



Genetic Resources
Progress Report 36

SORGHUM AND MILLETS GENETIC RESOURCES AT ICRISAT

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(September, 1981)

GR/81-001



ICRISAT

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INTRODUCTION AND OBJECTIVE

One of the major objectives of ICRISAT is to improve the genetic potentials for grain yield and nutritional qualities of its mandate crops for the well being of present and future farmers in the semi-arid tropics. This objective is partly realized through the timely collection and conservation of the germplasm that is otherwise facing extinction. Needless to say, the first beneficiaries of germplasm collection and conservation programs are those countries and regions where the collection has been made. This is so because, as soon as the landraces arrive, they will be evaluated and screened for their special and potential qualities which will be utilized by plant breeders in creating new, high yielding and stable varieties and hybrids that are likely to adapt reasonably well in their original habitat.

The availability of germplasm is of fundamental importance in any crop improvement program. There is no other alternative source for this unique raw material. The importance of having diverse germplasm at hand is even more important when the development scheme covers a wide range of ecological zones in the semi-arid tropics. In the past, primitive cultivars and their wild relatives have made immeasurable contributions (as raw material) in the development of the new, high yielding varieties and hybrids throughout the world. While the newly developed varieties have made substantial increase in food production in developing countries, they have inevitably replaced the genetically broad based cultivars upon which both the farmer and the plant breeder have relied in one way or another. Unfortunately, the primitive cultivars are vanishing at an accelerated rate. It is therefore a matter of urgent concern to collect and conserve the primitive cultivars for immediate as well as future utilization.

The Genetic Resources Unit of ICRISAT has been established in 1979 to collect, evaluate, catalogue, conserve, utilize, and distribute the germplasm of the Institute's mandate crops for the purpose of improving their grain yield and nutritional quality. Sorghum and millet being the two most important cereal crops in the semi-arid tropics, the collection and conservation of their germplasm deserve special attention.

Lately, our worldwide germplasm collection efforts of sorghum and millets have been accelerated in Asia and Africa. The missing gaps of the world collection are also being filled by correspondence, and exchanges with other gene banks. This important effort will continue.

Two strategies of germplasm collections are followed. They are:

1. General collection in a priority area where there is some evidence of germplasm erosion.
2. Pointed collection in a specific area where a known and useful source material of special interest viz., resistance to disease, insects, drought, etc., has been reported earlier and where a special attempt is made to recover new sources of desirable characters.

FUTURE AREAS OF COLLECTION AND FINANCIAL SOURCE

The priority areas for future collection of sorghum and/or millet germplasm are the following. New and important collection areas are identified annually based on fresh information on genetic erosion of the area.

- i) Asia - Nepal, Burma, Indonesia, India
- ii) Eastern Africa - Southern Tanzania, Ethiopia, Burundi, Rwanda, Uganda, Kenya, Mozambique, Zimbabwe
- iii) West Africa - Sierra Leone, Ghana, Ivory Coast, Upper Volta, Gambia, Chad, Benin
- iv) Other areas - South and North Yemen, China, Central South Africa, African Republic, Congo

The priority areas are identified in collaboration with the FAO/IBPGR, ICRISAT scientists and national scientists in germplasm resource areas.

In regard to financial source, it will be increasingly difficult for ICRISAT to cover the cost of all future collection missions. Some collection programs have so far been supported by IBPGR and the UNDP. Those supports are gratefully acknowledged.

In the future, much more expensive collection expeditions are to be undertaken in the interior parts of resource countries. A good number of the missions have to be done in collaboration with germplasm collectors from other institutions and countries. More funds will be required to employ collectors on medium and short term basis. The FAO, UNDP and UNEP can play major role in supporting our future collection mission and their continued support is essential.

SORGHUM GERMPLASM

Collection and Assembly

The sorghum germplasm assembly work at ICRISAT is currently developing at an accelerated pace. A special effort is being made to assemble the missing gaps of the world collection from other gene banks. In addition to the world collection, 9486 new accessions were assembled from 68 countries by organising collection expeditions in priority areas and by correspondence from other gene banks. With these, the total sorghum germplasm collection at ICRISAT reached 21,264. In addition, 774 new accessions recently assembled from 14 countries are under Plant Quarantine for release in this year. With the release of these new germplasm lines this year, the total collection at ICRISAT would go up to 22,038. Accessions assembled countrywise can be seen in Table '1'.

Future collections would cover Angola, Benin, Burundi, Congo, Egypt, Ethiopia, Gambia, India, Indonesia, Ivory Coast, Libya, Mozambique, Northern Nigeria, Rwanda, Sierra Leone, South Africa, Togo, Uganda, Yemen and Zimbabwe. Some rare types of sorghum germplasm have been reported to exist in Venezuela and surrounding areas, where collection possibilities will be explored.

Conservation and Maintenance

All collections were maintained by selfing about 20 representative heads in each line. Seed harvested from the selfed heads is mixed and a bulk of about 500 g is preserved in bottles under cold storage. 1 to 2 kg samples are maintained for named cultivars and genetic stocks where seed demand is more. Cytoplasmic male steriles are maintained by hand pollination with their counterpart B lines. The entire sorghum germplasm is now being conserved in the medium term (4°C and 40% RH) cold storage.

167 accessions from 10 taxa of wild sorghums have been assembled and maintained.

Evaluation

16,587 accessions were evaluated for important morpho-agronomic descriptors. Sorghum Descriptors recently published in collaboration with IBPGR will promote a more systematic and uniform system of evaluation around

the world, which will in turn enhance a common language and better understanding among sorghum scientists. Screening sorghum germplasm for insect, disease, striga, drought resistance and grain quality is being carried out in collaboration with other disciplines. The following are the details of the accessions screened.

Screened for	No. of accessions	No. of promising lines	Described
Insect resistance	7874	323	Sorghum Entomology
Disease resistance	7429	64	Sorghum Pathology
Striga resistance(Lab. screening)	15504	641	Sorghum Breeding
Drought resistance	1075	133	Sorghum Breeding and Physiology

Recently a large number of germplasm lines have been taken up for screening for grainmolds, downymildew, leaf disease, shootfly and stemborer resistances by the Sorghum Pathology and Entomology Units.

Basic Collection

A basic collection consisting of about a thousand accessions was selected from the world collection stratified taxonomically, geographically based on their ecological adaptation at the Patancheru location. At present this is being used by the sorghum scientists to work with in their improvement programs.

Regional Evaluation

Evaluation of sorghum germplasm in the rainy season (kharif) at Patancheru cannot give us complete information, for, most of the tropical germplasm accessions are photoperiod sensitive. That is why we place much importance on future evaluation of germplasm at or close to their original habitat. This project could be started at carefully selected regional centers in collaboration with national programs.

Documentation and Publication

Data tabulated for 7114 IS numbers were computerized at IS/GR, Colorado, USA, using EXIR program for easy retrieval. The same data were transferred to ICRISAT computer through magnetic tape and a computer printout was brought out in the form of a catalogue. The data is being updated on the ICRISAT computer for all the accessions and for the added descriptors.

Distribution

The supply of seed material to sorghum improvement scientists around the world is one of the major responsibilities of ICRISAT and so far 117,231 samples have been distributed from the ICRISAT gene bank.

Introgression and Conversion

For an effective and easy flow of tropical germplasm into various sorghum improvement programs around the world, an introgression and conversion project has been initiated. At present we are in the process of converting 'Zera-zera' landraces from Sudan and Ethiopia which are highly prized for their superior agronomic characters but are of restricted utility because of their photoperiod sensitivity and plant height.

(Table 1-on p.7)

Table 1: Sorghum germplasm collection status at ICRISAT (Sept. 1981)

Sl. No.	Source	No. of accessions assembled by		Total
		Rockefeller Foundation	ICRISAT/IBPGR/ ORSTOM/National Programs	
(1)	(2)	(3)	(4)	(5)
<u>AFRICA</u>				
1	Angola	23	6	29
2	Benin	1	3	4
3	Botswana	28	162	190
4	Cameroun	1753	82	1835
5	Central African Republic	37	2	39
6	Chad	125	13	138
7	Egypt	15	7	22
8	Ethiopia	1446	2667	4113
9	Gambia	1	-	1
10	Ghana	11	53	64
11	Ivory Coast	1	-	1
12	Kenya	313	448	761
13	Lesotho	-	7	7
14	Malagasy Republic	-	1	1
15	Malawi	58	312	370
16	Mali	95	16	111
17	Morocco	-	3	3
18	Namibia	-	1	1
19	Niger	25	383	408
20	Nigeria	897	276	1173
21	Senegal	11	219	230
22	Sierra Leone	-	3	3
23	Somalia	5	120	125
24	South Africa	483	176	659
25	Sudan	855	1400	2255
26	Swaziland	18	1	19
27	Tanzania	31	102	133
28	Uganda	471	141	612
29	Upper Volta	160	56	216
30	Zaire	24	-	24
31	Zambia	3	207	210
32	Zimbabwe	123	63	186
<u>ASIA</u>				
33	Afghanistan	5	1	6
34	Bangladesh	-	9	9
35	Burma	2	6	8
36	China	24	44	68
37	India	2732	1295	4027
38	Indonesia	6	26	32
39	Iran	6	1	7
40	Iraq	2	2	4

..contd.

(1)	(2)	(3)	(4)	(5)
41	Israel	22	-	22
42	Japan	106	5	111
43	Lebanon	-	179	179
44	Nepal	7	1	8
45	Pakistan	18	11	29
46	Philippines	1	4	5
47	Saudi Arabia	-	1	1
48	South Korea	2	-	2
49	Sri Lanka	-	25	25
50	Syria	-	4	4
51	Taiwan	12	1	13
52	Thailand	5	-	5
53	Turkey	1	50	51
54	Yemen	-	27	27
55	Yemen D.R.	-	1	1
56	USSR	5	64	69
<u>EUROPE</u>				
57	Belgium	-	1	1
58	Cyprus	1	-	1
59	France	5	-	5
60	Greece	1	-	1
61	Hungary	-	22	22
62	Italy	8	-	8
63	Portugal	-	6	6
64	U.K.	-	1	1
<u>AMERICA</u>				
65	Argentina	2	14	16
66	Cuba	1	2	3
67	El Salvador	-	1	1
68	Gautemala	-	6	6
69	Honduras	-	1	1
70	Mexico	207	27	234
71	Nicaragua	-	1	1
72	Spain	-	3	3
73	Uruguay	-	1	1
74	USA	1208	659	1867
75	Venezuela	-	1	1
76	West Indies	-	3	3
<u>AUSTRALIA</u>				
77	Australia	6	22	28
78	New Guinea	-	1	1
<u>UNKNOWN</u>		370	27	397
Total:		11778	9486	21264

PEARL MILLET GERMPLASM

Collection and Assembly

The pearl millet genetic resources maintained at ICRISAT comprise of 14,340 cultivated, 633 intermediate weedy types and 35 accessions of 18 wild species and 6 possible interspecific hybrids. In addition, 170 accessions recently collected from Mozambique and Ghana are yet to be released by quarantine. The gaps in the world collection assembled in India by the Rockefeller Foundation will be filled with the incomplete set of IP lines recently obtained from ICARDA, Syria. Most of the accessions from West Africa were collected by ORSTOM. The accessions from East Africa were collected by ICRISAT in collaboration with the IBPGR. Most of the accessions from Asia are from India which were either collected by ICRISAT or donated by various millet scientists in India.

Future collection programs are being planned for different priority areas covering Angola, Benin, Burma, Chad, Burundi, Egypt, Ethiopia, Gambia, Ghana, India, Ivory Coast, Mali, Pakistan, Rwanda, Sierra Leone, Uganda, Upper Volta, Zaire and Zimbabwe.

Conservation and Maintenance

All the accessions are being maintained in a viable condition in temporary cool room conditions. They have recently been shifted to their medium-term cold storage where the temperature is maintained at 4°C and 40 per cent relative humidity. For each accession, a maximum quantity of 500 grams is stored in air-tight plastic bottles after treating with insecticide and fungicide. Rejuvenation is done in the post-rainy season as and when the seed quantity reaches a critical level of viability. During the first seed increase "Cluster Bagging Method" is used to reconstitute the original population and maintain the genetic diversity. Selfed seeds are also maintained for distribution.

Evaluation

Evaluation is necessary for effective utilization of the germplasm which is done during rainy season, the main season for growing pearl millet. Each accession is grown in 4 rows of 4 m length at a spacing of 75 x 12 cm. All the accessions except the recent collections from Tanzania, Malawi and Uttar Pradesh have been evaluated for important agronomical characters. Recently the IBPGR/ICRISAT sub-committee on descriptors of pearl millet developed a list of descriptors in terms of which the entire collection is being evaluated.

Realising the need to evaluate the germplasm at or near the place of collection, a multilocal evaluation of selected pearl millet germplasm project was initiated at Patancheru, Bhavanisagar, Hissar, Ludhiana, Jaipur, in India; Bobo-Dioulasso and Kamboinse in Upper Volta and Maradi in Niger. A set of 343 diverse accessions were planted in three replications using the triple lattice design. The work is continuing.

In general, the accessions from India differ greatly from those of Africa. The Indian material flower early, produce many tillers with small heads and small but many grains per spike. The African material is very tall, flower very late, produce very few tillers with thick stems with long, loose spikes and bold grain. Some of the West African material flowers only during short days.

There is a tremendous diversity in the material collected. Days to flowering 34 to 135 days, tillers 1 to 40, plant height 30 to 400 cm, spike length 5 to 160 cm and 1000 grain weight 2.84 to 12.86 grams. Seed color varies from ivory to purple black, seed shape oval to globular. The endosperm texture varies from completely starchy to corneous.

Working Collection

After preliminary evaluation of the available collection, accessions were carefully identified and stratified by geographical distribution and general variability. So far, 581 accessions were selected which represent the general variability of the world collection available with us. It consists of the accessions from Botswana (10), Cameroun (46), Central African Republic (23), Ghana (1), India (75), Malawi (6), Mali (84), Niger (184), Nigeria (24), Senegal (61), Sudan (8), Uganda (1), Upper Volta (5), USSR (3), Zambia (5) and unknown sources (45).

Documentation

The evaluation data are documented for computerization.

The evaluation data which are being maintained will be used in the retrieval system.

Distribution and Utilization

The germplasm is extensively utilized by millet scientists not only at ICRISAT but also elsewhere. ICRISAT pathologists continuously screen germplasm for resistance against downy-mildew, ergot, smut and rust. Some potentially useful lines have already been identified by ICRISAT scientists. Millet workers in India liberally use the germplasm. The photosensitive lines from West Africa were used directly for fodder purpose. So far 11,456 samples were despatched to millet workers in India and 7,874 samples were despatched to scientists elsewhere.

Table-2

Pearl millet germplasm assembled at ICRISAT Center as of September 1981

Country	No. of accessions assembled by		Total
	Rockefeller Foundation	ICRISAT/IBPGR/ ORSTOM/National Programs	
<hr/>			
<u>AFRICA</u>			
Botswana	0	45	45
Cameroun	0	171	171
Central African Republic	0	58	58
Chad	62	0	62
Gambia	0	17	17
Ghana	1	156*	157
Kenya	2	45	47
Mozambique	0	14*	14
Malawi	2	221	223
Mali	39	488	527
Mauritania	1	0	1
Niger	36	996	1032
Nigeria	282	117	399
Senegal	27	277	304
Somalia	0	3	3
South Africa	10	6	16
Sudan	2	166	168
Tanzania	0	136	136
Uganda	48	0	48
Upper Volta	22	6	28
Zambia	0	25	25
Zimbabwe	2	50	52
Sources Unknown	11	0	11
<u>ASIA</u>			
India	793	2777	10656**
Lebanon	71	0	71
Pakistan	5	0	5
<u>USSR</u>	0	12	12
<u>AMERICA</u>			
USA	48	0	48
<u>AUSTRALIA</u>	0	4	4
	<u>1464</u>	<u>5790</u>	<u>14340</u>

*To be released from quarantine

**Includes 7086 accessions donated by Millet Scientists in India

PRESENT STATUS OF MINOR MILLETS COLLECTION

The minor millets world collection assembled by the Rockefeller Foundation in the sixties has been kept at room temperature at Rajendranagar for about eight years before the material was transferred to the ICRISAT Center. The 3428 accessions covering six minor millets were planted in field at ICRISAT center in 1976 when it was unfortunately discovered that over 50% of the material had already lost its viability. Only 1475 accessions germinated and were consequently rejuvenated.

At its 2nd meeting of 9-12 January, 1978, the IBPGR Advisory Committee on Sorghum and Millets recommended for ICRISAT to accept the responsibility for maintenance of germplasm collection on hand and improve them by obtaining additional materials of six specific minor millets listed below. Later on in 1978 the Governing Board of ICRISAT accepted and approved the minor millets germplasm assembly, conservation and distribution, at the ICRISAT Center. From then on ICRISAT intensified its minor millets germplasm assembly. Presently, the total number of minor millet accessions maintained at ICRISAT is over 4039, as detailed below. The effort in this area is continuing.

<i>Eleusine coracana</i> (Finger millet)	-	1241
<i>Setaria italica</i> (Foxtail millet)	-	1160
<i>Panicum miliaceum</i> (Proso millet)	-	715
<i>Panicum sumatrense</i> (Little millet)	-	243
<i>Echinochloa crusgalli</i> (Barnyard millet)-		380
<i>Paspalum scrobiculatum</i> (Kodo millet)	-	300

4039

While collecting sorghum and millets, especially from remote and hilly areas, some minor millets were also collected by ICRISAT.

The following are new arrivals from the following countries which are presently under quarantine inspection.

Malawi	-	42
Mozambique	-	2
Nepal	-	3
Sri Lanka	-	46
West Germany	-	51
Zambia	-	80

Evaluation

A preliminary evaluation of the existing minor millets collection was recently made for the following descriptors.

1. Plant height
2. Days to 50% flowering
3. Pigmentation
4. Lodging
5. Peduncle exertion
6. Panicle type
7. Grain colour
8. Glume length (in case of *Eleusine*)
9. Bristling (in case of *Setaria*)
10. Plant aspect score

Seed Distribution

So far 9185 samples were distributed to scientists in India and 4738 samples to scientists abroad against the indents received.

Future trends of development

As seen from the current activities, the Indian and International requests for minor millets germplasm is steadily increasing thus demanding a larger and ready supply of the material. The cost of maintenance of the viability and distribution of the material is also gradually increasing.

In view of the importance of minor millets in SAT countries and in the light of IBPGR's request, ICRISAT will continue its genetic resources activities with minor millets.