

# **The Present Status and Future Prospects of the NIAS Genebank Project in Japan**

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## **Abstract**

Since 1985 the National Institute of Agrobiological Sciences (NIAS) has coordinated a national genebank project in Japan that has focused on conservation of plant, microorganism and animal genetic resources related to agriculture. More recently DNA materials have been added to the project. NIAS has also established a Rice Genome Resources Center. Central to the efficient working of the genebank project has been the database system that now includes illustrated databases and marker databases. Research to develop core collections for various crop species has progress recently and germplasm users are requesting these germplasm research sets. Future challenges including continuously incorporating new technologies to improve efficiency, cost effectiveness and usefulness of genebank materials and operations. International cooperation is a key component of Japan's strategy to ensure global safety and exchange of conserved genetic resources. Key to the future of the national and global genetic resources system will be realizing and recognition of the usefulness of genetic resources to sustaining and improve agricultural productivity.

## **Introduction**

The Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan initiated the genebank project in 1985 to focus on conservation of genetic resources related to food and agriculture. The National Institute of Agrobiological Sciences (NIAS) has functioned as the "center-bank" for genetic resources of plants, microorganisms, and animal for food and agriculture in cooperation with "sub-banks" or agricultural research institutions across Japan. The center-bank at NIAS is responsible for the coordination of the project, planning and implementation of domestic and international activities. The NIAS Genebank project

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activities encompass collection, conservation, characterization and distribution of genetic resources including agricultural plants, microorganisms and domesticated animals. In the 1990's it became apparent that DNA was a necessary component of the center-bank at NIAS to reflect progress in plant genomics and genome informatics and this aspect became incorporated into the genebank project. In 2003 a new center was established the Rice Genome Resources Center to provide retro-transposon-mediated insertion mutant lines of rice, useful rice experimental materials for genetic analysis such as recombinant inbred lines, and full-length rice cDNA clones, and rice genome information and analytic tools. Now NIAS has a genebank that coordinates plant, animal, microorganism and DNA genetic resources related to food and agriculture and a Rice Genome Resources Center.

### **Present status on plant genetic resources for food and agriculture (PGRFA) in the NIAS Genebank project**

The Plant Section of the NIAS Genebank project conducts exploration, collection, characterization, evaluation, preservation, multiplication, and distribution services of PGRFA for traditional landraces, improved cultivars, breeding lines, and to some extent wild relatives to fulfill expanding demands of plant breeders and research scientists.

The plant collections conserved in NIAS genebank are included in the following 13 groups (Number of accessions as in 2008);

- \* Rice (44,224),
- \* Wheat and barley (62,333),
- \* Legumes (18,956),
- \* Root and tuber crops (8,889),
- \* Millets, other cereals, industrial crops (19,058),
- \* Grasses and forage crops (33,099),
- \* Fruit trees (10,300),
- \* Vegetables (27,224),
- \* Ornamental flowers and trees (5,873),
- \* Tea (7,547),
- \* Mulberry (2,178),
- \* Tropical and subtropical crops (418), and
- \* Others, such as herbs and spices (3,364).

The Plant Section has been dispatching both domestic and overseas exploration teams annually to survey the distribution and collect the variation of plants. The total number of newly registered PGRFA amounts to over 5,000 accessions per year, including accessions obtained by exchanges with domestic and overseas research institutes. Activities of such exploration missions can be viewed in the Annual Report on Exploration and Introduction of PGRFA at:

<http://www.gene.affrc.go.jp/publications.php?section=plant&type=report>.

Collected plants are identified, characterized and analyzed by researchers. Cultivation for seed multiplication is conducted at the same time. The harvested seeds are preserved in a low-temperature and low-moisture environment over the long term. The number of registered accessions is over 240,000 as of 2008.

The information on the history and properties of the registered genetic resources is added to the database and is made open to the public through the Internet. The database can be searched by property, and information on any genetic resource with the desired properties can easily be obtained at:

<http://www.gene.affrc.go.jp/plant/SEARCH/db/index-e.html>.

The genetic resources preserved at the NIAS Genebank can be requested for testing/research or educational purposes. Annually 5,000~10,000 accessions are distributed to both domestic and overseas research institutes, contributing to research and development. Materials from the genebank are used in analyses of genetic, physiological, ecological diversity, plant breeding and as possible raw materials for food processing. Our PGRFA are expected to bring about major developments in agriculture and agricultural science through breeding programs and other procedures as exemplified by "Nipponbare" whose whole genome information was analyzed by scientists mainly based at NIAS and by "Wataribune", an old cultivar that has been underutilized but is now used as brewing rice.

Among the total of over 240,000 accessions, the NIAS center-bank conserves 156,909 accessions of which 112,015 are in the active collection. The remaining PGRFA are preserved at sub-banks. As the center-bank of the project, NIAS has two seed conservation facilities; one for long-term conservation (base collection) and another for distribution (active collection). The former is kept at  $-10^{\circ}\text{C}$  and 30% RH, while the latter at  $-1^{\circ}\text{C}$  and 30% RH. Each accession registered in the NIAS Genebank system is grown for multiplication and characterization, and the seed is gently dried at room temperature and preserved in the two storage facilities. The seed germinability is tested once every five-year, accessions with

germination below a set threshold or with few seeds are multiplied from the seed samples preserved at the long-term conservation facility.

Domestic and international collaborative field surveys and exploration missions are organized by the Project. Routine characterization for primary characters (basic morphological and ecological characters), secondary characters (stress tolerance) and tertiary characters (crop quality characters) are investigated mainly by specialists in sub-banks according to Japanese descriptor lists. In 2007 data items totaling 120,000 (no. of accessions x characters) were recorded for primary characters, 25,000 for secondary ones, and 29,000 for tertiary characters. In addition, new characterization trials, pre-breeding or genetic enhancement, and selection of core collection or special germplasm research sets of genetic diversity are supported by the genebank project based on research proposals. Examples of recent research of genebank project scientists related to core collections can be found in the following publications: Kojima *et al.*, 2005 in rice; Sangiri *et al.* 2007 in mungbean; and Xu *et al.* 2008 in azuki bean. About 5000 PGRFA accessions are multiplied annually for seed crops. Cryopreservation has successfully been performed for about 1500 mulberry accessions. Research is currently being conducted to improved cryopreservation technology for different PGRFA such as Chrysanthemum and Juncus species.

The NIAS genebank project intends to expand the active collection that is available for users. After the CBD came into effect in 1993, the genebank project has been careful regarding sovereign rights and intellectual property rights on PGRFA, since our policy is compliance, accountability and ethics. For that reason we have precisely examined each accession regarding status. We are striving to ensure whole information of accessions conserved in the NIAS Genebank is available and all collections are able to distribute for requester.

The NIAS Genebank has the responsibility to distribute the PGR for breeding, research, and educational purposes to the breeders and scientists of research institutions in Japan and international request. For scientists who are interested in germplasm related to food and agriculture within the NIAS Genebank system, they are directed to the databases that provide full details of how to request materials in each category of genetic resource. The databases including information on passport data, evaluation as well as more general information on genetic resources in the NIAS Genebank that can be found at this web site at: [http://www.gene.affrc.go.jp/databases\\_en.php](http://www.gene.affrc.go.jp/databases_en.php).

## **Future prospect of the NIAS Genebank in relation with international research cooperation**

Japanese scientists are eager to establish cooperative linkages and exchange genetic resources with other countries.

### ***International relations of the NIAS Genebank project***

The NIAS Genebank actively participates in collaborative activities with other countries in relation to surveys and research related to agricultural related genetic resources. In all activities related to conservation of genetic resources the NIAS Genebank follows the international community norms and national regulations. Plant and microorganism germplasm within the NIAS Genebank system collected in Japan is available for research purposes.

In addition to exchanges of PGRFA and their information, four different kinds of international cooperation program are incorporated into the NIAS Genebank project – joint explorations, a cooperative research programs especially related to *in situ* conservation of PGRFA with developing countries, overseas multiplication and evaluation of PGRFA, and international workshops on PGRFA.

Approximately four missions are dispatched overseas annually to conduct exploration and collection of PGRFA in collaboration with scientists in other countries. The plant materials collected in each country are always divided into two sets: one set is transferred to Japan based on the material transfer agreement (MTA) between Japan and the country and another set is conserved in the country. The duplication of conserved genetic resources is beneficial to researchers of both countries. This has always been the practice since the beginning of the NIAS Genebank project. Such joint exploration enhances conservation and understanding of PGRFA, increases mutual understanding and provides a basis for further research cooperation.

Regarding the conservation of wild species, it is often difficult to preserve their diversity *ex situ* within a genebank and *in situ* conservation is necessary. The project of NIAS Genebank is consisting of a special program to encourage researchers in developing countries to survey the status of populations in the field and monitor them in cooperation with Japanese scientists at the sites as well as analysis of the populations by molecular

techniques at NIAS and other related institutions. This reciprocal approach helps *in situ* conservation of PGRFA, especially wild relatives of cultivated plants, and also assists capacity building of researchers in collaborating countries. *In situ* conservation research activities of the NIAS on wild legumes and wild rice were started in collaboration with the Plant Genetic Resource Centre (PGRC) of Sri Lanka in 2000. Japanese researchers joined the missions in Sri Lanka to monitoring genetic structure of wild *Vigna* species and wild *Oryza* species. While Sri Lankan researchers who participated in the program could learn various molecular techniques in Japan as well as join collecting missions in Japan (Jayasuriya and Vaughan, 2003). An *in situ* conservation project on *Fagopyrum* species sponsored by Bioversity International (then IPGRI) was conducted in Nepal from 1999 to 2001 in a similar manner. Genetic diversity of the wild species *F. cymosum* successfully identified the populations most suitable for *in situ* conservation of this species. Indonesian and Korean researchers have participated in a similar program on sweet potato (*Ipomoea batatas*) and *Perilla* species, respectively.

An overseas multiplication and evaluation program has been initiated to ensure sufficient quantity of quality seeds for the secure conservation of PGRFA in the NIAS Genebank, since it is difficult to grow certain crop species under the climatic conditions of Japan. Japan and the collaborating country can share both the multiplied seeds and obtained characterization and evaluation data. For example, wheat and barley genetic resources are being multiplied and evaluated in cooperation with scientists at the Vavilov Institute of Plant Industry, Russia, and soybean and other food legumes genetic resources are being multiplied and evaluated in Thailand.

International workshops on PGRFA serve as a good opportunity for researchers worldwide to exchange up-to-date information and to initiate future research cooperation. For example, the International Genetic Resources Workshop supported by the genebank project of Japan titled as "The Genus *Oryza*" was held at Tsukuba from 24<sup>th</sup> to 26<sup>th</sup> September, 2003 at NIAS. In 2006, an international symposium supported by the genebank project and OECD on crop domestication and super-domestication was held in Tsukuba (Annals of Botany Special Issue in October, 2007).

### ***International cooperation on PGRFA through JICA projects***

The Japan International Cooperation Agency (JICA) has implemented a series of grants-in-aid and technical cooperation projects as official development aid (ODA) of Japan

in relation to PGRFA. It contributed to the establishment of genebanks in Sri Lanka, Chile, Pakistan, and Myanmar as well as scientific capacity building. As the responsible institute on PGRFA in Japan, NIAS has always participated in feasibility studies at project sites, the detailed project planning, and research coordination for smooth implementation and fruitful achievements of the JICA undertakings.

For example, construction of a Seed Bank and a technical cooperation project was planned based on collaboration between Japan and Myanmar under a scheme of JICA to collect, evaluate, and conserve agricultural PGRFA in Myanmar and to promote their use in breeding programs. The Myanmar Seed Bank was created within the Central Agriculture Research Institute (CARI) at Yezin in 1990, and a technical cooperation project was implemented as “Myanmar Seed Bank Project” from 1997 to 2002. The project objective was to develop the Seed Bank into a sustainable national genebank, and Myanmar staff and Japanese experts collaborated well to set up and improve the PGRFA management system suited to the conditions of Myanmar.

During such technical cooperation projects, long-term and short-term experts are dispatched from Japan. They make suggestions to improve the management of genebanks, supervise the research activities on genetic resources and conducted cooperative research. Young researchers in the country are invited as trainees to a 6-month JICA sponsored group-training course on genetic resources held annually based at NIAS or to an individual training course to study various aspects of genetic resources in Japan. A few excellent young researchers from a project site can apply for a MONBUKAGAKUSHO (MEXT) Scholarship to study PGRFA and related research fields at some universities in Japan.

### ***Cooperation with the international framework***

The Bioversity International (previous IBPGR, later IPGRI) is the world's largest non-profit agricultural research and training organization devoted solely to the study and promotion of agricultural biodiversity. The Government of Japan started assistance to the Bioversity International in 1979, and has been one of the main financial supporters since 1987. Japan also supported several international projects organized by Bioversity International. The NIAS Genebank was assigned by Bioversity International to be the global base genebank for Japonica cultivar group of rice.

Japanese scientists have been dispatched to carry out collaborative exploration for PGRFA in Nepal, Pakistan, Vietnam, Mongolia and other countries based on the special

funds provided by the Ministry of Foreign Affairs (MOFA) of Japan to Bioversity International. The materials collected were divided into three sets for conservation by the countries explored, Japan, and Bioversity International.

Bioversity International and Japanese agricultural research institutes have cooperated for holding international meetings. For example, the NIAS cooperated with Bioversity International in holding international symposia on several underutilized crop genetic resources (e.g. IBPGR, 1992). The Japan International Research Center for Agricultural Sciences (JIRCAS) and Bioversity International co-sponsored an international symposium on Cryopreservation of Tropical Plant Germplasm, held in Tsukuba (Engelmann and Takagi, 2000).

### ***Future perspectives from Japan on international relations and PGRFA operations***

Japan is generally considered to be a gene-poor country. However, it was germplasm developed in Japan, Norin 10, which provided vital genes for the green revolution in wheat. This illustrates that so-called gene-rich and gene-poor countries depends very much on what you are looking for in germplasm.

Japan has been an active partner in all the major international developments related to PGRFA and biodiversity. The CBD will meet in Nagoya in 2010. The global consensus related to PGRFA is changing. An International Treaty on PGRFA came into force in 2004. A Trust Fund to assist sustainable conservation of PGRFA is now established. Japan will continue to be an active partner in these international activities related to PGRFA and biodiversity in the future.

Japan has established strong collaborative relationships with many countries over the past decades in relation to PGRFA. Japan seeks to extend these linkages to other countries by helping capacity building and importantly understanding plant genetic resources and developing safe sustainable means of their conservation.

The future challenges include sustaining concern for the never-ending job of PGRFA conservation that means countering funding fatigue. To sustain funding for genebank operations it is necessary to be proactive in explaining that efficient and effective genebanks are the foundation upon which future agricultural development and thus food security depends. It is also necessary that genebanks evolve quickly to keep up with technological developments to improve all aspects of genebank operations. For example, genebanks will

need to become “green” as costs of maintaining cold storage facilities increases. In addition, genebanks are challenged to use research tools and new approaches to find within our germplasm collections the new superstar accessions like Norin 10. The future of the genebanks ultimately rests on providing high quality of service to users particularly plant breeders.

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