(특별강연요지)

Plant Genetic Resources and Biotechnology:Perspectives from Japan

Masahiro NAKAGAHRA
National Institute of Agrobiological Resources

1. Introduction

Many parts of the world have experienced astonishing economic development in recent decades, particularly here in East Asia, and the foundation upon which this industrial development rests is agriculture. Improved crop production requires diverse plant genetic resources. Biotechnology provides mechanisms for using these plant genetic resources. Future agricultural productivity must increase in a sustainable way.

For food importing countries, like Japan, the need for adequate food supplies worldwide is of the utmost importance.

The National Institute of Agrobiological Resources(NIAR) was established in 1983 to conduct basic research in both the field of genetic resources and biotechnogy. Since 1983 these two research areas have globally undergone great waves of intellectual and technological change. Plant genetic resources were seen as common heritage of mankind, but now are viewed increasingly in terms of belonging to sovereign states and their citizens. Issues related to biotechnology revolve around intellectual property rights, biosafety and technology transfer.

In Japan the main changes related to plant genetic resources and biotechnology research have been:

1) From individual to group and interactive effort;
2) From small scale projects with limited financial and manpower support to large scale projects with much manpower and strong financial backing;
3) The strategic research framework was strengthened;
4) Collaboration has increasingly become international in nature.

2. Plant Genetic Resources

1) National system

[Mechanism] The national genebank system in the Ministry of Agriculture, Forestry and Fisheries(MAFF) was established in 1983 to promote effective use of genetic materials for varietal improvement. The comprehensive new system, called the MAFF Genebank Project, involves collection, introduction, characteri-

zation, evaluation, rejuvenation, conservation, exchange, data management and use of genetic materials. In 1986, by reorganizing the project and establishing the Genetic Resources Center in NIAR, development of the genetic resources system has accelerated to cope with urgent problems in the overall management of genetic resources.

MAFF Genebank Project includes not only plants but also microorganisms, animals, forest trees, and aquatic organisms. NIAR is the organizational center for plants, microorganisms and animals. In 1993, the project entered a second eight year phase. From 1994, DNA and molecular genetic information was added as a new topic in the Genetic Resources Center of NIAR.

The framework for MAFF plant genetic resources activities comprises a national center(NIAR) and sub-banks located throughout the country. Sub-banks are located in 15 national agricultural institutes, and share research activities on collecting, multiplication, characterizing, and use of the germplasm as new breeding materials especially assigned plant species. 43 research laboratories in prefecural institutes are included in the network of the project with special assignments from MAFF.

MAFF plant germplasm is divided into 12 groups, i.e. rice, wheat/barley, tuber crops, legumes, small grains/industrial crops, forage/fodder crops, fruit trees, vegetables, ornamentals, tea, mulberry, and tropical plants. A curator in each plant group makes annual plans, long term schemes for all the areas of genetic resources activities.

In 1988, NIAR constructed the third generation genebank with a complete robot system in the storage rooms. The whole system built in 1978 was renovated in 1991 to enlarge the capacity for long term storage of original seeds.

[Conservation] Collection in the MAFF Genebank System are classified into three, base, active and working collections. Field genebanks are still important to maintain fruit trees, tea, mulberry and other vegetatively propagated crop species. Cryopreservation has been adopted for micro-organisms, animal cells and some important plant species in the base collection.

[Evaluation] Although characterization and evaluation of genetic resources are essential and valuable for germplasm users, evaluation is not always welcomed by researchers. The MAFF Genebank Project strengthens evaluation efforts by providing supporting financial resources.

2) International activities

The MAFF Genebank Project has sponsored 5-6 international missions annually, and collaborated with host country institutes for exploration and *in-situ*

research activities. Other international missions have been actively organized from different budget sources such as IPGRI and JICA(Japan International Cooperation Agency). International workshops and meetings sponsored by MAFF or JIRCAS(Japan International Research Center for Agricultural Sciences) are held periodically. Development of scientifically sound *in-situ* conservation techniques for wild relatives of crop species, and research on genetic resources *in-situ* is a new direction of collaboration.

3) Post Biological Diversity Convention

The 1992 Earth Summit held in Rio de Janeiro by UNCED and the subsequent adoption of the Convention on Biological Diversity in 1993 brought a dramatic change in the concept of genetic resources and future use of biotechnology. The paradigm on plant genetic resources shifted from common heritage for mankind to issues of sovereign right or farmer's right in agricultural communities. The FAO is hoding contentious deliberations to revise the FAO Intermational Undertaking on Plant Genetic Resources to harmonize it with the convention. In the future more attention is likely to be given to *in-situ* conservation and sharing the benefits of genetic resources and new technology among nations. Japan is working vigorously towards strengthening its national program on plant genetic resources, at the same time cooperating and being a full partner with genetic resources programs in neighburing countries.

3. Biotechnology

1) Developments to the present

Biotechnology is not a single technology. In Japan, the virus free technique in strawberry is a well known application of biotechnology to ensure stable production of good quality of strawberries. More than 80% of strawberry production is using this technology. Embryo culture in lily and anther culture in rice have been applied and resulted in new varieties for farmers. Micro propagation for species such as orchids has been successfully introduced at the commercial level. Somatic cell mutation culture, cell fusion and artificial seed production are now established technologies in the improvement of new varieties and stable agricultural practices.

Recently, DNA recombinant techniques are rapidly being applied to many organisms. The use of transformation techniques in plant breeding is a new tool for the next era. Transgenic plants such as rice, melon and tobacco have been created by this method in Japan. The next target of transgenic technology is to introduce useful genes to crops from species unrelated to the crop. But useful

genes have not systematically been isolated. Advances in basic systematic molecular genetics is necessary. The Rice Genome Project in MAFF provides a good example of this.

2) Rice Genome Research Project

NIAR and STAFF institute began to conduct the Rice Genome Research Project to understand the whole rice genome as a core organization of a nation-wide project in 1991. The aims of the research are 1) to establish a high-density genetic maps using DNA fragment markers such as RFLPs and cDNA, 2) to construct a physical map using artificial chromosomes such as YAC clones, and 3) finally to read whole sequences of the rice genome and isolate single genes.

By 1996, five years after the project began, a high density map was successfully elucidated and published. The rice genome map now has more than 2,400 markers including RFLPs, cDNA and PCR markers. The next step, to establish a physical map, is under construction. A physical map is now being developed using YAC clones of Japonica rice chromosomes.

One of the major results of the project was to isolate a single gene for bacterial leaf blight resistance in 1997. Additionally, QTL analysis has given detailed information on useful genes such as photoperiodic response, field resistance for pests and diseases, and grain quality. These should lead to new breeding techniques in the near future.

The first phase of the Rice Genome Project taught us that we will need information on whole DNA sequences in rice. This data will be available early in the next century. The benefits from these research results will be a common heritage of human beings. The new phase of genome research, therefore, should integrate steadily accomplished of all researchers.

4. Perspective - Practical application toward the year 2,000 and beyond

The investments made over the last 20 years in biotechnology are now beginning to bear fruit. A tremendous range of new bio-engineered varieties are being tested and released to farmers. Now we have to refine the tools that have been developed to improve the precision of these techniques. At the same time, greater emphasis is needed to understand the whole genetic system of crops - *analysis* has been emphasized with biotechnology in the past. Now we need greater attention on *synthesis* - understanding systems. To this end NIAR is involved in a project, which we call a COE(Center of Excellence) project, on Genome Function. This project, with the results of the Rice Genome Project,

will give a much more complete picture of crop genetic systems organization.

For the products of biotechnology to be accepted by farmers and to deliver their potential to the consumer, it is necessary for biotechnologists, breeders, as well as regional and locally based scientists to work in partnership. Recently in MAFF we have developed a new rice breeding framework involving NIAR(rice biotechnology), NARC(National Agricultural Research Center, national based rice breeding) and HNAES(Hokuriku National Agricultural Experiment Station, regional rice breeding, testing and selection) to develop this type of partnership.

Since the 1960's the international genetic resources conservation system has developed. Since the 1970's the biotechnological revolution has been under way. The momentum in both spheres has not diminished. As we end one millennium and begin another, these two major developments in the agricultural sciences need to form an increasingly synergetic relationship, so that the genetic base of mankind's food is protected and always available and greatly improved varieties for farmers and consumers using conserved germplasm is realised.