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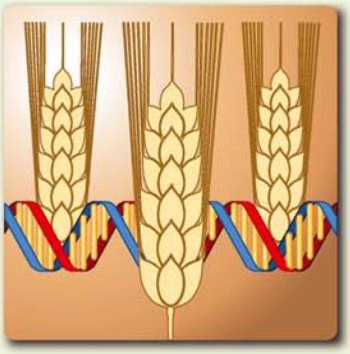

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Mutant wheat resistance screening at Moi University, Chepkoilel University College, Eldoret, Kenya (Photo: courtesy of Prof Miriam Kinyua)

To Our Readers

The end of the year, and the end of a biennium, is a good moment in time to reflect on our past activities, to take some breath and contemplate the present, in order to project ourselves into the future.

Activities in 2010–2011 were numerous. We served 93 Member States through seven Coordinated Research Projects (CRPs) and 65 Technical Cooperation Projects (TCPs) (on the national, regional and interregional level).

The food crisis, combined with the global financial crisis of 2008 and 2009, natural resources depletion, and emerging climate change issues, threatens the livelihoods of millions of poor people in many developing countries. About 60% of rural communities in the tropics and subtropics are persistently affected by a decline in household food production. Technology, such as irrigation and improved crop varieties, has changed the situation for some people, but insecurity still prevails for the poorest and most vulnerable. Progress in achieving the Millennium Development Goals, particularly on halving hunger and poverty by 2015, are behind track. As the Food and Agriculture Organization of the United Nations (FAO) reported, the number of undernourished people in the developing world actually increased in the past two to three years (CGIAR 2009). This justifies our focus of activities being more centred on the sustainable intensification of crop productivity for food security and livelihood improvement under the negative effects of climate change and variability (abiotic stress and the emergence of old/new transboundary plant diseases). Inside this issue, you will find reports (see especially 'Coordinated Research Projects (CRPs) and Research Coordination Meetings (RCMs)' section) on approaches to improve genotypes with high water and nutrition use efficiency for water scarce environments and on climate proofing food crops.

The improvement of crops for adaptation to high temperatures in drought prone areas, and addressing other negative effects of climate variability and change, is of prime importance to achieve sustainable food security. To this end, technology packages must be developed and adapted and capacity must be developed. Please read about how our Plant Breeding and Genetics Laboratory is addressing these issues in the section about the 'Development at the Plant Breeding and Genetics Laboratory, Seibersdorf'. We report on the availability of new protocols and guidelines on low cost, simple and user-friendly mutation detection (http://mvgs.iaea.org/LaboratoryProtocals.aspx). These genotyping and phenotyping protocols are adapted for use by breeders in developing countries and include DNA extraction techniques and simple gel electrophoresis methods as well as seedling salinity screening of rice in hydroponics and soil, and drought tolerance screening. There are also new protocols for irradiation screening and radiosensitivity testing for mutation induction.

Further, this biennium, we provided 10 low cost technology packages for mutation detection to national breeding programmes and other research institutions, the last six months alone three, encompassing low cost, PBGL developed and adapted TILLING kits, including reference DNA and specific protocols and guidelines (learn more about further PBGL activities in this issue).

In line with tradition, we aim to report highlights to you in each volume of our newsletter. One major achievement to single out for the current volume is undoubtedly the promising development reported by participants in the Technical Cooperation project INT/5/150 on 'Responding to the transboundary threat of wheat black stem rust (Ug99)', that ten M_5 resistant lines have been submitted to international yield trials (read the full story inside this issue).

Finally we want to thank you for your continuous support and input as Chief Scientific Investigators (CSIs) in our Coordinated Research Projects (CRPs), counterparts in Technical Cooperation projects (TC), consultants and experts. It is your success story that this biennium 25 new officially released mutant varieties have been added to the Mutant Variety Database (http://mvgs.iaea.org), which now holds more than 3200 entries.

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

Please allow me to take this opportunity to wish you peace, health and prosperity for the year 2012.

May you succeed in all your endeavours!

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[1]	Plant Breeder/Geneticist	s.nielen@iaea.org	21617
Marie Madeleine Spencer	Plant Biotechnologist	m.m.spencer@iaea.org	21623
Yvonne Rosaline Lokko[2]	Plant Breeder/Geneticist	y.lokko@iaea.org	21619
Vacant	Plant Breeder/Geneticist		
Sridhar Dharmapuri[3]	Consultant	s.dharmapuri@iaea.org	26843
Katayoun Allaf	Senior Office Clerk	k.allaf@iaea.org	21621
Mario Dani	Secretary	m.dani@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[4]	Laboratory Head	b.forster@iaea.org	28285
Bradley J. Till	Plant Breeder/Geneticist	b.till@iaea.org	28260
Vacant	Plant Breeder/Geneticist		
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	Attendant	g.seballos@iaea.org	
Anne Lorenz	Senior Secretary	a.lorenz@iaea.org	28274
Joanna Malgorzata Mletzko[4]	Team Assistant	j.mletzko@iaea.org	28362

[1] Joined the IAEA in October 2011
[2] Seperated from the IAEA in December 2011
[3] Seperated from the IAEA in July 2011
[4] Joined the IAEA in September 2011

Let us introduce to you our new Laboratory Head, Mr Brian Peter FORSTER. Brian was born in the United Kingdom (UK), and obtained his BSc in Agricultural Botany from the University of Leeds, England, UK and his PhD in Agricultural Botany from the University of Edinburgh, Scotland, UK. He was employed for more than 20 years by the Scottish Crop Research Institute (SCRI) in various positions with increasing responsibilities as plant breeder/geneticist, interrupted for two times one year as sabbatical leave at the Svaloev Weibull AB (International Seed and Breeding Company), Svaloev, Sweden and as consultant at the FAO/IAEA Plant Breeding and Genetics Laboratory, Seibersdorf, Austria. The last four years, Brian worked as a consultant for Biohybrids International Ltd. (International Consultancy Agency for Plant Breeding/Biotechnology), Reading, UK. In this function, his duty station as a Biotechnology Scientific Advisor was at the Sumatra Bioscience, Bah Lias Research Station, Indonesia. His areas of expertise encompass plant breeding (pre-breeding), crop genetics and enabling technologies (including mutation induction) and seed biology. He is knowledgeable about temperate and tropical cereals (wheat, barley, rye and rice, including landraces and wild relatives), rapeseed (Europe and North America) and tropical plantation crops (oil palm, rubber, cocoa and banana). Brian, thus, has worked closely with plant breeders and has expertise in high-throughput trait selection methods, plant reproductive biology, tissue culture and DNA marker diagnostics. He has published extensively in high standing peer reviewed journals. If you want to contact Brian, please feel free to use the following electronic address: mailto:b.forster@iaea.org

In the same spirit, let us welcome Mr Stephan NIELEN to the Plant Breeding and Genetics Section (PBGS). Stephan was born in Germany and holds First and Master's degrees in Biology and obtained a PhD in Molecular Cytogenetics, Genetics and Plant Biotechnology from the Free University in Berlin in 1999. He was formerly a staff member of PBGL and PBGS (1997–2004) in a very similar position. His research experience extends from the use of molecular cytology and molecular markers in screening for biotic and abiotic stress, to resistance in natural and induced mutagenesis derived populations of a range of plant species including Arachis, Brassica and Musa. He has published in several peer reviewed journals. Since his tenure at the International Atomic Energy Agency (IAEA), Stephan has worked as a consultant for EMBRAPA, Brazil. We welcome back Stephan to our section in Vienna and encourage you to contact him using the following electronic address: mailto:s.nielen@iaea.org

If we had the pleasure to welcome two new colleagues, on the other hand we have to bid farewell to an excellent colleague, Ms Yvonne LOKKO. Yvonne was called to higher duties at the United Nations Industrial Development Organization (UNIDO). Thus she is not leaving the Vienna International Centre (VIC); she is just transferring to the neighbouring tower to perform her new duties. A loss to us, a gain to UNIDO, thus is the balance in the UN family. We wish our dear colleague all the best and success in her new tasks. We are sure that she will be as solid, an asset to UNIDO as she was to us, the Subprogramme of Sustainable Intensification of Crop Production Systems implementation team.

Last but not least, let to the outstanding performance of two of our colleagues in the PBGL, Ms Anne LORENZ and Mr Bradley J. TILL be acknowledged. Both were granted merit awards this year for 'going the extra mile' in the execution of their administrative and scientific duties respectively, implementing their tasks in support of the subprogramme.

Mr Daud Mohamad, Deputy Director General, Department of Nuclear Sciences and Applications, presenting Merit Awards to Mr B.J. Till and Ms A. Lorenz

Forthcoming Events

Planning Meeting of the New TC Regional Project on Support Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change, RAS/5/056, Vienna, Austria, 10–13 April 2012

Technical Officer: P.J.L. Lagoda

The project will provide technical support to enhance national and regional capacities through regional training courses, expert missions and technical meetings. Regional training and information will be provided on the use of technology packages integrating mutation induction and best fit soil and fertigation management practices. This will be distributed at the national level by the national team, who will devise their own national strategies with regard to the institutes, policy makers, extension agencies and farmers. Not only the farming community but also consumers will benefit from the introduction and dissemination of these technology packages, which will enhance ecosystem service efficiency, reduce environmental pollution and reduce costs through improved efficiency. The private sector, who is involved in drip irrigation and fertilizer distribution, will also be engaged.

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

Based on the outstanding success of the previous regional project, several scientists will apply adapted technology packages to improve the so-called 'neglected crops', which in fact are important for food supply and as income generation means for the populations in adverse and marginal regions of the Andes: high altitudes, remoteness and degraded soils.

The project aims to promote the conservation and use of valuable native genetic resources (some of them endangered) while favouring the development of a sustainable agriculture through the use of induced mutant varieties with improved adaptability and agronomic traits. Sixteen countries will be part of this project (Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Mexico, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Paraguay, Peru and Venezuela).

Third and Final Research Coordination Meeting (RCM) on Enhancing the Efficiency of Induced Mutagenesis through an Integrated Biotechnology Pipeline, D2.40.12, Vienna, Austria, tentatively planned for June 2012

Technical Officer: B. Till

Preparations are under way for the third and final RCM of this CRP. The CRP was initiated in 2008, with the first RCM held in May 2009 and the second in December 2010. Participants will present their efforts to develop mutagenesis, phenotypic and genotypic strategies to enhance the efficiency of mutation based approaches for functional genomics and breeding. (See also 'Coordinated Research Projects and Research Coordination Meetings').

Past Events

Group Fellowship on Induced Mutations and Biotechnologies in Plant Breeding, RER/5/013, Ankara, Turkey, 6 June–2 September 2011

Technical Officer: Y. Lokko

The second in the series of group fellowships for counterparts in various IAEA TC projects was organized at the Turkish Atomic Energy Authority, Saraykoy Nuclear Research and Training Center in May–October 2011. The main focus of this training was the use of the basic mutation induction and related techniques for plant breeding. In this series, researchers from countries participating in the Eastern Europe and Central Asia project RER/5/013 from Bulgaria, Moldova, Ukraine, Uzbekistan and researchers from Moi University in Kenya under the TC project KEN/5/029 were trained. The training was provided in the form of formal lectures on mutation induction, tissue culture, PCR based marker systems and cytology as well as practical laboratory and field sessions.

The lectures on mutation breeding also included irradiation dose determination and statistical analysis of data, field observations and individual mutant evaluation, philosophy of mutation breeding studies, tissue culture methods (anther culture, shoot tip culture, callus culture) plus in vitro mutation programmes and genetic identification of mutants by molecular techniques. A range of crops, including tomato, barley, wheat and soybean relevant to the various nations' programmes, were used for radiosensitivity assays.

The candidates were thoroughly tutored on the key steps in tissue culture, such as:

- Determination of ploidy level of microspores under microscope;
- Cold treatment for anthers, preparation of stock solution for BAC in vitro induction media;
- Transfer the anthers from spikes to in vitro nutrient media;
- Incubation of the cultures;
- Plantlet regeneration to transfer the plantlets into fresh media;
- Plantlet transfer to greenhouse;
- Colchicine treatment to double the haploids;
- Chromosome counting to determine the ploidy level of plants;
- In vitro plantlet formation on modified MS media;
- In vitro plantlet irradiation;
- Explant transfer onto proper induction media after irradiation;
- Callus evaluation.

Barley was used for experiments on anther culture and also for in vitro mutagenesis using gamma irradiation, as well as in vitro explants of pepper.

The molecular characterization studies of mutants were carried out by COS II markers for tomato and pepper and SSR markers for soybean. The candidates were given extension lectures and hands on practicals on:

- Seedling production for DNA analysis, DNA isolation;
- Conducting different PCR reactions using SSR markers;
- Electrophoresis;
- Purifying polymorphic DNA fragments;
- Reamplification of isolated DNA fragments;
- Evaluation of the results.

The course director, Dr Yaprak Kadriye Kantoglu, and staff of the Saraykoy Nuclear Research and Training Center are commended for the excellent training provided.

Regional Meeting on Mutation Breeding Technology and Its Socio Economic Impact (ARASIA), RAS/5/048, Muscat, Oman, 10–12 July 2011

Technical Officer: P.J.L. Lagoda

As Oman, a recent member of ARASIA, is developing a mutation breeding programme in wheat with the support of the IAEA and the technical and scientific backstopping of the Joint FAO/IAEA Division, a regional meeting on Mutation Breeding Technology and its Socio Economic Impact was held at the Ministry of Agriculture and Fisheries in Muscat, Sultanate of Oman, 10–12 July 2011, under the project RAS/5/048.

The meeting was attended by 22 participants from seven target countries of the project (Iraq, Jordan, Lebanon, Oman, Saudi Arabia, Syrian Arab Republic and Yemen). Representatives from the Ministry of Agriculture and Fisheries also participated in the meeting.

The regional meeting was declared open by His Excellency, Dr Hamad Bin Said Al-Awfi, Under Secretary of the Ministry of Agriculture and Fisheries (Fisheries Wealth). Dr Ahmed Bin Nasser Al-Bakri, Director General of Agricultural and Livestock Research, welcomed the FAO/IAEA representative and all participants on behalf of the Ministry of Agriculture and Fisheries, Oman.

The purpose of the regional meeting was to exchange experience and data as well as updating knowledge and know-how on mutation induction technology packages integrating mutation induction and efficiency enhancing molecular and biotechnologies plus assessing the socio-economic impact of these in the ARASIA Member States. Lectures and round table discussions included:

- Mutation induction technology packages;
- Ongoing programmes and projects in the region;
- Socioeconomic impact of mutant varieties and cultivars;
- Biosafety of mutation induction and public awareness.

It was concluded that the use of mutation induction for generating useful new germplasm and developing new cultivars is a profitable approach to crop improvement. ARASIA State Parties have recognized the prime importance of developing improved varieties of food crops through the application of mutation techniques. If desired traits are to be enhanced and mutant varieties with high yield, short duration, shatter resistance and stress tolerance are to be developed, it is important that mutant germplasm is generated, identified and made best use of in the set-up of a nationally supported breeding programme. Wheat and barley amongst other crops are the most important contributors to food security and sufficiency in ARASIA Member States participating in this project. It is thus paramount if not mandatory to assess policies concerning the sustainability of breeding programmes vis-à-vis the integration of enhancing technology packages based on mutation induction.

Second Technical Meeting on Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99), INT/5/150, Eldoret, Kenya, 22–26 August 2011

Technical Officer: P.J.L. Lagoda

Since its first detection in Uganda in 1999, the stem rust race Ug99 has spread to many countries on the African continent, the Mediterranean region and some countries in Asia. It has also produced variants, which are virulent to some of the most commonly used stem rust resistance genes.

The spread and virulence of Ug99 has raised concern all over the world and a global initiative, the Borlaug Global Rust Initiative (BGRI), named after Dr Norman Borlaug, has been started to keep track of the spread of Ug99 and breed varieties of wheat with resistance to the newly evolved race of stem rust.

An IAEA interregional TC project INT/5/150 'Responding to the Transboundary Threat of Wheat Black Stem Rust Ug99' was initiated, scientifically and technically backstopped by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, to induce mutations conferring resistance to Ug99 in wheat and barley. Under this project, the member countries are required to select a variety of local significance and mutagenize it using mutagenic treatment (mainly gamma rays) and send the M_2 generation seeds to Kenya for screening. Among the locations which have been identified as hotspot locations, a field at the Chepkoilel University College (Moi University), Eldoret, Kenya has been designated for field screening and also for screening under controlled conditions. Member countries have sent seeds to Eldoret (and earlier to Njoro, Kenya) and screening has been carried out.

The second technical meeting of the project INT/5/150 was held at Eldoret, Kenya from 22–26 August 2011 to observe the populations of wheat plants in the field, to discuss the results of the screening carried out so far as well as the problems encountered and to find solutions. Seventeen countries (Algeria, Australia, China, Egypt, India, Iraq, Islamic Republic of Iran, Kenya, Lebanon, Oman, Pakistan, Saudi Arabia, South Africa, Sudan, Syrian Arab Republic, Turkey and Uganda) were represented in the meeting along with officials from the Joint FAO/IAEA Division.

The meeting was inaugurated by the Deputy Principal of Chepkoilel University College in charge of Administration, Finance and Planning, Prof Jacob Bitok. In his inaugural speech, he stressed the importance of the project to Kenya and to the whole world. He assured all support and cooperation for the project and expressed optimism that resistant varieties will be developed from this project. The Dean, School of Agriculture and Biotechnology, Prof Julius Ochuodho, and the National Liaison Assitant (NLA), Mr Wanama, also expressed their views and optimism about the outcome of the project. Further, given the importance of the project for the world in general and specifically for Kenya, the NLA assured the participants of the support of the Kenyan Government. Mr Qu Liang (Director, Joint FAO/IAEA Division) attended the meeting as an expert.

During the week, workshops were conducted to discuss the work carried out, to plan work for the coming year and to address problems, challenges or issues pertaining to executing the project workplan.

The issue of varieties to be selected as parents was discussed. The choice was left to each member country; however, it is recommended that the pedigree may be checked with authentic sources to avoid two member countries using the same or similar genotypes for mutation induction. The possibility of producing effective new alleles of the existing resistance genes through mutation induction, using parental varieties with known rust resistance gene(s), was also discussed.

There was discussion on the use of inoculum, spreader, tester stocks and other appropriate controls. It was suggested that inoculum with equal proportion of the component races may be used, spreader lines should be planted at a frequency which will ensure spread of the rust and tester lines should be planted to identify the composition of natural/artificial infection. However, it was agreed that under field conditions, comparison of parent, spreader and mutants would be adequate to provide indication of induced resistance in the mutant plants. It was felt that in the M_3/M_4 generations seedling tests under controlled conditions with all controls would be possible.

The issue of population size was discussed and it was recommended that a population size of 10 000 M_2 should be the target to optimize the possibility of identifying a mutant.

The possibility of resistant mutants being sent to countries of origin, other member countries and other interested countries was discussed. Member countries could take the mutants (from their varieties) back to their countries following the applicable phytosanitary and quarantine procedures. Other members could take the mutants under the SMTA or other legally adequate procedures required by their national rules. Where the SMTA is not applicable, a bilateral agreement could enable countries to obtain mutant material.

It was also felt that additional sites should be identified for screening of M_2 or later generation populations. This would cover the possibility of interference of climate, type or composition of inoculum, local stem rusts and diseases other than black stem rust Ug99, which are of significance to the member countries.

Prof Miriam Kinyua, assisted by Mr Ego Kibiwoti Amos (M.Sc. student, contributing to the project), reviewed the progress so far. M_2 and M_3 generation populations have been screened and currently M_4 generations are being raised in replicated design to test for resistance to rust and also possibly for yield and grain quality. The hypersensitive reaction in mutants appeared to reduce the extent of infection.

A total population of 283 660 plants was screened. In M_2 generation 15R, 42MR and 65MS plants were observed. In the M_3 generation there were 5R, 6MR and 11MS. The M_4 population, 22 lines (originating from four countries), was carried forward and the successful confirmation screening for resistance has been carried out using a mixture of the three endemic races at Eldoret.

Regional Training Course on Standardisation of Techniques for Quality Evaluation of Solancaceous Food Crops, RER/5/013, Budapest, Hungary, 5–16 September 2011

Technical Officer: Y. Lokko

Under the regional European TC project, RER/5/013 on ‘Evaluation of Natural and Mutant Genetic Diversity in Cereals Using Nuclear and Molecular Techniques’, the International Atomic Energy Agency, in cooperation with the Government of Hungary through the Central Food Research Institute (CFRI) in Budapest, organized this training course, which was facilitated by staff of the Institute, with Dr H. Daood as the Course Director. Twenty participants from Albania, Bulgaria (3), Croatia, Georgia, Hungary (5), Kazakhstan (3), the Former Yugoslav Republic of Macedonia (2), Poland, Romania, Serbia and Turkey attended the training course.

The objective of the training course was to provide participants with standard protocols in extraction, analysis and screening of carotenoids, tocopherols and flavinoids to facilitate screening of mutant populations with improved levels of these antioxidants.

After the opening ceremony, participants were given a tour of the facilities and different departments of the CFRI. The training course then started with oral lectures on the occurrence, chemistry and principle of recent chromatographic analyses of different antioxidants, such as vitamin C, poly-phenols, carotenoids and tocopherols, the components of vitamin E in different plant crops and animals. This was followed by the experimental part, which included optimisation of sample preparation, HPLC determination and method validation. The intensive practices were extended to a detailed description of spectrum analysis and chromatographic behaviour to be used for the identification of the different compounds, especially the derivatives of the main components, for which standard materials are not often available. Tomatoes, peppers and eggplants were the experimental samples analysed during the course for their content of carotenoids, poly-phenols, vitamin C and vitamin E.

The participants also visited the Agricultural Biotechnology Centre and the Szent-István University in Gödöllő to see the research being carried out on physical and natural mutations, breeding and applications of irradiation in the local gamma field.

At the closing ceremony, participants had the opportunity to exchange opinions, suggestions and ideas for future cooperation between countries in the project. At the end of the training course, the participants were given certificates issued by the IAEA and signed by both IAEA and CFRI.

Third Coordination Meeting on Development and Dissemination of Improved Crop Varieties Using Mutation Induction and Biotechnology Techniques (AFRA), RAF/5/056, Accra, Ghana, 30 October–4 November 2011

Technical Officer: M. Spencer

The main objectives of this meeting were to:

- Review the progress made in the project since the last meeting;
- Review and integrate the individual work plans and needs for a successful completion of the project;
- Identify and discuss measures to ensure sustainable continuation of work after the completion of the project, including exchange of material and information;
- Review and update the Logical Framework Matrix, including activities, training and budget for the new project planned for 2012–2016.

The meeting was opened by Prof B.J.B. Nyarko, Deputy Director of Ghana Atomic Energy Commission, and Dr G.Y. Gomda, Deputy Director of BNARI. They both expressed their thanks to the IAEA for the continuing support to Ghana and the whole African agriculture development in terms of capacity building and infrastructure enhancement. They also warmly welcomed all participants and wished them great success for the meeting.

Mr Eric Cole, Programme Management Officer (PMO) from the Technical Cooperation Department, Africa Section, welcomed the participants as well and highlighted the objectives of the meeting for the next five days. Mr Kenneth Danso, the counterpart from Ghana, proceeded with the introduction of the participants and discussion and adoption of the agenda.

The meeting was attended by nine participants from Benin, Burkina Faso, Democratic Republic of Congo, Egypt, Ghana, Mauritius, Namibia, Senegal and Zimbabwe.

The reports, presented by the participants, contained information covering the following items:

- Progress achieved since 2009 under the project RAF/5/056.
- Present status of the implementation of the work plan as drafted in 2009 in Cameroon for each participating country.
- The continued relevance of the project under their individual government policy.
- Information on the enhancement of the capacity building aspects of the project in each participating country.

Based on the participants' reports and the extensive discussion, several achievements could be outlined:

- Crop germplasm, including several valuable neglected crops such as Colocasia and Chinese yam was collected and maintained.
- Mutation induction and supportive plant biotechnologies were embraced and fully implemented by participating Member States.
- The number of publications was increased.
- Two new mutant varieties for safflowers were released in Egypt: *Inshas10* and *Inshas11*. These varieties could be added to the 12 mutants reported under the TC project RAF/5/056 since 2005.
- Several advanced mutant lines are currently under screening, stabilization and multi-location trials.
- More scientists and/or breeders were trained in mutation breeding, plant tissue culture techniques and molecular characterization techniques.
- Two additional countries joined the project (Benin and Namibia).

Following extensive and very thorough discussions, participants made recommendations to ensure a harmonious and standardized approach for the future:

1. Further efforts should be made by national governments to more aggressively promote the utilization of the products of mutation breeding among major stakeholders including government officials, private sector, NGOs and farmers.
2. Socioeconomic and market studies, to provide bases for the assessment of the impact of released mutants in the farming systems and economy, should be conducted.
3. Sources of extra-budgetary funds should be investigated for such studies.
4. Provision of adequate support and incentives to retain trained staff should be envisaged.

5. Adoption of the SMTA protocol should be encouraged in participating countrie (http://mvgs.iaea.org/).
6. The number of crops entered in the RAF/5/056 project should be limited according to the level of capability of participating countries.
7. Interaction between participating countries should be strengthened through exchange of protocols, guidelines and the organization of sub-regional workshops. The initiators and host principal investigators (PIs) should take the lead in the implementation of this initiative.

The objectives of the meeting were fully accomplished. National profiles were updated for RAF/5/056 and achievements extracted. All national counterparts, present at the meeting, agreed to the work plan for 2012–2016 under the new regional TC project RAF/5/066 and committed themselves to achieve their roles, so that the expected outcomes of the project will be attained in each participating Member State.

Fourth Coordination and Steering Meeting on Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99), INT/5/150, Vienna, Austria, 21–25 November 2011

Technical Officer: P.J.L. Lagoda

For the fourth Coordination and Steering Meeting of INT/5/150, 15 national coordinators from Algeria, China, India, Islamic Republic of Iran, Iraq, Jordan, Kenya, Pakistan, South Africa, Saudi Arabia, Syrian Arab Republic, Tunisia, Turkey, Uganda and Yemen met at IAEA headquarters in Vienna, to discuss the future developments of this successful endeavour.

Consolidation and harmonization of cooperation between the IAEA and its partners, i.e. Member States, CIMMYT, ARS (Agricultural Research Services of the USDA), BGRI, CAAS (Chinese Academy of Agricultural Sciences), BARC (Bhabha Atomic Research Centre, India) ICARDA, the International Treaty on Plant Genetic Resources for Food and Agriculture and the Western Australian Department of Agriculture and Food of the Government of Western Australia, was one of the foci of this meeting

The objectives of the meeting included a full progress evaluation (activities planned and accomplished; identification of bottlenecks and planning of the way forward). Evaluated mutant germplasm was discussed and the project strategy consolidated.

One of the highlights worth mentioning is the submission of 10 M_5 black stem rust disease (Ug99, three most virulent strains) resistant wheat mutant lines (three major and seven minor gene resistance types) to international yield trials. (Detailed information on this Technical Meeting can be found under 'Past Events').

Regional Meeting of Project Counterparts, Stakeholders and End Users on Evaluation and Utilization of Natural and Mutant Cereals Germplasm, RER/5/013, Vienna, Austria, 7–8 December 2011

Technical Officers: Y. Lokko and S. Nielen

This project, initiated in the 2007/2008 TC cycle, arose from the fact that cereals make up the most important component of the daily human diet and have, therefore, been a subject of extensive studies aimed at improving their agronomical characteristics. While cereals are the most important grain crops in south-east Europe, their production is greatly affected by various biotic and abiotic stresses, particularly drought. New varieties with enhanced tolerance to drought stress are in high demand to ameliorate cereal production in the affected areas; however, due to the complex nature of drought and its effect on various physiological activities of plants, development of drought tolerance has been hampered by the lack of necessary knowledge of biological control as well as methods and techniques that can be efficiently used in breeding programmes in developing countries. The objective of this regional project was to evaluate and increase genetic diversity in major cereals using nuclear techniques, molecular genetics and biotechnology.

For the 2009–2011 TC cycle, a second project on evaluation of natural and mutant resources for increased phytonutrient levels in solanaceous food crops was incorporated into this project with a proposition to include vegetable crops and potato. During the project design stage, it was decided that this project be included in the existing project RER/5/013 as a new component with separate funding and participating counterparts.

In the third quarter of 2010, coordination meetings for the two components were held in Ohrid, the Former Yugoslav Republic of Macedonia (for the cereals group) and at IAEA headquarters in Vienna, Austria (for the solanaceae group), to discuss major achievements and agree on key activities for the final year of the project. Both meetings revealed that significant progress has been made in most of the actively participating countries in achieving the project objectives. As a follow-up, this regional stakeholders meeting with participants from both components of the project was organised. The main purposes of the meeting were:

- To review the overall achievements by individual countries and by the Region as a whole since 2007;
- To review remaining challenges and emerging areas to be addressed by the RER/5/013 consortium;
- To identify and discuss measures to ensure sustainable continuation of work after the completion of the project, including exchange of material and information with end users in the region.

Project counterparts from Albania (3), Bulgaria (2), Croatia, Hungary (2), Kazakhstan, the Former Yugoslav Republic of Macedonia (2) Moldova, Ukraine (2), Poland, Serbia, Romania, Turkey and Uzbekistan and stakeholders from Bulgaria, Georgia, Montenegro, Portugal participated in the meeting, which was facilitated by IAEA staff, Ms Alessia M. Roderiguez Y Baena (Europe Section, TC), Ms Yvonne Lokko and Mr Stephan Nielen (Plant Breeding and Genetics Section) and Ms Hafiz Muminjanov, FAO Sub-regional Office for Central Asia (SEC), Ankara, Turkey.

Following participants' presentations on the status of the work done in their respective countries since the last meeting, particularly in developing new mutant germplasm of the target crops — wheat, maize, barley, chickpea, soybean, tomato, pepper, eggplants and potato — the group evaluated the achievements from each country in contributing to the expected outputs of the project to date and brainstormed on modalities for the continuation of the work of the consortium from 2012 onwards.

We, in the Plant Breeding and Genetic Section, would like to thank all our counterparts of the project RER/5/013 for the work done in the last five years.

First Research Coordination Meeting (RCM) on Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments, D1.50.13, Vienna, Austria, 12–16 December 2011

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

Twelve scientists from ten Member States (Bangladesh, Indonesia, Kenya, Malaysia, Mexico, Pakistan, Peru, South Africa, Uganda and Vietnam) were invited to attend the first Research Coordination Meeting in Vienna. The objective of the meeting was to revise the annual work plans and to harmonize the Coordinated Research Project's activities.

As the world population is expected to exceed nine billion by 2050 (37% increase over the current population) a more than 50% increase in food production will be required to meet the demands of the growing population. For example, it has been estimated that 100 million tonnes more rice (paddy) need to be produced annually for every one billion people added to the global population with less land, water and labour available. Such an increase needs to be achieved through crop intensification in production systems that are more resilient to climate change and contribute less to greenhouse gas emissions. Only 12% of the future increase in arable land in developing countries can be achieved through area expansion without high environmental costs. Also climate induced temperature increases are projected to reduce global agricultural production by 20–30%. Existing disparities in crop production between the developed and developing countries are estimated to grow in the future. Decreases in production lead to increases in prices (by 25–150%) and in hunger by 10–60%. In addition to climate change, drought, soil characteristics (acidity and salinity) and nutrient deficiencies are major constraints to agricultural production in Asia, Africa and Latin America.

In upland and rain-fed lowland rice production areas of Asia, drought is a major problem and is the most important abiotic stress for wheat in central Asia and West Africa. High temperature accounts for a significant proportion of wheat yield decrease under delayed sowing (1–1.5% per day after November 30) in South Asia. Recent droughts in Australia and the Southern USA also contributed significantly to reduced agricultural productivity.

A large part of agricultural upland soils in South-east Asia (China, Indonesia, Malaysia, Vietnam and Thailand) and the Indian subcontinent have soil acidity problems leading to aluminium toxicity in soils, which is detrimental to root systems of rice, wheat and maize affecting nutrient uptake from soil. This results in decreased grain yield and above ground biomass. Similarly, agricultural productivity in lowland dry savannahs of sub-Saharan Africa is also affected by soil acidity.

Soil and water salinity is widespread across the arid and semiarid regions of South Asia, Central Asia, the Arabian Peninsula and North Africa and affects agricultural productivity and livelihood of rural population. The last two decades or so have witnessed a sharp increase in losses of agricultural land to soil salinity. In arid regions with low rainfall and poor internal drainage, irrigation induced soil salinity is a major issue affecting crop production.

For arid and semiarid regions, particularly for the Sahel, nutrient limitations set a stronger ceiling on yield than water availability. In much of Africa fertilizer usage is low, at only nine kilograms of nutrients per hectare in sub-Saharan Africa compared with 73 kilograms in Latin America, 100 kilograms in South Asia and 135 kilograms in East and South-east Asia.

Thus the opportunities to increase yields in many regions of Asia, Africa and Latin America are high. The extremely low yields in West African rainfed agriculture, due to limited availability of nutrients, could be increased with improved mutant crop varieties, combined with improved soil fertility and water management. The soil and water salinity problems in Asia and Africa can be better addressed through using improved mutant crop varieties tolerant to salinity with better agronomic practices. With improvements in soil fertility and management of water to reduce evaporation and divert more flows to transpiration, yields may be tripled.

The IAEA has been involved in developing improved crop varieties that are tolerant of environmental stresses. In Asia, salt tolerant rice, mustard and tomato, soybean, wheat and rice varieties that are efficient users of nitrogen fertilizer under water stress; wheat, potato and banana varieties that are tolerant to pest and rust disease for

Africa, improved varieties of cereals and legumes (e.g. quinoa, lupins) native to South America and crops that are suitable for Andean mountains (extreme temperatures) have been developed. However, it is important to evaluate the performance of these improved crop varieties under existing field conditions in different agroecological zones using best fit soil, water and nutrient management technologies and practices to improve yield, water and nutrient use efficiencies.

A suite of nuclear and isotopic techniques, such as soil moisture neutron probe and stable isotopes of ^{15}N and ^{13}C, are important for agricultural water management to improve water and fertilizer use efficiencies. Without the use of nuclear and isotopic techniques, processes and pathways of water and nitrogen within the soil-plant system remain uncertain and difficult to establish.

The outputs of the CRP will contribute to the FAO and IAEA strategic objective of supporting sustainable land and water management for food and agriculture and to achieve the United Nations Millennium Development Goals for food security and environmental sustainability. The research objectives and expected project outputs are highly relevant to Member States with a need to develop strategic plans for increasing food production and environmental protection in a changing climate and with increasing population.

Consultants Meeting on Assessing and Enhancing Soil Plant Resilience to Climate Change Conditions for Sustainable Food and Biomass Production, Vienna, Austria, 12–16 December 2011

Technical Officer: B.P. Forster

Four consultants from Australia, Austria, Kenya and Indonesia met in Vienna with three FAO expert colleagues in Plant Production and Protection, Animal Production and Health and Good Agricultural Practices for a consultants meeting. The purpose of this meeting was to bring together experts to help us initiate a five year CRP on nuclear technologies for Assessing and Enhancing Soil Plant Resilience to Climate Change Conditions for Sustainable Food and Biomass Production. The consultants discussed the intersection of food and feed: a large part of residual food crop biomass, yet poorly usable for husbandry, could be used as fodder and thus improve biomass productivity. Mutant cultivars for improved fodder, i.e. the use of appropriate mutants in breeding, would have beneficial effects on animal nutrition, but may have knock-on effects on soil fertility.

The focus should be on barley as a model with an expansion to sorghum and potentially other fodder crops. In addition to being an important crop for human food production, barley is an important feed crop for a wide range of animals (sheep, goats, cows, pigs). Barley is fed to animals as seed, green foliage and as hay and silage. The awns of barley are a major problem with respect to feed quality. Awns are abrasive organs that protrude from the ear and act to protect the seed. Awns contain silica bodies and barbs and have no nutritional value. Furthermore they cause lacerations in the mouths of animals and reduce consumption by livestock. Barley is also a model crop/genetic species in which accelerated breeding for desired genotypes may be developed, e.g. in the rapid transfer of mutant traits into Member State breeding materials.

The most important traits in barley forage quality are yield and the elimination of the awn. However, in breeding for fodder quality for developing Member Sates information is needed on what stage or stages of the barley crop are used as feed for livestock, e.g. in Australia barley is usually harvested 10–14 days after heading for hay or silage.

The USA is the most advanced in mutation breeding for barley fodder, In North Dakota mutant lines have been exploited to produce high yielding awnless and hooded fodder cultivars. Attempts are now under way to breed similar cultivars in Australia. To date the potential of barley mutants has not been fully realised, especially for developing countries. In addition to awnless and awn replacement (hooded) mutants there are several other mutants that have potential in improving the quality of barley fodder. These include: awnless (*Lks*1), hooded (*Kap*1), low lignin (*rob*1), high anthocyanin (*Blp*1, *Pre*2.), multi-noded (*mnd*1, *mnd*6), fragile stem (*fst*1), high lysine (*lys*).

We propose to exploit mutants available in the Bowman backcross derived lines and other mutant barley germplasm to deliver these to Member State barley fodder breeders. Many of the mutant genes are available in elite genetic backgrounds, but may be produced by mutation induction directly in local MS cultivars. In barley the main objective is to gather these desired mutants together in locally adapted material in Member State countries as fast as possible.

Sorghum in addition to its use in human food production is much preferred to maize as a forage crop in some regions. There are two types of forage sorghum: 1) the silage type (tall material for one cut fodder/immature grain production) and 2) sudangrass (for grazing and/or hay production). More research on fodder quality has likely been done in sorghum than barley and sorghum does have brown midrib mutants (low lignin, similar to *rob*1 of barley). The advantage of sorghum over maize and barley is in part related to drought tolerance, especially in hot environments, and brings in a different spectrum of countries/regions.

Both barley and sorghum have mutant stocks and many traits associated with molecular markers. However, speed breeding (four or more generations per year when grown under constant light) can be applied more readily to barley. Thus, barley could provide a model in which breeding results can be achieved in a shorter time frame. The development of a strategy for forage breeding is dependent on the current status of genetic resources and ability to establish rapid field evaluation programmes in target countries. Results of breeding need to be validated in animal health and nutrition studies. Any impacts on animal wastes need to be evaluated in terms of soil fertility.

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
	New CRP starting in 2011	
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

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

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

After a successful pilot phase in 2010, the CRP was launched in 2011 and the first RCM was organized in Vienna, 12–16 December 2011. The pilot phase encompassed technical contracts, to test the concept of integrated technology packages of mutation induction and efficiency enhancing biotechnologies, combined with nuclear technology based best fit soil and water management practices. The purpose of this pilot phase was to assess the different components of the planned CRP including the distribution of mutant varieties, locally establishing best fit soil and water management practices and farmer participation.

Current concerns about the increasing global population and the impacts of climate change and climate variability on agriculture highlight 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. Improved crop varieties tolerant to environmental stresses (extreme temperature, drought, salinity and disease) have been developed under IAEA project 2.1.1.3 on 'Crop Improvement for High Yield and Enhanced Adaptability to Climate Change'. Similarly through IAEA project 2.1.1.2 on 'Technologies and Practices for Sustainable Use and Management of Water in Agriculture' improved soil-water-nutrient management technologies were developed and/or adapted. Integrated technology packages and capacity were developed in Member States to use these, yet, the end-users, smallholder farmers, will have to adopt these for optimal efficiency. 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 field demonstration set ups and farmers' capacity development, in order to increase sustainable crop productivity in harsh environments and resource use efficiency.

In selected countries from Asia, Africa and Latin America (Bangladesh, Pakistan, Mexico, Peru, Kenya, Vietnam, Uganda and South Africa), identified as part of a pilot phase study using nuclear techniques, resources were and are being assessed, in order to define and adapt best fit soil and water management practices depending on the available mutant varieties to be extended. Demonstration field studies support farmers' field days, in which smallholder farmers are informed of the availability of the specific technology packages. Improved seeds are being multiplied for distribution to famers.

Performance indicators for the project include the number of farmers adopting the technology packages, acreage of mutant varieties used and possible effect on livelihoods through socioeconomic data.

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

Technical Officer: S. Nielen
Former Technical Officer: Y. Lokko

Food security, nutrition and health are key issues in the national agenda of government planning in many countries in the world. In addition to forming the major components of human diets, providing the required calories and nutrients to sustain life, edible crops also contain most of the essential vitamins and minerals required to prevent common micronutrient deficiency disorders. As the major staple crops are often deficient in some of these vitamins and minerals, in many areas of the world the basic monotonous diet does not provide them in sufficient quantities. Thus, malnutrition, with respect to micronutrients like vitamin A, iron and zinc, affects >40% of the world's population. It is estimated that, of the seven billion people in the world, 60–80% are Fe deficient, over 30% are Zn deficient and certain social groups do not receive sufficient Ca and Mg in their diets. Biofortification, which is defined as enriching the nutritional properties of edible crops, can be achieved through the combination of agronomy and plant breeding. An essential requirement for plant breeders to develop nutrient rich crops is the availability of suitable germplasm with the desired traits. Among the tools available to plant breeders, mutation induction is highly efficient in altering the genetic constitution of plants, creating a wealth of genetic variability including desirable changes in nutrient content and composition.

Over the years, mutant resources in crops, such as barley, rice and tomato with a wide range of variation in traits such as starch quality, fatty acid composition and concentration of essential minerals, vitamins and beneficial compounds (carotenoids and tocopherol) have been developed. Recent advances in molecular biology, which have allowed investigations of whole genomes by integrating genetics with informatics and automated systems, have provided insight into nutritional target traits by identification of key genes in their biosynthetic pathways.

This CRP aims at exploiting mutant collections in selected model crops (a short season crop, with a large collection of well characterized mutants and advanced genomic resources), integrating tools from genomics, providing resources and delivering solutions to Member States, to facilitate breeding for improved nutritional quality of food crops. Both, the resulting genetic resources and the methodologies for identifying them, constitute the main expected outputs from this proposed CRP.

The first RCM was held at IAEA headquarters in Vienna, Austria, 29 June–3 July 2009. The main purposes of the meeting were: i) to discuss and plan the future research activities of the CRP, ii) to review the individual work plan and adjust/increase activities, where necessary, to lead to the outputs of the CRP. Eleven research contract holders from Botswana, Bulgaria, China, Ghana India (2), Kenya, Peru, South Africa and Ukraine and four research agreement holders from Denmark, Germany, the United Kingdom (UK) and the USA attended the meeting. During the first RCM, it was agreed that the CRP should focus on improving nutrient quality in elite varieties of six food security crops (groundnut, wheat, rice, soybean, barley, sweet potato, with support (mutants and techniques) from the solanaceous food crops (potato, tomato and pepper), sugar beet and *Brachypodium.* Between the original proposal submitted in 2007 to date, there has been a wealth of genomic information generated in several crop species including the target crops. The original intention to extrapolate information from model crops into the target crops is now being complemented with direct information from target crops in the CRP. There was also a general consensus during the first RCM to slightly modify the title of the CRP to accurately reflect the project objectives. The suggested title agreed upon was 'Improving Quality of High Yielding Crops for a Changing Climate, by Altering Concentrations of Nutritional Factors Using Induced Mutation and Biotechnology'.

The second RCM of this CRP was held in Pretoria, South Africa, 11–15 April 2011 in collaboration with the Agriculture Research Council, Vegetable and Ornamental Plant Institute (ARC-VOPI). The meeting was attended by 10 research contract holders from, Botswana, Bulgaria, China, Ghana India (2), Kenya, Peru, South Africa, Ukraine, three research agreement holders from Denmark, Germany, the United Kingdom and three researchers from the host institution and Ms Yvonne Lokko, the technical officer of the project. Participants presented results with significant progress, discussed modalities for dissemination of protocols and results within the project and continued to ensure that the CRP achieved its expected objectives and outcomes. The next RCM is scheduled to be held in Hangzhou, China, 15–19 October 2012.

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.

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

Technical Officer: B. Till

This CRP aims to develop and adapt technologies and strategies to increase the efficiency of mutation based approaches for functional genomics and breeding. A 'modular pipeline' concept is employed whereby nuclear techniques and other enabling methods are treated as modules that can be combined in an efficient path towards the development of novel traits. Modules include phenotyping, the development of suitably mutagenized and sized populations for both forward and reverse-genetics, dissolution of chimeric sectors, the development of TILLING reverse-genetics platforms for vegetatively propagated species, and investigations into novel technologies for mutation discovery and characterization. The four target crops chosen for this CRP are banana, barley, cassava and rice. Specific constraints for each crop are used to fuel technology adaptation. For example, traditional mutation based approaches for banana improvement involves extensive tissue culture manipulations to generate plantlets that are devoid of chimeric sectors that occur upon mutagenesis of multi-cellular tissues. This CRP seeks to evaluate and develop a platform for mutagenesis of cell suspensions. After mutagenesis of suspensions, a single cell can divide and form a whole plant that may be devoid of chimeric sectors. Such a platform would represent a major efficiency gain. Advanced mutation discovery technologies are also being evaluated. Such methods can provide information on mutation densities and spectra enabling a precise estimation of the population size and mutagenesis dose needed for a high probability of recovering useful alleles. 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 and the second RCM was held in Vienna from 13–17 December 2010. The third RCM is scheduled for the summer of 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 USA), who were invited to present their work in the concurrent session number two of the International Symposium on Induced Mutations in Plants (ISIMP, Vienna). 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 USA (2), participated in this RCM. The second RCM was held in Vienna, Austria, 30 May–3 June 2011. The CRP is progressing well and the milestones reached already hint at some future exciting developments, such as 50 identified and catalogued mutant lines in rice (phenotypes and homologies in Arabidopsis and other plant species were mined), potentially harbouring genes involved in DNA damage response and repair. These lines will be the basis for further gene discovery and gene function analyses. The gene responsible for the 'mutator' syndrome in genetically unstable mutants (GUMs), inducing narrow spectra of cytoplasmically inherited mutants, from the barley chloroplast mutator genotype is bound to be 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. Another potentially workable way to increase the efficiency of mutation induction in barley is to make good use of the fact that in barley seedlings photorepair is the main mechanism efficiently removing cyclobutane pymidine dimers (CPD) from both total genomic DNA and ribosomal genes. Acute exposure to short wave UV irradiation induces oxidative DNA damage in barley seedlings. Under dark recovery conditions, no repair of oxidative DNA damage occurs in the differentiated leaf cells up 24 hours after irradiation. Thus, in UV-C irradiated barley leaves, incubated in darkness, there seems to be no alternative repair mechanism for CPD removal able to compensate for the lack of photoreactivation.

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 **NEW**	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 **NEW**	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 **NEW**	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
BOL/5/018	Bolivia	Enhancing Food Security Using Conventional and Nuclear Techniques for the Acquisition of Climate-Change Tolerant Commercial Potato Seed	M. Spencer/S. Nielen
BOT/5/009 **NEW**	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/5/003	Central African Republic	Development of New Varieties of Cassava Through Mutation Breeding and Biotechnology Techniques	M. Spencer/B. Till
CAF/5/006 **NEW**	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/5/023	Colombia	Enhancing Mutagenesis and Biotechnology Used in the Improvement of Rice	B. Till/S. Nielen
COL/5/024 **NEW**	Colombia	Supporting Mutagenesis and Functional Genomics Applied to 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

Project Number	Country	Title and Objective(s)	Technical Officer
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 **NEW**	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/5/035	Indonesia	Application of Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	B.P. Forster/M. Spencer
INS/5/036 **Awaiting Financing**	Indonesia	Genetic Improvement of Artemisia Cina Using Irradiation Technique	B.P. Forster/M. Spencer
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
INS/5/038	Indonesia	Using Induced Mutations to Improve Rice Productivity through a Hybrid Rice Breeding Programme	B.P. Forster/M. Spencer
INS/5/039 **NEW**	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 **NEW**	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
JAM/5/010	Jamaica	Plant Breeding and Diagnostics Technologies	S. Nielen/M. Spencer
KAZ/5/002	Kazakhstan	Improving Wheat and Maize Using Nuclear and Molecular Techniques	S. Nielen/P.J.L. Lagoda
KAZ/5/003 **NEW**	Kazakhstan	Increasing Micronutrient Content and Bioavailaility in Wheat Germplasm by Means of an Integrated Approach	S. Nielen/P.J.L. Lagoda
KEN/5/029	Kenya	Developing Appropriate Artemisia Varieties for Management of Malaria	M. Spencer/S. Nielen
KEN/5/032 **NEW**	Kenya	Characterising and Improving Germplasm of Selected Crops at the Molecular Level Using Nuclear and Biotechnology Techniques	P.J.L. Lagoda/B. Till

Project Number	Country	Title and Objective(s)	Technical Officer
LES/5/001 **NEW**	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 **NEW**	Madagascar	Strengthening Food Security	M. Spencer/B.P. Forster
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	S. Nielen/B.P. Forster
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 **NEW**	Malaysia	Applying Mutation Breeding and Optimized Soil, Nutrient and Water Management for Enhanced and Sustainable Rice Production	S. Nielen/M. Spencer
MAR/5/020 **NEW**	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 **NEW**	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
MOR/5/033 **NEW**	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 **NEW**	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	M. Spencer/S. Nielen in collaboratin with Soil and Water Management and Crop Nutrition Section
NAM/5/010 **NEW**	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)	M. Spencer/S. Nielen
NEP/5/001 **NEW**	Nepal	Improving Nepalese Cardamom Using nuclear and Molecular Techniques	S. Nielen/B.P. Forster

Project Number	Country	Title and Objective(s)	Technical Officer
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
NER/5/015 **NEW**	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
PAK/5/044	Pakistan	Improvement of Drought Tolerance in Chickpea Through Induced Mutations	B. Till/S. Nielen
PAK/5/047 **NEW**	Pakistan	Developing Germplasm through TILLING in Crop Plants Using Mutation and Genomic Approaches	B. Till/S. Nielen
PAL/5/005 **NEW**	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	M. Spencer/S. Nielen
RAF/5/066 **NEW**	Regional Africa	Improving Crops Using Mutation Induction and Biotechnology Through a Farmer Participation Approach (AFRA)	M. Spencer/S. Nielen
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
RAS/5/048	Regional Asia	Mutation Induction and Supportive Breeding and Biotechnologies for Improving Crop Productivity (ARASIA)	P.J.L. Lagoda/B.P. Forster
RAS/5/056 **NEW**	Regional Asia	Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change	S. Nielen/P.J.L. Lagoda
RAS/5/058 **NEW**	Regional Asia	Supporting Mutation Induction and Supportive Breeding and Biotechnologies for Improved Wheat and Barley – Phase II	P.J.L. Lagoda/B.P. Forster
RAS/5/064 **NEW**	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 **NEW**	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/5/013	Regional Europe	Evaluation of Natural and Mutant Genetic Diversity in Cereals Using Nuclear and Molecular Techniques	S. Nielen/P.J.L. Lagoda
RER/5/017 **NEW**	Regional Europe	Enhancing Productivity and Quality of Major Food Crops	S. Nielen/P.J.L. Lagoda

Project Number	Country	Title and Objective(s)	Technical Officer
RLA/5/056	Regional Latin America	Improving Food Crops in Latin America though Induced Mutation (ARCAL CV)	M. Spencer/S. Nielen
RLA/5/063 **NEW**	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/5/030	Senegal	Integrated Approach to Develop Sustainable Agriculture in Senegal	M. Spencer/S. Nielen in collaboration with Soil and Water Management and Crop Nutrition Section
SEN/5/032	Senegal	Improving the Productivity of Jatropha Curcas Plantations in Semi-Arid Areas	M. Spencer/S. Nielen
SEN/5/034 **NEW**	Senegal	Using an Integrated Approach to Develop Sustainable Agriculture in a Context of Degrading Soil Fertility, Climate Change and Crop Diversification	M. Spencer/S. Nielen
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	M. Spencer/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
SUD/5/033 **NEW**	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	M. Spencer/P.J.L. Lagoda 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/5/024	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	M. Spencer/P.J.L. Lagoda
URT/5/026	United Republic of Tanzania	Improving Rice Varieties through Mutation Breeding and Biotechnology in Zanzibar	M. Spencer/S. Nielen
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)	S. Nielen/P.J.L. Lagoda
YEM/5/008	Yemen	Introduction of Gamma Ray Irradiation Techniques for Agriculture Purposes	S. Nielen/P.J.L. Lagoda

Project Number	Country	Title and Objective(s)	Technical Officer
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 **NEW**	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/B.P. Forster
ZAM/5/026	Zambia	Improving Crop Varieties through Use of Nuclear Techniques	M. Spencer/P.J.L. Lagoda in collaboration with Soil and Water Management and Crop Nutrition Section
ZAM/5/027 **NEW**	Zambia	Developing Maize Genotypes for Drought and Low Soil Fertility Tolerance	M. Spencer/P.J.L. Lagoda 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 **NEW**	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 2011

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
ECU/5/023	Ecuador	Inducing Mutations in Agriculture with the Aid of Radiation	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
PER/5/030	Peru	Genetic Improvement of Quinoa and Kiwicha Using Mutation Induction and Biotechnology	Y. Lokko
SAF/5/010	South Africa	Development of New Maize and Sorghum Germplasm with Enhanced Nutritional Content	Y. Lokko
TUN/5/023	Tunisia	Radiation-Induced Mutations for Improvement of Cactus	M. Spencer
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

News

Development and Dissemination of Improved Crop Varieties Using Mutation Induction and Biotechnology Techniques, RAF/5/056

Professor Abdel Shafy Ibrahim Ragab from Egypt reports the release of a new spineless mutant variety of safflower (*Carthamus tinctorius*) with increased yield, high oleic acid content and resistance to leaf spot disease and tunnel insect transmitted diseases as well as its adaptability throughout the country.

Safflower (*Carthamus tinctorius*) is a flower used by the ancient Egyptians for dying and for medicinal uses. It is also known as false saffron, American saffron or dyers' saffron. Its Arabic name is Usfor or Asfor (meaning yellow, or the color yellow). It is a native of the mediterranean region. The main active ingredient in safflower medicines is safflower yellow, which is water soluble. The orange-red flowers of safflower sometimes serve as a substitute for saffron, since they give a (rather pale) colour to the food. Safflower supplies oil, meal, birdseed, and foots (residue from oil processing) for the food and industrial products markets. Safflower oil, rich in linoleic acid (an essential fatty acid), is commonly used in cooking to aid in lowering cholesterol. The oil also contains a high concentrate of polyunsaturates, which provide the raw material for prostaglandins, the hormone-like substances that function in cell membranes and molecular regulation. The flowers are considered as diaphoretic (taken hot, safflower tea produces strong perspiration and has thus been used for colds and related ailments), emmenagogue (stimulating blood flow in the pelvic area and uterus), and in large doses laxative (taken as an infusion). The flowers are sometimes used in children's and infants' complaints, such as measles, fevers, and eruptive skin problems. It has also been used at times for its soothing effect in cases of hysteria. Safflower blossoms are used in a tea form to treat hysteria, fevers, phlegm, and panic attacks. It is a pretty strong cathartic, and also clears the lungs and helps the phthisis.

Developments at the Plant Breeding and Genetics Laboratory, Seibersdorf

Introducing a new head of the Plant Breeding and Genetics Laboratory, Seibersdorf

The Plant Breeding and Genetics Laboratory (PBGL) has a new face Brian P. Forster was appointed Head of PBGL in September 2011. It is therefore appropriate to introduce Brian to our readership. Brian's academic record includes a BSc in agricultural botany (University of Leeds, UK, 1979) and a PhD on early seed development in barley and rye and their hybrids (University of Edinburgh, UK, 1982). This was followed by post-doctoral studies in tissue culture (University of Saskatchewan, Canada) and wheat/alien chromosome engineering (Plant Breeding Institute, Cambridge, UK in collaboration with CIMMYT, Mexico). In 1987 he took up a position as Cytogeneticist at the Scottish Crop Research Institute and became acting head of the Cell and Molecular Genetics Department in 1991. Brian's career included sabbaticals in Svalöv, Sweden (head of genetic markers in breeding and seed production), CSIRO, Canberra, Australia (genetics and physiology of salt tolerance) and the Plant Breeding Unit, IAEA, Austria (mutation breeding). In 2007 he became a consultant for BioHybrids International with a major commitment in developing methods for F_1 hybrid breeding in oil palm. His areas of expertise include: 1) plant breeding, pre-breeding and their enabling technologies (e.g. doubled haploidy, marker assisted selection and accelerated breeding); 2) reproductive biology; 3) crop genetics; and 4) high throughput genotyping and phenotyping.

Whilst working on barley at SCRI Brian discovered pleiotropic effects of the induced mutant dwarfing gene in Golden Promise barley on salt and drought tolerance. This inevitable brought Brian in contact with the IAEA. Since then he has had numerous involvements with the IAEA, including teaching on training courses, expert missions, joint projects and joint publications, e.g. 'Mutant Germplasm Characterization Using Molecular Markers – a Manual', 'Doubled Haploid Production in Crop Plants – a Manual', and the book 'Plant Mutation Breeding and Biotechnology'.

Brian has worked on a number of crops including temperate and tropical cereals (wheat, barley, rye and rice), rapeseed (Europe and North America), and tropical plantation crops (oil palm, rubber, cocoa and banana). Brian will be familiar to many European breeders through his role as chairman of the EU COST action on: 'Gametic cells and molecular breeding for crop improvement' (2001–2006, involvement of 26 European countries) and will be familiar to many Member State participants of IAEA/FAO training courses in which Brian has been involved. His international projects have included salt and drought tolerance (Kuwait, North Africa and Pakistan) F_1 hybrid breeding (Indonesia, UK and Zambia) and germplasm conservation (Ghana and South Africa). Most recently, he has been involved in pioneering work in Indonesia on the production of haploids and doubled haploids in oil palm, which has paved the way for F_1 hybrid cultivars in this crop. In many of these projects success has been achieved through the application of nuclear techniques.

Brian tells a story of his early days as a young post-doc whilst visiting CIMMYT, Mexico. He was up early one morning in preparation for trip to field trials and was having breakfast in a deserted canteen when a stranger came up and sat down beside him. The stranger quizzed him on what he was doing at CIMMYT. Full of enthusiasm he espoused the virtues of chromosome engineering and how he was going to solve the world's food problems by introducing genes into wheat from alien species for salt tolerance and disease resistance. Whilst in full swing a third person arrived in the canteen shouting 'Norman, Norman there you are ….we have to go.' and the young post-docs jaw dropped. Just before leaving the stranger had some encouraging words but with the caveat:

'…. it means nothing until it is tested in the field.'

Norman Borlaug

These words from the 'father of the Green revolution' and 1970 Nobel Peace Prize laureate have remained etched in Brian's work ethic.

Resurgence of mutation breeding

Mutation breeding has a great history and an equally bright future. The FAO/IAEA database now lists over 3200 officially released cultivars in over 200 plant species. This, however, is a huge underestimate as:

1. In many countries breeders are not required to provide pedigrees of their newly released cultivars, and information gathered on cultivars carrying mutant genes is largely based on volunteered information.
2. Most modern mutant cultivars are not direct mutants, but a product of additional breeding. In general, breeders are not particularly interested in the source of the variation and mutated lines, like other genetic stocks, are considered as basic, raw materials. Once a mutation for an important trait is captured and used over many years its novelty/origin is often lost, ignored or forgotten and often not reported.
3. Mutation breeding is often a collaborative venture among institutions worldwide. Issues in international politics, protectionist policies, plant breeder's rights,

ownership of materials, patents and profit sharing often contrive to promote individual interests and often cloud the source of variation.

4. Economically important mutants can arise as bi-products of more basic research and not directly from a deliberate mutation breeding programme.

5. There is a concern in some countries that mutations may be (but wrongly) defined as GMOs (genetically modified organisms, a term applied to transformation events).

6. Producers are often reluctant to advertise the use of mutants because of (often missguided) public/consumer perceptions.

Nevertheless, some 142 new cultivars carrying mutated genes were added to the mutant variety data base this year, testament to thriving global mutation breeding programmes (http://mvgs.iaea.org).

There is no doubt that mutation breeding has played a significant role in improving crops and alleviating food security world-wide. Equally there is no doubt that this will continue to be the case; moreover, we expect increased activity in mutation breeding. Here are some of the reasons why we believe this to be the case:

1. Human population growth is projected to reach over nine billion people by 2050, hence crop production needs to be increased.

2. Climate change requires rapid breeding responses in adapting crops to changing environments.

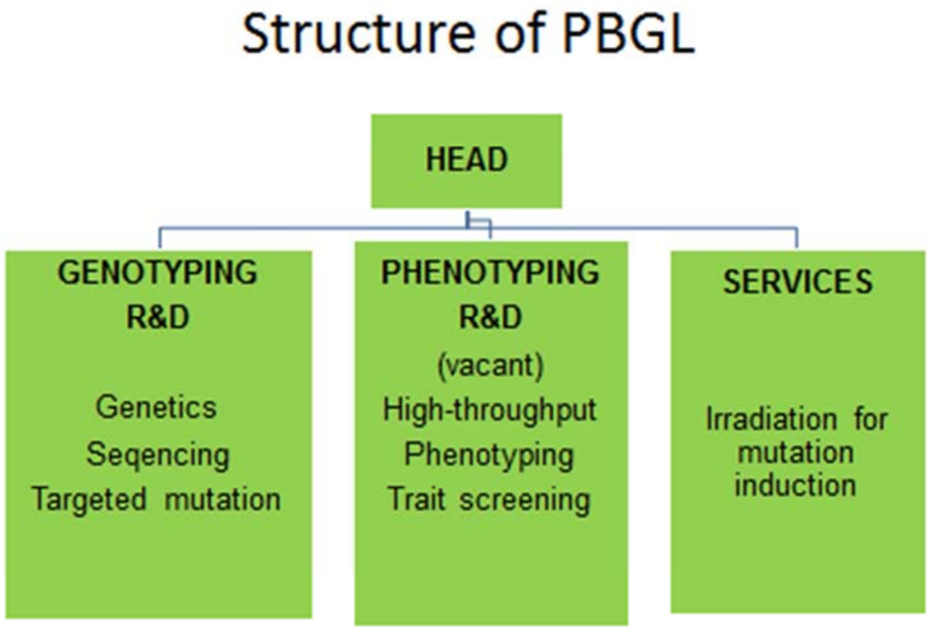
3. Induced mutation is a proven method of providing novel variation directly in relevant, local breeding materials.

4. Selection of desired variation has become more efficient with the development of high-throughput technologies in genotyping and phenotyping. Thus rare desired mutant individuals can now be easily detected and recovered among thousands of mediocre siblings.

5. There has been an explosion in the use of mutants in plant science, especially in understanding and manipulating gene function. The results will inevitably feed into plant breeding and indeed we are seeing the first signs of this.

Restructuring of the Plant Breeding and Genetics Laboratory

The Plant Breeding and Genetics Laboratory (PBGL) has a mandate to carry out: 1) research and development, 2) training and 3) irradiation services (gamma and X ray) directed at the mutation induction, mutation identification and the take up of promising mutants by plant breeders, especially those in developing countries. Success is dependent upon building links to practical plant breeding. Therefore, the PBGL is strengthening activities in phenotyping and developing protocols for breeders. In breeding terms, plant phenotype relates to expressed traits, particularly those that provide improved field performance. The primary targets are yield and yield stability, but other traits include quality, pest and disease resistance, tolerance to abiotic stresses and agronomy. Post-harvest traits include handling, post-harvest loss, storage and processing. Traits of concern to Member States are a major driver for our work at the PBGL and the PBGL has recently advertised a new position to develop high-throughput phenotypic screens for mutant trait selection.



New seed phenotyping laboratory

A recent initiative at the PBGL is the development of seed phenotyping. High throughput phenotyping (often referred to as 'phenomics') has been identified as being a bottleneck in plant genetics and breeding. Whereas high throughput genotyping, and especially current sequencing capabilities, can provide tens of thousands of data points, our ability to phenotype remains poor. In the last few years large scale whole plant phenomics facilities have been built and more are under construction in several countries. A major application of these facilities is the detection of mutant traits. Seed phenotyping is of particular interest to the PBGL as seeds are not only a major planting material but are the harvestable products of many of our major crops, notably cereals (wheat, rice and maize). Seeds also have an advantage in being transportable. The seed laboratory is being equipped with non-destructive imaging systems that measure seed shape, size and colour and soft X ray imaging in detecting seed density. These methods act as surrogates for seed composition, e.g. altered starch, protein and oil composition, which can be examined in greater detail using near infrared analysis. They also enable the detection of haploid seeds in some crops.

Reverse genetics in plant breeding

Plant breeding has been a test bed of innovations in genetics ever since Mendel demonstrated the principles of inheritance in the garden pea. Mendel's work changed plant breeding from an art into a science since the basic mathematics could be exploited to predict the results of specific matings. Other facets of genetics that have impacted on crop improvement include polyploidy, chromosome engineering, manipulation of recombination, transformation and of course induced mutation. In parallel with genetic manipulations, developments in biotechnologies such as doubled haploidy and marker assisted selection have accelerated the breeding process and have increased its precision. However, none of these processes have emerged without a struggle; Mendel's work was hindered until acceptance by the scientific elite, the initial enthusiasm for doubled haploidy as set back by recalcitrance in many species and the take up genetic markers proved too expensive for all but the most high value traits until cheap and simple methods were developed. Similarly reverse genetics has faced criticism in having little relevance to plant breeding. Reverse genetics is a relatively new concept in plant breeding that targets genes controlling trait, whereas forward genetics targets the trait and then seeks to understand the genetics. Sceptics of reverse genetic methods such as TILLING (targeting induced local lesions IN genomes) argue that there is a lack of knowledge of which genes control key traits, whether specific gene mutations will express in different genetic backgrounds and most importantly, the costs of developing and identifying targeted mutation are prohibitive. Nevertheless successes are beginning to emerge. In 2009 the starch industry in Germany began processing a new amylopectin mutant cultivar of potato produced by reverse genetics breeding. Other examples include allergen free wheat and peanut. Interest in reverse genetics breeding can also be gauged by the increased patent filing as developers in reverse genetics breeding seek to protect their investments and intellectual property.

A major limitation in transferring reverse genetics breeding to developing countries is the cost of mutation detection. The PBGL has therefore been engaged in developing low cost methods such as low cost DNA extraction, simple agarose gel electrophoresis for DNA fragment and SNP (single nucleotide polymorphism) analysis, and positive control kits. We also train and assist fellows who come to the PBGL with TILLING projects, e.g. climate hardening in tomato and chilli (Mauritius), seed quality in lupin (Poland) and sorghum improvement (Iraq).

Crops and traits

Traditionally the PBGL has focused on three tropical crops: rice, banana and cassava. Although these crops continue to be part of our R&D activities there has been a shift of focus from crops to traits. Traits are seen as being of primary interest to breeders in Member States and this should be reflected in our activities. In addition to our main tropical glasshouse, the PBGL has a temperate glasshouse, growth chambers and field plots in which a greater range of crop species may be grown locally. For many activities it is important to recover as much seed as possible, e.g. from a mutant plant expressing a novel trait of interest. It is therefore vital that good growing conditions are provided to maximise plant health and thereby seed production for the next generation. Crops that have responded well in our hands include barley, lupin, maize, sorghum and tomato. We hope to add to this list in the future.

Mutant traits under research and development include fodder quality in barley, salt tolerance in rice and wheat, seed quality in rice and drought tolerance in banana.

Irradiation services

The main service activities of the PBGL are gamma and X ray irradiation for mutation induction and subsequent seedling radio-sensitivity tests (to determine optimal dosage when requested). Gamma irradiation has been, by far, the most important method of inducing mutations in plant breeding. More than 50% of mutant cultivars carry genes mutated by gamma ray irradiation. However, gamma ray facilities are now subject to rigid security regulations and have become prohibitive to install and to upgrade; as a consequence alternative mutation induction methods are needed. The PBGL has been engaged in developing and optimizing X rays as an alternative. Gamma and X ray irradiation services are available for seed, pollen, tissue, organ and propagule irradiation. Although all service requests for 2011 have been for gamma, we anticipate increased interest in X ray in the future.

Table of gamma ray irradiation requests for 2011

Member State	**Crop species**
Pakistan	Wheat (seeds)
Germany	Ornamental plants (cuttings)
Jamaica	Sweet yam (cuttings)
Jamaica	Ginger (cuttings)
Poland	Lupin (seeds)
Kenya	Barley (seeds)
Mauritius	Brassica *capitata* and *botrytis*
Germany	Barley (seeds)
Former Yugoslav Republic of Macedonia	Wheat (seeds); Barley (seeds)
Iraq	Wheat (seeds); Sorghum (seeds)
Kenya	*Artemisia annua* (seeds and *in vitro* plantlets)*;* Barley (seeds)
Namibia	*Vigna subteranea* (seeds); *Tylosema esculentum* (seeds)
Jamaica	Sweet yam (*Dioscorea spp in vitro* plantlets)
Tunisia	*Olea europa* (*in vitro* plantlets)
United States of America	Sugar beet (seeds)
Spain	*Zantedechia aethiopica* (seeds)
Nigeria	Cowpea (seeds)
Botswana	Groundnut (seeds)
United Kingdom	Wheat (seeds); *Primula veris* (seeds)
Senegal	*Jatropha curcas* (seeds)*;* Groundnut (seeds)
Czech Republic	*Ballantia antipoda* (seeds)*; Harmsiodexa brevipes* (seeds)
Mauritius	Banana (in vitro samples)
Oman	Barley (seeds); Wheat (seeds)
Uganda	Wheat (seeds)

Request forms for irradiation services are available at: http://mvgs.iaea.org/LaboratoryProtocols.asp

Protocols

In order to facilitate uptake of mutants all sections of the PBGL (genotyping, phenotyping and services) are involved in the development of simple, user friendly protocols that can be used by breeders in developing countries. Protocols recently developed for genotyping include DNA extraction methods and simple gel electrophoresis methods; those for phenotyping include seedling salinity screening in rice in hydroponics and soil, and drought tolerance screening in banana; and there are protocols for irradiation and radio-sensitivity testing for mutation induction. The PBGL protocol collection is available at http://mvgs.iaea.org/LaboratoryProtocals.aspx.

Trainings

Fellows trained at the PBGL in 2011

Name	Country	Training topic	Period
Ms Banumaty SARAYE	Mauritius	• Screening of M_4 tomato and pepper populations for temperature resistance and genetic diversity studies in chilli and tomato from Mauritius. • TILLING and Ecotilling for characterization of chilli and tomato germplasm and putative mutants.	January–May
Ms Moe Thida KYAW	Myanmar	• Induced mutagenesis for crop improvement. • Seed mineral analysis of rice mutants for nutrition traits. Molecular characterization using TILLING.	March–June
Mr Stephen K. KIMNO	Kenya	• Induced mutation in Artemisia. • Germplasm characterization.	March–July
Ms Raouia DHOUIBI	Tunisia	• Induced mutation in olive and genotyping of olive germplasm for diversity studies.	March–August
Ms Wajida ZAARAWI	Iraq	• Mutation induction in sorghum. • Salinity screening in wheat mutant lines and molecular characterization.	April–June
Mr Harimialimalala J. RABEFIRAISANA	Madagascar	• Mutation induction for striga resistance in maize and mutant characterization.	June–September
Mr Maman B. MAMAN	Niger	• Induced mutation in cowpea and germplasm characterization using molecular markers.	July–October
Mr Ibrahima DIEDHIOU	Senegal	• Molecular markers for genotyping Jatropha germplasm.	July–September
Mr Elias PELOEWETSE	Botswana	• Induced mutation in groundnut and bambara groundnut and mutant characterization.	August–November

Interns trained at the PBGL in 2011

Name	Country	Areas of training	Period
Ms Kamila KOZAK	Poland	• Cytological and phenotypic analyses of M_2 rice plants. • Technology transfer to lupin.	August 2010–December 2011
Ms Farzaneh SHIRAZI	Iran	• Induced mutation in Jatropha and molecular characterization.	July–December 2011

Scientific visitors to the PBGL in 2011

Name	Country	Month of visit
Ms Julia BROWN	Jamaica	May
Ms Rita Devi NOWBUTH	Mauritius	September
Mr Mohamed Ahmed ALI	Sudan	September
Mr Lubomir STOILOV	Bulgaria	September
Mr Mahfoudh JOUHR	Syrian Arab Republic	October

Plant Breeding and Genetic Laboratory staff travel to Member States

Mr B. Till: Visited the John Innes Centre, Norwich, UK, 9–10 June 2011 to give a seminar on the activities of the PBGL in developing TILLING and ecotilling platforms for vegetatively propagated crops.

Ms J. Jankowicz-Cieslak: Visited the Agricultural Research and Extension Unit, Quatre Bornes, Mauritius 22–25 November to provide technical support for mutation breeding.

Feedback and professional networking

We would like to hear your views and any feedback you have. Success stories, e.g. the release of a new mutant cultivar, are particularly well received, but we seek to improve all our outputs in promoting plant mutation breeding; therefore we are open to criticism, suggestions and/or correction. We are keen to know what happens to mutants we have induced, detected and delivered to you. Let us know if you have made progress in developing these, or whether any of our services, protocols and manuals have helped you in your endeavours.

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.

Publications

Staff Publication in the Field of Plant Breeding and Genetics

Journal Publications/Book Chapters and Reviews

LOKKO, Y., MBA, C., SPENCER, M., TILL, B., LAGODA, P.J.L., Nanotechnology and Synthetic Biology – Potential in Crop Improvement. Journal of Food, Agriculture & Environment (JFAE), Vol. **9** 3&4 (2011) 599–604.

CALIGARI, P.D.S., FORSTER, B.P., Plant breeding and crop improvement (2011) John Wiley & Sons Ltd ; els@wiley.com

MAGHULY, F., JANKOWICZ-CIESLAK, J., CALARI, A., RAMKAT, R., TILL, B.J., LAIMER, M., Investigation of genetic variation in Jatropha curcas by Ecotilling andISSR. IUFRO Tree Biotechnology Conference 2011. BMC Proceedings (ISSN 1753–6561).

JAIN, S.H., TILL, B.J., SUPRASANNA, P., ROUX, N., Mutations and cultivar development in banana. Chapter 10 in: Banana Breeding: Progress and Challenges; CRC press (2011) 203–218.

JANKOWICZ-CIESLAK, J., HUYNH, O.A., BADO, S., MATIJEVIC, M., TILL, B.T., Reverse-genetics by TILLING expands through the plant kingdom. Emirates Journal of Food and Agriculture **23** 4 (2011) 290–300.

Publications within Coordinated Research Projects (CRPs) 2010–2011

Enhancing the Efficiency of Induced Mutegenesis through an Integrated Biotechnology Pipeline (D2.40.12)

DANSO, K.E., ELEGBA, W.K., ODURO, V.B, KPENTEY, P.B., Comparative study of 2,4-D and Picloram on friable embryogenic calli and somatic embryos development in cassava (*Manihot esculenta* Crantz) Int. J. Integ. Biol. **10** 2 (2010) 94–100.

TILL, B.J., JANKOWICZ-CIESLAK, J. SAGI, L., HUYNH, O.A., UTSUSHI, H., SWEENEN, R., TERAUCHI, R, MBA, C., Discovery of nucleotide polymorphisms in the *Musa* gene pool by Ecotilling, Theoretical and Applied Genetics, **121** 7 (2010) 1381–1389.

Molecular Tools for Quality Improvementin Vegetatively Propagated Crops including Banana and Cassava (D2.30.27)

SMITHA, P.D., NAIR, A.S., Somatic embryogenesis and plant regeneration in diploid banana cultivars from Kerala, Indian Journal of Plant Genetic Resources, **23** 1 (2010) 69–72.

GAYATHRI, NAIR, A.S., Isolation purification and characterization of polygalactouranase enzyme from Musa acuminate cv. Palayamcodan fruits, Indian Science Congress (2010).

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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

Year	Edition	Contents (a sampling of the papers are listed below):	Reference No.
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 • Use of induced mutants in rice breeding in Japan • Katy deletion mutant populations • Rice mutation breeding in Vietnam	ISSN 1011-260X

Mutation Breeding Newsletter and Reviews

Year	Edition	Contents (a sampling of the papers are listed below):	Reference No.
2005	No. 1	• High yielding mutants in cotton • Drought resistant tomato • Groundnut resistant to foliar diseases • Lodging resistant glutinous rice • First ever oilseed mustard mutant	ISSN 1011-260X

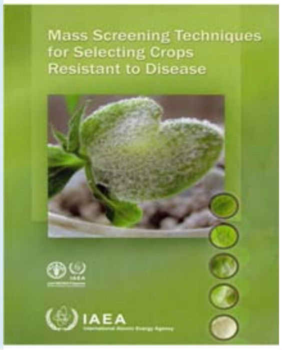
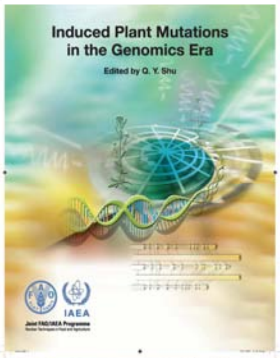
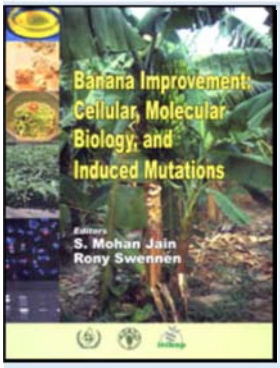
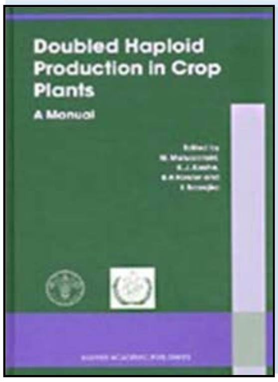
Mutation Breeding Review (published until 2004)

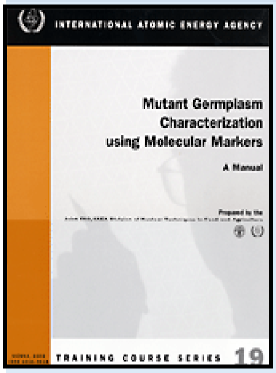
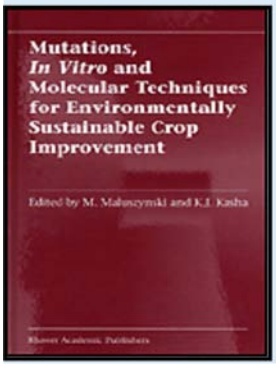
Year	Edition	Title	Reference No.
2004	No. 14	Officially released mutant varieties in China	ISSN 1011-2618
2001	No. 13	Grain legume cultivars derived from induced mutations, and mutations altering fatty acid composition	ISSN 1011-2618
2000	No. 12	Officially released mutant varieties – The FAO/IAEA database	ISSN 1011-2618
1999	No. 11	Oilseed cultivars developed from induced mutations and mutations altering fatty acid composition	ISSN 1011-2618

Mutation Breeding Newsletter (published until 2003)

Year	Edition	Title	Reference No.
2003	No. 46	Index Issue No. 21–44	ISSN 1011-260X
2001	No. 45	Issue No. 45	ISSN 1011-260X
1999	No. 44	Issue No. 44	ISSN 1011-260X

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

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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
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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

Year	Type of Publication	Title	Reference No.
1998	IAEA-TECDOC-1010	Application of DNA based marker mutations for improvement of cereals and other sexually reproduced crop plants	ISSN 1011-4289
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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New FAO/IAEA Database of Mutant Varieties and Genetic Stocks

Welcome to our new 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 new 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).

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Joint FAO/IAEA Programme
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Plant Mutation Reports

Author's Guidelines for Manuscript Submission

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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.

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

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- The main text should follow the title page and abstract.
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- 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/).

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

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- A figure caption should be brief, but informative. It should be set in italics and should be placed under the figure.
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