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Conservation and Risk Management of Plant Genetic Resources in Thailand

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Abstract

There are many relevant organizations that are active in the conservation of plant genetic resources in Thailand, namely organizations which are under the responsibility of the Ministry of Agriculture and Cooperatives, organizations which are under the responsibility the Ministry of Natural Resources and Environment, and also some academic institutions. The Department of Agriculture has played significant roles as a key national organization which is responsible for agricultural genetic resource conservation, whereas the Royal Forest Department is accountable for forest genetic resource conservation. Examples of universities which are carrying out conservation of plant genetic resources are Chiang Mai University, Khon Kaen University, Maejo University, and Prince of Songkla University. To maintain good management of plant genetic resource conservation, it is necessary for all sectors to analyze and handle the potential risks which both directly and indirectly affect conservation.

This report describes potential risks to plant genetic resource conservation: 1) difficulties of management that are the result of changing policies, insufficient budgets, and retirement of genebank experts; 2) the loss of plant genetic resources that are the result of natural disasters, biotic and abiotic stresses, genetic erosion, and lack of awareness of genetic resource values; and 3) regeneration of mixed genotypes in the same accession which can lead to the loss of minority ones. In order to minimize these risks, some management practices should be carried out; for instance, duplicate collection of both on-farm conservation and genebanks can save genetic resources from unexpected incidents like natural disasters. Some systems should be created to prevent the consequences of changing policies on plant genetic resource conservation. Moreover, building public awareness of the value of genetic resources should be done by promoting their utilization.

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Finally, human resource development is urgently needed. The staff should attend training sessions and workshops to enhance their expertise and knowledge. Like other countries, Thailand tries to manage and minimize the risks with all its capability even though some factors are out of our direct control.

Introduction to Thailand

General Basic information

The Kingdom of Thailand is situated on the Indo-China Peninsula, covering an area of 514,000 square kilometers. It shares borders with the Union of Myanmar to the west and north, Lao P.D.R. to the north and northeast, the Kingdom of Cambodia to the east, and Malaysia to the south. It is divided into four distinct areas: the mountainous north, the fertile Central Plains, the semi-arid plateau of the northeast, and the peninsular south, distinguished by its many beautiful tropical beaches and offshore islands. Thailand lies within the humid tropics. There are three seasons: the cool season (November to February), hot season (April to May), and the rainy season (June to October), although downpours rarely last more than a couple of hours. The population is about 60 million. Ethnic Thais form the majority, although the area has historically been a migratory crossroads, and thus strains of Mon, Khmer, Burmese, Lao, Malay, Indian, and, most strongly, Chinese blood produce a degree of ethnic diversity. Integration has, however, produced enormous unity both culturally and socially.

Agricultural Sector Information

Thailand is a small country of approximately 320,700,000 rai (2.5 rai = 1 acre). The agricultural sector is classified into four major groups of livestock, fishery, vegetation, and forestry. According to the Office of Agricultural Economics, the total area of Thailand is divided into many categories depending on the usage: forests (104,744,313 rai), agricultural land (130,275,993 rai), and wastelands or grasslands (2,532,003 rai).

Almost all of the agricultural land is used for growing rice (63,861,066 rai), field crops (27,400,423 rai), horticultural crops (29,017,779 rai), and livestock (1103.3 rai). The agricultural sector dominates the Thai economy, providing two-thirds of employment and almost half of total exports. The economic crops are rice, para rubber, maize, sugarcane, sorghum, cotton, soybeans, pineapple, oil palm, ornamental flowering plants, etc. Not only do these crops bring great national profit to the country, they also enhance farmers' earnings in terms of household income.

The vegetation is divided into two major zones, namely lower tropical rainforests and upper tropical rainforests. Lower tropical rainforests occupy the peneplains and also hill slopes up to 600 m in elevation, whereas upper tropical rainforests cover slopes of 600 to 900 m. To produce good varieties and good seeds, germplasm may be obtained by collecting from the wild, landraces, and cultivated areas, and has been introduced from foreign countries. Today there is more progress in the production of good seeds. Cooperation between the government and private sector is underway particularly in the use of modern technologies. However, seeds produced by the government are limited in quantity, so seed supplies rely on those stored by farmers themselves or produced locally.

Status of plant genetic resource conservation in Thailand

Relevant organizations

In fact, there are many organizations which conduct plant genetic resource conservation throughout Thailand. The outstanding organizations can be briefly described as follows:

1. Department of Agricultural Extension

The Department of Agricultural Extension is also under the jurisdiction of the Ministry of Agriculture and Cooperatives. It plays a role as a key organization which engages in extension and distribution of good varieties. There are regional offices which are located in almost every district of the country. Its distinguished missions regarding plant genetic resource conservation are good varieties of horticultural crop collection for the purpose of propagation and distribution to farmers. In total, 46 species of crops have been collected, such as mango, longan, lychee, jackfruit, pomelo, durian, mangosteen, orange, macadamia, pomegranate, rose apple, etc.

2. Universities and academic institutes

Almost every institution has collected and conserved plant genetic resources in both the field and laboratory. The collections are kept in accordance with their objectives of research and study programs. Some examples are as follows.

Faculty of Agriculture, Chiang Mai University carries out conservation of plant genetic resources with the objectives of collecting and conserving materials for investigations and

research including studies on suitable means of resource utilization. Plant germplasm can be grouped into cereals, legumes, herbs, native species, beverage plants, vegetables, and fruit tress. All plants are *ex situ* conserved.

The plant germplasm collection at Khon Kaen University is carried out by the Faculty of Agriculture. The Departments of Agronomy and Horticulture are responsible for this job. The collected germplasm includes sesame, peanuts, soybeans, cowpeas, yard long beans, tamarind, guava, etc.

Maejo University has been conserving plant genetic resources both *in situ* and *ex situ*: for example, the Plant Genetic Resources Conservation Project in Banpong Forest conserves 223 species of herbarium specimens, the Department of Agronomy conserves six species of agronomic plant genetic resources through field collections, a seed bank, and germplasm, the Department of Ornamental Horticulture (Vegetable Technology) has collected five species of economically important vegetables including nine varieties in a seed bank and 23 species of important local vegetables from four provinces in northern Thailand through field collections and a seed bank, and the Department of Ornamental Horticulture (Pomology) has conserved 11 varieties of longan (*Dinocarpus longan* Lour) and nine varieties of lychee (*Litchi chinensis* Sonn) through field collections.

Prince of Songkla University receives a budget from the Princess Sirindhorn Royal Project on Plant Genetic Resources Conservation to carry out the conservation of seven varieties of rattan and also local durian varieties.

3. Royal Forest Department

The main mission of the Royal Forest Department is to conserve and protect forest genetic resources. Recognizing the threat to valuable forest genetic resources, the Royal Forest Department has taken steps toward both *in situ* and *ex situ* conservation. In total, about 200 natural reserved areas have been established. Efforts to encourage an understanding of the importance of conservation projects among local populations are very important.

The Natural Resources Conservation Office is responsible for the project of forest natural resource conservation and management. It conducts *in situ* conservation called “protected areas” like national parks. Another important office is the Forest Research Office

which is responsible for *ex situ* conservation. Existing conserved flora include pine, teak, hardwood species, bamboo, Ma cha mong (*Afzelia xylocarpa* Craib), eucalyptus, etc.

4. Queen Sirikit Botanic Garden

The Queen Sirikit Botanic Garden (QBG), Maerim, Chiang Mai Province, was established in 1992 by the Botanical Gardens Organization of Thailand. It was the first true botanical garden in the country. The conservation programs include *in situ* conservation and *ex situ* conservation (field, seed banks, and *in vitro* conservation). Rare species and endangered species are emphasized. Living collections under its protection include 11 families and four groups such as Palmae, Orchidaceae, Moraceae, Musaceae, Caesalpiniaceae, ferns, and medicinal plants.

Collaborations in scientific research, information exchange, and training programs are encouraged at the QBG. Furthermore, coordination with other national and international institutions in conservation of plant genetic resources has been undertaken.

5. Department of Agriculture (DOA)

The DOA, a governmental sector under the Ministry of Agriculture and Cooperatives, has played a significant role in the collection, conservation and research of plant genetic resources. Almost all of the crops it is responsible for are economically important crops. Conservation can be divided into two types of *ex situ* and *in situ* conservation.

There are 40 regional crop research centers and stations throughout the country, which have conserved about 127,416 accessions. Most of them are horticultural crops which comprise 5334 varieties of fruit crops (e.g., durian, mangoes, rambutan, pineapples, and bananas), 1430 varieties of vegetables (e.g., baby corn, garlic, chili, and onions), 1109 varieties of ornamental plants (e.g., orchids, roses, and lilies), 698 varieties of industrial crops (coconut, oil palm, para rubber, coffee, and cocoa), and medicinal plants. Besides horticultural crops, other field crops are also conserved include 594 varieties of cassava, 453 varieties of sugarcane, paper mulberry, five varieties of kapok, 30 varieties of jatropha, and 36 varieties of ramie.

As to seed banks, plant genetic resource conservation particularly for rice was conducted after the end of World War II. In the early period, those conserved crop seeds were kept in air conditioned rooms. Consequently, seed longevity was quite short and caused

problems of regeneration for maintaining the varieties. In 1981, the DOA received donated money from the Government of Japan to set up the first seed bank located at the Pathumthani Rice Research Center. It is called The National Rice Seed Storage Laboratory for Genetic Resources. Not only are rice seeds conserved, other crops from many sources are also kept there. Until 2002, according to reorganization, collections from the first seed bank were transferred to a new location in the Sirindhorn Plant Genetic Resources Building, Biotechnology Research and Development Office. The main responsibilities are collection, conservation, and utilization of plant genetic resources.

Storage facilities in DOA's seed bank

- **Incoming seed room**: The room is 40 m^2 and maintained at 15 °C and 60% relative humidity (RH). Before being stored, seeds are placed in this room to determine moisture content and germination tests as well as to reduce the moisture content. Seeds ready for seed bank storage must be at an 8% moisture content and possess 80% germination.
- **Laboratory room**: This room has two parts: a) a space for a hot air oven and seed germinator, and b) space for moisture and germination analyses and purity tests.
- **Unheated seed room**: This room is used for seed moisture reduction with its low level of RH of 6%.
- **Sun drying room**: This room is used for moisture reduction using the sun's heat. When the room temperature reaches 43 °C, a heater is automatically switched on to increase the temperature. A computer is used to control the system.
- **Medium-term storage**: Its capacity is about 150,000 accessions. The room temperature is maintained at 5 °C with 60% RH. An automatic bullet crane system controlled by a computer is used.
- **Long-term storage**: This room is 86 m^2 in size and its temperature is maintained at –10 °C. Seeds are packed in vacuum-sealed aluminum foil packages. The maximum capacity is 40,000 accessions.
- **Information processing room:** Information is recorded on both computers and in documents in this room. Information records are passport data, characteristics and evaluation, percent seed germination, weight of stored seeds, rejuvenation data, seed distribution data, etc.

Status of the collections

Collections consist of both active and base collections that are maintained in PET plastic bottles with silica gel inside at 5 °C storage in vacuum-sealed aluminum foil packages at -10 °C storage conditions (Table 1).

Table 1. The total number of 30,029 accessions stored in genebanks in Thailand.

No.	Crops	No. of accessions
1	Rice	24,535
	Native and improved varieties	20,899
	Overseas varieties	2571
	Wild species	1065
2	Cowpeas	83
3	Sesame	241
4	Corn	113
5	Black gram	446
6	Safflower	72
7	Cotton	330
8	Soybeans	1923
9	Jute	50
10	Peanuts	1840
11	Vegetables	22
12	Others	374
Total		30,029

Rice is the majority whereas other plants are also conserved including cowpeas, sesame, corn, black gram, safflower, cotton, soybeans, jute, peanuts, pigeon peas, roselle, castor beans, kenaf, wheat, barley, and several varieties of vegetables.

Moreover, there are duplicate collections of rice collections at the International Rice Research Institute (IRRI).

Total accessions		5,981
	1. *Oryza sativa*	5,492
	2. Wild species	489

Regeneration and utilization

Regeneration is usually carried out on accessions when they approach the low percentage of germination (< 50%) and weigh < 50 g. Actually, regeneration must be done in order to enhance the quality and quantity of existing collections.

As regeneration is carried out; the use of the collection continually proceeds. Main users of materials in the seed bank are researchers (from both governmental and private sectors), plant breeders, students, farmers, and other users with various requirements. Many collections have frequently been used as materials for different objectives, e.g., research, breeding programs, and academic purposes. Presently, rice is the only plant which can be given upon request. Each accession can be provided if it has a high percent of germination and adequate amounts. Other crops will, hopefully, be distributed to recipients in the near future.

Laws and relevant legislation

Thailand signed the Convention on Biological Diversity (CBD) on 12 June 1992 and became a party of the CBD on the 29 January 2004. The Ministry of Natural Resources and Environment is responsible for the national focal point of the CBD and cooperation with the DOA as the competent authority of plants/crops.

Regarding intellectual property protection, Thailand has enacted several laws that are applicable to the protection of biotechnological products and processes, namely, the *Patent Act*, *Plant Variety Protection Act*, *Bill on the Law of Trade Secrets*, etc. Thai patents are given to inventions and processes which are new, posses an inventive step, and are capable of industrial application. However, patents are not given to naturally existing microorganism or their components, animals, or plant extracts. The *Thai Patent Act* is still struggling with protecting DNA, genes, and proteins, particularly those extracted, isolated, and purified from plants and animals. The issue of patentable subject matter is indeed not only a question of law but also a policy consideration.

For the International Treaty on Plant Genetic Resources for Food and Agriculture, (ITPGRFA) which Thailand signed on 4 November 2002, our country has not yet ratified it due to a government decision.

Risk management on plant genetic resources

Potentials risks and their causes

Risk 1: Difficulties in managing plant genetic resource conservation

Cause 1 – Changing policies

According to the instability of Thai politics, changing policies frequently occur within the governmental sector. For example, because of a reorganization of the Ministry of Agriculture and Cooperatives, all agricultural crops were previously under the DOA's jurisdiction, but in the last 2 years the Rice Department was set up in order to oversee all activities concerning rice. The DOA itself still has to conserve rice collections whereas the Rice Department simultaneously carries out the same activities. Unavoidably, an overlap of missions occurs.

A second example which is a result of changing policies is the direct impact on on-farm conservation. Nowadays energy crops are considered to be a hot worldwide issue. Like in other countries, Thailand currently promotes expansion of areas planted in energy crops due to strategies of the government. Thus, the lands formerly dedicated to on-farm conservation are being invaded and replaced.

Cause 2 – Insufficient budgets

Adequate money is necessary for every operation. By comparison, inadequate budgets are considered important obstacles to meeting many commitments. In Thailand, there are many research projects and activities on genetic resource conservation. Unfortunately, some of them have not received enough fiscal support from the sponsor. Thus, they cannot accomplish their goals.

Cause 3 – Retirement of genebank experts

Nowadays, the numbers of experts in genebanks tend to decrease for several reasons. One obvious reason is retirement. Those vacant positions are replaced by young staff who do not have much expertise or profound knowledge. What is more, these new staff members are not enthusiastic about this work because they do not have sufficient motivation, do not receive encouragement, and so on.

Risk 2: Loss of plant genetic resources

Cause 1 – Natural disasters

Each year, Thailand frequently faces impacts of natural disasters such as flooding, wildfires, storms, and mudflows. These severely harm plant genetic resources and especially directly affect *in situ* and on-farm conservation efforts. These rapidly damage natural resources and seem to be out of control whether any measures are tried to prevent their effects or not.

Cause 2 – Biotic and abiotic stresses

For field collections, plant genetic resources can be threatened by both biotic (pathogens, insects, and other pests) and abiotic stresses (drought, flooding, global warming, and other environmental factors). These stresses lead to the loss of resources and are sometimes simultaneously beyond prevention and control.

Cause 3 – Genetic erosion

Because of advancements in plant breeding, many new improved varieties with dominant genes like those for pest resistance are likely stronger than older cultivars. So, many local varieties can potentially lose their original genetics and tend to be replaced by high-yield varieties.

Monoculture is also a major cause of genetic erosion. For instance, many farmers consider that one crop is the preferred crop. At the same time, other local crops are neglected because of their weaknesses and incompetence such as low yields and lack of pest resistance. In consequence, those local varieties tend to be supplanted and eventually lost.

Other human behaviors such as deforestation, improper use of modern technologies, and lack of sustainable use of natural resources can threaten plant genetic resources in both direct and indirect ways; for example, gathering various kinds of forest resources especially rare and endangered species can lead to their extinction.

Cause 4 – Lack of consciousness regarding evaluations of plant genetic resources

Presently, there are a lot of genetic resources the value of which has not been evaluated, because they tend to be overlooked by many farmers and researchers. Hence, their useful characteristics are not being utilized.

Risk 3: Mixture of genotypes

Most scientists have as their objective the collection of genotypes for building up genetic diversity so that there are many collections which are kept in genebanks, especially upland rice, which has mixed genotypes in the same accession. When regeneration is carried out for many generations, the stronger or predominant genotype will be in the majority because the weaker varieties are oppressed.

Risk management

Although there are several risks with plant genetic resource conservation, they can probably be managed in order to minimize the threats. We, however, should realize that the management practices we choose to handle many risks must be able to be properly implemented and must not affect other sectors.

Duplicate collections in other places should be done for both on-farm conservation and genebanks, in order to save them from unexpected incidents like natural disasters. For example, the conserved collections in genebanks should be deposited in other genebanks such as places located abroad. At present, there are approximately 5,000 accessions of rice from the DOA genebank kept at the IRRI. What's more, studying further techniques which can be other alternatives of conservation of on-farm collections such as slow growth (growth-retardant method) and cryopreservation seem necessary. These optional methods can minimize the effects of both biotic and abiotic stresses.

Some systems should be created to prevent the consequences of changing policies on plant genetic resource conservation. Moreover, the building of public awareness of the value of genetic resources for people especially local people should be done by promoting utilization, educating them about the importance of the resources, and trying to build up their consciousness that the genetic resources are national treasures so that they realize how to protect and use genetic resources in sustainable ways.

Finally, human resource development is urgently needed. With many experts in the field of genetic resources conservation retiring, young staff in each sector should be supported to enhance their knowledge and expertise. Not only do they need to attend training sessions and workshops, older staff members also need to convey knowledge from actual practice.