International Cooperation for the Collection of Endangered Plant Genetic Resources

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Abstract

Plant genetic resources are now confronted with a gradual extinction due to the widespread use of improved uniform varieties, socio-economic changes in agriculture, urbanization of farms mainly. Considering the worldwide trend of genetic erosion or genetic uniformity, emphasis should be placed on the collection and conservation of endangered plant genetic resources on the earth for future utilization. Since 1983, Japanese scientists have taken part in the international missions organized by the National Institute of Agrobiological Resources (NIAR) and International Board for Plant Genetic Resources (IBPGR) to collect plant genetic resources in South, Southeast and Central Asia. The missions collected a total of 6,549 samples of citrus, cereals, grain legumes, fruit trees, fodder crops and root crops. These international cooperative activities contribute to the collection and *ex situ* conservation of plant genetic resources in the respective countries. NIAR has also planned joint explorations with the scientists of Russia and the adjacent republics to collect plant genetic resources in the centers of diversity of Central Asia and the Middle and Near East proposed by N. I. Vavilov. This report deals with the recent activities of the international explorations coordinated and funded by IBPGR, in particular in Pakistan in 1989 and 1991, and in Central Asia in 1992 and 1993, in addition to the national project of overseas exploration sponsored by the Ministry of Agriculture, Forestry and Fisheries of Japan.

Introduction

Plant genetic resources have played an important role in plant improvement as gene donors. In particular, landraces which have adapted to local environments over a long history and wild relatives of crop species could be used as breeding materials in future breeding programs. These plant genetic resources, however, are now confronted with a gradual extinction referred to as genetic erosion due to the widespread use of improved uniform varieties, socio-economic changes in agriculture and urbanization of farms mainly. The erosion of genetic diversity implies the loss of diverse genes in individual plant species. Considering the worldwide trend of genetic erosion or genetic uniformity, emphasis should be placed on the collection and conservation of endangered plant genetic resources for future utilization.

N. I. Vavilov, a well-known Russian geneticist and plant breeder, firstly established a scientific base concerned with the exploration of plant genetic resources. He suggested that plant improvement should draw from wide genetic variation, and he also collected cultivated plants and their wild species in various regions of the world. Based on these activities, he postulated that the genetic diversity in each of the cultivated plant species was concentrated in certain regions of the world which he named "centers of origin of cultivated plants". Although this concept has been modified by other scientists since the 1970's, it is still an important part of basic tenets on the exploration of plant genetic resources.

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International explorations organized by IBPGR

Since 1983, Japanese scientists have taken part in the international missions organized by IBPGR to collect endangered plant genetic resources in South and Southeast Asia. For example, an exploration was carried out in Laos in 1983, in Nepal in 1984 and 1985, in Thailand in 1984 and 1986, in Papua New Guinea in 1986 and 1987, in Pakistan in 1989 and 1991 (Table 1). These repeated explorations make it possible to analyze in detail present situation of biodiversity and intra-specific genetic diversity of plants. The exploration projects sponsored by IBPGR, thus, have contributed to collection and conservation of endangered plant genetic resources on the earth.

National Institute of Agrobiological Resources (NIAR), Japan, has also participated in the IBPGR joint explorations with the scientists of Russia and the adjacent republics to collect plant genetic resources in Caucasia and Central Asia. These regions are two of the eight centers of diversity of cultivated plants proposed by Vavilov. In 1992, two missions firstly explored the northern part of Caucasia to collect fodder crops and Central Asia to collect fruit trees. These missions collected a total of 416 plant samples, including 232 samples of fodder crops and 184 samples of fruit trees (Table 1). An exploration in 1993 has been planned to collect genetic resources of cereals, vegetables and grain legumes.

In this report, examples of international missions funded by IBPGR will be discussed with emphasis placed on the missions in Pakistan and Central Asia.

1 Explorations and collections in Pakistan

Pakistan shares the borders with Afghanistan, China, Iran and India and is adjacent to Central Asia which is the center of diversity of many kinds of crops. An ancient trade route from China to West Asia via Central Asia which was called the silk road passed through present Pakistan. The trade route from Afghanistan and Iran to India also passed through present Pakistan. These routes contributed to the introduction of many kinds of crops to present Pakistan from the East and West. The crops were domesticated as landraces indigenous to this region in which the geography and climate are variable. Pakistan is considered to be an important center of diversity of cereals and grain legumes. NIAR organized the collecting missions in collaboration with the scientists of Pakistan Agricultural Research Council.

The exploration in Pakistan was planned to survey the crop cultivation and to collect landraces of various kinds of crops in 1989 and 1991. The first year's exploration was undertaken to investigate the current situation of plant genetic resources in wide areas (Nakagahra *et al*., 1990). The missions covered about 15,000 km throughout Pakistan. We recognized through the exploration in 1989 that Pakistan, in

Table 1 Exploration missions organized by IBPGR

Year	Country	Major plants collected	No. samples
1983	Laos	grain legumes	92
1984	Thailand, Malaysia, Brunei,	citrus	1,150
	Nepal	cereals, fruit trees, vegetables	
1985	Nepal	cereals, fruit trees, vegetables	2,870
1986	Indonesia, Thailand	citrus	60
	Papua New Guinea	tuber and root crops	120
1987	Papua New Guinea	tuber and root crops, banana	420
1988	Indonesia	citrus	91
1989	Pakistan	cereals, grain legumes	705
1991	Pakistan	cereals, grain legumes	412
1992	Russia	fodder crops	232
	Kazakhstan, Kirgizstan, Uzbekistan	fruit trees	184
1993	Turkmenistan, Kazakhstan, Uzbekistan	wheat, barley, wild relatives	123
			(6,549)

particular the mountainous area in northern Pakistan, still holds a wide range of variation in cereal crops, millets and grain legumes. On the basis of the exploration in 1989, the mission in 1991 focused on northern Pakistan which is located within the Central Asia center of diversity. The missions collected a total of 1,117 plant samples, including 249 samples of rice (*Oryza sativa*), 124 samples of mungbean (*Vigna radiata*), 68 samples of blackgram (*Vigna mungo*), 64 samples of foxtail millet (*Setaria italica*) and 59 samples of common bean (*Phaseolus vulgaris*) (Table 2).

Landraces of rice still remain in the vicinity of Chitral in northern Pakistan. Paddy fields in this region are cultivated with two different *japonica* varieties which are characterized by round-shaped grains, zymogram pattern of esterase isozyme, tolerance to cold injury and plant type. These two varieties differ from one another in several agronomic traits, for example transplanting or direct seeding, resistance or susceptibility to rice blast fungus, positive or negative reaction to phenol, and presence or absence of seed dormancy. Most of the old varieties of rice, except for the above two varieties have been replaced by improved high-yielding varieties in the past decade.

To clarify the genetic variation of common bean germplasm collected in Pakistan, we analyzed seed samples for total seed proteins using SDS polyacrylamide gel electrophoresis (SDS-PAGE). Patterns of globulin which is a major component of seed storage protein in common bean can be classified in world collections into two types, A and B. A large number of accessions from South America (Peru and Bolivia) showed the A type, while the accessions from Central America (Mexico and Guatemala) showed the B

Table 2 Summary of plant samples collected in Pakistan

Plant species	1989	1991	Total
[Gramineae]			
Echinochloa frumentacea	16	2	18
Hordeum vulgare	29	5	34
Oryza sativa	191	58	249
Panicum miliaceum	21	13	34
Pennisetum americanum	45	7	52
Setaria italica	35	29	64
Sorghum bicolor	43	9	52
Triticum aestivum	33	8	41
Zea mays	43	1	44
Others	20	1	21
Sub-total	478	133	611
[Leguminosae]			
Cicer arietinum	1	21	22
Glycine max	7	6	13
Lens curinalis	16	20	36
Phaseolus vulgaris	32	27	59
Pisum sativum	3	8	11
Sesbania sesban	1	4	5
Vicia faba	13	0	13
Vigna radiata	41	82	123
Vigna mungo	16	51	67
Vigna aconitifolia	4	8	12
Vigna unguiculata	9	37	46
Others	5	10	15
Sub-total	148	274	422
[Other plants]	79	5	84
Total	705	412	1,117

type. These two types were also subdivided into 6 patterns of A type (A 1–A 6) and 4 patterns of B type (B 1–B 4). Seven of the ten different types of electrophoregrams detected in the world collections were observed in the seed samples introduced from Pakistan (Takeya *et al*., 1992). More than 80% of the samples from Pakistan showed the B type which was more frequently detected in the collections of Central America. Fig. 1 shows the geographical distribution of electrophoregrams of total seed protein in common bean germplasm from Pakistan. B 3 type predominated throughout northern Pakistan and Punjab. There were differences in the distribution of seed protein electrophoregrams among small areas and among valleys.

Foxtail millet germplasm certainly varied between landraces in the northwestern and northeastern regions of Pakistan. Landraces in the northwestern region were characterized by short stems, small panicles and many tillers, whereas those in the northeastern region had tall stems, large panicles and fewer tillers. All the samples belonged to the non-glutinous type of endosperm starch and produced a larger amount of *Wx* protein with a molecular weight of 60 kDa bound to starch granules which is responsible for amylose production. Farmers in northern Pakistan have preserved a variety of millet genetic resources, although the cultivation of millets has disappeared due to the dissemination of maize in northern Pakistan, especially in regions of less than 2,000 m elevation.

Based on the repeated explorations in 1989 and 1991, we would like to emphasize that a rapid and not gradual erosion of plant genetic resources is taking place in northern Pakistan.

2 Explorations and collections in Central Asia

Central Asia which consists of Turkmenistan, Uzbekistan, Kazakhstan, Kirgizstan and Tadzhikistan is one of the centers of origin of cultivated plants proposed by Vavilov. This center is considered to show a large diversity in apple, pear, broad bean, onion and spinach.

NIAR has organized explorations to Russia and Central Asia to collect fruit trees, fodder crops, cereals, vegetables and grain legumes. The missions in 1992 explored Russia to collect fodder crops and also explored four countries in Central Asia except for Turkmenistan to collect fruit trees. For example, a total of 184 germplasm accessions of fruit trees, including wild species of apple, plum, apricot and walnut were collected in Central Asia. In 1993, field surveys and collections were carried out for wheat, barley and their wild relatives in Turkmenistan, Uzbekistan and Kazakhstan. As the old landraces had already been replaced by improved varieties, the mission focused on the collection of *Aegilops* and wild species of *Hordeum*. In Central Asia, five of 20 *Aegilops* species, *Ae. squarrosa*, *triuncialis*, *crassa*, *juvenalis* and *cylindrica* were growing on roadsides, in the vicinity of fields, on slopes of hills and mountains. Among these *Aegilops* species, *Ae. cylindrica* and *Ae. triuncialis* were distributed all over Central Asia. The highest area in which these two wild species were growing was 1,500 m in Turkmenistan and 1,700 –1,800 m in Uzbekistan. On the other hand, *Hordeum bulbosum* formed large colonies in areas at higher elevations than 1,000 m and was growing up to 1,700 m. The mission collected a total of 123 samples of *Aegilops* and wild species of *Hordeum* and *Avena*. This exploration project will be followed by missions to collect vegetables and grain legumes.

Overseas explorations sponsored by MAFF Gene Bank Project

An overseas exploration project had been planned by the Ministry of Agriculture, Forestry and Fisheries (MAFF) to introduce useful plant genetic resources for the breeding program in 1975. From 1975 to 1983, one mission was dispatched abroad to collect plant samples. This project was followed by the MAFF Gene Bank Project aimed at collecting, characterizing and conserving plant, animal and microbial genetic resources. As it is important to pay more attention to the collection of plant genetic resources before their extinction, overseas explorations have been carried out more frequently within the framework of the Gene Bank Project. From the viewpoints of potentials of plant genetic resources, Suzuki and Watanabe (1988) stressed that the following standards should be kept in mind when proceeding to collections: 1) plants which are completely endangered and may be lost for ever, 2) plants which are distributed mainly in areas difficult to reach, 3) indigenous plants which are domesticated in the areas, and 4) historically important but now almost abandoned plants.

Four overseas exploration missions are planned annually. Since 1985, thirty four missions have been dispatched abroad to collect various kinds of plants including rice, wheat and barley, grain legumes, tuber and root crops, millets and industrial plants, fodder crops, fruit trees, vegetables, flowers and ornamental plants, tea trees, mulberry trees and their wild species (Fig. 2). The MAFF missions have explored about forty countries in South and Southeast Asia, Europe, Africa, and Central and South America. For instance, overseas explorations from 1991 to 1993 have been carried out as follows: collections of temperate grasses on Sakhalin Island of Russia, vegetables in Poland, millets in Sri Lanka and Thailand, Irish and sweet potatoes in Uruguay and Chile, sesame in India, pineapple in Brazil, mulberry tree in Mexico, and cultivated and wild rice in Madagascar. More than 5,000 plant samples have been collected through overseas explorations from 1985 to 1992.

In addition to the MAFF Gene Bank Project, the Tropical Agriculture Research Center (TARC) of MAFF has also organized overseas explorations for the collections of plant genetic resources in tropical and subtropical regions. The Ministry of Education, Science and Culture also organizes explorations for the collections of plant species in foreign countries.

The plant materials collected by overseas explorations are shared with the respective countries and institutes as well as evaluated for their utilization.

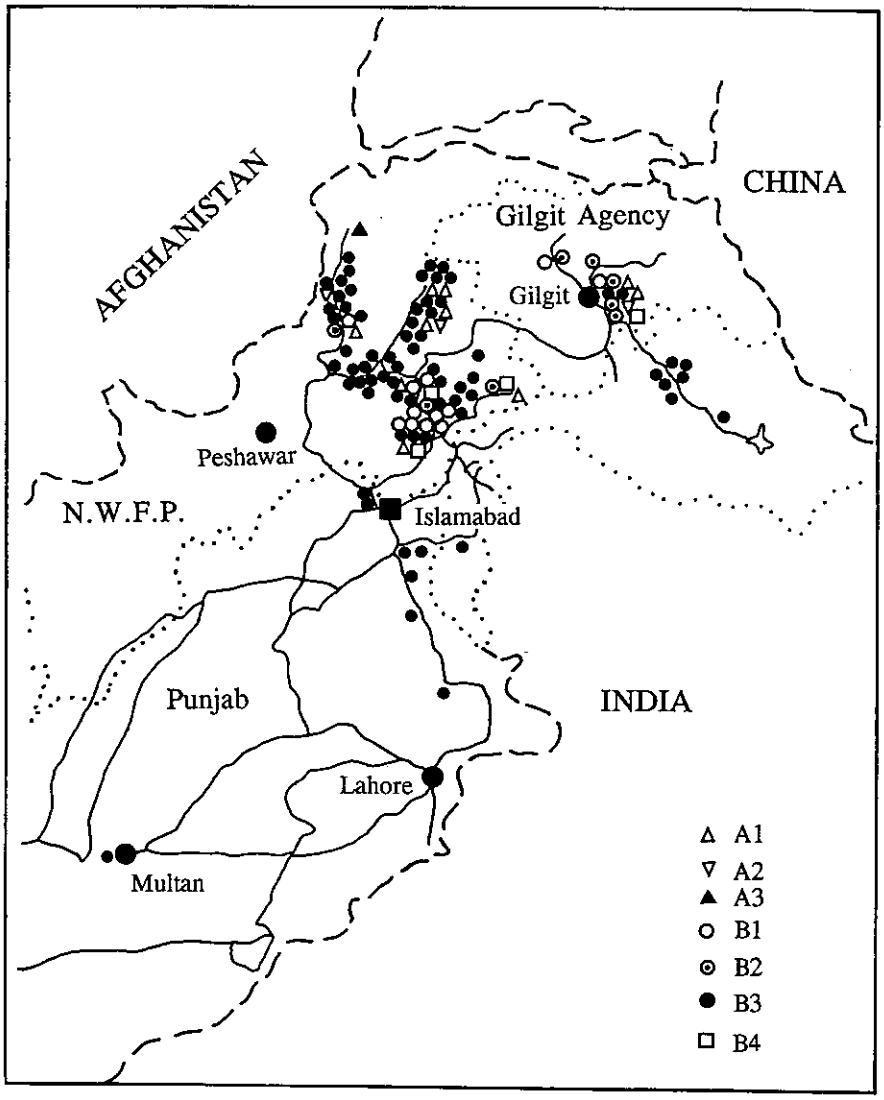

Fig. 1 Geographical distribution of seed protein electrophoregrams of common bean cultivars collected in Pakistan

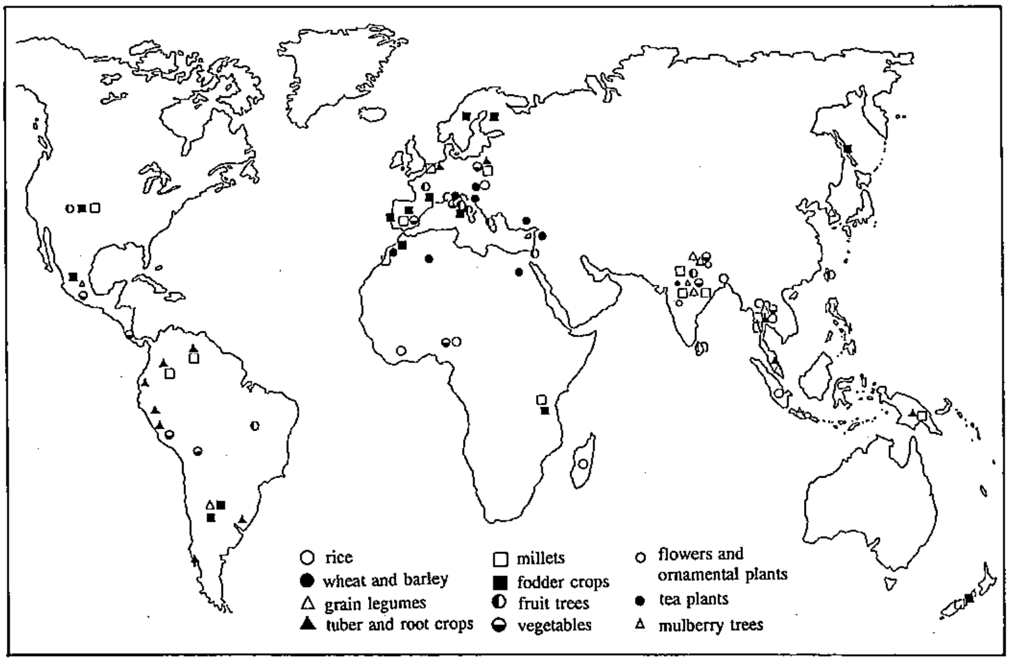

Fig. 2 Overseas explorations of plant genetic resources from 1975 to 1992

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Discussion

Iwanaga, M. (IBPGR): Regarding the strategy of the expeditions for collecting genetic resources, one approach is to collect germplasm in areas with a high level of genetic diversity of a target germpool. An other approach is to organize expeditions according to specific traits for use in plant breeding, for example drought tolerance.

Answer: Both approachs are very important in planning expeditions for germplasm collections. Considering plant species in their geographical distribution, focus should be placed on 1) the center of diversity of plants and 2) areas in which plants occur under biological and environmental stresses.

Rana, R. S. (India): Comment: Under joint exploration programs, national and foreign scientists tend to give different identity numbers to the collected samples of germplasm, leading to duplications. This situation has improved since exploration team members give common collector's numbers. It is important that the gene banks also give the original collector's number as the link number to their accession number while supplying samples to indentors.