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EXPLORATION AND COLLECTION OF CEREAL GENETIC RESOURCES CONDUCTED BY KYOTO UNIVERSITY FIELD RESEARCH TEAMS

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INTRODUCTION

During the past 32 years (1955-1982), Kyoto University has sent botanical field research teams to the following areas for the exploration and collection of various cultivated plants and their wild relatives.

(1) Pakistan, Afghanistan and Iran (1955)
(2) The Mediterranean region (1959)
(3) Transcaucasia (1966)
(4) Ethiopia (1967-1968)
(5) Iraq, Turkey and Iran (1970)
(6) Turkey (1976)
(7) Afghanistan and Romania (1978)
(8) Spain (IBPGR, 1979)
(9) Turkey, Greece and Romania (1980)
(10) Turkey and Greece (1982)
(11) India (1985)
(12) India and Pakistan (1987)

In the present paper, results of several of these field researches are discussed.

COLLECTION OF GENETIC RESOURCES FOR *TRITICUM* AND *AEGILOPS*

Of the 12 botanical expeditions listed-above, 10 (No. 1 - No. 10) were devoted mostly to the exploration and collection of *Triticum* and *Aegilops* species. From a total of 6,834 accessions, 3,518 of *Triticum* including 22 conventionally classified species, and 3,316 of *Aegilops* covering 24 traditional species, were collected during the 30 year period as summarized in Table 1. The results clearly indicate that good collection of plant genetic resources requires a long-termed, systematic program of continuous effort.

A QUASI-RANDOM SAMPLING METHOD OF GENETIC VARIATIONS IN CEREAL CULTIVATION FIELDS

We have practiced a method called quasi-random sampling which is done without any disturbance to standing crops grown by local people. Two examples, one in Ethiopia for wheat and barley collection and another in Afghanistan for the observation of two associated weeds to wheat cultivation, are shown.

Ethiopan crop fields seemed to be randomized plant populations mostly due to broad-casting sowing of randomly mixed grains or seeds by local farmers. Therefore, one or two reaped bundles of wheat or barley were sampled from the field. The sampling was made at 11 different wheat and 6 barley fields using the method mentioned-above. Samples were classified based on species, spike shape and color, awnedness, pubescence of spike and color of grains. Among them one example of wheat sample is listed in Table 2. This sample was collected on Feb. 23rd, 1968, at 33km from Addia Ababa to Ghion (alt. 2060m), Shoa Province. This sample is comprised of 168 spikes (64.4%) of *Triticum durum* and 93 spikes (35.6%) of *T. turgidum*. The sample was classifed into 17 forms based on species, spike and grain color. There was no apparent morphological differences between (1) and (2), (3) and (4), (5) and (6), (7) and (8), (12) and (13), and (14) and (15), respectively, only but different in grain color. Out of 168 spikes of *T. durum*, 48 (28.6%) and 22 (23.7%) among 93 spikes of *T. turgidum* were those having purple-colored grains which are endemic to Ethiopia.

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During our botanical expedition to the northeastern provinces of Afghanistan in 1978, we frequently saw severe contamination by *Secale afghanicum*, a weed rye, in irrigated wheat fields, and contamination by *Avena fatua*, a weed oat, in irrigated barley fields. But these two weed species seldom invaded the dry-farming wheat fields in this area. To obtain an approximation of the amount of the two weeds in cultivation fields, a quasi-random sampling of spikes was carried out in an irrigated wheat field at Barak, Badakhshan (alt. 1,460m). The results are shown in Table 3. The admixed rate of *S. afghanicum* and *A. fatua* in this field varied for the randomly selected wheat bundles from 1.7 to 35.3 per cent indicating some cases of serious contamination.

Data supporting our field observation were obtained from three wheat grain samples kept for sowing given by a local farmer at the village of Rezwon (alt. 1,940m), 27km east of Barak (Table 4). They are (1) irrigated-winter sowing (collection No. SGK-245), (2) irrigated-spring sowing (SGK-246) and (3) dry-farming-spring sowing (SGK-247). As shown in Table 4, the admixed rate of *S. afghanicum* and *A. fatua* in SGK-245 was 17.0 per cent, a high proportion. As astonishingly, total of 41.8 per cent of this particular sample was weed seeds of wild grasses and wild legumes. In SGK-246 the mixed rate of weed seeds was 8.9 per cent, and several grains of *S. afghanicum* and *A. fatua* were recognized in this sample. In SGK-247, which is sown in dry-farming fields, neither grains of *S. afghanicum* nor of *A. fatua* were found, it contained only 0.6 per cent weed seeds.

CRYPTIC CULTIVATION OF EINKORN WHEAT IN SOUTHWESTERN EURASIA

During our field trips to Turkey (1959, 1976 and 1982), Spain (1979), and Romania (1980), we had the good fortune to observe the cryptic cultivation of einkorn wheat (*Triticum monococcum*), one of the basic grain crops of Neolithic agriculture in the Middle East and once a principal winter crop of the earlier European farmers.

Cultivation of einkorn wheat in northern Turkey was firstly observed in 1959. This wheat has been cultivated widely on the hillside, north of the Apolyont Lake, west of Bursa, and also between Bandirma and Gonen. This species was cultivated singly or mixed with oat or barley for fodder. Sometimes, however, einkorn wheat was used for human consumption as a *pilauf*. In 1976 we collected einkorn wheat in three different localities of northern Turkey, at 5km north of Cay, at 26km west of Kastamonu and at 55km east of Kastamonu. In 1982 a sample of einkorn wheat, consisting of only two spikes, was found by us at Kapakli, 19.6km east from Gerade to Cankiri, northern Turkey. The sample was sporadically found among two-rowed barley mixed with rye and oat.

During the field trip in Spain in 1979, the spikes of einkorn wheat were found sporadically in oat fields at Canada del Hoyo (alt. 1,050m), Cuenca Province. The samples collected near Cuenca are seemed to be remnants of formerly extensive cultivation of einkorn wheat in this region of Spain.

The nine samples of einkorn wheat were collected in Transilvanian region of Romania in 1980. Three were found in oat field, hulled barley field and barley field mixed with oat. Einkorn wheat found sporadically in barley and oat fields probably is a remnant of the cultivation of this crop which ceased several years ago in the hilly Transilvanian region of Romania. The remaining six threshed grain samples of einkorn wheat were collected at several villages in Judet Cluj by Dr. A. T. Szabó and given to us. Composition of four samples clearly indicated that einkorn wheat is cultivated with oat as a fodder crop for the livestocks. The present einkorn wheat collections are quite important representing the last remaining germplasm of a cryptic cultivation of this crop which was widely cultivated

throughout Romania. It is quite interesting to note that the cultivation of einkorn wheat has continued on a small scale at Sic, Judet Cluj, because people in this village make a special straw hat from the culum of this crop as a mark of identity for the villagers.

Schieman (1956) and Borojević (1956) reported that *T. monococcum* and *T. dicoccum*, a hulled emmer wheat, are cultivated in mountainous regions in Yugoslavia, where the climate is severe and soils are poor, or in dry continental conditions. Emmer is usually grown mixed with oat or barley while einkorn is mainly found in pure stands. Both crops are usually used as fodder for horses and pigs and rarely for bread.

According to A. Peters (pers. comm., 1980), einkorn wheat. locally called *espéoute* is cultivated in Brantes (alt. 600m), a small village on the northern slope of Mt. Ventoux, southeastern France. In this village the local farmers cultivate only einkorn wheat, using it for gruel. Dr. G. Second (pers. comm., 1981) found another cultivation site of einkorn wheat in Aixen-Provence in southeastern France.

Perrino and Hammer (1982) reported that *T. monococcum* and *T. dicoccum* are still cultivated in a mountainous agricultural zone in the Appennino Sannita (alt. 700m) in the south of Italy. The unthreshed spikelets of those two wheats are used mostly to enrich swine feed.

The geographical distribution of the cryptic cultivation areas of einkorn wheat is shown in Fig. 1. All information clearly indicates that (1) einkorn wheat has been cultivated since its first domestication in the Middle East in the Neolithic era throughout southwestern Eurasia, (2) the cultivation of einkorn wheat in each site represents the last remaining germplasm, and (3) presently this crop is used as fodder for livestocks, but rarely used as food for man or other special purpose.

CHARACTERISTICS OF FOXTAIL MILLET AND COMMON MILLET IN NORTHERN MOUNTAINOUS AREAS OF PAKISTAN

Recently we have proposed a new theory on the geographical origin of foxtail millet (*Setaria italica*) and common millet (*Panicum miliaceum*). They were first domesticated within the area ranging from Central Asia and Afghanistan to India, and from there they were dispersed both eastward and westward being gradually differentiated genetically (Sakamoto, 1987b). Therefore, the northern mountainous region of Pakistan is quite interesting place for the domestication and genetic differentiation of foxtail millet and common millet. However, little is known about millet cultivation in this region. In 1987 we have made collection and field observation in three provinces; the North-West Frontier Province(NWFP), Gilgit Agency and Baltistan Province. During this trip 74 samples of foxtail millet and 37 samples of common millet were collected. Collection sites of those samples are plotted in Fig. 2.

Based on the morphological characteristics observed in foxtail millet, the region studied can be divided into three areas; (1) area ranges from Chitral District of the NWFP to the western part of the Gilgit Abency, (2) area contains the Hunza valley in the Gilgit Agency and Baltistan, and (3) area is the southern part of the NWFP. A clear gap was found among these three areas.

Foxtail millet in (1) has in general a shorter plant height and many tillers with small panicles. Mixed cultivation of foxtail millet and common millet are widely practiced. The strains grown in this area closely resemble morphologically to the landraces grown in Afghanistan. In (1) foxtail millet is called *gras* and it is used mainly as unleavened bread. On the other hand, in (2) foxtail millet of a tall, non-tillering plant with a large panicle is cultivated. There was a little morphological

variation through the villages in the Hunza valley, while a wider variations was observed in Baltistan especially on panicle shape. It is called *cha*. Local farmers developed several kinds of food preparation methods. This implies a long history of the cultivation and utilization of foxtail millet in Baltistan. In (3) we could observe scarecely the cultivation of foxtail millet and the number of samples obtained were limited.

There is a clear difference in grain size between the samples collected from (1) and (2). The foxtail millet strains collected from (1) have long grains, while those from (2) have rather round grains. At a glance, the plants standing in the fields in Baltistan looked quite similar to Japanese strains in their plant shapes. They have, however, much larger and heavier grains than Japanese strains. They showed a very short stature when cultivated under the conditions of Japan.

It is not clear, but there is also a tendency that the areas of (1) and (2) exhibit a difference on variation of common millet. The plants in Chitral and in western Gilgit Agency are of short stature. The vernacular name of this crop is *olean* throughout this area. Common millet was much taller in (2) than in (1). This crop is called *tzetze* in Baltistan. Usually common millet is rarely cultivated mixed with foxtail millet in Baltistan. No common millet was collected in (3).

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Table 1. Collection of *Aegilops* and *Triticum* by 10 botanical expeditions sent by Kyoto University, Kyoto, Japan

Name of expedition Year Areas	KUSE 1955 Pakistan Afghanistan Iran	BMUK 1959 Mediterr. Region	BEC 1966 Trans- caucasia (USSR)	KUSES 1967-68 Ethiopia	BEM 1970 Iraq Turkey Iran	KUET 1976 Turkey	KUSWE 1978 Afghanistan Romania	SPAIN 1979 Spain	KUSWE 1980 Turkey Greece Romania	KUSWE 1982 Turkey Greece	Total
Aegilops:											
No. of species collected	7	20	9	0	16	12	4	3	10	15	24
No. of accessions collected	302	607	101	0	824	364	55	12	321	736	3,316
Triticum:											
No. of species collected	10	11	10	8	7	6	3	4	4	4	22
No. of accessions collected	295	233	215	928	776	268	193	147	158	305	3,518
Total:											
No. of species collected	17	31	19	8	23	18	7	7	14	19	46
No. of accessions collected	597	840	316	928	1,600	632	248	159	479	1,035	6,834

Table 2. A quasi-random sample of wheat at 33km from Addia Ababa to Ghion (alt. 2,060m) (Sakamoto and Fukui, 1972)

(1)	*T. durum* with yellow spike and yellow seeds	59 spikes
(2)	*T. durum* with yellow spike and purple seeds	23
(3)	*T. durum* with brown spike and yellow seeds	32
(4)	*T. durum* with brown spike and purple seeds	7
(5)	*T. durum* with black spike and yellow seeds	4
(6)	*T. durum* with black spike and purple seeds	2
(7)	*T. durum* with yellow spike but black color on the margin of glumes	14
(8)	*T. durum* with yellow spike but black color on the margin of glumes and purple seeds	16
(9)	*T. durum* with brown-striped yellow spike	6
(10)	*T. durum* with pubescent spike	4
(11)	*T. durum* with brown compact spike	1
(12)	*T. turgidum* with yellow compact spike	9
(13)	*T. turgidum* with yellow and extremely compact spike	33
(14)	*T. turgidum* with pale brown spike and yellow seeds	13
(15)	*T. turgidum* with pale brown spike and purple seeds	9
(16)	*T. turgidum* with black-brown spike and yellow seeds	16
(17)	*T. turgidum* with black-brown spike and purple seeds	13

Table 3. Amdixed rate of *Secale afghanicum* and *Avena fatua* in a irrigated wheat field at Barak, Badakhshan, Afghanistan (Sakamoto, 1987a)

Bundle number	I	II	III	IV	V	VI	VII	Total
Number of spikes:								
Wheat	159	75	117	171	163	186	248	1,119
Barley	1	0	0	0	1	0	0	2
Secale afghanicum	18	18	13	3	14	35	36	137
Avena fatua	19	23	4	0	2	3	6	57
Total	197	116	134	174	180	224	290	1,315
Admixed rate of *Secale* and *Avena* (%)	18.8	35.3	12.7	1.7	8.9	17.0	14.5	14.8

Table 4. Grain samples of wheat given by a local farmer at Rezwon (alt. 1940m), 27km east of Barak, Badakhshan, Afghanistan (Sakamoto, 1987a)

Collection number	SGK-245	SGK-246	SGK-247
Irrigation Sowing time	irrigated winter	irrigated spring	dry-farming spring
No. of seeds			
Wheat	157 (56.7%)	169 (71.0%)	310 (97.5%)
Barley	2 (0.7)	2 (0.8)	3 (0.9)
Lens esculenta	1 (0.4)	3 (1.3)	3 (0.9)
Lathyrus sativus	1 (0.4)	43 (18.1)	0 (0)
Secale afghanicum	46 (16.6)	3 (1.3)	0 (0)
Avena fatua	1 (0.4)	4 (1.7)	0 (0)
Lolium temulentum	2 (0.7)	0 (0)	0 (0)
Other wild legumes	35 (12.6)	4 (1.7)	0 (0)
Other weeds	32 (11.5)	10 (4.2)	2 (0.6)
Total	277 (100%)	238 (100%)	318 (100%)

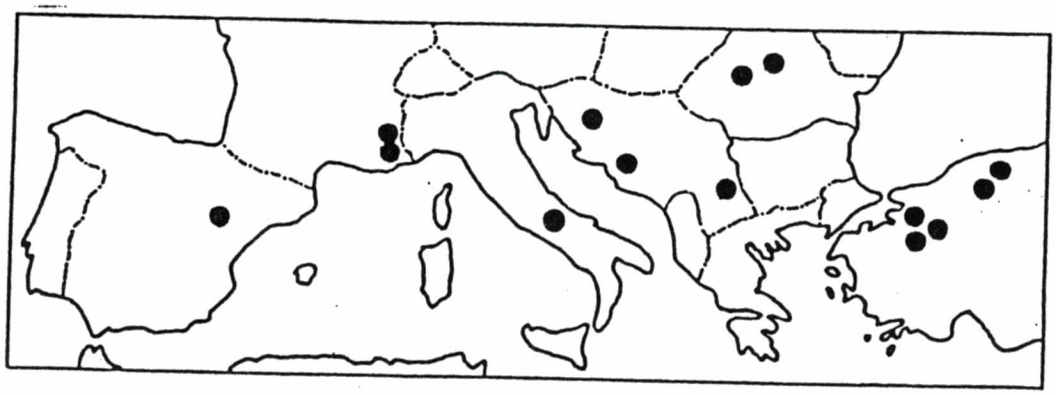

Fig. 1. Geographical distribution of the cryptic cultivation of einkorn wheat (*Triticum monococcum*) in southwest Eurasia (Sakamoto, 1987a)

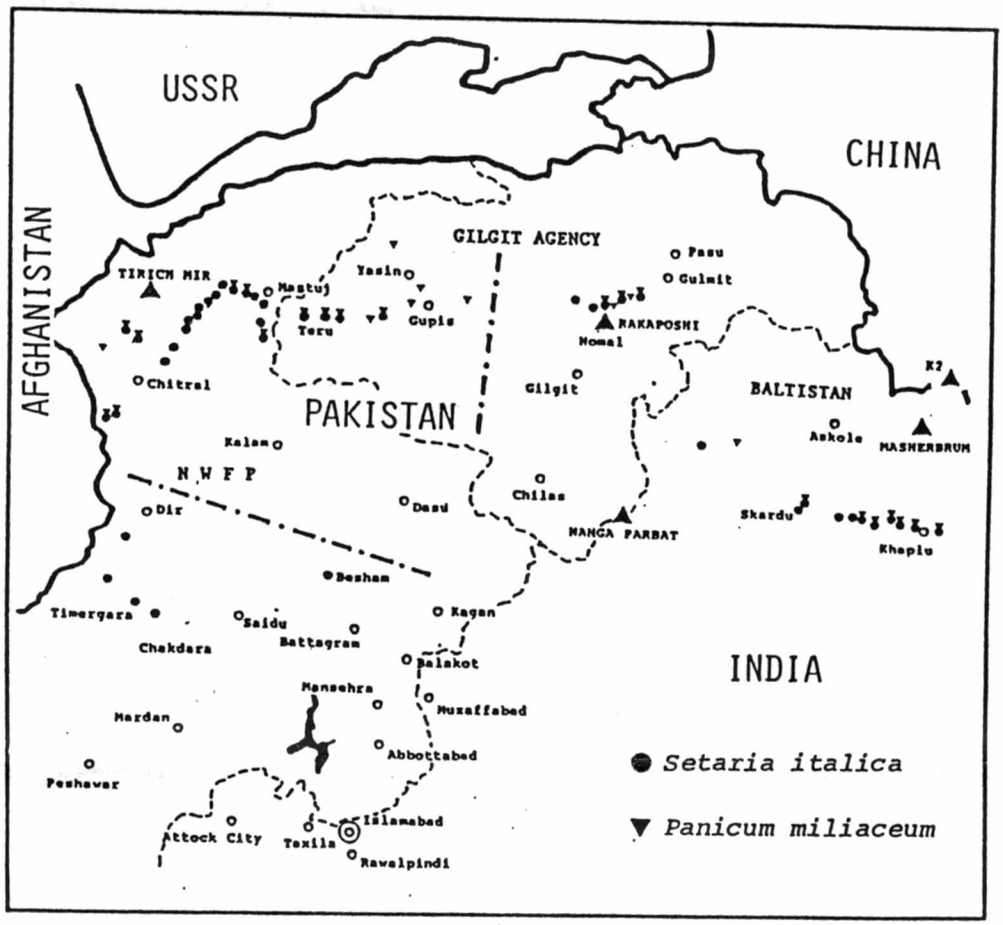

Fig. 2. Collection sites of foxtail millet (*Setaria italica*) and common millet (*Panicum miliaceum*) in northern mountainous areas of Pakistan