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Genetic Resources Activities at ICRISAT

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Established in 1979, the Genetic Resources Unit (GRU), ICRISAT, is implementing short and long-term work plans in areas of germplasm collection, evaluation, maintenance, documentation, conservation and utilisation. The GRU has assembled 93,951 accessions in its gene bank from 125 centres which pertain to sorghum, pearlmillet, chickpea, pigeonpea and groundnut. The status of these collections and the collaborative role of GRU in collection and conservation of genetic resources in national and international context is stressed. Future lines of activity are indicated. There is a need to have duplicate germplasm conservation centres and collection of wild relatives is stressed. ICRISAT has developed short-term, medium-term and long-term conservation facilities and its gene bank is now operational.

The Genetic Resources Unit (GRU) of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established in 1979. Since then it has made good progress not only in developing facilities required for work but also in structuring its short and long-term work plans and implementing its programme of activities in the area of germplasm collection, maintenance, evaluation, documentation, conservation, and distribution for utilisation. It is imperative that, for the benefit of the present and future generations, the endangered genetic resources must be collected and conserved before they are lost to humanity for ever (Mengesha, 1984). In this regard, the Genetic Resources Unit of ICRISAT is playing a major role not only in assembling the vast resource of world germplasm of sorghum, millets, chickpea, pigeonpea and groundnut, but also in making them readily and freely available to national programmes.

MAJOR ACTIVITIES OF GENETIC RESOURCES UNIT

The various activities carried out in the GRU are :

1. Collection and assembly of the cultivated and wild relatives of ICRISAT mandate crops and six minor millets.
2. Evaluation and characterisation of the collected material and its documentation.
3. Maintenance and rejuvenation of the germplasm without altering the original genotype.
4. Conservation of germplasm in mandate crops and six minor millets, and to serve as the repository of the world collections.
5. Distribution of the germplasm for present and future utilisation.
6. Conduct research on relevant genetic resource activities.

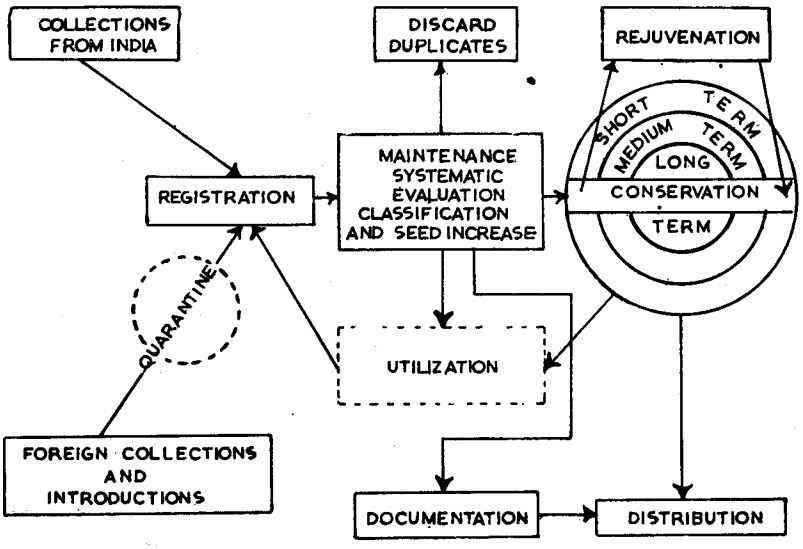

Fig. 1. Various Activities and Operational Flow Chart for the Genetic Resources Unit, ICRISAT.

Germplasm collection

Since the establishment of GRU in 1979, ICRISAT has launched a number of germplasm collection missions in several centres of diversity, particularly in Africa, Asia and South America (ICRISAT, 1987). Some of the earlier germplasm exploration and collection missions in Africa were supported by or undertaken in collaboration with the International Board for Plant Genetic Resources (IBPGR). In the past, the IBPGR/ICRISAT crop germplasm advisory committees have contributed to identify priority areas of collection. Such areas are further identified in collaboration with national scientists; based on fresh information received about genetic erosion, diversity, and level of representation in the ICRISAT gene bank. In terms of germplasm collections and subsequent utilisation, the first beneficiaries are those countries where the collections are made. This is because promising cultivars that are developed by hybridising those landraces are likely to be well adapted in their original habitat.

Status of millet germplasm

So far ICRISAT has assembled 30,277 sorghum germplasm accessions from 87 countries, 19,085 pearl millet germplasm accessions from 42 countries, and 6,457 accessions of minor millets from 38 countries. In view of the diversity areas yet to be explored, the number of samples collected is small compared to what is available in nature. However, it represents the largest collection of these millets assembled and conserved at any one place. Several genetic stocks with desirable genes have been identified, many of which have already been incorporated in current breeding programmes in and outside ICRISAT.

TABLE 1. STATUS OF GERMPLASM AT ICRISAT AS OF JANUARY 1988

Crop	Number of accessions/samples								
	Conserved	Evaluated	Documented in computer	Samples distributed			Wild relatives maintained		No. of Countries represented
				ICRISAT	India	Abroad	SP	No. of Acc.	
Sorghum	30 277	30 277	20 915	206 310	53 354	100 072	23	345	87
Pearl millet	19 085	18 904	9 414*	22 628	27 806	22 884	20	68	42
Chickpea	15 246	14 000	15 246	84 744	32 950	40 130	16	47	41
Pigeonpea	11 034	10 699	10 699	53 019	20 234	9 963	47	271	52
Groundnut	11 852	11 600	11 600	43 449	22 741	18 030	35	207	89
Minor millets									
Foxtail millet	1 380	1 380	1 195	—	4 468	2 202	2	22	17
Finger millet	2 751	2 761	1 948	—	6 832	3 425	2	4	12
Kodo millet	526	526	—	—	1 074	749	—	—	1
Proso millet	831	831	742	—	2 467	1 093	—	—	13
Barnyard millet	582	582	—	—	1 206	650	1	4	8
Little millet	377	377	242	—	829	291	1	1	1
Total	93951	91937	72001	410150	173961	199489	145	969	125**

*Pearl millet is from IP 3018 to IP 12431. IP 1 to IP 3017 was done in 1967 by Dr. B.R. Murthy et al.
**Aggregate total

Evaluation, screening, and identification of new and useful genetic traits are carried out in close collaboration with crop improvement scientists in and outside ICRISAT. Some of the most encouraging results are the fruits of such interdisciplinary efforts. In this respect, collaborative germplasm collection and evaluation programmes that started in India in 1986 are commendable. The cooperation and support of the National Bureau of Plant Genetic Resources (NBPGR), India is highly appreciated.

The germplasm conversion and introgression programmes have made it possible for breeders to utilise tropical germplasm. Conversion activities, especially in sorghum, have generated a large source of new material to breeders in the semi-arid tropics and elsewhere. The wide range of germplasm variation GRU now has looks promising and it is still expanding. This is summarised in Tables 2 and 3.

Status of pulse germplasm

The total number of accessions consist of 11,034 for pigeonpea (from 52 countries), and 15,246 for chickpea (from 41 countries) (Table 1). These are the largest collections of pigeonpea and chickpea conserved at any one place. Although GRU has a relatively large collection of chickpea, there are still a number of important areas of diversity to be explored for both cultivated and wild species. In pigeonpea, the major areas in the primary centre of diversity (India) have been well sampled, but important areas in secondary centres of diversity such as Africa and the Caribbean Islands are still poorly represented in the world collection. As regards wild species, our collection is far from complete.

The GRU has characterised 10,699 accessions of pigeonpea and 14,000 of chickpea. In pigeonpea, 52 descriptors are used which include 7 passport descrip-

TABLE 2. RANGE OF VARIATION IN *SORGHUM*

Character	Min.	Max.
Days to 50% flowering	36	199
Plant height (cm)	55	655
Peduncle exsertion (cm)	0.0	55.0
Midrib color	White	Brown
Panicle length (cm)	2.50	71.0
Panicle width (cm)	1.00	29.0
Glume color	Straw	Black
Glume covering	Exposed	Covered
Grain colour	White	Dark brown
Grain size (mm)	1.00	7.5
100 grain weight (g)	0.58	8.56
Tillering	1	15
Stalk sugar content (%)	12.0	38.0

TABLE 3. RANGE OF VARIATION IN PEARL MILLET

Character	Min.	Max.
Days to 50% flowering	33	140
Plant height (cm)	35	475
Peduncle exsertion (cm)	−21	+30
Midrib colour	White	Purple
Spike length (cm)	6	165
Spike thickness (mm)	11	64.5
Glume colour	Straw	Dark purple
Glume covering	Exposed	Completely covered
Grain colour	White	Dark purple
Bristle length (mm)	2	60
1000 grain weight (g)	3.02	14.20
Tillering (no.)	1	210
Stem sugar content (%)	4.94	19.74
Grain no./spike	489	3447
Stem thickness (mm)	2.8	15
Leaf (no.)	6	25
Leaf length (cm)	25	120
Leaf width (mm)	315	78

tors. In chickpea, 30 descriptors are recorded which include 7 passport descriptors. In addition to this, preliminary evaluation has been carried out to identify accessions with high yield potential and other desirable agronomic traits (Tables 4 and 5). Special screening is conducted to identify accessions with desirable traits like tolerance to adverse environmental conditions, day length insensitivity, etc. Many accessions are now used in current breeding programmes. Lately, the number of environments under which diverse germplasm lines are being tested has increased. Thousands of our germplasm accessions are distributed for evaluation and use around the world. The range of variation is wide and is still increasing. Germplasm catalogues of both pigeonpea and chickpea are in press. This is the result of several years of germplasm collection, evaluation, and screening work up to 1985.

Status of groundnut germplasm

So far GRU has assembled 11,852 groundnut germplasm accessions from 89 countries (Table 1). Though the collection still has gaps, a fairly good representation from most of the priority countries is now available, and it is the largest collection assembled and conserved at any one centre. Evaluation, screening, and identification of new and useful genetic traits in collaboration with other groundnut scientists are progressing well. Several useful accessions have been identified and are being used in groundnut improvement programmes. Groundnut descriptors developed and published in collaboration with the IBPGR, are used for

TABLE 4. RANGE OF VARIATION IN PIGEONPEA

Character	Range
Growth habit	compact and erect, semi-spreading spreading, trailing
Stem colour	green, red, purple, dark purple
Flower colour	ivory, yellow, orange, red, purple with or without streaks
Seed colour	white, cream, brown, orange, purple, almost black, with or without second colour
Seed shape	oval, pea-shaped, square, elongate
Days to 50% flowering	55 —210
75% maturity (days)	97 —260
Plant height (cm)	39 —385
Primary branches per plant (no.)	2 —66
Secondary branches per plant (no.)	0.3 —145
Racemes per plant (no.)	10 —915
Seeds per pod (no.)	1.6 — 8.5
100 seed weight (g)	2.8 — 22.4
Harvest index (%)	0.6 — 62.7
Shelling ratio (%)	5.8 — 86.6
Yield per plant (g)	1.66—357.83
Protein content (%)	12.4 — 29.5

TABLE 5. RANGE OF VARIATION IN CHICKPEA

Character	Range
Growth habit	erect, semi-erect, semi-spreading, spreading, prostrate
Stem colour	pale green, light green, green, purple
Flower colour	pink, white, light pink, blue
Seed colour	24 classes, main colours : yellow brown, brown, black, green, creamy white
Seed shape	angular, oval, pea-shape
Seed surface	rough, smooth, reticulate
Days to 50% flowering	28–96
Days to maturity	90–137
Flowering duration (days)	15–40
Plant height (cm)	16–93
Plant width (cm)	18–70
No. of pods per plant	few 168
Seeds per pod	1- 2.88
100 seed weight (g)	4.95–59.45
Harvest Index (%)	21.9 -64.8
Protein content (%)	15.4 -30.9

morphological evaluation of the germplasm. The wide range of variation available in groundnut germplasm is shown in Table 6. Computerisation of passport information on all accessions is complete and evaluation data on 11,600 accessions

TABLE 6. RANGE OF VARIATION IN GROUNDNUT

Character	Minimum	Maximum	Intermediate
Length of reproductive branch	< 1 cm	> 10 cm	Continuous
Flowers/inflorescence	1	5	2,3,4
Leaflet length (mm)	24	86	Continuous
Leaflet width (mm)	8	41	—do—
Leaflet L/W	1.53	4.2	—do—
Seeds/pod	1	5	2,3,4
Pod length (mm)	11	80	Continuous
Pod width (mm)	9	27	—do—
Seed colour	Off-white	Dark purple	Yellow, shades of tan, shades of red, grey-orange, purple and variegated
Seed length (mm)	7	21	Continuous
Seed width (mm)	5	13	—do—
100-seed weight (g)	19.8	121.5	—do—
Days to emergence	4	13	—do—
Days to 50% flowering	16	58	—do—
Days to maturity	75	>155	—do—
Oil content (%)	31.8	53.1	—do—

are already computerised. Documentation will be further strengthened to facilitate retrieval of both passport and evaluation information.

PRESENT AND FUTURE TRENDS OF DEVELOPMENT

Germplasm accessability

The GRU collects and conserves germplasm and makes it readily available for utilisation, primarily in the developing countries of semi-arid tropics. Because of the large number of germplasm maintained at ICRISAT and because of our non-restricted and free distribution policy, no other agency can claim monopoly on the germplasm of ICRISAT mandate crops. Presently, many developing countries, who still have much genetic diversity, do not seem to give appropriate care to collect and conserve their germplasm. They may have other pressing needs and priority programmes. Therefore, international institutes like ICRISAT have a unique role and responsibility in collecting and conserving the vanishing germplasm in collaboration with national and international organisations.

Accelerating collection work

The collection programme will be further accelerated and more remote areas will be explored. Specific and pointed collections will be made in areas where important genetic traits are known to occur. Early-maturing types will be given high priority in future collection programmes.

Regional evaluation

Regional and multilocation evaluation will be further expanded particularly at or near the areas of original habitat of the listed mandate crops. This work will provide a more meaningful and complete data for documentation. In order to promote a safe and proper germplasm collection, evaluation, conservation and utilisation programme, it has been proposed to establish regional genetic resources activities for Africa and the Americas. The first such regional programme has been started at the ICRISAT Sahelian Centre, Niamey, Niger. This development is in line with the ten-year plan of ICRISAT and is presently being carried out in collaboration with the IBPGR.

SPECIFIC RESEARCH ACTIVITIES

The GRU is gradually expanding its research activities in the area of germplasm enhancement, seed quality, genetic studies, effects of long-term cold storage, insecticides and fungicides on seed viability of conserved germplasm, and search for new and desirable genes and studies on their mode of inheritance. The possible use and application of other methods of germplasm conservation and maintenance, such as cryopreservation and *in vitro* culture techniques, will be investigated. Ongoing research activities in the area of germplasm diversity studies, gene frequency and distribution, formation of gene pools and other specific groups, and classification and stratification of the world collection in various types of basic material will be strengthened and continued. Some of the useful examples of such grouping are :

(i) In sorghum : the groups of basic rabi (post-rainy) material, yellow endosperm, converted Zerazera, forage types, dwarfs, male sterile lines.

(ii) In pearl millet : large seeded, large headed, early maturing dwarfs, male sterile lines.

(iii) In pigeonpea : photoperiod insensitive, vegetable types, early, medium and late maturing types.

(iv) In chickpea : desi, kabuli types.

(v) In groundnut : runner, spreading bunch, erect types.

To achieve some of these research objectives, cooperative programmes will be planned and implemented in close collaboration with national and international research organisations, universities, and other mentor institutes. Introgression work and interspecific hybridisation will be given more emphasis. It is intended that more attention be given to conserved material by proper maintenance, monitoring of viability and undertaking rejuvenation as and when needed.

Duplicate germplasm conservation centres

Duplicate germplasm conservation centres are necessary for safe and reliable conservation. The development and implementation of such centres are being emphasised in our present efforts and future outlook. Although there have been

broad international discussions on the need for such centres, very little progress has been made so far other than the facility available at the National Seed Storage Laboratory, Fort Collins, Colorado, USA, where a large number of sorghum germplasm accessions are kept in long-term (base) conservation. We hope to see some new development in this area particularly on the possibility of utilising material from permafrost regions,

Some attempts have been made to establish duplicate conservation centres at Junagadh, Gujarat, India for groundnut, and Ottawa, Canada for pearl millet. The NBPGR could serve as a centre for pigeonpea and minor millets base collections. The International Centre for Agricultural Research in the Dry Areas (ICARDA) and the Ethiopian gene bank have facilities to hold the chickpea base collection. We must continue to establish reliable duplicate centres with the help and collaboration of concerned national and international organisations, particularly the IBPGR.

Wild relatives

It is well known that wild relatives are good sources of desirable genes for resistance to certain biotic and abiotic stress (Hawkes, 1977; Remanandan, 1981). With the recent advances in biotechnology, it may be easier to transfer desirable genes from wild relatives to cultivated species. Accordingly, emphasis on collection and conservation of wild relatives is stressed and so far, GRU has assembled 145 species and 969 accessions (Table 1). Further plans call for accelerated collection of wild relatives mainly from their centres of origin and diversity.

Documentation

Documentation is one of the major activities in the GRU, which is dealing with a large number of accessions. Obviously, proper documentation and management of data is imperative (IBPGR, 1985). In GRU, we use the ICRISAT Data Management and Retrieval System (IDMRS), which has been developed by the Computer Services of ICRISAT to record and retrieve passport and evaluation data. This computer system has helped to maintain an active and dynamic data base that can be retrieved in any combination of characters. Our future effort will include the possible development of computer-based inter-centre and international links with all interested centres.

Conservation

The germplasm samples of ICRISAT mandate crops and six minor millets (93,951) are conserved under appropriate conditions that meet international standards including those suggested by the IBPGR (IBPGR, 1985). Presently, all germplasm samples are kept in the medium-term cold storage. The long-term cold storage is now ready for use and seeds will soon be preserved as long-term, base collections. For conservation, seed is produced mostly during the post-rainy season, when good quality seed can be obtained. The standing crop is usually inspected by plant protection experts and every attempt is made to harvest and conserve disease and insect-free material. The moisture content of the seed is brought down to 5–7% by drying in cool and dry atmosphere.

The GRU has developed short (up to two or three months), medium (up to 15 to 20 years) and long-term (over 25 years) storage facilities with controlled temperature and humidity. In short-term storage, the temperature is maintained at 20°C, and 35% Relative Humidity (RH). Short-term store is used mainly for preparing the seed for conservation. After harvesting, threshing, cleaning and drying, the seed is brought to short-term store where it is further dried slowly and processed for medium and long-term storage. The medium-term store which holds our active collections for exchange and distribution is maintained at + 4°C, and 20% RH. To minimise genetic drift during storage, large quantity of seed, 500 g in case of sorghum, pearl millet and minor millets, 800 g seed of pigeonpea and chickpea, and one kg unshelled groundnut pods with seeds are stored. Seeds or pods are stored in aluminium cans with screw caps having rubber gasket or in plastic bottles with screw caps. Seed viability is monitored by drawing samples periodically and testing them for their viability. Accessions with less than 85% viability or reduced seed stocks are rejuvenated and replenished. Long-term storage chambers have been installed to maintain the temperature at -18 to -20°C and are now under test for the last one year. On a trial basis, chickpea germplasm has already been kept in the long-term store. Other crops will soon be transferred to the same facility.

Training

Practical training in the form of guidance and sharing technical information is offered to collaborators and other trainees during field collection and germplasm evaluation. Occasionally, special training programmes are offered in genetic resource activities. With the development of our laboratory, the compilation of massive evaluation data and with the growing knowledge and experience of our staff, there is much scope for developing and offering specialised genetic resources training to interns, in-service trainees and research scholars.

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