screening Against Abiotic Stress, RAS/5/058, Seibersdorf, Austria, 4–8 June 2012

Technical Officer: P.J.L. Lagoda

Course Director: B.P. Forster (Laboratory Head, Plant Breeding and Genetics)

The training course was open to 14 participants from ARASIA Member States (Iraq (3), Jordan (2), Lebanon, Oman, Saudi Arabia (2), Syrian Arab Republic (3) and Yemen (2)). The purpose of the training course was:

1) Capacity development;
2) Technology transfer;
3) Awareness of opportunities in the application of nuclear techniques in plant breeding.

The focus lies on efficient screening methodologies for tolerance to drought and salinity. Drought, heat, salinity and disease are major constraints affecting sustainable agricultural productivity in ARASIA States. Most of cultivated areas depend on rainfall. Where cropping relies on limited rainfall, the concerned areas are already affected by drought. Where the complementary part depends on irrigation, disease infection results in significant reduction in yield. This situation requires an integrated approach to develop technology packages of mutant lines (resistance to diseases, salinity and heat traits, and sustainable high yield under variable climatic conditions) with proper water utilization practices. In this context, mutation induction technique has shown potential as a valuable tool in developing drought / salinity tolerant and disease resistant mutant lines of wheat and barley.

First Coordination Meeting on Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI), RLA/5/063, Ocoyacac, Mexico, 16–20 April 2012

Technical Officer: M. Spencer

Each Member State participant made a presentation showing the objective of their project as well as the activities planned for supporting the project. The programme management officer (PMO) and technical officer (TO) provided technical feedback to the counterparts to further develop the work plans in order to fully participate to the overall objective of the project.

Considering that three new Member States were new in the use of mutation breeding for crop improvement, additional activities were proposed by the counterparts to be included in the national plans to ensure the fulfillment of the outputs and project objectives to create new varieties of native and/or underutilized crops including amaranthus, quinoa, native potatoes and tomatoes, stevia and also some other corps important for ensuring food security in their countries such as rice, bean, and avocado.

A regional work plan and budget for 2012–2016 was finalized while the following aspects were taken into consideration:

- For Member States where the targeted crops were already under study, a continuation of the programme and advancement of the mutant lines followed by the initiation of physiological and molecular characterization; i.e. for wheat, bean, amaranthus, quinoa and rice.
- Fine-tuning and finalization of the screening protocols for grain quality, abiotic and biotic stresses as determined by the individual projects.
- Introduction of more advanced molecular techniques in the countries where characterization using basic morphological, physiological and molecular techniques have been developed.
- Initiation and mutation induction and establishment of preliminary experiments by the newly participating countries: Chile, Honduras and Nicaragua.
- Introduction of new crops such as stevia, *Vigna unguiculata* and *Chenopodium pallidicaule* in the mutation induction programmes.
- Continuation and/or initiation of farmers' participatory approach for dissemination of mutant lines.

National counterparts were mindful of their role at the regional and national level on the promotion of mutation breeding and dissemination of improved varieties of these already popular native crops which also are gaining increased attention as part of an eco-friendly agriculture and valuable export commodities (Figures 1 and 2).

Figure 1. Chitomato, a native tomato tolerant to diseases is assessed in a programme of re-introduction of wild and neglected varieties into the national germplasm in Mexico

Figure2. Quinoa variability as observed among advanced mutant lines in Peru

It was decided to hold the next coordination meeting in Santiago, Chile, in 2015.

First Coordination Meeting on Enhancing Productivity of Locally-underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices, RAS/5/064, Kuala Lumpur, Malaysia, 18–22 June 2012

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

Seventeen representatives (breeders and soil specialists) from nine Member States (Bangladesh, China, Indonesia, Cambodia, Malaysia, Myanmar, the Philippines, Thailand and Vietnam) were invited to attend the meeting in Kuala Lumpur. The meeting included round table discussions on mutation induction technology packages, nuclear technologies in soil/water/nutrient management, ongoing programmes and projects in the region and socio-economic impact of mutant varieties and cultivars.

The objective of this first coordination meeting was to discuss project activities and implementation strategies to enhance national capacities for the application of isotopic and nuclear techniques by using improved crop varieties with best practice soil, water, crop and nutrient management for increasing the productivity of locally underused crop. The specific objectives of the coordination meeting were defined as:

1. Review and preparation of the national work plan with reference to the regional work plan of the project;
2. Discussion of evaluated mutant germplasm, nuclear techniques in best fit soil, water and nutrient management practices and consolidate/update strategy;
3. Development of strategies to upgrade the national capability, Member States skills and laboratories; strengthening the network of cooperation among the project participating Member States;
4. Production of guidelines and recommendations for enhancing the transfer of plant breeding technologies and soil and water management practices to RCA Member States addressing their present needs and specific gaps in past projects with the same nature.

Every participating country gave a presentation reflecting (1) the underused crops that are important to the country, (2) the breeding programmes for underused crops, and (3) current national, regional and international programmes for improving the productivity of underused crops.

All country project coordinators prepared a concise review document on the above topics linked to their country (including a brief description of potential study sites for the RAS/5/064 project, and reference list of publications on the topic).

During the coordination meeting, the country project coordinators prepared a meeting report that includes a review of the log frame which was originally prepared and a detailed work plan reflecting the national, regional and international activities for the first project phase 2012–2013.

The main crops grown in Asia are cereals (rice, wheat, maize) and grain legumes (e.g. soybean, pigeon pea and mung beans) for human consumption. However, a number of presently underused crops could be grown to diversify agricultural production and enhance farmers' incomes. Additional benefits include breaking pest and disease cycles and improving local diets.

Several food crops qualify as underutilized in the region, including aerobic rice (e.g. the concept of aerobic rice is relatively new to Malaysia, hence relatively few insights exist into the dynamics of water, nitrogen and other major nutrients and their interactions in aerobic rice production), sorghum, okra, amaranth, taro, sweet potato and beans, and some fibre crops (e.g. ramie) also qualify. Mutant varieties of these crops have been obtained through IAEA's cooperation with Asian countries. These mutant varieties need to be evaluated in multi-location trials for their resilience to abiotic stresses (e.g. drought and soil salinity) and resource use efficiency (nutrients and water) in the face of a changing climate in Asia and the Pacific region. The final beneficiaries are the farmers (small scale and commercial), households and the population, while the direct beneficiaries are the national research institutions/institutes, the national breeding programmes, the scientists in national programmes and the counterpart institutions in the region.

Third Research Coordination Meeting (RCM) on Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline, D2.40.12, Vienna, Austria, 18–22 June 2012

Technical Officer: B. Till

Major achievements

For vegetatively propagated cassava and banana, topics included methodologies for maximizing mutation densities while minimizing the heritability of chimeric (genotypically heterogeneous) tissues when plants are cultured in vitro. In seed propagated rice and barley, more focus was on phenotyping strategies (e.g. X ray imaging discussed above) that can be integrated into a mutation breeding project to enhance the efficiency of generating and recovering useful traits. The evaluation of microspore mutagenesis to increase the efficiency of barley mutagenesis was also being explored. More details can be found in the Coordinated Research Projects section of this newsletter.

The RCM brought together all nine participants from Austria, Cuba, Germany, Ghana, Poland, Sierra Leone, the United States of America (2) and Vietnam. One consultant from China also attended the meeting. The main aims of the meeting were to assess the progress achieved since the last meeting, review the timeframe and goals of activities through the close of the CRP and to make any adjustments to work plans or broader aims of the CRP based on data and lessons learned to date. Topics discussed included efficient strategies for the mutagenesis of barley, cassava, rice and banana.

First Coordination and Steering Meeting of RAS/5/065 Supporting Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Manila, Philippines, 25–29 June 2012

Technical Officer: P.J.L. Lagoda

Nineteen counterparts (experts in plant breeding and soil sciences) from 10 Member States (Bangladesh, China, Indonesia, Cambodia, Laos, Malaysia, Myanmar, the Philippines, Thailand and Vietnam) were invited to this meeting. The overall objectives of the meeting were to:

- Discuss and finalize details of activities stipulated in the work plan to be implemented under RAS/5/065;
- Review the current status of mutants and advance rice crop varieties availability in participating Member States; identify and address gaps and needs for selecting advanced, new rice crop varieties adaptable to climate change;
- Review the current status of best fit soil and water management practices in participating Member States; identify the roles of nuclear and isotopic techniques; address gaps and needs for the application of integrated mutation/soil and water management technology packages, tailored to fit the local socio-economic and agro-ecological conditions, adaptable to climate change;

The meeting discussed, reviewed and updated a regional work plan and national work plans for implementation of the new project RAS/5/065, with the following expected outputs:

- Discussion of the training needs regarding rice variety selection and evaluation techniques, isotope techniques in soil water monitoring, assessing fertilizer and water use efficiency (draft prospectus for regional training courses and information sheets for regional meetings, with potential host countries identified);
- Consolidated list of expert missions required by the participating Member States, detailing/providing the scope of these activities and tentative schedules;
- Strategy for the implementation of technical cooperation among developing countries and involvement and expected output/expertise of project stakeholders including partners, such as Ministries of Agriculture and National Agricultural Research and Extension Systems (NARES), International Rice Research Institute (IRRI) and Food and Agriculture Organization (FAO) national and regional offices;
- Development of strategies to upgrade the national capabilities, Member States' skills and laboratories; strengthening the network of cooperation among the project participating Member States;
- Production of guidelines and recommendations for enhancing the development of integrated mutation/soil and water management technology packages, tailored to fit the local socio-economic and agro-ecological conditions, adaptable to climate change to participating Member States addressing their present needs and specific gaps in past projects with the same nature.
- A meeting report of the project planning and coordination meeting, including a summary of the current status of advanced rice varieties and best fit soil and water management practices in the region.

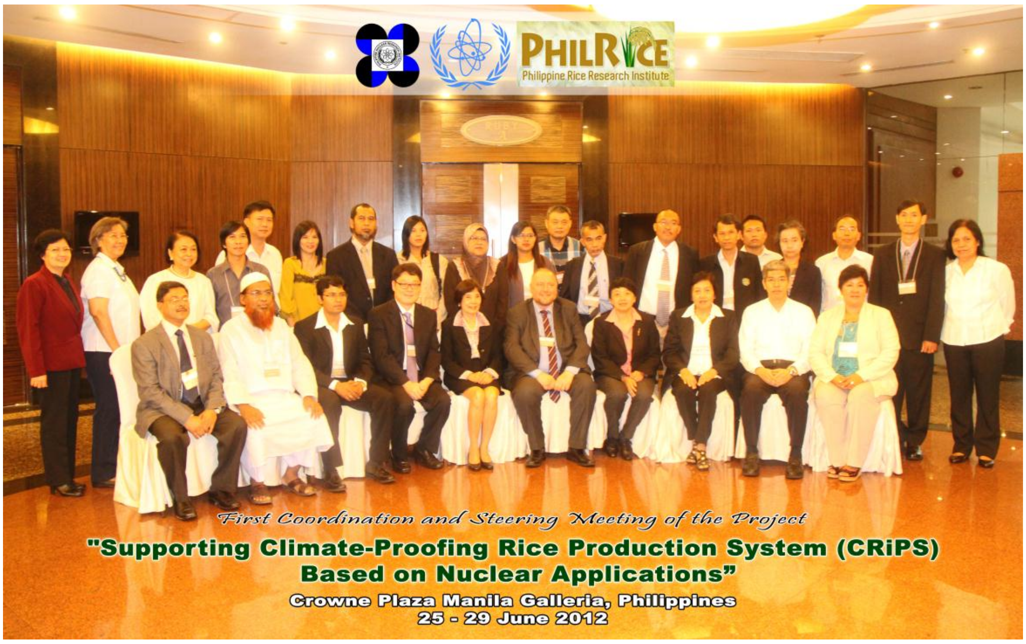
Climate variability and change is affecting all aspects of agriculture including rice production in Asia. To produce more and better quality rice, to reduce hunger and malnutrition and enhancing human health, ultimately contributing to the achievement of MDG 1, it is paramount to use mutant crop genotypes which have been selected and evaluated with enhanced adaptability that can produce under conditions of high temperatures and low rainfall, high soil salinity or acidity. Nuclear techniques in conjunction with efficiency enhancing molecular and biotechnologies, coupled to effective, best fit soil, water and plant nutrition management methodologies (good agricultural practices, GAP technology packages tailored to fit the local socio-economic and agro-ecological conditions) can help meet this challenge. The project thus aims to adopt an integrated approach whereby good agricultural practices/packages or best-fit practices/toolkits based on innovative soil and water technologies, integrated with the exchange of newly-developed mutant crop varieties with enhanced adaptability to climate change and variability (drought/salinity tolerance, enhanced water use efficiency) which can be developed and disseminated and accessed by agricultural practitioners and farmers.

Partnership building will be a key ingredient in optimizing the project's impact on the ground for the end-users. In order to reach the end-users, i.e. rice farmers, the national seed sector and NARES, strong partnerships are important to pursue with national Ministries of Agriculture, the FAO national offices, FAO regional office Bangkok, the International Rice Research Institute (IRRI), PhilRice, and the Asian Development Bank, amongst other partners. Therefore, holding this meeting in the Philippines provided a unique opportunity to congregate in one place, key stakeholders that could optimize the impact of the project.

Rice farming in Asian countries suffers from low productivity and rice farmers are still using outdated technologies and inputs to grow rice. With increasing climate change and variability, it is important to select and evaluate improved rice varieties with enhanced adaptability to harsh conditions of high temperatures, low and erratic rainfall, soil salinity, acidity or low nutrient availability. Producing sufficient rice is an important pathway towards contributing to the achievement of MDG 1 (reducing poverty and hunger by 2015). Significant opportunities exist for meeting this challenge by harnessing nuclear techniques in conjunction with molecular and biotechnologies, coupled with effective soil, water and nutrient management practices and technologies. Meeting this challenge not only requires best-fit, good agricultural practices technologies, but also a mechanism that can be easily accessed and accepted by farmers. This project aims to develop integrated technology packages based on innovative soil, water and nutrient management, improved rice varieties with enhanced adaptability to abiotic stresses for rice farmers.

The project objective and sustainability will be achieved with the implementation of the following activities: (1) Select improved rice varieties and define best fit soil, water and nutrient management practices for field sites selected by participating countries, (2) Identify appropriate pilot farmer's fields, (3) Evaluate the agronomic performances of each of the improved rice varieties for nutrient and water use efficiencies and (4) Conduct field days/farmer's schools on pilot farms to transfer technologies and practices developed in the project.

The appropriate soil, water and nutrient management technologies and practices together with the improved rice varieties selected will benefit the farmers, national agricultural research systems and extension services including breeders, agronomists/soil scientists (NARS) amongst others.



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

Project Number	Ongoing CRPs	Scientific Secretaries
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 Agreas and Beyond	M. Spencer
D2.40.12	Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline	B. Till
D2.40.13	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 Scares Environment	K. Sakadevan and P.J.L. Lagoda
	New CRP starting in 2012	
D2.30.30	Integrated Utilization of Cereal Mutant Varieties in Crop/Livestock Production System	B. Forster

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

Technical Officers: B.P. Forster

This will be managed by the Plant Breeding and Genetics Section of the FAO/IAEA Joint Division. In this CRP participants will identify mutant crop varieties and agronomic practices for increased yield production and investigate fodder quality in animal production systems. This CRP is expected to begin in the third quarter of 2012 and to be concluded in the third quarter 2017.

Background

Cereals are harvested for their grain for human consumption, but may also be harvested throughout their life cycle as fodder and feed for animals. Cereals are adapted to a wide range of growing conditions, barley, for example, is a useful food and feed crop in cool, dry conditions whereas maize fits into cropping systems with a warm wet season.

The type of mutant variety used will vary depending on the participating country. These will be used to develop soil and water management practices that maximise biomass production. For fodder production, this may be before flowering, i.e. much earlier than standard harvests at grain maturity The CRP will establish the base line for agronomic practice for biomass production and feed value. In developed countries cereals are commonly separated into food and feed varieties, but this may be a new concept for some developing countries. The CRP aims to provide flexibility to farmers; the crop may be sown and harvested early for rapid green fodder production, harvested for maximum biomass or grown to maturity for grain yield.

The project involves three FAO/IAEA disciplines: (1) plant breeding and genetics, (2) soil and water management, and (3) animal nutrition. Progress will be measured in terms of performance in the field (yield), and by animal and crop nutrition studies.

Objectives

1. Increase crop and animal production by developing dual purpose (food and feed) mutant cereal crops in developing countries.
2. Evaluate mutant cereal varieties for agronomic performance and feed quality.
3. Multiply seed of superior lines for fodder production trials.
4. Evaluate the nutritive value of new mutant lines in animal production systems.
5. Determine biomass, harvest index and nitrogen-use efficiency of mutant varieties and advanced lines.
6. Publish protocols and guidelines for speeding up the establishment of useful mutants in desirable genetic backgrounds.
7. Develop locally adapted breeding material.
8. Deliver useful mutant genetic stocks to interested Member States, including those not participating directly in the CRP.

More information can be found on: http://www-naweb.iaea.org/nafa/pbg/announcements-pbg.html and on the Coordinated Research Activities (CRA) website: http://www-crp.iaea.org/.

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

Technical Officer: M. Spencer

This CRP was initiated in 2010. The first RCM was held in Vienna, Austria, 2–6 May 2011. Eleven research contract holders (Colombia, China, Cuba, India, Mexico, Pakistan, the Philippines, Senegal, the United Republic of Tanzania and Zimbabwe) and five agreement holders (China, International Rice Reserch Institute (IRRI), Japan, Spain and the United Kingdom) attended the RCM. The next RCM is scheduled to be held in Mexico City, Mexico in November 2012.

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

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

This CRP aims to explore the adoption of integrated technology packages, based on best fit soil and water management practices and adapted mutant varieties by small farmers through demonstration in the farmers' fields, in order to increase crop productivity and resource use efficiency in harsh environments. The overall objective of this CRP is to increase crop productivity and food security by developing and extending rapidly to farmers the improved crop varieties and soil, water, nutrient and crop management technologies 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 soil, water, crop and fertilizer management.

This CRP has a total of 13 participants (all research contract holders) from Bangladesh, China, Indonesia, Kenya, Malaysia (2), Mexico, Pakistan, Peru (2), South Africa, Uganda and Vietnam. The first RCM of the CRP was held in Vienna, Austria, 12–16 December 2011 and eleven participants attended the meeting. China and South Africa did not attend the meeting due to delays in the processing of research agreements. During the first RCM revised country work plans were developed for all research contract holders.

There was general consensus that the work plan needs to be revised to reflect the importance of soil and water management. The participants agreed that soil characterization (physical and chemical properties) and a baseline survey of soil and water management practices, crop management and fertilizer application rates need to be carried out at the beginning of the experiment. Common experimental protocols and techniques will be carried out for all participating countries. It was proposed to have the second RCM in Malaysia in April 2013.

Participants at the first RCM of CRP D1.50.13

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

The project started beginning 2009 and had its first RCM in Vienna, Austria, 29 June–3 July 2009 and the second meeting in Pretoria, South Africa, 11–15 April 2011. Currently, 15 research groups from 13 countries (Botswana, Bulgaria, China, Denmark, Germany, Ghana, India, Kenya, Peru, South Africa, the United Kingdom, Ukraine and the United States of America) participate in the project, 10 under research contracts, three under research agreements and two under technical contracts. In course of the project, new mutant germplasm collections from elite varieties of the target crops 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, increased carotenoids, decreased oxalate, decreased phytate and increased tocopherols. Among the markers systems developed are retrotransposon based marker for screening *solanaceae* and QTLs associated with Zn, Fe, Ca, Mg identified in potato.

The next RCM, where the CRP team will present newest results and discuss and adapt further actions to meet the projects objectives, is planned to be held in Hangzhou, China, 15–19 October 2012.

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

Technical Officer: B. Till

The broad goal of this CRP is to develop and test strategies and methodologies to increase the efficiency of the induction, retention and recovery of induced mutation events for the generation of novel and useful crop traits. The process of utilization of induced mutations is broken up into four main parts: inducing mutations at a desired density and spectrum, dissolving chimeric sectors, phenotyping, and genotyping. Each of these 'modules' can be adapted to fit a specific crop or propagation strategy (seed or vegetative) and integrated into a pipeline to enhance the efficiency of mutation assisted breeding. Four crops were chosen to serve as models for technology development and adaptation: banana, barley, cassava and rice. Edible banana is triploid, parthenocarpic and sterile and serves as a model for obligate vegetative propagation. Methods being explored for the efficient induction of induced mutations include shoot tip and embryogenic cell culture mutagenesis. The former is being combined with TILLING mutation discovery strategies to monitor the spectrum and density of chemically induced mutations and to measure the rate at which chimeric sectors are dissolved when applying meristem isolation and longitudinal bi-section. Cell cultures are also being investigated in facultatively propagated cassava. The development of efficient cell cultures in both banana and cassava would allow mutagenesis of single cells that would most likely obviate the need for chimera dissolution because plants growing from a single cell would be genotypically homogenous allowing for immediate use of resulting plantlets. A similar approach is being investigated in barley, whereby isolated microspores are being mutagenized allowing for the generation of instantly true breeding doubled haploid mutants. Seed mutagenesis in barley is also being optimized through the use of TILLING, allowing accurate estimations of mutation densities and spectra and also for targeting desired mutations in target genes. In rice, seed mutagenesis is being combined with next generation sequencing technologies to rapidly access mutation density and spectrum and to also target mutations to specific genes. Phenotyping activities include near infrared spectroscopy (NIRS) measurements of mutant rice and the development of non-destructive approaches to measure differences in M3 and higher generation seed derived from irradiation with either gamma or X rays. Field evaluations are also being carried out on mutagenized rice and banana. 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.

The 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.

Isolation and Characterization of Genes Involved in Mutagenesis of Crop Plants, D2.40.13

Technical Officer: P.J.L. Lagoda

This CRP started with a consultants meeting in 2008 in Vienna, Austria, gathering five experts (Austria, Germany, Israel, Switzerland and the United States of America), who were invited to present their work in the concurrent session number two of the International Symposium on Induced Mutations in Plants (ISIMP, Vienna, Austria). They worked out the proposal for this CRP on Plant DNA Damage, Repair and Mutagenesis. The first RCM was held in St. Louis, Missouri, USA in conjunction with the ninth International Plant Molecular Biology Congress (IPMB), 26–31 October 2009. Eight research contract holders from Argentina, Bulgaria, China, India, Republic of Korea and Poland and four agreement holders and consultants from Germany, Switzerland and the United States of America (2), participated in this RCM. The second RCM was held in Vienna, Austria, 30 May–3 June 2011. The third RCM is scheduled to take place in Jeju Island, Republic of Korea as a satellite meeting during the third International Workshop on Plant Genetic Resources, 16–19 April 2013.

So far, a strategy for mutation breeding based on mismatch repair (MMR) suppression to widen the genetic diversity after mutagenesis is being developed. Suppression was achieved by reverse genetic selection of mutants or cultivars defective in MMR in tomato. The mutant lines are expected to have a wider spectrum of genetic alterations, such as base substitutions leading to enhanced mutation frequencies. It was also reported that deficiency in MMR can lead to both base substitutions and deletion mutations in the population even without mutagenic treatment, thus increasing frequency of spontaneous mutations in the population. This may allow targeting of novel loci which may not be amenable to chemical or physical mutagenesis. Since these lines are hypermutable, the mutant lines can be crossed back to the wild relative to restore the wild copy gene and stabilize the selected mutant trait.

A strategy for mutation breeding based on genetically unstable mutants (GUMs) is being studied. Interesting genetic observations about GUMs inducing narrow spectra of cytoplasmically inherited mutants from the barley chloroplast mutator genotype suggest that the gene responsible for the syndrome is DNA repair-related. It would be involved in maintaining genetic stability of the plastome. The normal vigour observed in some homozygous mutator plants indicates that failure of the repair mechanism involved in the mutator activity has no severe effects in plant/cell viability, which opens up new perspectives for enhancing the efficiency of the process of mutation induction.

Fifty rice mutant lines were identified and catalogued (according to knowledge in Arabidopsis and other plant species), potentially harbouring genes involved in DNA damage response and repair. These lines will be the basis for further gene discovery and gene function analyses.

Technical Cooperation Field Projects

The Plant Breeding and Genetics Subprogramme currently has technical responsibility for the following technical cooperation projects that are managed by the IAEA's Department of Technical Cooperation.

Project Number	Country	Title and Objective(s)	Technical Officer
AFG/5/003	Afghanistan	Sustainable Increase in Crop Production in Afghanistan	S. Nielen/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
AFG/5/004	Afghanistan	Enhancing Crop Productivity through Mutation Breeding and Pest Control	S. Nielen/P.J.L. Lagoda in collaboration with Insect Pest Control Section
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	M. Spencer/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/M. Spencer
BKF/5/007	Burkina Faso	Improving Voandzou and Sesame Based Cropping Systems through the Use of Integrated Isotopic and Nuclear Techniques	M. Spencer/P.J.L. Lagoda
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	M. Spencer/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	B.P. Forster/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	M. Spencer/B. Till
COL/5/024	Colombia	Supporting Mutagenesis and Functional Genomics Applied to the Improvement of Rice	B. Till/S. Nielen
ECU/5/025 **Awaiting Financing**	Ecuador	Inducing Genetic Variability in Soya, Banana and Rice	M. Spencer/S. Nielen
ERI/5/004	Eritrea	Improving Crop Productivity and Combating Desertification	B.P. Forster/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
ERI/5/008	Eritrea	Supporting the Livelihood of Barley Farmers thorugh Mutation Techniques and N15 Technology to Improve Malting, Food and Feed Barley Production	B.P. Forster/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
INS/5/037	Indonesia	Applying Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	B.P. Forster/M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section

Project Number	Country	Title and Objective(s)	Technical Officer
INS/5/039	Indonesia	Enhancing Food Crop Production Using Induced Mutation, Improved Soil and Water Management and Climate Change Adaptation	B.P. Forster/M. Spencer
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
IRQ/5/017	Iraq	Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies	S. Nielen/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
IVC/5/031	Cote d'Ivoire	Improving Plantain and Cassava Yields thought the Use of Legume Cover Crops	M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section
KAZ/5/002	Kazakhstan	Improving Wheat and Maize Using Nuclear and Molecular Techniques	F. Sarsu/S. Nielen
KAZ/5/003	Kazakhstan	Increasing Micronutrient Content and Bioavailaility 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/5/029	Kenya	Developing Appropriate Artemisia Varieties for Management of Malaria	F. Sarsu/M. Spencer
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	M. Spencer/S. Nielen
MAG/5/022	Madagascar	Strengthening Food Security	M. Spencer/F. Sarsu
MAK/5/006	Macedonia, the Former Yugoslav Republic of	Improving Wheat, Barley and Triticale for Food and Feed in Drought-Prone Areas, Using Nuclear Techniques	F. Sarsu/S. Nielen
MAL/5/028 **Awaiting Financing**	Malaysia	Enhancing the Production of Bioactive Compounds in a Local Herbal Plant by a Soilless Planting System and In Vitro Mutagenesis	S. Nielen/M. Spencer
MAL/5/029	Malaysia	Applying Mutation Breeding and Optimized Soil, Nutrient and Water Management for Enhanced and Sustainable Rice Production	S. Nielen/M. Spencer
MAR/5/020	Mauritius	Developing Stress Tolerant Banana and Tomato Varieties by Enhancing the National Capacity in Mutation Induction and Biotechnology	M. Spencer/B. Till
MON/5/021	Mongolia	Improving the Productivity and Sustainability of Farms Using Nuclear Techniques in Combination with Molecular Marker Technology	M. Spencer in collaboration with Animal Production and Health Section

Project Number	Country	Title and Objective(s)	Technical Officer
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	M. Spencer/P.J.L. Lagoda
MYA/5/016	Myanmar	Development of Rice Varieties with Improved Iron Content/Bioavailability through Nuclear Techniques	S. Nielen/P.J.L. Lagoda
MYA/5/017	Myanmar	Studying Yield Improvement of Local Rice Varieties though Induced Mutation	S. Nielen/P.J.L. Lagoda
MYA/5/019 **Awaiting Financing**	Myanmer	Developing Thermo-Insensitive (Cold-Tolerant) Green Gram Genotypes, Using Mutation Techniques	S. Nielen/P.J.L. Lagoda
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/5/009	Namibia	Using Mutation Breeding and Integrated Soil Plant Management Techniques to Develop Sustainable, High Yielding and Drought Resistant Crops	F. Sarsu/M. Spencer in collaboratin with Soil and Water Management and Crop Nutrition Section
NAM/5/010	Namibia	Developing High Yielding and Drought Resistant Pearl Millet (*Pennisetum glaucum* L.), Sorghum Bicilor (L) Moench, Bambara Groundnut (*Vigna subterranea*) and Cowpea (*Vigna unguiculate* (L) Walp) Following Up a Previous Project (Phase II)	F. Sarsu/M. Spencer
NEP/5/001	Nepal	Improving Nepalese Cardamom Using nuclear and Molecular Techniques	S. Nielen/F. Sarsu
NER/5/015	Niger	Improving Productivity of Millet-Cowpea Cropping System through Development and Dissemination of Improved Varieties and New Water and Fertiliser Management Techniques	M. Spencer/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	T.T.U.T.J. of T. Palestinian A.	Improving Local Palestinian Wheat and Barley Varieties for Salt and Drought Resistance through Mutation Breeding and Biotechnology	B.P. Forster/P.J.L. Lagoda
QAT/5/002	Qatar	Developing Biosaline Agriculture in Salt-Affected Areas in Qatar	S. Nielen/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
RAF/5/056	Regional Africa	Field Evaluation and Dissemination of Improved Crop Varieties Using Mutation Breeding and Biotechnology Techniques	F. Sarsu/M. Spencer
RAF/5/066	Regional Africa	Improving Crops Using Mutation Induction and Biotechnology through a Farmer Participation Approach (AFRA)	F. Sarsu/M. Spencer
RAS/5/048	Regional Asia	Mutation Induction and Supportive Breeding and Biotechnologies for Improving Crop Productivity (ARASIA)	P.J.L. Lagoda/F. Sarsu

Project Number	Country	Title and Objective(s)	Technical Officer
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 Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley – Phase II	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
RER/5/017	Regional Europe	Enhancing Productivity and Quality of Major Food Crops	S. Nielen/F. Sarsu
RLA/5/056	Regional Latin America	Improving Food Crops in Latin America though Induced Mutation (ARCAL CV)	M. Spencer/S. Nielen
RLA/5/063	Regional Latin America	Supporting Genetic Improvement of Underutilized and Other Important Crops for Sustainable Agricultural Development in Rural Communities (ARCAL CXXVI)	M. Spencer/S. Nielen
SAF/5/012	South Africa	Analysing the Level of Drought Tolerance in Mutant Gerplasms of Cowpea and Amaranthus Using Molecular Biotechnology	S. Nielen/M. Spencer
SAU/5/003	Saudi Arabia	Improving Fertilization under Saline Conditions for Sustainable Crop Production	S. Nielen/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
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/M. Spencer
SIL/5/009	Sierra Leone	Improving Sorghum Productivity through Nuclear and Biotechnology	S. Nielen/M. Spencer
SUD/5/030	Sudan	Increasing productivity of Selected Crops Using Nuclear Related Techniques	F. Sarsu/M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section
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/M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section
TUN/5/024	Tunisia	Development of Improved Strains of Olive Tree through Mutation Breeding and Biotechnology	M. Spencer/S. Nielen
TUR/5/025	Turkey	Using Molecular Techniques for Enhancing the Efficiency of Mutation Induction and Utilization of Mutants in Agriculture	F. Sarsu/M. Spencer
UZB/5/004	Uzbekistan	Development of Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity	S. Nielen/P.J.L. Lagoda
UZB/5/005	Uzbekistan	Developing Mutant Cotton Breeding Lines Tolerant to Diseases, Drought and Salinity (Phase II)	F. Sarsu/S. Nielen

Project Number	Country	Title and Objective(s)	Technical Officer
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 the Congo	Developing Mutations, In Vitro and Molecular Techniques for Further Dissemination to Breeders and Pharmaceutical Plant Producers to Enhance the Livelihood of Target Populations	M. Spencer/F. Sarsu
ZAM/5/026	Zambia	Improving Crop Varieties through Use of Nuclear Techniques	F. Sarsu/M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section
ZAM/5/027	Zambia	Developing Maize Genotypes for Drought and Low Soil Fertility Tolerance	F. Sarsu/M. Spencer in collaboration with Soil and Water Management and Crop Nutrition Section
ZIM/5/013	Zimbabwe	Development of Drought Tolerant and Disease Resistant Grain Legumes, Phase I	M. Spencer/S. Nielen
ZIM/5/015	Zimbabwe	Development of Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content, Phase II	M. Spencer/S. Nielen

TC Projects Closed in 2012

Project Number	Country	Title and Objective(s)	Technical Officer
ALG/5/023	Algeria	Protection of Date Palm Trees Against Bayoud Disease	M. Spencer
ALG/5/024	Algeria	Improvement of Cereals for Tolerance to Drought and Resistance to Disease	M. Spencer
ANG/5/006	Angola	Improvement of Food Crops through Mutation Breeding and Biotechnology	S. Nielen/M. Spencer
BOL/5/018	Bolivia	Enhancing Food Security Using Conventionbal and Nuclear Techniques for the Acquisition of Climate Change Tolerant Commercial Potato Seed	M. Spencer/S. Nielen
CAF/5/003	Central African Republic	Development of New Varieties of Cassava through Mutation Breeding and Biotechnology Techniques	M. Spencer/B. Till
COL/5/023	Colombia	Enhancing Mutagenesis and Biotechnology Used in the Improvement of Rice	B. Till/S. Nielen
COS/5/027	Costa Rica	Generation of Promising Strains of Beans through Induced Mutations in Calluses and Seeds to Increase Competitiveness	M. Spencer/S. Nielen
COS/5/028	Costa Rica	Generating Promising Strains of Beans through Induced Mutations in Calluses and Seeds to Increase Competitiveness (Phase II)	M. Spencer/S. Nielen
CPR/5/017	China	Construction of Radiation-Induced Mutant Libraries and Function Analysis of Mutated Genes in Crop Plants	M. Spencer/S. Nielen
ECU/5/023	Ecuador	Inducing Mutations in Agriculture with the Aid of Radiation	M. Spencer

Project Number	Country	Title and Objective(s)	Technical Officer
INS/5/035	Indonesia	Application of Nuclear Techniques for Screeding and Improving Cash Crop Plants in Coastal Saline Lands	B.P. Forster/M. Spencer
INS/5/038	Indonesia	Using Induced Mutations to Improve Rice Productivity through a Hybrid Rice Breeding Programme	B.P. Forster/M. Spencer
JAM/5/010	Jamaica	Plant Breeding and Diagnostics Technologies	S. Nielen/M. Spencer
MAG/5/018	Madagascar	Improving Cereal Production (Rice and Maize) through Mutation Breeding for Tolerance/Resistance to Striga (*Striga asiatica*)	M. Spencer/B.P. Forster
MAR/5/018	Mauritius	Improvement of Banana and Tomato Varieties through the Use of Nuclear Techniques for Mutation Induction and Biotechnology	M. Sepncer/B. Till
NER/5/014	Niger	Improving the Productivity of Cowpea/Finger Millet Based Cropping Systems	M. Spencer/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
PAK/5/044	Pakistan	Improvement of Drought Tolerance in Chickpea through Induced Mutations	B. Till/S. Nielen
PER/5/030	Peru	Genetic Improvement of Quinoa and Kiwicha Using Mutation Induction and Biotechnology	Y. Lokko
RAS/5/045	Regional Asia	Improvement of Crop Quality and Stress Tolerance for Sustainable Crop Production Using Mutation Techniques and Biotechnology (RCA)	S. Nielen/B.P. Forster
RER/5/013	Regional Europe	Evaluation of Natural and Mutant Genetic Diversity in Cereals Using Nuclear and Molecular Techniques	S. Nielen/P.J.L. Lagoda
SAF/5/010	South Africa	Development of New Maize and Sorghum Germplasm with Enhanced Nutritional Content	Y. Lokko
SEN/5/032	Senegal	Integrated Approach to Develop Sustainable Agriculturel in Senegal	M. Spencer/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
THA/5/049	Thailand	Increasing productivity of Selected Crops Using Nuclear Related Techniques	M. Spencer/P.J.L. Lagoda
TUN/5/023	Tunisia	Radiation-Induced Mutations for Improvement of Cactus	M. Spencer
URT/5/026	United Republic of Tanzania	Improving Rice Varieties through Mutation Breeding and Biotechnology in Zanzibar	M. Spencer/S. Nielen
ZAI/5/016	Democratic Republic of the Congo	Mutation Techniques for Improving Nutritional and Medicinal Plants with a Curative Effect on Human Diseases and Alimentary Plants	M. Spencer

For details, see the IAEA Technical Cooperation Programme's Website at:

http://www-tc.iaea.org/tcweb/default.asp

Success Stories

Mutation Induction and Supportive Breeding and Biotechnologies for Improving Crop Productivity in ARASIA Member States, RAS/5/048

Technical Officer: P.J.L. Lagoda

Researcher sharing ideas with farmers in the demonstration field designed for wheat Shibam-8 variety in Kawkban region — 201, Yemen (Photo courtesy of Dr Saif, counterpart from Yemen)

Open discussions among researcher, extensions and farmers about farmers' preferences of barley mutants grown in their own fields at Kawkban region under rainfed conditions — Season 2011, Yemen (Photo courtesy of Dr Saif — counterpart from Yemen)

In the Kuhlan Affar region (Yemen), two varieties of wheat and barley named Shibam-8 and Kawkban-1 have been selected for a cycle of production seeds from breeders' seeds till certified seeds. Two ton quantities of each seed were collected and distributed to the growers in the Kuhlan Affar region for planting. By introducing these two new varieties of wheat and barley under rain-fed conditions, the average yield of wheat will increase from 1.5 tons/ha presently to 3 tons/ha; the yield of barley is even envisaged to increase three fold, from 700 kg/ha now to more than two tons/ha. The introduction of the improved seeds also allows the diversification of crops that can easily adapt to climate, soils and rainfall patterns.

Improving Crop Quality and Stress Tolerance in Plants in Asia and the Pacific Region, RAS/5/045

Technical Officer: S. Nielen

Water culture screening for salinity tolerance and susceptible mutant lines

Through the IAEA technical cooperation project RAS/5/045, Member States of the Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific (RCA) were able to improve quality and stress tolerance in high-end crops, using mutation techniques and biotechnology, and applying marker-assisted selection (MAS) to accelerate the process. The project developed and transferred methodologies and techniques for identifying the mutant genes that contribute to the quality characteristics and stress tolerance of important crops. One national and three regional training courses were carried out. Six expert missions took place and five meetings, comprising planning, expert, mid-term, consultant and final review meetings. A total of 47 people were trained through the regional training courses on the use of mutation breeding and biotechnology to improve water use efficiency and tolerance to drought, salinity and other soil stresses. Training materials on the use of mutation techniques and biotechnology for routine application in identifying specific desirable plant characteristics and procedures, together with manuals, were developed and utilized in the regional training courses. The project has enhanced national and regional capacities in mutation techniques and biotechnology. All participating countries have used the training to develop new mutant varieties and important agronomic traits in a wide range of crops, leading to better crop quality and stress tolerance. The mutant varieties and advanced pre-breeding lines produced are expected to increase farmer incomes and agricultural production, and to improve food security in the participating Member States.

The Asian Association of Mutagenesis in Crop Plants (AAMCP) was established as a result of the technical support provided by the project. The association is managed by the Member States and provides a good platform to support and sustain the networking of professionals and researchers working in the area of plant breeding.

Developing Sorghum for Supporting Food Security, INS/5/030

Technical Officer: M. Spencer

Sorghum is a potential crop for Indonesia owing to its wide adaptability and tolerance to adverse conditions. Sorghum is also a good source of food, feed and biofuel (bioethanol). Growing sorghum can increase crop productivity in dry land areas, and thus promote food diversification and sustainable agriculture development, provide employment and improve farmers' welfare.

Sorghum (*Sorghum bicolor* L.) is considered a suitable crop for dry land farming and is usually grown under hot and dry climates in various regions in the world. In Indonesia, sorghum is still regarded as a minor cop and its cultivation is limited, mostly grown by local farmers in a specific region for animal feed. The limiting factors in dry land farming agriculture are mostly related to drought and acid soil problems. Hence, an aggressive and efficient plant breeding programme is needed for sorghum development. The use of mutation induction was proposed as the best tool to rapidly and efficiently create new genotypes showing both suitable adaptation to the Indonesian conditions while retaining high yield and excellent grain qualities for human consumption and/or industrial applications.

Unfortunately, sorghum being an introduced crop to Indonesia there is not much genetic variability available for breeding. In the past years attempts to increase genetic variation had been achieved through introduction of plant materials from ICRISAT and China. Mutation induction using gamma irradiation of seeds was conducted at the Center for the Application of Isotope and Radiation Technology, National Nuclear Energy Agency (BATAN). This mutation breeding programme was supported by the IAEA through RAS/5/040 and RAS/5/045 projects and also a national IAEA TC project INS/5/030. The breeding objectives were to improve sorghum genotypes for tolerance to adverse conditions (drought and soil acidity problems) with increased yield and grain quality for food, feed and fuel (3F). Several sorghum mutant lines with improved drought and acid soil tolerance had been developed and are being stored in the institute's sorghum germplasm collections for future breeding programmes. One sorghum variety registered as 'Pahat' was released in 2011. Some end users, including farmers and private companies, are starting to introduce sorghum for developing novel products in their business, particularly for food and feed industries. One of these products is the 'katari' sorghum-based chips with high protein and calcium content, available for children snacks. This result has a very positive impact on food security in Indonesia since sorghum use will promote food diversification and sustainable agriculture development.

A success story from Afghanistan

Technical Officer: B.P. Forster

About 80% of Afghans are dependent on agriculture and related agri-businesses for their livelihoods. Hence commercial agriculture plays a significant role in increasing the income of rural populations. The major food crops produced are wheat, maize, rice, barley, vegetables, fruits and nuts. Agricultural production is constrained by an almost total dependence on erratic winter snow and spring rain for water and the agronomy is predominantly low input (machines, chemical fertilizers, certified seed and pesticides are little used).

Good quality sowing materials are essential, but these are often too expensive and unavailable for Afghan farmers. In the late 1970s a programme to provide improved seeds to farmers was initiated by the Governmental Agricultural Research Institute (Kabul). Later, Dr Hussaini Sekander was selected to participate in a FAO/IAEA training course on radiation techniques at Seibersdorf in June 1992. After completion of the course he returned home and directed a project for seed improvement of local wheat varieties using induced mutation. In 1995 Dr Hussaini treated seeds of 16 wheat varieties with X rays (5, 10 and 15 Krad, or 50, 100 and 150 Gy). The mutant populations developed from the irradiation treatments produced lines with superior yields. The most effective treatment was 150 Gy. Mutant lines were selected for yield, height, tiller number and disease resistance. These mutant lines were developed into several varieties: BCH(s), BOW(s), Afghan(14), KL-HB(36), Kuz(4), Maya74(s) and Nangarhar. In some cases the yield of mutant lines was twice that of the parent, *e.g.* from 3000–6600 kg per hectare. Afghan farmers began to use these mutants in their fields in 1998/99 and got higher yields and mutant wheat varieties spread to Kunar, Nangarhar and Novistan and other provinces. The success of these varieties has led to Dr Hussaini being nominated by the Afghan government for the World Food Prize 2012-2014 (World Food Prize Foundation). Dr Hussaini has now returned to the Seibersdorf laboratories as a fellow and is continuing his training in mutation induction, mutation detection and mutation development for plant breeding at the Plant Breeding and Genetics Laboratory (PBGL).

News

IAEA
International Atomic Energy Agency
Atoms for Peace

50th Anniversary of the Agency's Nuclear Sciences and Applications Laboratories in Seibersdorf

Believe it or not: the Agency's Nuclear Sciences and Applications (NA) Laboratories in Seibersdorf have just completed half a century of dedicated support to Member States in their efforts to optimally exploit 'atoms for peace'. It seems to be an appropriate time to celebrate the completion of these five decades in a fitting manner.

Throughout these many years, the activities of the NA Laboratories in Seibersdorf have continuously evolved, also through their partnership with FAO, in response to the ever changing landscape of nuclear technologies and applications, and to the multitude of expectations of national and international organizations for cooperation in nuclear research and technology transfer. In this process, the Laboratories have consistently remained at the forefront of assisting Member States in fostering the use of nuclear science and technology wherever these offer unique opportunities or provide added value.

The Laboratories have indeed come a long way. Starting with a mere 1736 m² of combined laboratory, office and corridor space in 1962, the original U-shaped building housed 14 professional and 24 general service staff. Today, it covers an area of more than 13 000 m² and is a dynamic hub for nearly one hundred scientists, technicians, fellows, visitors, interns and students from all over the world that are engaged in a wide range of activities dedicated to supporting global development and cooperation. These dedicated and concerted efforts have led to a myriad of success stories in the many areas of work in the Laboratories, which is both satisfying and enthusing.

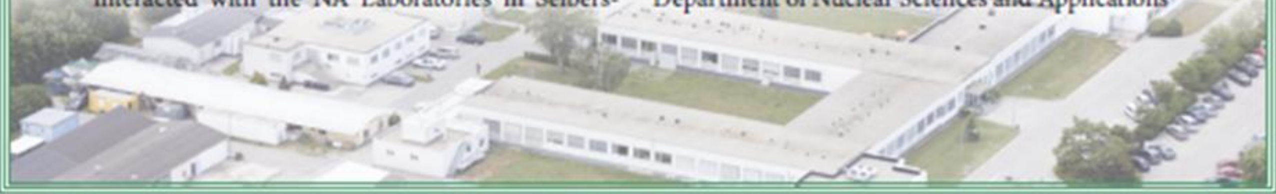
Many of you have, at some stage in your career, interacted with the NA Laboratories in Seibersdorf and contributed to these successful projects and programmes, which are glowing examples of success stories that fully justify the mandate of these Laboratories. We are very grateful to all of you for seamlessly working with us, as we realize that it is only through the dedication, the enthusiasm and the numerous ideas of our many internal and external stakeholders, that it has been possible for the Laboratories to consistently remain at the forefront in our numerous and very diverse endeavours.

Nonetheless, this is not the time to lay back in satisfaction but a time to look forward to further enhance the performance of the Laboratories and to improve our outreach. While the NA Laboratories in Seibersdorf have served the Member States well over the last half century, they need to be modernized and upgraded to cater to growing demands and to keep pace with increasingly rapid technological developments. The planned 50 year anniversary celebration of the Laboratories is an apt time to look back and feel proud of the numerous achievements, as well as to plan the future road map that will enable the Laboratories to retain the high level and quality of service that Member States have come to expect.

So, when we celebrate the 50th anniversary of the NA Laboratories in Seibersdorf, it is really you we are celebrating. We sincerely hope to see as many of you as possible during this year of celebration or maybe even at the actual event in late November 2012 at the Laboratories.

Daud Mohamad

Deputy Director General
Department of Nuclear Sciences and Applications



IAEA Scientific Forum 2012

Food for the Future: Meeting the Challenges with Nuclear Applications, Vienna, Austria, 18–19 September 2012

The IAEA Scientific Forum, held alongside the fifty-sixth regular session of the IAEA General Conference, will take place on 18 and 19 September 2012 at the Vienna International Centre. The theme of this year's Scientific Forum is: Food for the Future: Meeting the Challenges with Nuclear Applications. The Forum will consist of four sessions. Each session will feature a short film showing successful cooperation between the IAEA and its Member States in dealing with food problems, followed by a discussion. During all the sessions, a renowned professional moderator from a leading broadcaster (BBC) will guide the discussions with international experts and government officials on the podium and in the audience to ensure a stimulating and interactive event.

In the introductory session, the IAEA Director General and high-level invited guests will address participants. The session will also be used to present major food problems and highlight the role of nuclear techniques made available by the IAEA to help solve them.

The second session, Food for the Future: Increasing Food Production will focus on increasing food production to meet the demands of growing populations. It will provide a forum for an exchange of ideas on how to sustainably intensify and diversify production to ensure the availability of more, better-quality food.

The third session, Food for the Future: Ensuring Food Protection will focus on major animal and plant pests and diseases which hamper food production and trade, resulting in overuse of pesticides and drugs. International experts will discuss how nuclear technology can help Member States in dealing with the global challenge of managing these pests.

The fourth session, Food for the Future: Enhancing Food Safety will focus on the problem of biological and chemical contaminants in food and the use of radiation and traceability systems. The expert panel will discuss global challenges in food safety and propose solutions using nuclear technologies.

The aim of the IAEA Scientific Forum on Food Security is to inform IAEA Member States about the use of nuclear applications for food security in food production, food protection and food safety. Human population is projected to reach a staggering nine billion people by 2050, 34% higher than today. Who will feed the growing billions; how can more food be produced on less land; how can we protect crop yields from climate variability, pests and diseases? These are major issues of our generation. Population increase, urbanization, degradation of resources, climate variability and change, arable land reduction, water scarcity, migration, diet change, and the shift to biofuels, are affecting local and global food security and putting pressure on productive capacity and ecosystems, unprecedented challenges to agriculture. In order to warrant food security for the increased and more urbanized population, food production must grow by more than 70%. Annual cereal production will need to rise to about three billion tonnes from 2.1 billion today and annual meat production will need to rise by over 200 million tonnes to reach 470 million tonnes. Never before, on such a scale, has it been more important for the world to generate and use agricultural technologies to reduce hunger and poverty in an equitable, environmentally, socially and economically sustainable manner. The IAEA promotes the value added use of nuclear techniques and efficiency enhancing biotechnologies to develop and improve strategies for affordable and sustainable food. Nuclear techniques enable farmers, food processors and government agencies to provide people with more, better and safer food, while conserving soil and water resources and the biodiversity on which these products depend.

High Level Visit to the Joint FAO/IAEA Agricultural and Biotechnology Laboratories (ABL) of the IAEA's Standing Advisory Group on Nuclear Application (SAGNA)

Established in 2000 as a high-level body reporting directly to the Director General of the IAEA, SAGNA provides advice on the application of nuclear techniques in the programmes of food and agriculture, human health, water resources, protection of the marine and terrestrial environment, and physical and chemical applications, in terms of their relevance, delivery and impact. At present, 22 scientists across the world are working for the group.

The fourteenth Meeting of SAGNA was held on 11–15 June at the VIC in Vienna to provide programmatic and policy advice on the use of nuclear applications and sciences. This guidance is vital in meeting Member States priorities efficiently and effectively. A visit to the Joint FAO/IAEA Agricultural and Biotechnology Laboratories (ABL) was organized on Tuesday, 12 June. ABL and its sister IAEA environment-dedicated laboratory in Monaco present a unique feature in the UN system, as per their adaptive R&D, capacity development and services, and producing international acclaimed reference material and standards.

Developments at the Plant Breeding and Genetics Laboratory, Seibersdorf

Evaluating and establishing reverse-genetic platforms for vegetatively propagated crops

Work is on-going in the PBGL in the areas of developing efficient reverse-genetic strategies for TILLING in vegetatively propagated crops. Triploid banana of the genus Musa (consisting of banana and plantains) serves as a model for technology development for obligate vegetatively propagated crops. These can be defined as species that propagate solely asexually through mitotic division. Such species represent some of the most challenging crops when considering applying mutation based approaches for functional genomics and crop improvement. In seed propagated crops, plants that are genotypically heterogeneous at the time of mutagenesis can be made non-chimeric through sexual reproduction. The predominantly recessive alleles that are induced can be made homozygous to reveal new traits. Such approaches are unavailable in obligate vegetatively propagated species. The effect of such bottlenecks can be easily observed when consulting the Mutant Varieties Database (http://mvgs.iaea.org/): the majority of released mutant varieties are seed propagated crops. New technologies and approaches can therefore have a major positive impact in the improvement of obligate vegetatively propagated crops.

The TILLING population developed for triploid banana has served as a tool to evaluate the induction, stability, inheritance and potential functional consequence of induced mutations. Experiments utilizing high-throughput mutation discovery techniques have been employed to discover and monitor induced mutations. The density and spectrum of induced mutations is under evaluation and when complete, will lead to best practices for population development and management.

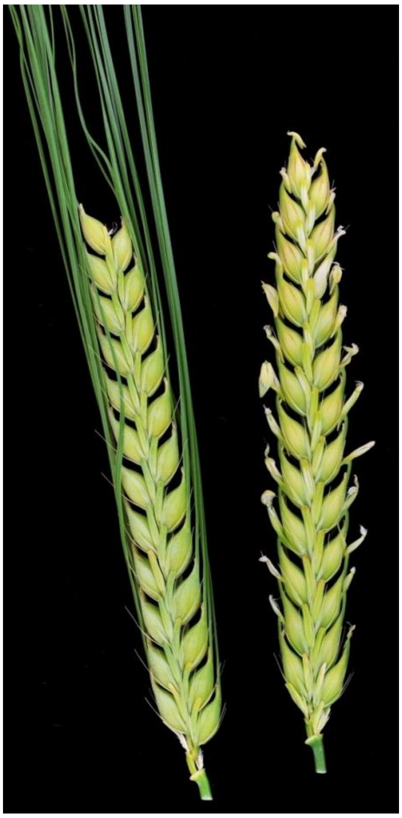
Facultative vegetatively propagated species are those that can undergo either sexual or asexual propagation. For many reasons, such as increased yield, farmers have had thousands of years of selection for some species to favour asexual propagation. The result can be crops where sexual reproduction is limited. We are using cassava as a model for facultative vegetatively propagated plants. As with banana, our on-going work is aimed at enhancing the efficiency of both inducing and recovering novel alleles. The work to date suggests that mutation densities from gamma irradiation may be sufficiently low as to make traditional mutation discovery methods inefficient. Our recent work this year has been to consider alternative mutation discovery platforms that cover larger regions of the cassava genome. We are combining a traditional gene-by-gene TILLING approach using enzymatic mismatch cleavage and fluorescence detection and next generation sequencing technologies to evaluate mutation density and spectrum in cassava. Current efforts are under way to produce and evaluate a broader range of mutagenic treatments to define the effect of dosage and mutagen on the cassava genome.

The development of non-destructive Near Infrared Spectroscopy (NIRS)

As part of the Coordinated Research Project on 'Enhancing the efficiency of induced mutagenesis through an integrated biotechnology pipeline', staff of the PBGL in collaboration with Dr Johann Vollmann of BOKU University (Tulln, Austria), has been developing methods for spectrophotometric analysis of mutant rice seed. The goal is to develop a rapid and robust method for measuring quality differences in mutant seed lines. Careful studies have been undertaken to evaluate and optimize protocols for both destructive and non-destructive measurements. Non-destructive measurements are desired in order to save potentially enhanced seed for field propagation. To date, over 1300 measurements have been taken on mutant M4 and control material. Ongoing analysis suggests that non-destructive methods can be optimized that provide data analogous to those obtained *via* destructive methodologies. After optimization we applied these methods to rice mutant populations from Madagascar and Sierra Leone. Spectroscopic outliers have been identified that may indicate enhanced seed quality features and these are now being forwarded for further studies, including protein analysis.

Barley mutants for feed traits

Barley is an important feed for a wide range of animals (sheep, goats, cattle, pigs). The crop is consumed by animals as seed, green forage, hay and silage, however, barley has a major problem as a feed, the ears are awned. Awns are abrasive organs that protrude from the ear and have no nutritional value; in fact they are detrimental to animals as they contain silica bodies and barbs that cause lacerations in the mouths of feeding animals. The most important breeding goals for forage barley are high yield and the elimination of the awn. In the USA awnless (*Lks1*) and hooded (*Kap1*) mutant cultivars have been released specifically for forage use. Awnless mutants have no awns but can suffer from a decrease in yield; the hooded mutants have their awns replaced by an inverted spikelet (see picture) and there is no apparent yield penalty. A PhD programme has been initiated between the PBGL and Dr Heinrich Grausgruber (BOKU University) to introduce the hooded trait into an Austrian two row feed barley and a North African six row barley using mutation induction for the hooded character and introgression *via* rapid backcrossing using an existing mutant line.



Wild type two row barley with awns anlongside a hooded mutant where the awns are replaced by an inverted floret.

Positive control kits for mutation detection

The PBGL continues to provide assistance on mutation detection through production and distribution of positive control kits that contain DNA with known mutations or polymorphisms, gene-specific primers, and other materials for mutation discovery by agarose gel or Li-Cor DNA analyzer. Fellows trained at the PBGL also benefit from using the kit for learning this low-cost alternative for DNA mutation discovery. Two requests for the positive control kit have been received in the first half of 2012 from Nigeria and the United States of America. (Protocols for the positive control kits can be found online at: http://mvgs.iaea.org/LaboratoryProtocols.aspx)

Conferences

Staff from the BPGL attended four international conferences in the first six month of 2012:

1) Plant and Animal Genome XX International Conference, San Diego, USA, 14–18 January.
2) Molecular Mapping & Marker Assisted Selection, Vienna, Austria, 8–11 February.
3) Plant Growth, Nutrition & Environmental Interactions, Vienna, Austria, 18–21 February.
4) International Conference on: Plant Abiotic Stress Tolerance II, Vienna, Austria, 22–25 February.

In total, three oral and three poster presentations were given, the posters from the Vienna conferences are reproduced here.

These conferences were targeted as they not only provided venues for the PBGL to present its work, but also provided opportunities to meet potential partners/collaborators in new areas of interest such as the new CRP on 'Integrated utilization of cereal mutant varieties in crop/livestock production systems', Musa genomics and mutation breeding for human food nutrition.

Irradiation services

Irradiation services have been provided for the countries listed in the table below. All requests have involved gamma ray irradiation, but requests for Eritrea and Indonesia also include X ray irradiation. Interest in X rays has been increasing; this is due in part to restrictions in setting up and refurbishing new gamma irradiators that involve radioactive elements. Radio-sensitivity tests have also been performed on the M1 (irradiated) material to determine the most effective dose for mutagenesis.

Member State	Species
USA	*Acer truncatium*
Central African Republic	Cassava
Poland	Lupin
Eritrea	Barley
Burkina Faso	Sorghum
Indonesia	Rice
Afghanistan	Wheat

Human capacity development

Fellowship training

Name	Country	Area of training	Period
Ms Noeall Benedicte MANDAKOMBO	Central African Republic	• Induced mutations	15 January–16 February 2012
Mr Sekander HUSSAINI	Afghanistan	• Enhancing crop productivity through mutation breeding and pest contro	16 May–17 September 2012
Mr Mohammad ALI	Bangladesh	• Mutation induction and detection, with special reference to abiotic stress tolerance. Training in collaboration with the Soil and Water Management and Crop Nutrition Laboratory	4 June–1 September 2012

Cost-free scientific visitor

Cost-free scientific visitors come to the PBGL for training using own funds.

Name	Country	Areas of training	Period
Ms Catherine Esuola OLUWAKEMI	Nigeria	• Induced mutations, molecular markers and TILLING for vegetatively propagated *Musa* acuminata (banana) and *Telfairia occidentalis* (fluted pumpkin)	7–18 May 2012

Consultant

Name	Country	Areas of expertise	Period
Mr Heru RUSFIANDI	Indonesia	• Pollen irradiation	15 May–16 November 2012

PhD student

Name	Country	Topic (University)	Period
Ms Farzaneh TAASSOB SHIRAZI	Islamic Republic of Iran	• Rapid introgression strategies for mutant genes (BOKU University, Austria)	January 2012–December 2014

New faces in the Laboratory:
From left to right: Sekander Hussaini (Afghanistan), Mohamed Ali (Bangladesh), Heru Rusfiandi (Indonesia) and Farzaneh Taassob Shirazi (Iran)

Professional networking

In an effort to enhance scientific networking and increase the quality of services provided to Member States, the PBGL and Plant Breeding and Genetics Section developed a LinkedIn profile (http://at.linkedin.com/pub/iaea-plant-breeding-and-genetics/31/4b6/aa3). We have also created a LinkedIn discussion group called IM PLANTS (Induced Mutations in Plants). We hope that this can serve as a real-time resource where experts can share views and advice on topics surrounding induced mutations and plant breeding. You are welcome to join our network!

Plant Breeding and Genetic Laboratory staff travel to Member States

Mr B. Till

San Diego, USA

- Attended the Plant and Animal Genome XX International Conference 14–18 January 2012 to give invited oral presentations in the Mutation Screening and Plant Phenotypes workshops. Participated in the Musa Genomics Consortia Meeting running in parallel.

Davis, USA

- Attended a two-day workshop on Next Generation Sequencing Technologies 19–20 January at the UC Davis Genome Center, hosted by Professor Luca Comai.

Mr B. Forster

Cologne, Germany

- One day visit to Innovative Röntgentechnik, Faxitron, Kreizhof 3, 53804 Much, Germany to carry out tests on X ray imaging of barley, rice and sorghum seeds.

Publications

Staff Publication in the Field of Plant Breeding and Genetics

Journal Publications/Book Chapters and Published Abstracts

Peer-reviewed

KOZAK, K., JANKOWICZ-CIESLAK, J., BADO, S., TILL, B.J., GALEK, R., SAWICKA-SIENKIEWICZ, E. Inter-varietal differences of *Lupinus angustifolius* in response to chemical and physical mutagens. In: B. NAGANPWSKA, P. KACHLICKI, B. WOLKO (eds.) 2011. 'Lupin crops – an opportunity for today, a promise for the future'. Proceedings of the 13th International Lupin Conference, 6–10 June 2011, Poznań, Poland. International Lupin Association, Canterbury, New Zeland. ISBN 978-83-61607-73-1 (2012) 112-117.

MAGHULY, F., JANKOWICZ-CIESLAK, J., TILL, B., LAIMER, M. The use of ECO-TILLING for the genetic improvement of *Jatropha curcas*. In: SUJATHA M., BAHADUR B. AND CARELS N., Compendium of Bioenergy Crops: *Jatropha curcas*. 2 (2012) Science Publishers, USA.

SHU, Q.Y., FORSTER, B.P., NAKAGAWA, H. Plant mutation breeding and biotechnology. CABI International (2012) 600.

WENING, S., CROXFORD, A.E., FORD, C.S., THOMAS, W.T.B., FORSTER, B.P., OKYERE-BOTENG, G., NELSON, S.P.C., CALIGARI, P.D.S., WILKINSON, M.J.. Ranking the value of germplasm: new oil palm (*Elaeis guineensis*) breeding stocks as a case study. Annals of Applied Biology **160** (2012) 145-156.

WANG, T.L., UAUY, C., ROBSON, F., TILL, B. TILLING in extremis. (2012) Plant Biotechnology Journal in press.

Published conference abstracts

KYAW, M.T., BADO, S., MATIJEVIC, M., HUYNH, O.A, MYINT, T.T. Phylogenetic analysis of Myanmar rice and its mutant varieties. Myanmar Health Research Congress 2011, 9–13 January 2012.

JANKOWICZ-CIESLAK, J., DUSSORUTH, B., FORSTER, B.P., TILL, B.J. Characterization of Musa Germplasm using Low-cost SNP and Indel Discovery. Book of Abstracts: International Conference on: Molecular Mapping & Marker Assisted Selection, Vienna, Austria 8–11 February 2012.

MAGHULY, F., RAMKAT, R., TAASSOB-SHIRAZI, F., JANKOWICZ, J., LAIMER, M. Analysis of genetic variation among and within Jatropha species using dominant markers. In: Molecular Mapping & Marker Assisted Selection, Vienna, Austria, 8–11 February 2012.

HUYNH, O.A., JANKOWICZ-CIESLAK, J., KOZAK-STANKIEWICZ, K., DUSSORUTH, B., CUI, H., FORSTER, B.P., TILL, B.J. Developing low cost mutation discovery methods suitable for developing countries. Book of Abstracts: International Conference on: Molecular Mapping & Marker Assisted Selection, Vienna, Austria, 8–11 February (2012) 27.

TILL, B.J., JANKOWICZ-CIESLAK, J., HUYNH, O.A., BADO, S., FORSTER, B.P. Mutation based approaches for functional genomics in vegetatively propagated plants. Book of Abstracts: International Conference on: Molecular Mapping & Marker Assisted Selection, Vienna, Austria, 8–11 February (2012) 28.

MATIJEVIC, M., LAGODA, P.J.L., FRANCKOWIAK, J.D., FORSTER, B.P. Evaluation of barley mutants for improved fodder production. Book of Abstracts: International Conference on: Plant Growth, Nutrition & Environmental Interactions, Vienna, Austria, 18–21 February (2012) 80.

JANKOWICZ-CIESLAK, J., SCHARL, T., BROZYNSKA, M., ADU-GYAMFI, J., FORSTER, B.P., RAPACZ, M. (2012). Diversity in Physiological Responses to Drought by Musa Genotypes. Book of Abstracts: International Conference on: Plant Abiotic Stress Tolerance II, Vienna, 22–25 February (2012) No. 167.

BADO, S., ADU-GYAMFI, J., FORSTER, B.P., LAIMER, M. Ion Accumulation in Rice Genotypes varying in Salt Tolerance. Book of Abstracts: International Conference on: Plant Abiotic Stress Tolerance II 22–25 February (2012) No. 168.

MAGHULY, F., JANKOWICZ-CIESLAK, J., RAMKAT, R.C., TILL, B.J., LAIMER, M. Reverse genetics and dominant markers to determine the genetic variation in *Jatropha curcas*. In: Plant and Animal Genomes XX Conference, San Diego, USA (Abstract P0731), 14–18 January 2012.

TILL, B.J., JANKOWICZ-CIESLAK, J., HUYNH, O.A., BADO, S., HENRY, I., COMAI, L., FORSTER, B.P. Mutation Induction And Reverse-Genetics for Vegetatively Propagated Plants. In: Plant and Animal Genomes XX Conference, San Diego, USA (Abstract W450), 14–18 January 2012.

TILL, B.J., JANKOWICZ-CIESLAK, J., MAGHULY, F., HUYNH, O.A., BADO, S., FORSTER, B.P., LAIMER, M. Mutation based approaches for functional genomics and trait development in vegetatively propagated plants. In: Plant and Animal Genomes XX Conference, San Diego, USA (Abstract W547), 14-18 January 2012.

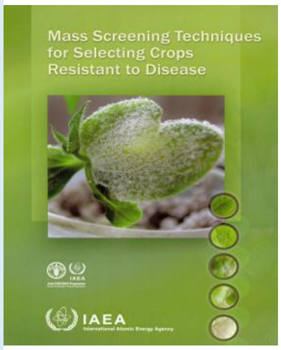
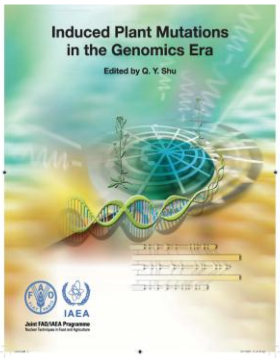
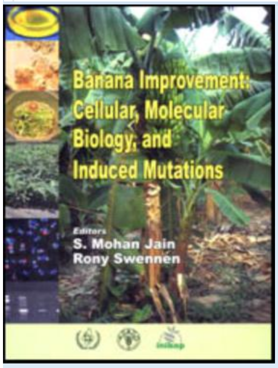
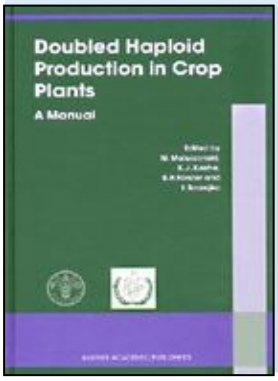
List of Plant Breeding and Genetics Section's Publications

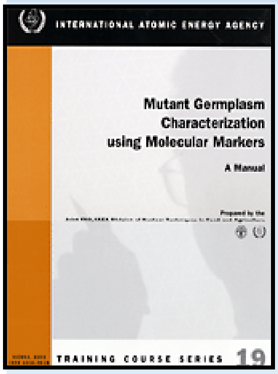
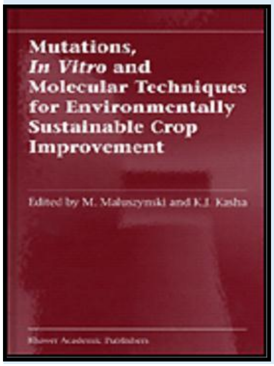
Plant Mutation Reports

Year	Edition	Contents (a sampling of the papers are listed below):	Reference No.
2011	Vol. 2, No. 3	• In vitro mutagenesis in mangosteen • Floral variation in cotton • Chemical mutagenesis in wheat • Mutation breeding in Brazil • Improved shelf life of garden pea • Improvement of lablab bean	ISSN 1011-260X
2010	Vol. 2, No. 2	• Mutation breeding in Bulgaria • Mutagenesis in clusterbean • Doubled haploid durum wheat • Improvement of indigenous rice • Mutant variety of groundnut • Gamma phytotron • Gamma greenhouse • Gamma field	ISSN 1011-260X
2008	Vol. 2, No. 1	• Induced genetic variability in kacholam • Mutagenesis of guar • Cocoyam radiation sensitivity • Virus resistant rice variety • Cold tolerant mutant rice • Proton radiation • Tomato adapted to low water supply • Increasing crossability of mungbean	ISSN 1011-260X
2007	Vol. 1, No. 3	• Mutation breeding and genetics in Korea • Genetic enhancement of groundnut • Virus resistant banana • Ion beams implantation on wheat • Trombay mutant groundnut varieties • Lodging tolerant rice variety	ISSN 1011-260X
2006	Vol. 1, No. 2	• 30 years rice mutation breeding and genetics • Mutant groundnut varieties in Bangladesh • Shortening durum wheat plants • Seedless mutant sweet orange • Colorful chrysanthemum mutations • Radiosensitivity of cassava in vitro culture	ISSN 1011-260X
2006	Vol. 1, No. 1	• Rice mutation breeding in China • Long grain aromatic rices and induced mutations • Significant contribution of mutation techniques to rice breeding in Indonesia	ISSN 1011-260X

Year	Edition	Contents (a sampling of the papers are listed below):	Reference No.
		• Use of induced mutants in rice breeding in Japan • Katy deletion mutant populations • Rice mutation breeding in Vietnam	

Books

Year	Edition	Title	Book Cover	Reference No.
2010		Mass Screening Techniques for Selecting Crops Resistant to Disease		ISBN 978-92-0-105110-3
2009		Induced Plant Mutations in the Genomics Era		ISBN 978-92-5-106324-9
2004		Banana Improvement: Cellular, Molecular Biology, and Induced Mutations		ISBN 1-57808-340-0
2003		Doubled Haploid Production in Crop Plants – A Manual		ISBN 1-4020-1544-5

Year	Edition	Title	Book Cover	Reference No.
2002	Training Course Series No. 19	Mutant Germplasm Characterization using Molecular Markers – A Manual		ISSN 1018-5518
2002		Mutations, In Vitro and Molecular Techniques for Environmentally Sustainable Crop Improvement		ISBN 1-4020-0602-0

Technical Documents

Year	Type of Publication	Title	Reference No.
2011	IAEA-TECDOC-1664	Physical mapping technologies for the identification and characterization of mutated genes to crop quality	ISBN 978-92-0-119610-1 ISSN 1011-4289
2009	IAEA-TECDOC-1615	Induced mutation in tropical fruit trees	ISBN 978-92-0-1027-09-2
2006	IAEA-TECDOC-1493	Mutational analysis of root characters in food plants	ISBN 92-0-103106-8 ISSN 1011-4289
2004	IAEA-TECDOC-1384	Low cost options for tissue culture technology in developing countries	ISBN 92-0-115903-X ISSN 1011-4289
2004	IAEA-TECDOC-1426	Genetic improvement of under-utilized and neglected crops in low income food deficit countries through irradiation and related techniques	ISBN 92-0-113604-8 ISSN 1011-4289
2003	IAEA-TECDOC-1369	Improvement of new and traditional industrial crops by induced mutations and related biotechnology	ISBN 92-0-101603-4 ISSN 1011-4289
2001	IAEA-TECDOC-1195	Sesame improvement by induced mutations	ISSN 1011-4289
2001	IAEA-TECDOC-1216	Induced mutations in connection with biotechnology for crop improvement in Latin America	ISSN 1011-4289
2001	IAEA-TECDOC-1227	In vitro techniques for selection of radiation induced mutations adapted to adverse environmental conditions	ISSN 1011-4289
2001	IAEA-TECDOC-1253	Radioactively labeled DNA probes for crop improvement	ISSN 1011-4289
1998	IAEA-TECDOC-1010	Application of DNA based marker mutations for improvement of cereals and other sexual-	ISSN 1011-4289

Year	Type of Publication	Title	Reference No.
		ly reproduced crop plants	
1998	IAEA-TECDOC-1047	Use of novel DNA fingerprinting techniques for the detection and characterization of genetic variation in vegetatively propagated crops	ISSN 1011-4289
1997	IAEA-TECDOC-951	Improvement of basic food crops in Africa through plant breeding, including the use of induced mutations	ISSN 1011-4289
1996	IAEA-TECDOC-859	Use of mutation techniques for improvement of cereals in Latin America	ISSN 1011-4289
1995	IAEA-TECDOC-800	In vitro mutation breeding of banana and plantains	ISSN 1011-4289
1995	IAEA-TECDOC-809	Improvement of root and tuber crops in tropical countries of Asia by induced mutations	ISSN 1011-4289
1994	IAEA-TECDOC-781	Mutation breeding of oil seed crops	ISSN 1011-4289

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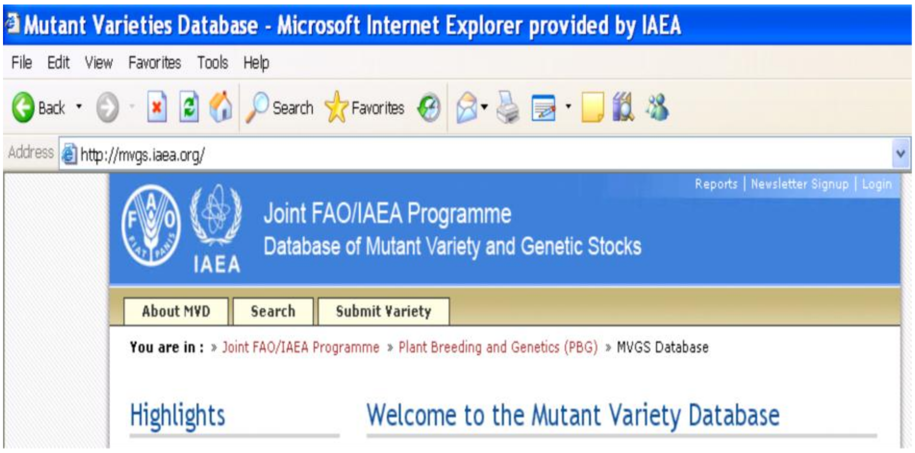
FAO/IAEA Database of Mutant Varieties and Genetic Stocks

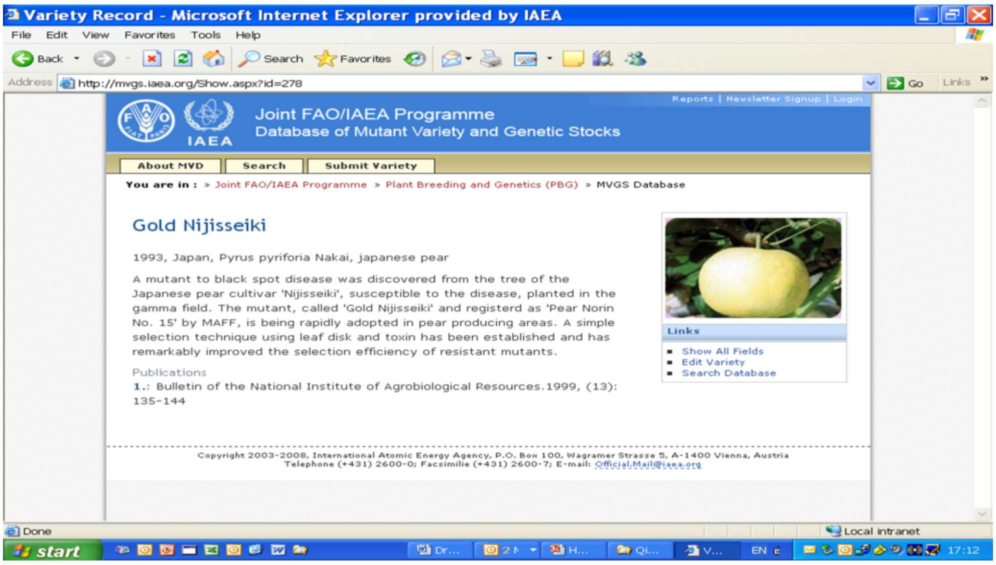
Welcome to our FAO/IAEA Database of Mutant Varieties and Genetic Stocks! At the moment, we just completed construction of the part for Mutant Variety Database, which is still in the process of information updating. We will add the other part for Mutant Genetic Stocks in due time. The database has improved over the FAO/IAEA Mutant Variety Database in many ways. We are working to make the new database as the global information source of mutant varieties and mutant genetic stocks, as well as 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 variety 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 this variety may be shown in local language).

Please visit the website 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 and mutant varieties, genetic stocks; we may post them on the website.



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

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Plant Mutation Reports

Author's Guidelines for Manuscript Submission

Scope

Plant Mutation Reports (PMR) publishes (mini) reviews, short communications and complete research papers in all areas of plant mutation research, focusing on mutagenesis, phenotyping and genotyping characterization of mutant populations and the application of mutation breeding and biotechnology in crop improvement. It also publishes description papers on mutant germplasm and mutant varieties. Papers on the socioeconomic impact analysis of induced mutations and mutant varieties are also accepted.

Style

The manuscript should be accurately and concisely written in English with the following sections:

Title page

- Title: The title should be brief and informative, 10 to 12 words (excluding 'and,' 'of,' and similar conjunctions and prepositions). As much as possible use common names for crops and avoid abbreviations.
- Authors: The names of all authors should follow the title line initials of given names followed by full family name. Place an asterisk (*) after the name of the corresponding author (i.e. the person from whom reprints are to be requested). If authors are from different institutions, indicate institutional affiliation with numbers in *superscript font* (1, 2 …).
- Affiliation(s)/Address(es):
- Email address: Provide the corresponding author's email address.

Abstract and keywords

Provide a brief and informative paragraph summarizing the content of article on the second manuscript page. The abstract should not exceed 150 words. Do not cite references. Each paper should have 3–5 keywords.

Main text

- The main text should follow the title page and abstract.
- Review articles may be organized according to their specific requirements.
- Research articles should be arranged in the following order: Introduction (which includes the literature review), Materials and Methods, Results, Discussion, Conclusions (optional), Acknowledgements (optional), and References, followed by any figure captions, and then tables. Use the '*Title Case*' for each section.
- Results and discussion may be combined and conclusions can be given at the close of the discussion section.
- Start each section (including figure captions and tables) on a new page and number all pages.
- New mutant germplasm should include a short description of initial material used and the mutagen and doses applied; selection process; mutated characteristics and its genetic and agronomic analysis. Description of the mutant variety should, in addition, include its performance in yield trials for varietal release and the releasing committee, when applicable, and proof of entry in the MVGS (http://mvgs.iaea.org/).

Acknowledgements

- Acknowledgements of grants, support etc, should follow the text and precede the references.

References

IAEA publishing style requires that references be keyed to the text by numbers in square brackets corresponding to the order in which they are first mentioned. If a reference is first cited in a table, figure or footnote, it should be numbered according to the place in the text where the table, figure or footnote is first mentioned (i.e. not where the table, figure or footnote happens to be located on the page). Normally references should be numbered serially throughout the document, including any appendices, and collected in a single list (headed REFERENCES) after the last appendix and before any annex. Each annex in which references are cited must have its own reference list.

A reference list should include only those references cited in the text. When cited in the text, references should be styled as numbers in square brackets corresponding to the order in which they are first mentioned (e.g. '…in improving productivity [17, 18].'). If the reference number is an integral part of a sentence, the abbreviation 'Ref.' should be included (e.g. "This is discussed in Refs [2, 3].").

When two authors are mentioned in the text their names are written as, for example, 'Smith and Jones', although in the list of references 'and' is omitted. If there are more than two authors, only the first name should be mentioned in the text, followed by 'et al.' (not in italics). Authors' names in the text are not fully capitalized. A reference that has more than five authors in the list of references should be set with only the first author's name, followed by et al.

The examples given below illustrate the IAEA's style for presenting references:

[13] STEPHENSON, R., Introduction to Nuclear Engineering, 2nd edn, McGraw-Hill, New York (1958) 491 pp.

[14] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Evaluation of Radiation Doses to Body Tissues from Internal Contamination due to Occupational Exposure, Publication 10, Pergamon Press, Oxford and New York (1968).

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Figures

- Figures, e.g. photographs, graphs and diagrams should be referred to as 'Fig.' numbered consecutively (1, 2, etc.).
- Submit figures in high resolution, individual files (one figure per file) and identify each file accordingly.
- A figure caption should be brief, but informative. It should be set in italics and should be placed under the figure.
- Identify curves, symbols, or structures with a legend within the figure itself, not in the caption. Define abbreviations in the caption and define symbols used in the caption or in the legend.
- Indicate the scale for micrographs, either in the illustration or the caption.

Tables

- All tables should be prepared with the '*Tables*' feature in your word processor, (do not use tabs, spaces, or graphics boxes) and must be numbered consecutively, using Arabic numerals, with brief headers explaining the content of the table. Use footnotes for detailed explanation of the tables. Each datum should be in an individual cell. Define all variables and spell out all abbreviations. Tables should be placed at the end of the main text document, with each table on a separate page.
- The *, **, and *** are always used in this order to show statistical significance at the 0.05, 0.01, and 0.001 probability levels, respectively, and cannot be used for other notes. Significance at other levels is designated by a supplemental note. Lack of significance is usually indicated by NS.
- Footnotes should be placed immediately below the table. The footnotes should be identified by superscript letter a, b, c, d............
- Do not use boxes; use horizontal lines only. Figures and tables should be placed on separate pages.

Abbreviations

All abbreviations should be fully defined when first mentioned in the abstract and also in the main text, and then the abbreviation may subsequently be used.

Nomenclature and identification of materials

Give the complete binomial and authorities at first mention (in the abstract or text) of plants, pathogens, and insects.

Units and symbols

The standard SI units (Système International de Unités) and symbols should be used throughout (www.scenta.co.uk/tcaep/science/siunit/index.htm).

Impressum

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