Groundnut Genetic Resources: Progress and Prospects

A.K. Singh[1], V. Ramanatha Rao[2] and M.H. Mengesha[1]

Abstract

*Progress during the past 11 years and future prospects of groundnut (*Arachis hypogaea*) genetic resources at ICRISAT are reviewed. The number of accessions in the ICRISAT gene bank have increased from 8500 to 13 460. However, many areas with limited cultivation but with extensive variability are yet to be covered. Most of the accessions have been characterized and evaluated for their reaction to diseases, insect pests, and other desirable characters, leading to identification of 506 useful genetic stocks. This information has been documented and is to be made available in a catalog. Most of the germplasm are conserved as pods or seeds in medium-term (4°C, 20% RH) and long-term (-20°C) storage conditions, while rhizomatous* Arachis *species are conserved as plants. ICRISAT serves as the world's largest repository of groundnut germplasm and has distributed 60 061 groundnut germplasm samples free of cost to the international scientific community involved in groundnut improvement worldwide.*

Despite significant progress, groundnut genetic resources activities still suffer from several limitations in assembly and characterization. The establishment of a groundnut genetic resources network is proposed to overcome many such limitations.

Résumé

***Ressources génétiques de l'arachide—Progrès et possibilités :** Les auteurs examinent les progrès effectués depuis 11 ans et les possibilités d'avenir pour les ressources génétiques de l'arachide (*Arachis hypogaea*) à l'ICRISAT. Le nombre d'obtentions à la banque de gènes de l'ICRISAT a augmenté de 8500 à 13 460. Toutefois, il reste encore à couvrir bien des domaines où la culture est restreinte et la variabilité très étendue. La plupart des obtentions ont été caractérisées et évaluées d'après leurs réactions aux maladies, aux insectes ravageurs et d'autres caractéristiques souhaitables menant à identifier 506 souches génétiques utiles. Cette information a été documentée et sera distribuée dans un catalogue. La majeure partie des ressources génétiques a été conservée sous forme de gousses et de semences dans des conditions de stockage à moyen terme (4°C, 20% HR) et à long terme (−20°C), tandis que des espèces d'*Arachis *rhizomateuses ont été conservées sous forme de plants. L'ICRISAT joue le rôle du plus grand stock mondial des ressources génétiques d'arachide et il a distribué 60 061 échantillons de ressources génétiques d'arachides gratuitement à la communauté scientifique internationale qui s'intéresse à l'amélioration de l'arachide dans le monde entier.*

En dépît des progrès marqués, les activités des ressources génétiques de l'arachide subissent encore plusieurs limites. L'établissement d'un réseau de ressources génétiques de l'arachide est proposé pour surmonter un grand nombre de ces limites.

1. Germplasm Botanist, and Principal Germplasm Botanist and Program Leader, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, A.P. 502 324, India.

2. Genetic Diversity Officer, International Board for Plant Genetic Resources (IBPGR), Food and Agriculture Organization of the United Nations (FAO), via delle Sette Chiese 142, 00145 Rome, Italy.

ICRISAT Conference Paper no. CP 805.

Singh, A.K., Ramanatha Rao, V., and Mengesha, M.H. 1992. Groundnut genetic resources: progress and prospects. Pages 297–309 *in* Groundnut – a global perspective: proceedings of an international workshop, 25–29 Nov 1991, ICRISAT Center, India (Nigam, S.N., ed.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

The importance of genetic resources in crop improvement has been repeatedly emphasized (Hawkes 1981). In addition to its other mandate crops, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), within the system of the International Agricultural Research Centers (IARCs), has global responsibility for collection, characterization, conservation, distribution, and utilization of groundnut (*Arachis hypogaea*) and other *Arachis* species germplasm. To achieve these objectives, the Genetic Resources Unit (GRU) at ICRISAT collaborates with various international and national programs involved with groundnut. It acts as the world's largest repository for more than 13 000 accessions of cultivated and wild *Arachis* species, and provides these basic genetic stocks to the international scientific community for further improvement of groundnut.

The range of genetic diversity available at ICRISAT in the form of cultivated groundnut and wild *Arachis* species is much wider than is generally thought. Nevertheless, it reveals a relatively limited representation from primary and secondary centers of diversity in South America and areas of early introductions in Africa and Asia. These areas may contain much more genetic diversity that may be lost through further expansion of improved cultivars and encroachment of modern civilization in remote areas. There is an urgent need to collect and assemble more germplasm from these priority areas to preserve genetic diversity of *Arachis* species. Significant progress in germplasm evaluation has been made in the last decade, leading to the identification of a number of lines with desirable traits and sources of resistance to both biotic and abiotic production constraints (Amin et al. 1985; Mehan 1989; Subrahmanyam et al. 1990). However, there are many lacunae, such as incomplete evaluation of the useful germplasm, restricting utilization of these sources, and lack of detailed knowledge on the useful gene(s), which are essential for selection of appropriate breeding strategies for their effective utilization. Similarly, extensive work has been done on evolutionary relationships between *Arachis* species and cultivated groundnut (Smartt et al. 1978; Singh 1988), but the taxonomy and the nomenclature of *A. hypogaea* and species of the genus *Arachis* still remain confusing (Resslar 1980). It is obvious that much more needs to be done to fully understand and utilize the available genetic diversity. This paper attempts to review the status of groundnut germplasm at ICRISAT and the limitations that must be overcome to improve utilization of the *Arachis* germplasm.

Sources of Genetic Diversity

The main sources of genetic diversity in groundnut include:

- The primary gene pool, consisting of landraces of cultivated groundnut from the primary center of origin and diversity in South America (Fig. 1) and Africa, the cultivars and breeding materials developed in various groundnut-growing countries, and the freely cross-compatible wild tetraploid species *A. monticola*.
- The secondary gene pool, consisting of species that are cross-compatible with *A. hypogaea* despite ploidy differences and classified in section *Arachis* with *A. hypogaea*.
- The tertiary gene pool, consisting of the other *Arachis* species that are cross-incompatible or weakly cross-compatible with *A. hypogaea* and classified into six other sections.

South America is the center of origin for the genus *Arachis*. The wild *Arachis* species are found in Argentina, Brazil, Bolivia, Paraguay, and Uruguay (Valls et al. 1985). Efforts to collect and conserve this genetic diversity have been made by scientists in countries having diversity and groundnut cultivation. The genetic diversity in South America has been continuously eroded by deforestation and political disturbances, and that, in Africa, by natural hazards, introduction of improved cultivars, and nonmaintenance of old collections and landraces.

Collection and assembly of germplasm at ICRISAT

Collection and assembly of groundnut genetic resources at ICRISAT commenced in 1976 with the establishment of the groundnut improvement program. By 1980, with the establishment of GRU, 8500 accessions were assembled from 49 countries (Rao 1980). Of these, 7703 accessions were transferred from various research institutions and gene banks (Table 1). Since 1980 we have added 1536 more accessions from collection expeditions by ICRISAT staff in 19 countries and assembled another 3102 accessions by request and/or as donation from 47 organizations (Tables 1 and 2). At present the ICRISAT gene bank contains 13 460 accessions, including 197 wild *Arachis* species accessions from 89 countries (Table 3). The collections are nondiscriminatory in the sense that both landraces and materials developed

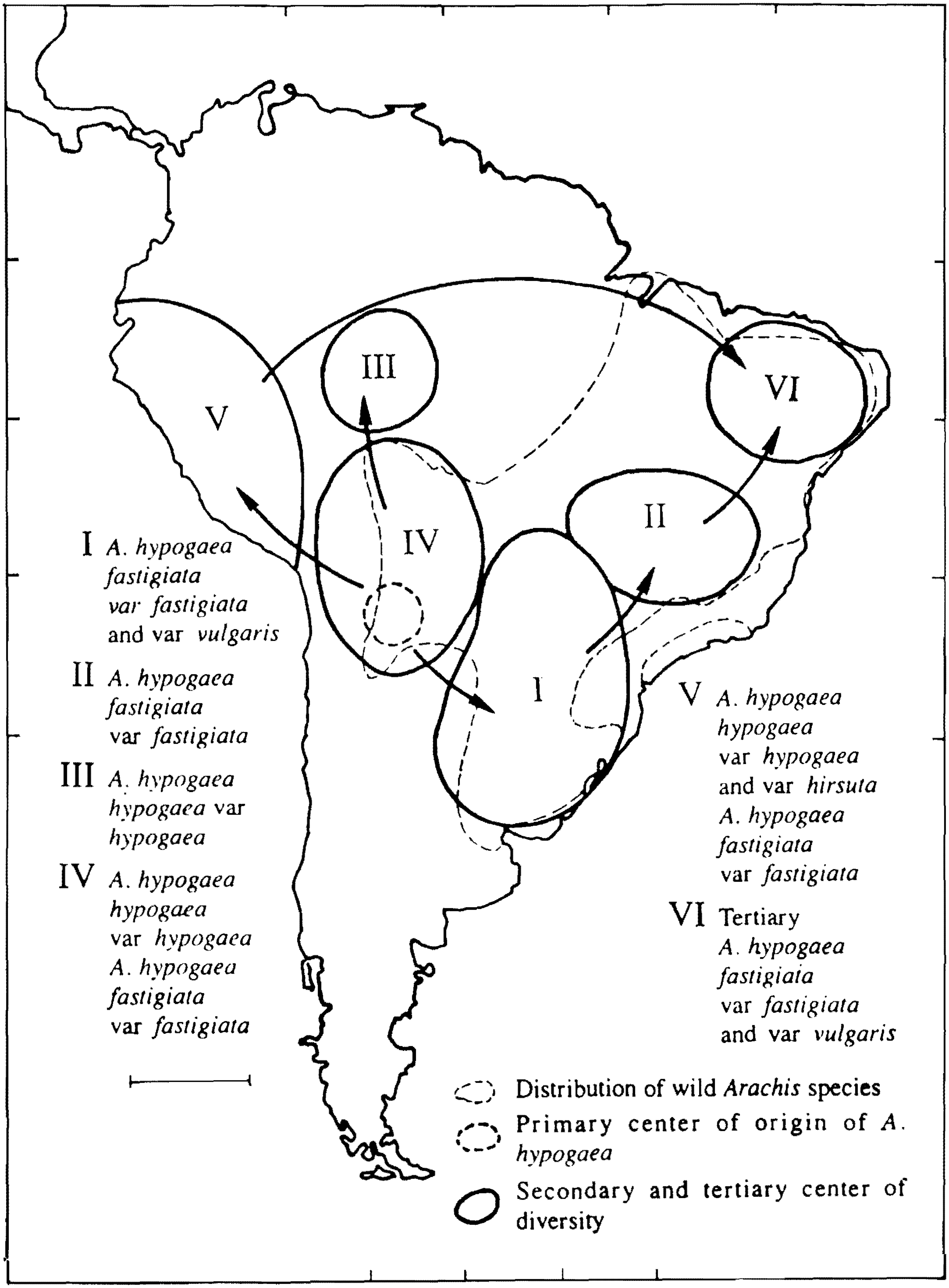

Figure 1. Centers of origin and diversity of cultivated groundnut (*Arachis hypogaea*). (Source: Gregory and Gregory 1976.)

Table 1. List of countries with number of institutions and *Arachis* germplasm accessions donated to ICRISAT.

	No. of institutions		No. of accessions	
Country	1980	1991	1980	1991
CIS (formerly USSR)	1	1	3	3
India	15	22	4 969	6 367
Indonesia	0	1	0	57
Japan	3	2	74	75
Malawi	1	1	263	283
Netherlands	0	1	0	4
Nigeria	1	1	103	106
People's Republic of China	1	2	5	31
Puerto Rico	0	1	0	14
Senegal	1	2	16	701
South Africa	0	1	33	117
South Korea	0	1	0	69
Sri Lanka	0	1	0	1
Sudan	0	1	0	1
Surinam	0	1	0	2
Tanzania	0	1	0	39
Trinidad	0	1	0	1
UK	1	1	20	20
USA	5		5	2 066
3 447				
Zimbabwe	1	1	151	151
Unknown	0	0	0	1
Total	30	48	7 703	11 490

by breeders and/or released cultivars, and wild relatives from the genus *Arachis* are collected, since any present day genotype could contain gene(s) that may be of future value. These collections are summarized in Table 4 and are classified into the following categories:

Accession collection. These are collections with identity assembled from other agencies.

Named cultivars. These are the cultivars released by various public and private institutions.

Landraces. These are unknown old cultigens collected from farmers' fields.

Breeding lines. These are materials developed by breeders but not released as cultivars after incorporating desired traits.

Genetic stocks. These are genotypes identified as sources of resistances to diseases and insect pests and other desirable traits, including mutants and experimental material.

Wild *Arachis* species. These are wild species belonging to the genus *Arachis*.

The assembly of such a large collection is an example of excellent international cooperation received from various international and national agencies. However, there have been several gaps, because of loss of collections in several African countries, difficulties experienced in exchange of germplasm from some quarters, resource constraints for obtaining infection-free material from areas of specific stresses,

Table 2. Number of expeditions and *Arachis* samples collected by ICRISAT staff since 1980.

Country	No. of expeditions	No. of accessions	Date of expedition
Botswana	1	8	Mar 1985
Brazil	3	38[1]	Mar 1982
		73	Mar 1982
		41	Mar 1987
Gambia	1	8	Nov 1980
Ghana	1	34	Aug 1981
India	7	185	Nov 1981
		8	Oct 1982
		1	Nov 1983
		19	Oct 1984
		21	Oct 1986
		30	Nov 1986
		16	Nov 1987
		126	Dec 1987
Indonesia	1	75	Dec 1989
Malaysia	1	43	Mar 1980
Mali	2	5	Oct 1981
		146	Oct 1986
Mozambique	1	131	May 1981
Myanmar	2	4	Mar 1980
		44	Nov 1987
Nigeria	1	48	Sep 1983
Philippines	1	9	Apr 1981
Rwanda	1	1	Jul 1982
Sierra Leone	1	2	Sep 1983
South Africa	1	1	Apr 1982
Tanzania	3	15	Aug 1981
		96	Apr 1985
		7	Apr 1987
Uganda	1	96	Feb 1991
Zambia	1	80	Jun 1980
Zimbabwe	3	7	May 1982
		68	Apr 1985
		44	Apr 1988
Total	33	1530	

1. Wild *Arachis* spp accession.

Table 3. *Arachis* germplasm status at ICRISAT, 1991.

Status/ representation	No. of accessions			
	A. hypogaea		*Arachis* species	
	1980	1991	1980	1991
Total accessions conserved	8 194	13 460	97	195
No. of countries represented	49	89	2	6
Primary centers				
Argentina	293	405	18	34
Bolivia	85	272	18	35
Secondary centers				
Brazil	329	465	43	87
Paraguay	106	163	17	33
Peru	69	316	0	0
Uruguay	25	40	0	1
Tertiary centers				
Africa	1 745	3 179	0	0

Table 4. Status of various *Arachis* germplasm conserved.

Resource	1980	1991
Accessions	3 974	7 817
Landraces	2 461	5 146
Named cultivars	130	230
Breeding lines	3 783	4 553
Genetic stocks	60	131
Wild *Arachis* spp	97	195
Taxonomic representation:		
Section		
Arachis	8 194	12 044
Erectoides		21
Caulorhizae		2
Rhizomatosae		90
Extranervosae		2
Trisaminalae		1
Procumbansae		0
Interspecific derivatives		165
Unknown		1 651

and political instability in regions of diversity. Non-discriminatory collection by several collectors and frequent exchange of germplasm between gene banks without original passport information has added to the inclusion of many duplicates and samples mainly from major areas of cultivation with a narrow level of representation of geographic (agroclimatic) and genetic diversity (most samples are variants of same genotype). These lacunae should be avoided in future, assemblies and duplicates should be identified using appropriate techniques. According to the original priorities major areas have been explored extensively. However, a number of countries/regions with limited groundnut cultivation may still contain extensive variability and it is essential that these areas should be explored to make world collection more comprehensive. Table 5 lists ICRISAT collection priorities for the next 10 years. We would appreciate support from different national and international agencies to limit the erosion of groundnut genetic resources in these areas.

Table 5. ICRISAT collecting priorities for *Arachis* germplasm.

Regions	In 1980 countries/regions	In 1991 countries
Asia	Indonesia[1] Myanmar[1]	Cambodia India Laos People's Republic of China Thailand Vietnam
Meso America	Caribbean islands Central America Mexico	Mexico
West Africa	Gambia[1] Nigeria Senegal Burkina Faso	Cameroon Central African Republic Gabon
Southern & Eastern Africa	Mozambique[1]	Angola Madagascar Namibia
South America	Argentina Bolivia Brazil[1] Paraguay Peru	Argentina Bolivia Brazil (Northeast) Paraguay Peru Uruguay

1. Explored.

Characterization

The entire groundnut germplasm collection at ICRISAT, with the exception of a few recently collected or acquired accessions, has been characterized at ICRISAT Center, located at 18°N, 78°E at Patancheru, Andhra Pradesh, India, according to the Groundnut Descriptors (IBPGR/ICRISAT 1981). Accessions are characterized under rainfed conditions during the rainy season (June to October) and irrigated conditions during the postrainy season (November to April). The wide range of variation in morphoagronomic characters in these collections is shown in Table 6.

Further screening of groundnut germplasm to assess its potential for various specific traits, particularly its reaction to different biotic and abiotic stresses, is carried out in collaboration with various disciplines of the ICRISAT Legumes Program. The results of this screening are summarized in Table 7. In addition, we collaborate in multilocation germplasm evaluation with the National Bureau of Plant Genetic Resources (NBPGR) of the Indian Council of Agricultural Research (Thomas et al. 1989).

After systematic characterization and evaluation of available germplasm at ICRISAT there are still several limitations restricting its utilization to the fullest extent. For a number of accessions identified as sources of resistance to various fungal diseases or pests, a complete picture on their reaction to other important biotic and abiotic stresses is lacking. Other limitations in characterization are lack of multilocation evaluation, including the place of origin, and lack of uniformity in scales used to characterize quantitative traits. In addition, most of the desirable traits identified in various accessions have not been characterized either at the genetic or the molecular level. Lack of this information limits our understanding of gene action and selection of the most appropriate breeding strategy. Similar ranges of variability observed for quantitative traits in a number of accessions indicate the presence of duplicates that should be sorted out to make the available variability more specific and save space for more important accessions.

Documentation

The morphological and agronomic data are collected in the form of preharvest and postharvest observations (see standard descriptors). It is tabulated on separate sheets, along with the passport information. Information on 12 160 accessions (excluding the ones assembled recently) is documented on computer using the ICRISAT Data Management System (Estes and Rao 1989). This program provides the option for retrieving the information in full or part with desired time periods and combination of descriptors. Thus it fulfills the requirement of the user for specific information in specific combinations on specific accessions. Documentation is updated as characterization is completed on acquired accessions. The information is available on request.

GRU also maintains a set of catalogs as ready reference on the identity of many accessions and collection status of groundnut germplasm in several gene banks around the world. The ICRISAT groundnut germplasm catalog with information on passport and morphoagronomic features of 12 160 accessions is ready for publication. Although significant progress has been made in documentation since 1980, the system has some limitations: for example, incomplete documentation on reaction to major stresses, and on the expression of characteristic traits in different agroclimatic conditions (because of lack of feedback from users or due to usage of different scale and language).

Conservation

The gene bank established at ICRISAT in 1979 serves as one of the major repositories for the world collection of groundnut germplasm and other mandate crops. It was established with the understanding that temperature and moisture are the two key factors influencing seed viability and longevity during storage. Control of these factors can dramatically improve the longevity of seeds in storage. At ICRISAT, we store the groundnut germplasm in the form of pods and seeds in moisture-proof and temperature-proof containers. The storage environment is controlled for low temperature and humidity in accordance with the guidelines of the International Board for Plant Genetic Resources (IBPGR) (Mengesha et al. 1989).

Short-term chamber

The short-term chamber maintains a temperature of 18°C and 30% relative humidity (RH) and holds freshly harvested material until it is dried and prepared for subsequent transfer.

Table 6. Range of variation in cultivated groundnut observed at ICRISAT Center.

Character	Minimum	Maximum	Intermediate(s)
Life form	Annual	-	-
Growth habit	Erect	Procumbent	Decumbent
Branching pattern	Sequential	Alternate	Irregular
Stem pigmentation	Absent	Present	-
Stem hairiness	Glabrous	Woolly	Hairy, very hairy
Reproductive branch length	1 cm	10 cm	Continuous
No. of flowers/inflorescence	1	5	2, 3, 4
Peg color	Absent	Present	-
Standard petal color	Yellow	Garnet	Lemon yellow, light orange, orange, dark orange
Standard petal markings	Yellow	Garnet	Lemon yellow, light orange, orange, dark orange
Leaf color	Yellowish green	Dark green	Light green, green, bottle green
Leaflet length	17 mm	94 mm	Continuous
Leaflet width	7 mm	52 mm	Continuous
Leaflet L/W ratio	1	6	Continuous
Leaflet shape	Cuneate	Lanceolate	Obcuneate, elliptic
Hairiness of leaflet	Subglabrous	Profuse and long	Scarce and short, scarce and long, profuse and short
No. of seed/pod	1	5	2, 3, 4
Pod beak	Absent	Prominent	Slight, moderate
Pod constriction	Absent	Very deep	Slight, moderate, deep
Pod reticulation	Smooth	Prominent	Slight, moderate
Pod length	14 mm	65 mm	Continuous
Pod width	7 mm	20 mm	Continuous
Seed color pattern	One	Variegated	-
Seed color	Off white	Dark purple	Yellow, shades of tan, rose shades of red, grey-orange, shades of purple
Seed length	4 mm	23 mm	Continuous
Seed width	5 mm	13 mm	Continuous
100-seed mass	14 g	136 g	Continuous
Days to emergence	4	18	Continuous
Days to 50% flowering	17	54	Continuous
Days to maturity	75	>155	Continuous
Fresh seed dormancy	0 days	>66 days	Continuous
Oil content	31.8%	55.0%	Continuous
Protein content	15.5	34.2	Continuous

Table 7. Status of screening of *Arachis* germplasm at ICRISAT Center.

	1980		1991		
Specific trait	No. screened	No. identified	No. screened	No. identified	Reported by
Disease resistance					
Leaf spot	8000	5	9400	76 (26)[2]	G'nut Path[3]
Rust	8000	13	9400	141 (35)	
TSWV	-[1]	0	7400	23 (6)	
PMV	-	2	1800	2 (2)	
Aflatoxin	-	3	582	17 (4)	
Pod rot	2000	6	3222	24 (6)	
Pest resistance					
Thrips	-	3	5000	14 (7)	G'nut Ent[4]
Jassids	-	5	6500	30 (7)	
Termites	-	6	520	20 (6)	
Aphids	-	1	300	4 (1)	
Leaf miner	-	6	930	18 (6)	
Multiple resistance	0	0	9400	85 (45)	
Abiotic stresses/nutrition					
Drought	0	0	742	38 (8)	G'nut Phy[5]
N fixation	-	3	342	4 (2)	
High oil	0	0	8868	44 (10)	Crop Qual[6]
High protein	0	0	8868	51	

1. Number of accessions screened not available.
2. Number of accessions commonly used in breeding programs are shown in parentheses.
3. G'nut Path = Groundnut Pathology.
4. G'nut Ent = Groundnut Entomology.
5. G'nut Phy = Groundnut Physiology.
6. Crop Qual = Crop Quality.

Table 8. Status of *Arachis* germplasm conservation at ICRISAT Center.

	No. of accessions conserved/conditions			
		Pod		Seed
Status	Plant natural	Short-term	Medium-term	Long-term
1980	0	6 791	8 291	0
1991	90	1 300	12 160	774

Medium-term chamber

The medium-term chamber has rooms maintained at 4°C and 20% RH, and conserves pods of 13 000 accessions.

Long-term chamber

The long-term chamber has rooms maintained at -20°C to store base germplasm and duplicates from other gene banks. At present, this conserves seeds of 1000 accessions in aluminium pouches. Table 8 summarizes the status of conserved germplasm.

Germplasm at ICRISAT has been carefully conserved to avoid genetic contamination, genetic drift, genetic shift, mechanical mixing, and loss of seed viability. Pathologists and virologists help us to stock the gene bank with disease-free seeds. However, we are short of resources for large-scale multiplication, and have limited opportunities for research on physical and chemical factors affecting viability and longevity of seeds in storage to make conservation more effective. It is possible to overcome some constraints such as space, low multiplication rate, and genetic damage in storage by using in-vitro techniques and cryopreservation.

Rejuvenation and Maintenance

Most of the groundnut accessions are seed producing and are maintained as seed. Rhizomatous accessions are maintained as plants in isolated concrete rings. Loss of seed viability and distribution of germplasm necessitate frequent rejuvenation and multiplication of large numbers of accessions. An accession is rejuvenated only when seed viability drops below 85% or the seed stock falls below 250 g. This activity is expensive and involves danger from genetic contamination, drift, and mechanical mixing. Hence, an attempt is being made to conserve a set of all accessions as base germplasm under long-term storage conditions, which will require more human and financial resources. All rejuvenation is done under ICRISAT conditions, rather than at the place of original collection (which may give an altogether different selection pressure); also the genetic stocks are not checked for the stability of their characteristic traits in each generation. Large multiplication and networking of genetic resource activities may help to overcome these problems.

Distribution

The distribution of seeds to scientists worldwide is one of the major responsibilities of the ICRISAT GRU. All exported material from ICRISAT is sent to the Indian Plant Quarantine Authority, which inspects it and grants phytosanitary certificates. Table 9 shows the number of accessions distributed by GRU since 1980. With each batch we also provide standard passport and other relevant information on identity, botanical group, and country of origin with remarks on any special features of the material. Distribution of groundnut germplasm has created an outstanding impact on research activities of various national agricultural research programs. However, vague requests, limited seed and pod quantity (because of large pod and seed size), and quarantine delays remain as constraints. Some of these limitations may be overcome by using in-vitro methods in conservation and exchange of germplasm.

Utilization

After centuries of natural and human selection, landraces and the wild relatives of groundnut have acquired resistance to specific biotic and abiotic stresses. This germplasm can be utilized as a source of resistances in breeding programs. At ICRISAT the available world germplasm has been evaluated for resistance to various groundnut diseases, insect pests, and environmental stresses, leading to the identification of a large number of genetic stocks (Table 7) (Amin et al. 1985; Mehan 1989; Subrahmanyam et al. 1990). GRU coordinates this activity to document

Table 9. *Arachis* germplasm distributed by ICRISAT to various regions/organizations.[1]

	No. of accessions					
	1980			1991		
Regions	*A. hypogaea*	*Arachis* species	Total	*A. hypogaea*	*Arachis* species	Total
Africa	724	4	728	8 225	14	8 967
America (North)	124	0	124	540	0	664
America (South)	103	0	103	204	0	307
Asia	9 080	9	9 089	39 227	308	48 624
Australia	42	0	42	87	0	129
Europe	69	0	69	853	2	924
Oceania	186	0	186	212	50	440
Individual	0	0	0	75	0	75
Research organization	0	0	0	4 529	0	4 529
Seed company	0	0	0	14	0	14
Total	10 328	13	10 341	49 348	322	60 061

1. Supplied also as cuttings and rhizomes.

complete information on each accession. ICRISAT scientists are also involved in introgression of specific resistance from several wild *Arachis* species and have generated much variability.

Significant progress in plant breeding has been made in the last decade but more exploitation of germplasm is needed. Incomplete evaluation of new sources, and their poor agronomic characteristics limit their use. The available interspecific variability has not been fully exploited either because of certain lacunae in the material generated or because of the shortage of expertise in the use of biotechnological techniques to transfer desirable traits. A more concerted effort in this area may provide benefits similar to those found for *Nicotiana tabacum*, *Medicago sativa*, and *Brassica* species.

Conclusions and Recommendations

During the last decade there has been good progress on the collection, characterization, and utilization of groundnut germplasm. However, there is still an urgent need to collect more germplasm from centers of diversity and areas of early introduction that are in danger from encroaching development. Landraces and wild *Arachis* species will be increasingly utilized if further evaluation can keep pace with collection and preliminary evaluation; otherwise these collections will not be properly utilized. Development of a uniform documentation system, and ready availability and exchange of information and germplasm would enhance their use by all scientists involved in crop improvement. Conservation of groundnut germplasm has received only limited research attention. In addition to conventional ex situ techniques, in-vitro conservation techniques will go a long way toward overcoming the present problems of conservation and distribution of germplasm. Immediate attention to the following recommendations will make conservation and utilization of groundnut germplasm more effective:

1. Strengthening resource centers in developing countries to facilitate collection, assembly, and evaluation in places of origin.
2. Setting up regional storage centers to conserve germplasm under natural or artificial conditions to reduce genetic variation or drift.
3. Increasing research into new techniques for conservation and distribution.
4. Developing rapid screening techniques to complete evaluation for reaction to virus diseases and fungal diseases such as *Aspergillus flavus*.
5. Including information on genetic characterization of useful traits and gene mapping in catalogs.
6. Transferring useful variability to good agronomic background.
7. Strengthening utilization of wild *Arachis* species through introgression into *A. hypogaea*, thus generating variability and broadening the genetic base of *A. hypogaea*.
8. Networking groundnut genetic resources activities to coordinate and to bring uniformity in characterization and documentation with facilities for international on-line searching.

Networking

Networking is a useful tool for improving the global status of crop genetic resources and bringing uniformity to various activities. We propose that curators, breeders, and researchers on *Arachis* present a plan of action to improve collection, conservation, and enhancement of available *Arachis* genetic resources. They can pool their resources and share the activities. A plan of action could be developed in a workshop convened jointly by ICRISAT and IBPGR during 1992, if the participants of the present workshop express interest in the proposal. ICRISAT conceives its role as an active partner of the network not only to help other *Arachis* genetic resources programs but also to benefit from the experience of other partners. IBPGR, in the framework of its program for crop networks, is keen to play a catalytic role in the establishment of this network. However, it does not foresee being an active participant as the network develops.

We see membership of the network not as a substitute for the policy of individual national program or of ICRISAT, but as a minimum basis for collaborative work on groundnut genetic resources. Such an effort will benefit all the members of the network and avoid duplication of effort. The agreement on a plan of action with well-defined priorities and commitments from all partners will also allow us to seek the additional funding that is necessary to achieve the objectives.

Objectives and Scope

To achieve uniformity and universalization of results, the following approaches are important.

Future collecting needs

Participants in networks could identify future needs, in addition to those given in Table 5 for ICRISAT, to enable them to decide priorities and share material collected, as in the workshop of *Arachis* workers held in 1989 (IBPGR 1990).

Characterization and documentation

Development of a common descriptor language and database is imperative. This will need:

- Development of an inventory of existing accessions. It is essential to provide access to the germplasm to all participants as is now the standard practice at ICRISAT. The production of comprehensive inventories requires an institute to compile and standardize data. For wild *Arachis* species, North Carolina State University, USA, is preparing an inventory in accordance with the recommendation of the Centro Internacional de Agricultura Tropical (CIAT) meeting on wild *Arachis* species.
- Development of common descriptors and compatible format. IBPGR and ICRISAT (1981) developed groundnut descriptors that are being revised. Efforts to produce descriptors for the wild *Arachis* species are in progress. They will result in developing a format to be used for exchange of information.
- An international database. Consequent sharing of results will require more than passport data in a central database. The database would include gene bank management data, characterization, preliminary evaluation data, and further evaluation data.
- Exchange of information. A crop network will facilitate a dynamic collaborative approach to making the data available in a form that will be useful to all the participants. One example is a computerized bibliography of crop genetic resource publications, listing reference material and updating research results. Further analysis of data will allow implementation of really collaborative efforts and sharing of work for better characterization and evaluation of *Arachis* germplasm.

Integrated conservation approach

A coordinated approach for conservation of genetic resources would need:

- Rationalization of collection. A database will provide information on redundancy of existing collections at different centers. This will help in rationalizing collection to avoid obvious duplications and sharing responsibilities in maintenance of accessions by participants.
- Safety duplication. The reduction in redundancy is important, but storage of each original accession in two separate long-term storage facilities is required to minimize the risk of loss of original germplasm.
- An integrated approach. Maintenance of a world collection should include studies on the influence of various techniques on viability and longevity of the germplasm conserved. The conservation methods may consist of cold storage of seeds, in-vitro conservation of vegetatively propagated wild *Arachis* species, and in-situ conservation of germplasm in their natural ecosystem. Networking can help to determine the appropriate approach.

Use of collection

To promote and improve utilization of germplasm by the international community, it is necessary make the collection more accessible through:

- Plant quarantine. With increasing exchange of germplasm an international network will help to facilitate meeting plant quarantine requirements of the participating countries. The support or strengthening of quarantine centers will be one of the responsibilities of the network. In the final analysis, however, plant quarantine is under national government responsibility and control.
- Characterization and evaluation. The registration of available evaluation data in the central database will increase the availability of evaluation information which in turn will enhance the use of germplasm.
- Enhancement. For better use of germplasm it is essential to transfer the desirable traits to good agronomic background, particularly when traits are transferred from wild *Arachis* species. Crop networking will not only have potential to stimulate collaborative activities for the enhancement of germplasm, but also will help smaller programs within the network to benefit from activities provided by larger institutions.
- Research. There is a need for additional research on proper maintenance conditions, use of collections, quality and quantity of genetic diversity available, incompatibility, etc. It will be very difficult for a single organization to undertake the research that is needed for groundnut germplasm. A collaborative approach within the network will

help to identify the research priorities and the appropriate organization to produce information useful to all the participants.

Development and Organization of the Network

Development and organization of the network will involve the following components:

- Inaugural workshop. An inaugural workshop will be organized, involving curators, breeders, and researchers working on *Arachis* will help to stimulate and establish a groundnut germplasm network.
- Basic principle. An agreement on free exchange of genetic resources and information should be required for membership of the network.
- Minimum action program. The participants should decide on priority of objectives, activities, and commitments for various participants.
- International database. The existing international database at ICRISAT will be further developed to strengthen the networking.
- Coordinating body. Election/nomination of a coordinating committee at the end of the workshop will be essential to support and execute the network activities. This will be subject to study and approval by participating organizations.
- Funding. Additional funding on clear and focused international programs of the network will be needed.
- Role of the IARCs and IBPGR. This will be discussed within the framework for participation of global responsibilities in agricultural research.

References

Amin, P.W., Singh, K.N., Dwivedi, S.L., and **Rao, V.R.** 1985. Sources of resistance to jassid (*Empoasca kerri* Pruthi), thrips [*Frankeniella schultzei* (Trybom)] and termites (*Odontotermes* sp.) in groundnut (*Arachis hypogaea* L.). Peanut Science 12:58-60.

Estes, J.W., and **Rao, V.R.** 1989. Computerized documentation and retrieval systems for genetic resources work at ICRISAT – present and future. Pages 71-74 *in* Collaboration in genetic resources: summary proceedings of a Workshop on Germplasm Exploration and Evaluation in India, 14-15 Nov 1988, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Hawkes, J.G. 1981. Germplasm collection, preservation and use. Pages 57-83 *in* Plant Breeding II (Frey, K.J., ed.). Ames, Iowa, USA: Iowa State University Press.

IBPGR (International Board for Plant Genetic Resources). 1990. International Crop Network Series 2. Report of a Workshop on the Genetic Resources of Wild *Arachis* Species, 29 Feb-2 Mar 1989, Cali, Colombia, including the preliminary descriptors for *Arachis* (IBPGR/ICRISAT). Rome, Italy: IBPGR.

IBPGR/ICRISAT (International Board for Plant Genetic Resources/ International Crops Research Institute for the Semi-Arid Tropics). 1981. Groundnut descriptors (revised). Rome, Italy: IBPGR. 23 pp.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1989. Summary proceedings of the Second Coordinators' Meeting on Peanut Stripe Virus, 1-4 Aug 1989, ICRISAT Center, India. Patancheru, A.P. 502 324, India: ICRISAT.

Mehan, V.K. 1989. Screening groundnuts for resistance to seed invasion by *Aspergillus flavus* and to aflatoxin production. Pages 323-334 *in* Aflatoxin contamination of groundnut: proceedings of the International Workshop, 6-9 Oct 1987, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Mengesha, M.H., Khanna, P.P., Chandel, K.P.S., and **Rao, N.K.** 1989. Conservation of world germplasm collections of ICRISAT mandate crops. Pages 65-69 *in* Collaboration on genetic resources: summary proceedings of a Workshop on Germplasm Exploration and Evaluation in India, 14-15 Nov 1988, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research for the Semi-Arid Tropics.

Rao, V.R. 1980. Groundnut genetic resources at ICRISAT. Pages 47-57 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Resslar, P.M. 1980. A review of nomenclature of the genus *Arachis* L. Euphytica 29:813-817.

Singh, A.K. 1988. Putative genome donors of *Arachis hypogaea* (*Fabaceae*), evidence from crosses with synthetic amphidiploids. Plant Systematics and Evolution 160:143-151.

Smartt, J., Gregory, W.C., and **Gregory, M.P.** 1978. The genomes of *Arachis hypogaea.* I. Cytogenetic studies of putative genome donors. Euphytica 27:665-675.

Subrahmanyam, P., McDonald, D., Reddy, L.J., Nigam, S.N., Moss, J.P., Singh A.K., and **Rao, V.R.** 1990. Resistance to rust and late leaf spot of groundnut at ICRISAT Center: problems and progress. Pages 85-91 *in* Proceedings of the Fourth Regional Groundnut Workshop for Southern Africa, 19-23 Mar 1990, Arusha, Tanzania. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Thomas, T.A., Rao, K.E.P., and **Pundir, R.P.S.** 1989. ICRISAT/NBPGR joint evaluation of germplasm in India. Pages 59-64 *in* Collaboration on genetic resources: summary proceedings of a Workshop on Germplasm Exploration and Evaluation in India, 14-15 Nov 1988, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Valls, J.F.M., Rao, V.R., Simpson, C.E., and **Krapovickas, A.** 1985. Current status of collection and conservation of South American groundnut germplasm with emphasis on wild species of *Arachis.* Pages 15-33 *in* Proceedings of an International Workshop on Cytogenetics of *Arachis*, 31 Oct-2 Nov 1983, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.