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# COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

**Item 9 of the Provisional Agenda**

**INTERGOVERNMENTAL TECHNICAL WORKING GROUP ON ANIMAL GENETIC RESOURCES FOR FOOD AND AGRICULTURE**

**Eighth Session**

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# APPLICATION AND INTEGRATION OF BIOTECHNOLOGIES FOR THE CONSERVATION AND SUSTAINABLE UTILIZATION OF GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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# I. INTRODUCTION

1. The Commission on Genetic Resources for Food and Agriculture (the Commission), at its Thirteenth Regular Session, decided to review the work of its Working Groups on the application and integration of biotechnologies for the conservation and sustainable utilization of genetic resources for food and agriculture, at its forthcoming Fifteenth Regular Session.[1] In addition, the Commission, at its last session, requested FAO to present information on new developments in the characterization, conservation and use of micro-organisms and invertebrates of relevance to food and agriculture, if applicable, at the Commission's Fifteenth Regular Session, when it would review the work of the intergovernmental technical working groups on the most recent application and integration of biotechnologies for the conservation and sustainable utilization of genetic resources for food and agriculture.[2]

2. This document briefly summarizes FAO's technical activities specifically related to biotechnology and reviews relevant work of FAO and the Commission's Working Groups on the application and integration of biotechnologies for the conservation and sustainable utilization of genetic resources for food and agriculture. The reporting period spans from July 2011, when the Commission decided to review the work of its Working Groups on the application and integration of biotechnologies, and May 2014 when the present document was finalized.

# II. FAO'S RECENT TECHNICAL ACTIVITIES SPECIFICALLY RELATED TO BIOTECHNOLOGY

3. The Commission, at its Thirteenth Regular Session, considered the status and trends of biotechnologies applied to the conservation and sustainable use of genetic resources for food and agriculture. It requested FAO to increase its efforts to strengthen the national and regional capacities of developing countries in the development and appropriate use of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture; to strengthen its activities for the regular dissemination of updated factual information on the role of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture through its existing databases, networks and newsletters, emphasizing also communication of biotechnology developments to the public; and to explore mechanisms for future cooperation with relevant international organizations, including for fostering North–South and South–South cooperation and for harnessing and sharing the benefits of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture.[3]

4. In 2013, FAO launched the publication *Biotechnologies at work for smallholders: Case studies from developing countries in crops, livestock and fish*[4] which presents a series of 19 case studies (seven for the crop sector, seven for the livestock sector and five for the fisheries sector) where agricultural biotechnologies were used to sustainably use genetic resources in view of serving the needs of smallholders in developing countries. The biotechnologies covered include some that are considered quite traditional, such as artificial insemination and fermentation, as well as other more modern ones, such as the use of DNA-based approaches to detect pathogens, but not genetic modification. The case studies were prepared by scientists directly involved in the initiatives who describe the background, achievements, obstacles, challenges and lessons learned from the different case studies. The book presents also ten general and interrelated lessons learned from the 19 case studies to guide future agricultural research investments in biotechnologies. These include: the absolute necessity for government policies and backing from donors and intergovernmental agencies,

[1] CGRFA-14/13/Report, Appendix F.
[2] CGRFA-14/13/Report, paragraph 90.
[3] CGRFA-13/11/Report, paragraph 45.
[4] Biotechnologies at work for smallholders: Case studies from developing countries in crops, livestock and fish, edited by J. Ruane, J.D. Dargie, C. Mba, P. Boettcher, H.P.S. Makkar, D.M. Bartley and A. Sonnino. FAO, Rome, 2013 (http://www.fao.org/docrep/018/i3403e/i3403e00.htm ).

and of partnerships both within and outside the public sector and with the farmers themselves in the planning and implementation of projects and programmes while bearing in mind also the need to retain flexibility in order to respond appropriately to evolving circumstances; and the recognition that while investments in science and technology are critical, the successful use of biotechnologies also requires their appropriate integration with other sources of science-based and traditional knowledge. Other lessons learned from the case studies are that agricultural research involving biotechnologies need not to be constrained by questions involving access to, or use of, genetic resources or issues of intellectual property rights, and that products developed through biotechnologies do not need to conform to specific biosafety and food safety regulations or standards. Finally, the studies indicated that it is essential to strengthen the planning, monitoring and evaluation of biotechnologies for agricultural development. Institutional arrangements and skills in these areas are currently weak or non-existent, and should therefore be strengthened to enable governments and donors to properly evaluate and justify the financial and other investments they allocate to agricultural biotechnologies. It is foreseen that the showcasing of these success stories will engender greater adoptions of these technologies and hence contribute to enhanced capacities and greater efficiencies in the implementation of the Second GPA by FAO member countries.

5. In 2012 and 2013, the FAO Biotechnology Forum[5] hosted two moderated e-mail conferences. The first e-conference, held from 5 November to 2 December 2012, discussed *GMOs in the pipeline: Looking to the next five years in the crop, forestry, livestock, aquaculture and agro-industry sectors in developing countries;*[6] the second e-conference, held from 4 to 24 March 2013, discussed the *Impacts of genomics and other 'omics' for the crop, forestry, livestock, fishery and agro-industry sectors in developing countries.*[7] Prior to each e-conference, background documents were made available with up-to-date information on the relevant topics. Participants in both conferences provided first-hand information and exchanged opinions, comments and proposals.

6. In 2013, FAO carried out an international survey to gather information on the extent and nature of problems incurred with low levels of GM crops in traded commodities. The results of the survey were used to conduct further analyses of the trade and economic impact of low levels of GM crops trade, and other related food/feed regulatory issues. In addition, FAO prepared technical background documents on regulatory issues of low levels of GM crops in food and feed[8] and a survey and economic analysis of low levels of GM crops in international food and feed trade.[9] On 20-21 March 2014, FAO held the *Technical consultation on low levels of genetically-modified (GM) crops in international food and feed trade* at FAO Headquarters in Rome, Italy.

## III. RECENT APPLICATION AND INTEGRATION OF BIOTECHNOLOGIES FOR THE CONSERVATION AND SUSTAINABLE UTILIZATION OF GENETIC RESOURCES FOR FOOD AND AGRICULTURE

### Plant Genetic Resources for Food and Agriculture

7. The capacity of countries to deploy molecular biology tools and applications has continued to increase significantly. This development is a direct result of the combination of the continuing sharp decreases in the costs of equipment and supplies and the availability of increasingly more powerful analytical and computing infrastructure and robotics. The increased throughput that these permit and the enormous amount of data that are generated have profound implications for the conservation and use of PGRFA. Molecular tools are being used routinely to characterize germplasm and to determine

[5] http://www.fao.org/biotech/biotech-forum/en/
[6] http://www.fao.org/docrep/017/ap998e/ap998e.pdf
[7] https://listserv.fao.org/cgi-bin/wa?A0=Biotech-Room3-L
[8] TC-LLP/2014/2: http://www.fao.org/fileadmin/user_upload/agns/topics/LLP/AGD803_2_Final_En.pdf
[9] TC-LLP/2014/3: http://www.fao.org/fileadmin/user_upload/agns/topics/LLP/AGD803_3_Final_En.pdf ; TC-LLP/2014/4: http://www.fao.org/fileadmin/user_upload/agns/topics/LLP/AGD803_4_Final_En.pdf

the genetic basis, and trace the inheritance, of traits of interest rapidly, reliably and cost-efficiently. By July 2013, 55 whole genome sequences, from 49 different species, had been published.[10]

8. Next-generation and third-generation sequencing technologies are generating tens of millions of increasingly longer DNA sequence reads in such short timeframes and lowered costs that genotyping-by-sequencing (GBS) is now becoming the germplasm characterization method of choice. As GBS becomes more routinely applicable, crop improvement approaches – including the introgressions of novel alleles – will benefit greatly by the corresponding routine applications of association mapping, allele mining, domestication and genomic selection.[11] The 1000 plants (oneKP or 1KP) initiative, an international consortium engaged with the sequencing of over 1000 plant species,[12] and the 1000 Plant and Animal Reference Genomes Project[13] of the Chinese Beijing Genomics Institute at Shenzhen are examples of previously unimaginable endeavours that are taking advantage of this exponential growth in capacities and the accompanying decrease in costs to generate massive amounts of publicly accessible data.

9. The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture (the Second GPA), prepared under the guidance of the Commission and its Working Group on Plant Genetic Resources and adopted by the FAO Council in December 2011, identifies as one of the major advances in key areas of science and technology "recent advances in molecular and genomic methods" that had a profound impact on key areas of GPA implementation. Accordingly, Priority Activity 9 calls upon Governments to recognize the importance of providing adequate support for the routine use of novel biotechnology tools, computational biology and information technology in PGRFA management, especially in characterizing germplasm and facilitating the introgression of desired traits into breeding materials. Governments, according to Priority Activity 10, should also make use of biotechnological techniques to facilitate broadening the genetic base of crops. In addition, the successful implementation of other priority activities of the Second GPA requires significant capacity for the deployment and use of biotechnologies to map and better assess the extent, distribution and erosion of plant genetic diversity and to promote their sustainable use through evidence-based exploitation of this diversity.

10. The Commission, at its Twelfth Regular Session, agreed on the need for revising the 1994 Genebank Standards in order to ensure that plant genetic resources are conserved under conditions that meet recognized and appropriate standards, based on current and available technological and scientific knowledge. It requested FAO, in cooperation with its partners, to undertake this review. In considering a first draft of the Genebank Standards covering the conservation of orthodox seeds, the Commission, at its Thirteenth Regular Session, agreed that the Genebank Standards should address also non-orthodox seeds and vegetatively propagated plants. The Genebank Standards,[14] as endorsed by the Commission at its Fourteenth Regular Session in April 2013, comprise standards for orthodox seeds, non-orthodox seeds and vegetatively-propagated plants. The Genebank Standards reflect the scientific advances in seed storage technology, biotechnology and information and communication technology, including advances in molecular marker technologies and genomics.

11. The Commission, at its Fourteenth Regular Session, requested FAO to develop Draft Guidelines for National PGRFA Strategies, for review by the Working Group at this meeting. The strategy is conceived as a set of actions across the PGRFA management continuum of interventions, including those related to biotechnology.

[10] Todd P. Michael and Scott Jackson. 2013. The First 50 Plant Genomes. The Plant Genome, July 2013, Vol. 6, no. 2: 1-7.
[11] Mahendar Thudi, Yupeng Li, Scott A. Jackson, Gregory D. May and Rajeev K. Varshney. 2012. Current state-of-art of sequencing technologies for plant genomics research. Briefings in Functional Genomics. Vol. 11. No. 1: 3-11
[12] https://sites.google.com/a/ualberta.ca/onekp/
[13] http://www.ldl.genomics.cn/page/pa-research.jsp
[14] http://www.fao.org/docrep/019/i3704e/i3704e.pdf

## Animal Genetic Resources for Food and Agriculture

12. The field of genomics has continued to advance rapidly, yielding more information at decreased costs. The tools that have resulted have increased the precision of molecular characterization of animal genetic resources (AnGR) and have had direct and indirect impacts on sustainable use. The genomes of most of the major livestock species have been sequenced and annotated and for some species, such as cattle, hundreds of individual animals have sequenced genomes. The commercial development of high-throughput genotyping assays has increased the precision of molecular characterization and provided the opportunity for the application of "genomic selection", a specialized type of marker-assisted selection. The theoretical basis for use of these assays in conservation has been established through research.

13. The new genomic biotechnologies have primarily been used in the industrialized countries and in the breeds and species of greatest commercial importance (e.g. transboundary dairy cattle breeds). International cooperation has, however, provided access to these technologies by developing countries for characterization. With regard to sustainable use, in addition to financial concerns, most AnGR in developing countries lack the historical phenotypic data necessary to take advantage of genomic selection, as well as the infrastructure required for distribution of germplasm of genetically superior animals identified via these assays. Statistical associations identified between markers and phenotypes in international transboundary breeds are poorly applicable to local breeds.

14. Within a population, genomic selection has the potential to decrease the loss in genetic variability associated with selection based on pedigree relationships, but some results suggest that loss in genetic variability has in fact accelerated since its adoption.

15. Research is accelerating on the "genome editing" approach for genetic modification. This approach allows for modification of the genome at specific regions, including alteration of a single nucleotide. This approach is several orders of magnitude more efficient than previous gene transfer approaches. As with traditional transgenic approaches, no genetically-modified animals have been approved for commercial food production.

16. The Interlaken Conference on Animal Genetic Resources for Food and Agriculture, as well as the Commission, called on FAO to continue developing technical guidelines and to continue coordinating training programmes to support countries in their efforts to implement the Global Plan of Action for Animal Genetic Resources. In response to these requests, FAO develop various activities relevant to biotechnology. The Commission endorsed guidelines prepared by FAO and reviewed by the Commission's Working Group on Animal Genetic Resources, on *Molecular Characterization of Animal Genetic Resources*,[15] on *Cryoconservation of Animal Genetic Resources*[16] and on *In vivo conservation of animal genetic resources*,[17] which presents the conservation of a breed through the maintenance of live animal populations. The aim of the latter publication is to provide the technical background needed by organizations or individuals who want to set up, implement and monitor *in vivo* conservation programmes in a rational manner. It describes the tasks and actions that should be undertaken to prevent the extinction of breeds and promote their sustainable use. The use of different biotechnologies, such as molecular markers and various reproductive technologies, is also covered.

## Aquatic micro-organism and small invertebrate genetic resources for food and agriculture

17. The increase in intensity of some aquaculture production, notably shrimp production, has in some cases led to environmental and culture problems such as increase use of anti-biotics, increase

[15] http://www.fao.org/docrep/014/i2413e/i2413e00.pdf
[16] http://www.fao.org/docrep/016/i3017e/i3017e00.pdf
[17] http://www.fao.org/docrep/018/i3327e/i3327e00.htm

disease and loss of production. To address these issues, the use of probiotics, micro-organisms that can survive in aquaculture systems, is gaining popularity. Probiotics can be used

- to improve water quality,
- as an additive to feed, and
- to improve disease prevention.

18. The use of probiotics is especially important in China, the world's aquaculture top producer. Numerous research academies and universities in China tried to select more efficient and specific probiotic strains for use in aquaculture. Many companies have already developed their own probiotic strains and are trying to produce enough to satisfy the market demand. In 2011, there was a reported demand for 30,000 tonnes of probiotic products in China for aquaculture practices. After decades of research and development, the use of probiotics is now popular in the commercial production of farmed shrimp.

## Forest genetic resources

19. The development of new technologies, including biotechnology, and their applications in tree breeding and genetic resources conservation, is expanding although at a much more lower speed in developing countries and in the tropics in general. In general current uses of biotechnologies in forestry fall broadly into three categories: those based on molecular markers, those that enhance vegetative propagation, e.g. micropropagation, and those for genetic modification of forest trees. Tools used in biotechnology differ slightly between studies related to naturally regenerated forest and those related to planted forest.

20. For naturally regenerated forest, molecular markers and genomics are providing important knowledge on genetic variation within and between species populations. Biotechnology further provides important insights into the nature of the entire tropical forest ecosystems including the relationship between forest trees and the soil microbial communities with which they interact.

21. For planted forest and depending on the level of management intensity and genetic material used, the biotechnology tools used include tissue culture in vegetative propagation, to molecular markers, quantitative trait locus analyses, whole-genome sequencing, and genetic modification. These tools are currently applied for a range of purposes and involve a varied number of species. Of the over 700 tree species reported by countries to FAO in the process of preparation of *The State of the World's Forest Genetic Resources*, as subject to tree improvement programmes, 241 species are included in biotechnology research.

22. The development of large scale clonal plantations of some economically important species (e.g. *Eucalyptus* spp, *Tectona grandis*) using biotechnology has been reported by a number of countries including Brazil, Chile, the Republic of Congo, India, South Africa, etc.

23. The *Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources*, prepared under the guidance of the Commission and its Working Group and adopted by the FAO Conference in 2013,[18] identifies the use of new technologies, including biotechnologies, as a Strategic Priority to be supported by the international community. In particular, the Strategic Priority 21 calls for the development of extension and education modules with special emphasis on modern technology (e.g. biotechnology), to support national education capacity on forestry and FGR management.

[18] C 2013/REP, paragraph 77.

## IV. GUIDANCE SOUGHT

24. The Working Group may wish to recommend that the Commission request FAO to continue its efforts:

(i) to strengthen the national and regional capacities of developing countries in the development and appropriate use of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture;
(ii) to strengthen its activities for the regular dissemination of updated factual information on the role of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture through its existing databases, networks and newsletters, emphasizing also communication of biotechnology developments to the public; and
(iii) to explore mechanisms for future cooperation with relevant international organizations, including for fostering North–South and South–South cooperation and for harnessing and sharing the benefits of biotechnologies for the characterization, conservation and utilization of genetic resources for food and agriculture.