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# The Management of National Plant Genetic Resources Centre in Taiwan

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## Summary

A national Plant Genetic Resources Center (PGRC) was established at Taiwan Agricultural Research Institute (TARI) in 1993. The facilities include long-term, medium-term, and short-term storage rooms with different storage conditions in which are suitable for preserving orthodox seeds. The long-term storage room has the capacity of 240,000 accessions in aluminum cans sealed under partial vacuum. Up to December 2006, collecting seeds of 31,832 accessions in the long-term and 64,118 accessions in the medium-term storage room are conserved. For the field genebank, the collection and preservation of germplasm including fruit trees, medicinal plants etc., approximately, 4,800 accessions are grown and maintained in several repositories. A total of 1,734 accessions of collecting clonal germplasm are cultured *in vitro.*

Germplasm distribution remains a major function of the PGRC. Germplasm materials stored at PGRC are available to people with academic purpose and can be applied on application via internet or intranet. The offer of seeds is free of charge and together with relative information included for referring. The varieties distributed from PGRC and transferred to research institute were approximately 1,000 accessions each year. TARI has engaged in international exchange of crop seeds and seedlings. During the past five years, the average numbers of varieties introducing or collecting from foreign countries were more than 1,000 accessions each year.

In order to modernize genebank operations, promote information exchange and international cooperation on germplasm collection, a computerized information system of PGRC was completed in 1993. It is well recognized that the establishment of information system of

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germplasm enables users and breeders to search for needed information and to choose appropriate genetic materials in use on crop improvement program. PGRC finally aim to become a regional center for tropical and subtropical crop, through international collaboration on collection.

## Introduction

We all realize and agree that agricultural improvement depends on both the utilization of abundant plant genetic resources and the achievement of scientific research. Plant germplasm is indeed the basis of crop improvement, plus the genetic variations and biodiversity are the motivating forces for continuous of progress in plant breeding. In recent years, the cultivation of hybrids and fixed commercial varieties has threatened the survival of indigenous varieties and wild plants. These primitive types may have genetically high disease resistance or environmental tolerance and are considered as precious source for utilization in future. In view of the long-term needs of ecological system, the sustainable conservation and utilization of plant genetic resources have called attention of the scientists and governors in countries all over the world. Additionally, the research and development of using skills, techniques, strategies to properly manage germplasm are also of importance. It is very meaningful to the understanding and maintaining the genetic diversity and conducting the precious plant genetic materials with care and efficiency. Besides, the establishment of an efficient information system can help genebank manager to better administer germplasm activities such as collection, preservation, regeneration, distribution, and exchange.

Taiwan Island has abundant flora, especially tropical and subtropical plants because of its geographical features. In recent years, according to the high enhancement in agricultural production and a mighty advance of economic progress, the native flora has been diminished by various development projects. The genetic base of fundamental crops became narrow by rapid progress in plant breeding and the large scale adoption and frequent turnover of the improved cultivars.

Taiwan has realized the importance of sustainable conservation and utilization of plant genetic resources. During the past decades, a crop committee of germplasm conservation and multiplication system has been organizing to assist in the development of high priority technologies for improving agricultural productivity. At that time, the Plant Genetic Resources Center (PGRC) was constructed and placed at Taiwan Agricultural Research Institute (TARI) in Taichung. The PGRC was inaugurating on August 10, 1993 and initiated operations. The center is administered by TARI under the supervision and funding from government.

## Status of Collections and Conservation of PGRs

- **Storage facilities and genebank management**

The PGRC of the Taiwan was established at TARI in 1993. The Center has storage facilities with long-term, medium-term, and short-term storage rooms with storage conditions of -12±2 °C and 40±3 %RH, 1±2 °C and 40±3 %RH, and 10±2 °C and 40±3 %RH, respectively. Activities at the PGRC can be divided into four parts: collection, preservation, distribution, and research on preservation and identification technologies on germplasm. The targets of collection include germplasm currently kept by Seed Units within the country, the new varieties bred by breeding programs, genetic materials acquired from international exchange, and germplasm collected by exploration teams to meet specific demands. When germplasm materials are imported, they have to be examined by the Bureau of Animal & Plant Health Inspection & Quarantine (BAPHIQ) for quarantine purposes so as to make sure it is infection-free and viable for reproduction and distribution.

For the processing of collected samples of germplasm preservation, the method of preservation is divided according to the type of germplasm which is seed or non-seed (clonal materials). For the aspect of storage of plant seeds, according to the storage tolerance of seeds to low temperature and dry environment, seeds are further divided into storable and non-storable types. These storable materials include small-seeded grain crops and vegetables. They can be stored for a long time under low-temperature and low-humidity environment and are separately stored in long, medium, and short-term store rooms in accordance to the purpose of storage.

The long-term preservation with storage conditions of -12±2 °C and 40±3% RH is provided mainly for the comprehensive base collection. Careful identification and selection processing are conducted stringently before storage. Storage capacity of the long-term room is 240,000 accessions in aluminium cans sealed under partial vacuum. Stored materials are not be used for exchange. They are only preserved for regenerating fresh seed and periodically examined for seed viability level. The main purpose of this storage is for the perpetuation of the seed stocks. Seed life expectancy of seed preserved in long-term storage at this Centre will last from 30 to 50 years.

The facility of medium-term storage with storage conditions of 1±2 °C and 40±3 % RH is provided solely for the seeds of actively used materials. This storage will accommodate 250,000 accessions or samples that can be used for distribution, exchange, multiplication, and evaluation purposes. The seeds are also supplement the base collection in long-term storage. Regular germination tests and seed regeneration are required for materials in the storage in order to maintain their viability.

The short-term storage room with storage conditions of 10±2 °C and 40±3 %RH is provided for storing working materials frequently requested or used, such as those parents and progenies of the breeding material or those with particular characteristics for research purpose are kept in this storage room. The storage capacities of the short-term rooms are 200,000 accessions.

Those classified as non-storable type of seed which can not be stored under low temperature and low humidity conditions, are certain vegetables, cocoa, longan, litchi, as well as those seeds are large and fleshly. Such seeds may be stored in low temperature ranges (0-10 °C) for short periods such as 1-5 years.

- **Number of accessions by crops/species**

Up to December, 2006, the PGRC has stored totally 67,942 accessions in its long-term, medium-term storage rooms, tissue culture rooms, or field repositories. These accessions represent more than 180 families, 696genus, and 1,058 species of plant germplasm (Table 1). The collections of seeds including 31,832 accessions in the long-term and 64,118 accessions in the medium-term storage room are conserved. For the field genebank, the collection and preservation of germplasm including fruit trees, medicinal plants etc., approximately, 4,800 accessions are grown and maintained in several repositories. A total of 1,734 accessions of collecting clonal germplasm are cultured *in vitro.*

Table 1. The summary of germplasm accessions preserved in PGRC in 2006.

| Crop | Scientific name | No. of passport data | No. of character data | No. of image data |
|---|---|---|---|---|
| Soybean | *Glycine max* | 18,940 | 14,876 | 64 |
| Tomato | *Lycopersicon esculentum* | 6,745 | 87 | 1459 |
| Mungbean | *Vigna radiata* | 6,301 | 9,438 | 51 |
| Rice | *Oryza sativa* | 5,910 | 15,520 | 84 |
| Pepper | *Capsicum annuum* | 4,301 | 917 | 118 |
| Eggplant | *Solanum melongena* | 2,740 | 470 | 320 |
| Peanut | *Arachis hypogaea* | 2,112 | 1,479 | 127 |
| Common flax | *Linum usitatissimum* | 1,811 | 0 | 3 |
| Sugarcane | *Saccharum officinarum* | 1,397 | 590 | 0 |
| Asparagus bean | *Vigna unguiculata* | 1,333 | 516 | 116 |
| Sweet potato | *Ipomoea batatas* | 1,309 | 596 | 0 |

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|---|---|---|---|---|
| Corn | *Zea mays* | 997 | 293 | 13 |
| Lettuce | *Lactuca sativa* | 710 | 0 | 0 |
| Edible amaranth | *Amaranthus tricolor* | 588 | 0 | 4 |
| Sorghum | *Sorghum bicolor* | 524 | 492 | 6 |
| Chinese cabbage | *Brassica campestris* Pekinensis group | 520 | 0 | 3 |
| Snap bean | *Phaseolus vulgaris* | 505 | 147 | 32 |
| Cucumber | *Cucumis sativus* | 465 | 48 | 100 |
| Spinach | *Spinacia oleracea* | 416 | 0 | 2 |
| Tobacco | *Nicotiana tabacum* | 385 | 0 | 0 |
| Watermelon | *Citrullus lanatus* | 381 | 134 | 6 |
| Black gram | *Vigna mungo* | 309 | 0 | 145 |
| Muskmelon | *Cucumis melo* | 305 | 354 | 4 |
| Adzuki bean | *Phaseolus angularis* | 280 | 490 | 25 |
| Luffa | *Luffa cylindrica* | 270 | 225 | 4 |
| Jute | *Corchorus capsularis* | 266 | 0 | 0 |
| Cauliflower | *Brassica oleracea Botrytis group* | 262 | 1 | 0 |
| Peach | *Prunus persica* | 260 | 183 | 59 |
| Squash | *Cucurbita moschata* | 234 | 99 | 15 |
| Banana | *Musa* spp. | 232 | 88 | 254 |
| Snow pea | *Pisum sativum* | 224 | 79 | 2 |
| Bitter melon | *Momordica charantia* | 219 | 122 | 20 |
| Mulberry | *Morus* spp. | 209 | 329 | 229 |
| Garlic | *Allium sativum* | 204 | 214 | 258 |
| Chinese mustard | *Brassica campestris* Chinensis group | 202 | 11 | 0 |
| Chinese kale | *Brassica oleracea* Alboglabra group | 201 | 102 | 0 |
| Bottle gourd | *Lagenaria siceraria* | 200 | 136 | 11 |
| Asparagus | *Asparagus officinalis* | 185 | 0 | 0 |
| Mango | *Mangifera indica* | 183 | 22 | 1 |
| Mustard | *Brassica juncea* | 136 | 20 | 6 |
| Sunflower | *Helianthus annuus* | 134 | 125 | 25 |
| Taro | *Colocasia esculenta* | 132 | 34 | 0 |
| Radish | *Raphanus sativus* | 129 | 15 | 0 |
| Buckwheat | *Fagopyrum esculentum* | 128 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| Tea | *Camellia sinensis* | 102 | 101 | 415 |
| Others | | 4,792 | 599 | 381 |
| **Total** | | **67,942** | **48,952** | **4298** |

- ***In-vitro* culture of plant germplasm**

Recent studies have made it possible to use tissue culture of plant parts such as shoot meristems, leaves, buds, tubers, etc., of vegetatively reproduced plants. Many clonal materials such as potatoes, sweet potato, yam, taro, strawberry, and some ornamental plants are cultured in artificial media. It is more space-saving of intensively managed than field plantings. Tissue culture also ensures virus-free condition and pathogen-free from plants. Moreover, these materials are also desirable for international shipment and germplasm exchange. A total of 1734 clonal materials are collected and cultured *in vitro* (Table 2). In order to save labour cost in a limited space, as well as maintain the minimum growth of plants *in vitro*, the low temperature, low light, and modified artificial medium are used in the tissue culture room in PGRC.

Table2. Accessions of clonal germplasm *in vitro* conservation in PGRC

| Crops | Number of varieties |
|---|---|
| Sweet potato (*Ipomoea babatas* (L.) Lam.) | 1361 |
| Yam (*Dioscorea* spp.) | 22 |
| Taro (*Colocassia esculenta* (L.) Schott.) | 40 |
| Potato (*Solanum tuberosum* L.) | 22 |
| Banana (*Musa sapientum* L.) | 123 |
| Strawberry (*Fragaria chiloensis* Duch. var. *ananassa* Hort.) | 16 |
| Lily (*Lilium* spp.) | 129 |
| Herbs | 16 |
| *Amoectochilus* spp. | 5 |
| Total | 1,734 |

- **Field genebanks**

Germplasm materials such as fruit trees, sweet potato, medicinal plants, and grasses are grown in nursery field for conservation. So far TARI has maintained seven field nursery sites at different elevations for clonal germplasm. Of two nurseries at TARI, one is used for quarantine and isolation reproduction purpose and one repository site is used for medicinal plants preservation. The aim of the repository is focusing on collection, introduction, propagation, and conservation. The total collections of fruit trees repository include 45 families, 88 genera, and about 800 accessions. In this repository system, tropical/subtropical fruits such as apple, plum, peach, pear, Chinese apricot, persimmon, grape, loquat, pimple, longan, litchi, citrus, avocado, passion fruit, banana, papaya, mango, Indiana jujube, star fruit, guava, wax apple, mulberry, and some exotic fruits were preserved in field genebank (Table 3).

Table 3. Germplasm materials of fruit trees grown in field nursery for conservation.

| Repository garden | Crops of preservation | Accessions |
|---|---|---|
| Wanshiang high-altitude field repository | Apple, Peach, Pear | 72 |
| Loona middle-altitude field repository | Peach, Plum, Chinese apricot, Persimmon | 240 |
| Wanfeng (TARI) low-altitude repository | Grape, Loquat, Peach, Plum, Chinese apricot, Persimmon | 178 |
| Chiayi tropical & subtropical repository | Pineapple, Longan, Litchi, Citrus, Avocado, Passion fruit, Banana, Exotic fruits | 596 |
| Fengsan tropical repository | Papaya, Mango, Indiana jujube, Star fruit, Guava, Wax apple | 311 |
| Guansih citrus repository | Citrus | 112 |
| Banana Research Institute | Banana | 214* |
| Miaoli Agricultural Research and Extension Station | Mulberry | 138 |

* Detail referring Table 4

Table 4. Collection of banana germplasm in different genome types.

| Type of genome | accessions |
|---|---|
| AA | 19 |
| AB | 2 |
| BB | 1 |
| AAA | 98 |
| AAB | 36 |
| ABB | 27 |
| AAAA | 1 |
| AABB | 1 |
| Other | 22 |
| Total | 214 |

In order to expand the functions of fruits germplasm, we investigate the growth habit, evaluate the utilization, and establish the primary database. The main purpose is to select the species or lines which may have the economic value or can be used as stocks with resistance to diseases or pests or can be used as the substrates for hybridization. Some indigenous or local plums with a distinct aroma and sweet skin (non-astringent) are adopted to breed with commercial variety and that become the important low chilling plum genepool in the world.

Most of citrus trees in Taiwan are likely infected with virus or virus-like disease. Nursery trees propagated from the material of existing trees in orchard are likely to be infected with these pathogens. Therefore, the program of establishment of virus-free citrus stock has been conducted since 1982. A two-level propagation procedure of foundation grove and scion grove was developed to improve the clonal germplasm. The mother trees in foundation grove are generated through shoot-tip grafting, heat therapy and indexed free from the above-mentioned pathogens. Scion trees from budwood are released and propagated directly from mother trees. Mother trees and scion trees are conserved in isolated screen house. There are 22 cultivars 36 lines have been preserved in scion grove.

Among the banana germplasm, using mass screening of resistant clones in indigenous plant *Musa formosana* (Warb.) Hayata, we investigate the feasibility of using root-pruning inoculation method. The results showed that the disease incidence of 'Pei Chiao' was 87%, but 0% of *M. formosana*. Browning internal symptom was appeared in 'Pai Chaio', but not in *M. formosana*. It obviously indicated the native species of *M. formsana* has high resistance to Fusarium wilt in banana. This character of disease resistance is considered as precious sources for utilizing banana gene pool in breeding program.

- **Germplasm collection of medicinal plants**

For the indigenous and local medicinal plant collection, PGRC collaborated with other agricultural institutes conducting the collection and preservation of genetic resources of medicinal plants. These materials including 23 species of Devision Pteridophytes, one species of Devision Gymnosperms, 880 species of Devision Dicotylendons, and 114 species of Devision Monocotyledons were added to PGRC collection. Among these materials, 109 species are native species (Table 5). Some materials are waiting for further regeneration, characterization, and utilization evaluation. Three conservation sites of medicinal plants were established for long-term preservation. A low altitude garden of medicinal herbs collection was set up at TARI. The germplasm of medicinal trees is located in Guansi Experiment Station and the other one repository nursery is established at Taitung District Agricultural Research and Extension Station for the manipulation of backup system. The information system of networks of medicinal plants germplasm has established to offer the academic research and genetic resources exchange. Aperiodical workshop has been held for exchanging knowledge and experiences on collection and development of native medicinal plants.

Table 5. Collection and conservation of medicinal plants added into PGRC in 2006.

| Devision | Families | Genera | Species | Native species |
|---|---|---|---|---|
| Pteridophytes | 14 | 16 | 23 | 0 |
| Gymnosperms | 1 | 1 | 1 | 0 |
| Dicotylendons | 90 | 312 | 880 | 92 |
| Monocotyledons | 19 | 56 | 114 | 17 |
| Total | 124 | 385 | 1,018 | 109 |

- **Distributions and exchange of germplasm**

Germplasm distribution remains a major function of the PGRC. Germplasm materials stored and maintained at PGRC are not only for conservation purposes but also to support research and utilization. These genetic materials are available to all persons with academic purpose and can be applied via internet or intranet. The supply of seeds is free of charge as well as including relative information for referring. In the past five years, many accessions of germplasm were distributed and transferred to domestic researchers listed in Table 6.

Table 6. Summary of germplasm distributed and transferred to domestic researchers in the past 5 years.

| Crop | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Food Crops | 13 (381) | 9 (295) | 5 (82) | 11 (1,069) | 9 (627) |
| Vegetable | 17 (583) | 12 (393) | 6 (76) | 28 (336) | 14 (516) |
| Fruit Crop | 1 (1) | 1 (2) | - | 6 (8) | - |
| Special Crops | 22 (28) | 1 (1) | 2 (22) | 7 (10) | 3 (139) |
| Forage | 1 (3) | - | - | 1 (1) | - |
| Ornamentals | 2 (2) | - | - | 5 (5) | 4 (60) |
| Total | 56 (998) | 23 (691) | 13 (180) | 58 (1,429) | 30 (1,342) |

The number of species and subsequent accessions in parentheses

International genetic resources exchange is also an important part of the center's service. Since 1960, TARI has been actively engaged in international exchange of crop seeds and seedlings for research purpose. The germplasm collections imported from foreign countries are conserved in an isolated greenhouse or repository nursery in TARI for quarantine examination. Crop seeds that go out of the center need pass through Seed Unit for monitoring and quarantine processing. In 2005, more than 1,000 accessions of seed packets were exchanged and distributed (Table 7). The diverse germplasm collection provides materials that genotypes can be particularly used to diversify production systems and chose as a source of novel varieties for development into new crops for commercialization.

Several kinds of publications have been printed from PGRC, such as proceedings of workshop on germplasm, annual report, catalogs, bulletins of genetic resources collection and exchange etc. Some publications also provide the regulations and instructions of application on germplasm which is available for exchange.

Table 7. Summary of germplasm exchanged to foreign countries in the past 5 years.

| Crop | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Food Crops | 4 (23) | 3 (3) | 1 (4) | 2 (499) | 3 (866) |
| Vegetable | 28 (69) | 18 (35) | 12 (18) | 3 (271) | 2 (230) |
| Fruit Crop | 4 (11) | 8 (35) | 1 (1) | 1 (11) | - |
| Special Crops | - | 65 (86) | - | - | - |
| Forage | 1 (3) | 2 (176) | - | - | - |
| Ornamentals | 2 (48) | 1 (1) | - | 5 (13) | 1 (12) |
| Total | 39 (154) | 97 (336) | 14 (23) | 11 (794) | 6 (1,108) |

The number of species and subsequent accessions in parentheses

## Status of Information Systems of PGRs

- **Information system for intranet and web-based systems**

In order to strengthen collection, conservation, and utilization of crop germplasm, plus to modernize management and operation of PGRC, a computerized information system has also been completed and called Plant Genetic Resources Information System (PGRCIS). Three main activities were set for the PGRIS including (1) setting up a database, including related germplasm information for breeders and researchers to search for needed information; (2) developing a genetic resources information network within the country and around the world to strengthen the communication of information on germplasm; (3) handling the processing and storage activities of germplasm at PGRC. In order to enhance the communication efficiency of germplasm information, an easy-to-query database and information network were developed through the “hyperlink” available on the WWW. We modified the original program and made it possible to link to other germplasm information centers around the world. This Center provides fibre-optic network system to researchers and breeders who are interested in genetic resources information and can search on the web site (http://www.npgrc.tari.gov.tw). PGRC also provides an excellent information system that can manage germplasm of storage activities. This system is linked to other germplasm informatory centers around the world. Researchers in our country may utilize the linked net to obtain information on plant genetic resources.

- **Hardware Architecture**

The frame of hardware architecture of PGRIS is consisted of ORACLE database management system and UNIX operation system which were built in the HP9000 800/G40 database server. To modernize and computerize the operations of the PGRC, all personal computers of PGRC-related laboratories are able to link to the server with a client-sever local network architecture. The system has been upgraded with band width to 2,048K BPS.

The PGRIS employs ORACLE as a relational database management system which is further divided into 12 subsystems according to operative functions. These available data of plant germplasm, including passport data, characterization data, and image data have been stored in PGRIS database. The passport data include background of distribution, donor information, common/scientific name, cultural practices, collection data, pedigree for each accession, and other notes etc. The characterization data records the characteristics of germplasm, such as agronomic traits, resistance and tolerances to stresses, chemical composition, etc. As the image data of plant germplasm can help the operators to differentiate possible duplication and help the researchers to be familiar with the germplasm rapidly. These efforts are being made by PGRIS working group to build up a complete image database relative to the plant germplasm.

- **Database Contents**

There are approximately 67,942 records of passport data, 48,952 records of characterization data, and 4,298 records of image data in the PGRIS database. The summary of the statistics on data records is shown in Table 1. The users of plant genetic resources can find detail information of donor of each material in each record of data. Since the PGRC preserves numerous plant germplasm accessions and their characteristic data of each species are quite different, we organized various crop committees to define and uniform items and related descriptor states depending on different crops.

The passport data and characterization data are provided by the breeders or collecting expeditions program. To ensure the accuracy of these data, the end-users from application have been assigned to feedback their data to PGRIS for the original breeders and donors. In order to provide a simple and useful tool to the public in country, we modified the program into English version and to establish our own germplasm database in Microsoft Window operation system. The main function of the program makes users enable to input easily and maintain efficiently the passport data as well as characterization data.

## Mission and Prospects

In order to maintain the quantity and quality of seeds in genebank, regeneration and characterization of the collected materials are being both at TARI headquarters and the participating farmers and other collaborating institutes. The standardized seed regeneration is being used. Regeneration procedures are based on a standard protocol that take into consideration the breeding structure of each species in order to preserve the genetic integrity of the original population in the regenerated materials.

For strengthening the acquisition, conservation, and utilization of crop germplasm, an advisory committee of plant germplasm and biodiversity has been organized to evaluate academic research proposals and the other issues pertaining plant genetic resources for supporting research and utilization. The plan calls for an amalgamation of existing capabilities of all agricultural research institutions with TARI playing a nuclear role. Under the system, TARI coordinates and collaborates with all research institutions and university on field collection, post-entry quarantine, conservation, regeneration, documentation, dissemination, and international cooperation.

The PGRC aims to serve as the storage site for all crops. Its mission also involves the development of new techniques for seed preservation and identification, provision of germplasm information, plus international exchange. We also aspire to become an international germplasm centre for tropical and subtropical crop, through international collaboration on collection, as a special feature of this centre.

Germplasm is the foundation of agricultural production. Regardless of future development in biotechnology (e.g. gene manipulation, tissue culture, etc.), the practical use of advanced biotechniques is not possible without germplasm. With the rapid loss of germplasm materials nowadays, the gathering and preservation of germplasm take on new urgency. Although we now have good facilities and equipment, we shall need help from all concerned people to provide us with information on germplasm and materials as to expand our holdings and to raise the level of research and agricultural production through richer germplasm collections.

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