Report of a Working Group on Tropical and Subtropical Forage Genetic Resources (Second Meeting)

Held at CIAT, Cali, Colombia
6-8 April 1994

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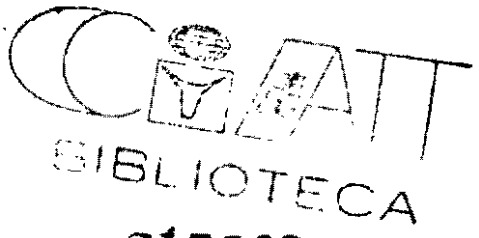

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Working Group on Tropical and Subtropical Forage Genetic Resources
(Second Meeting)

Introduction

Dr. B. Maass welcomed the participants (Appendix I) and opened the meeting. Dr. W. Scowcroft gave the welcoming address and stressed the importance of the genetic resources held in trust by the CGIAR and national Genetic Resource Centers. He stressed that these genetic resources have had a substantial impact on increasing animal production and contributing to the development of sustainable agro-pastoral systems. A good example is the acid soil regions of South America, where tropical forages introduced from Africa through CIAT have already provided a major contribution to the development of sustainable and productive land use. Forages are essential as a feed resource for livestock production and are also important for improving fertility and hence contributing to sustainable land use.

Dr. Scowcroft said that recent developments arising from the Convention on Biological Diversity and ownership issues may affect future access to genetic resources. In addition the CGIAR system is undergoing a period of change. A recent system wide Stripe Study of genetic resources recommended increased collaboration between Centers, and a new Center is being established to implement research on livestock, including forages.

Rationale for the workshop

In 1984, a workshop held in Brisbane, Australia (IBPGR, 1984), initiated a phase of closer interaction between the larger national and international genetic resource centers (GRC). The XVII International Grassland Congress in 1993 endorsed a resolution framed by participants from larger GRCs that a tropical forage network be set up to improve communication and effectiveness of conservation and developement of the world's tropical forage genetic resources. The resolution read as follows:

> *"Resolution 9. Recognising that functional networks associated with Forage Genetic Resource Centers currently exist in the European and Mediterranean zones, which promote the free flow of genetic resources, to the benefit of participating countries, it is recommended that there should be strong support for the further development of functional networks, including tropical and subtropical centers."*

Dr. P. Kerridge presented the rationale behind the meeting and expressed his hope that the outcome would be a continuing and proactive group acting in a coordinating role in research on the genetic resources of tropical and subtropical forages. The Working Group should increase collaboration on forage genetic resources acquisition, conservation and distribution and consider strategic studies needed to link *ex situ* and *in situ* conservation. The importance of involving additional NARS was stressed, but funding would be the crucial issue. The group should work towards obtaining funding for projects on forage genetic resources and biodiversity. He stressed that the way ahead will be through collaboration.

Review of the 1984 workshop

This workshop concentrated on setting an agenda for work on tropical forage genetic

resources, identifying key species, and linking species biodiversity and erosion of key species to collection needs and priorities. The need for *ex situ* base collections and responsibility was discussed, and research institutes accepted responsibility to maintain some of the more critical species. A major outcome of the meeting was the agreement that there should be coordination of work and enhanced collaboration between participating institutes.

Review of activities since 1984

Participating institutes

Each participating institute has made considerable progress in the various disciplines associated with genetic resource acquisition, study and conservation. More comprehensive accounts of these activities are given in Appendix II and III.

CIAT. Within the CGIAR system, CIAT now has a worldwide mandate for herbaceous leguminous and grass species adapted to acid, low-fertility soils of the lowland tropics. In tropical America, it is also responsible for selecting forage species for mid-altitudes, and multipurpose shrub and tree legumes for both lowlands and mid-altitudes. More than 30 collection missions were carried out in collaboration with NARS, ILCA and IBPGR, to acquire native legume germplasm from tropical America and Southeast Asia, and grasses from Africa. In recent years emphasis was put on consolidating the existing tropical forage germplasm collection, which comprises almost 21,000 accessions, being 84% herbaceous and 6% shrub legumes, and 10% grasses. Besides characterization and preliminary agronomic evaluation of large collections, studies on reproductive biology and genetic diversity were carried out. About 3,000-4,000 germplasm samples are distributed every year, mainly to national partners for evaluation, with particular emphasis on existing networks in tropical America.

CSIRO-ATFGRC. The ATFGRC has expanded its activities to include root nodule bacteria research and conservation, use of molecular markers for studying genetic diversity and has also started to address the specific problem of revegetating open cut coalmines. Acquisition has been strongly focused on key species and for key adaptive attributes. Characterization has been given priority and five legume and three grass collections have been characterized since 1984. The database management system has been progressively upgraded as an aid to effective operation and servicing the needs of clients. Methodology is being developed for evaluating physiological attributes such as tolerance of water stress in characterizing collections.

EMBRAPA/CENARGEN. In Brazil there is a strong focus on indigenous forages, and an extensive nationwide germplasm collection program has been carried out in collaboration with CIAT, CSIRO and Royal Botanic Gardens, Kew, UK. Thirty nine expeditions have been carried out since 1975, covering both tropical and subtropical regions. Collections include voucher herbarium specimens. Nearly 6,000 accessions have been assembled and catalogued and are undergoing botanical and agronomical characterization and evaluation. This has led to the release of several cultivars in Brazil and elsewhere. There has been recent emphasis on the legumes *Adesmia, Arachis, Centrosema, Chamaecrista, Cratylia* and *Stylosanthes*. Germplasm collected in the wild is conserved at -18°C and subsamples are distributed to other genebanks for multiplication, characterization and preliminary agronomical evaluation. Some problems

have been experienced in coordinating the multiplication phase of the program. There is an effort to integrate the conservation of biodiversity through the creation of *in situ* genebanks (genetic reserves). Priority is being given to existing conservation units.

ILCA. The Forage Genetic Resources Centre at ILCA has concentrated on the collection of forages in Africa and over 12,000 accessions are currently held in trust. The collection is made up of about 60% legumes, 15% fodder tree species and 25% grasses. There has been an emphasis on the development of drying and storage facilities, which will be further expanded in 1994-1995. About 3,000-5,000 samples are distributed every year, mostly to national programs in sub-Saharan Africa. The collection of *Sesbania* has been characterized morphologically and also for polyphenolics. Research has concentrated on the use of *in vitro* culture to support the germplasm activities, including *in vitro* storage of forage grasses, rapid clonal propagation of woody species, and also as a means of eliminating diseases. Present work is focused on the development of germplasm health testing to support germplasm exchange.

IPGRI. Dr. D. Debouck summarized the former role of IBPGR in tropical forages. The approach varied from that of food crops and progress has been slow owing to the lack of trained staff and scientific knowledge for forages in many national programs. IPGRI is now looking to work more on forages. Major efforts in the past were on collection in South America (Brazil with EMBRAPA/ CENARGEN and CIAT, Argentina with INTA, Chile with the national program), Africa with ILCA, CIAT and national programs, West Asia and North Africa (WANA) through support to NARS and Southeast Asia through CIAT and with NARS. Current projects are on genetic diversity studies. There is a need to do more in *in situ* conservation because of the size of the populations and amount of variation. Research is needed in areas of assessment of the amount of genetic diversity present in species, geographic distribution of species, breeding systems, and management and seed physiology for *ex situ* conservation. Introduction of well adapted germplasm is important for developing sustainable systems and for farmer conservation efforts. The future program of IPGRI will work in partnership with other Centers and NARS. A major thrust will be on *in situ* conservation, but there is need to develop the scientific base for *in situ* conservation in order to proceed. However, it was noted that *in situ* conservation presents many problems and is difficult, so will be a backup for *ex situ* conservation.

Non-participating institutes. The group identified active forage genetic resources programs which could be invited to become part of the network.

Revision of priority taxa and responsibilities

The working group agreed that there was a need to redefine the priority group of genera and species listed in the proceedings of the first workshop. A list of promising genera to be held for forage genetic resources was made (Appendix III) and from that list species were identified with priority for further collection/acquisition and characterization (Table 2).

Table 1. Potential network members.

Africa	Côte d'Ivoire	IIRSDA, Abidjan
	Kenya	GBK, Muguga
	South Africa	Roodeplaat Grassland Institute
	Regional	SADC
Asia	China	CAAS
	India	NBPGR
Europe	UK	1. OFI 2. R.B.G., Kew
North America	USA	1. USDA (Henry Shands) 2. Southern Regional Plant Introduction Station, Experiment, Georgia 3. IFAS, University of Florida, Ft. Pierce 4. Texas A&M University 5. NFTA, Hawaii
Central and South America	Belize	Ministry of Agriculture, Central Farm
	Honduras	
	Mexico	1. INIFAP 2. University of Chapingo 3. University of Saltillo
	Argentina	INTA
	Peru/Regional	CIP (Miguel Holle)

Research needs and priorities

The Group identified a set of general research needs in the area of tropical forage genetic resources:

- Studies on genetic diversity, population structure and coverage to identify gaps and provide information for *in situ* conservation.
- Adaptation of germplasm to environmental conditions and management with reference to use and prediction of forage potential.
- Studies on anti-quality factors, especially in woody species.
- Studies on seed physiology and storage.
- Studies in breeding systems and regeneration methods.
- Characterization, including use of markers and biotechnology for identification of useful characters.
- Studies in systematics and taxonomy.

Reference

IBPGR. 1984. IBPGR Working group on tropical and sub-tropical forages. Held at the CSIRO Division of Tropical Crops and Pastures, Cunningham Laboratory, St. Lucia, Queensland, Australia, 5-7 June 1984. International Board for Plant Genetic Resources, Rome, Italy. 29 p.

Table 2. Priority taxa for acquisition and characterization.

Legumes	Grasses
Acquisition	
Arachis pintoi/repens	*Pennisetum purpureum*
Calliandra calothyrsus and related spp.	
Chamaecrista rotundifolia	
Cratylia argentea	
Desmanthus virgatus	
Macroptilium gibbosifolium and related spp.	
Sesbania sesban	
Stylosanthes sp. aff. *scabra*	
Characterization (including systematic relationships)	
Galactia striata	*Digitaria eriantha/milanjiana*
Lablab purpureus	*Panicum coloratum*
Pueraria phaseoloides	*Paspalum atratum*
Stylosanthes guianensis	
S. macrocephala	
Vigna species (wild)	
Zornia species	

Development of a Proposal for a Tropical Forages Genetic Resources Network

Regional genetic resource networks

Dr. Debouck gave an outline of several regional plant genetic resources networks which have been established by IPGRI in the Americas. Their function is to improve consultation between institutes, develop common programs and joint activities, and set common priorities and goals on a crop basis within regions. These networks are run by Steering Committees composed of national scientists and a full time coordinator. They have common projects and training activities and may also use consultants from time to time. Networks should meet the needs of the clients. NARS need to take on full partnership responsibilities within the network. Regional networks which are crop-specific tend to be very focused. Collaborating institutes in these networks participate at different activity levels, depending on their needs and the scale of their operation.

The need for a Tropical Forage Genetic Resources Network

Potential benefits of collaboration are to ensure long-term conservation and availability of germplasm, and improve efficiency of operations through sharing information. Collaboration is enhanced through networks, which bring together small and large forage genetic resources centers and can make better use of resources, and may have better funding opportunities. Long-term financial support and a coordinator would be needed for an effective comprehensive network.

There is need to be aware of national concerns over access to and ownership of genetic resources. There is also a need to link to other networks concerned with biodiversity, systematics and utilization. A network may also provide opportunities for training.

The benefits of a tropical forage genetic resources network would be:

Acquisition/collection

- more effective information and germplasm exchange;
- opportunities for rescue of collections at risk;
- the identification of key regions and genera of interest;
- economic benefit where collecting expeditions are jointly funded.

Characterization/evaluation

- priority genera may be identified on an international rather than a parochial basis;
- an holistic approach to characterization and evaluation becomes more feasible;
- networking leads to the inception of joint studies, of benefit to both parties;
- results of studies are better communicated and all network members benefit.

Storage

- sharing the responsibility for conservation of base collections, by genus, species or region, makes economic sense;
- networking increases the opportunity for conservation of collections in duplicate, ensuring minimal genetic loss.

Core collections and distribution

- core sets may be established on agreed principles and criteria;
- efficiency of distribution is improved.

Databases

- establishment of a consistent data format;
- compatible performance databases;
- comprehensive ecological databases;
- indigenous knowledge databases.

Regeneration

- networking institutes benefit from access to more resources - including infrastructure and environments.

Research

- networking contributes to collaborative research and reduces likelihood of duplication;
- opportunities arise for use and development of improved techniques and new methodologies.

The benefits of networks are dependant on good communication between institutes. This particularly applies when there are opportunities for collaboration in collecting missions, when plans need to be made well in advance.

Options for information exchange

The Working Group discussed the options for communications between members. It was agreed that there may be a need for collaborators to have different ways of access to the data depending on their needs and state of technological development. Those institutes with major germplasm holdings may have a need to on line access to passport and other data from collaborators. It was agreed that some data may not be in the public domain and could be required to have restricted access. Production of amalgamated data bases using CD ROM technology which allows common access to databases of different structures can be cost effective and useful. However, it was also noted that it may be essential to have some paper copy for those institutes which do not have easy access to electronic technology. A newsletter could be very useful for communications.

Proposal for a Tropical Forage Genetic Resources Network

Given the clear advantages of networks, it is proposed that a Tropical Forage Genetic Resources Network be established. The proposed network should encourage the participation of national, regional and international forage genetic resources programs within tropical and subtropical regions of the New and Old Worlds.

An effective network will require a secretariat with a coordinator to enhance effective communication between members and a steering committee. It is envisioned that funding can be sought on a project basis to support collaborative projects and the secretariat. In the short term the Working Group will continue collaborative activities (Appendix IV), whilst working towards the formation of a wider network (Appendix V).

Appendix I - List of participants

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Appendix II - Activities of participating genetic resource centers

CIAT

Status of the collection. Since the first introduction in 1971, the germplasm collection of tropical legumes and grasses maintained at CIAT grew to about 150 genera with more than 700 wild and undomesticated species of possible forage potential. The collection currently comprises almost 21,000 accessions (Table 1), being 90% legumes and 10% grasses. Three quarters of the collection have been assembled by collection, with the direct participation of CIAT scientists. More than 70% of the accessions originated from tropical Central and South America, 15% from Southeast Asia, and 10% from Africa. The particular value of this collection lies in the fact that the majority of accessions originated from regions with acid, low-fertility soils.

Activities since 1984. Since the Working Group Meeting in 1984, germplasm collection was a major activity of CIAT. More than 30 collection missions were carried out with emphasis on *Centrosema* and *Stylosanthes* species in tropical America, *Desmodium* and *Pueraria* species in Southeast Asia, and *Brachiaria* and other grasses in Africa. Morphological characterization and preliminary evaluation for acid soil adaptation carried out at Santander de Quilichao (soil pH 4; 1000 m.a.s.l.), emphasized large collections of species in the legume genera *Stylosanthes*, *Centrosema*, and *Desmodium* among others. Almost all studies revealed large variation existing in the respective collections assembled.

Table 1. Tropical forages germplasm maintained at CIAT.

Legumes	Accessions (no.)	Grasses	Accessions (no.)
Aeschynomene	999	*Andropogon*	100
Centrosema	2404	*Brachiaria*	689
Desmodium	2925	*Hyparrhenia*	60
Macroptilium/Vigna	1353	*Panicum*	598
Stylosanthes	3586	*Paspalum*	119
Zornia	1030	Other	513
Other	6307	Total grasses	2079
Total legumes	18604	**Grand total**	20683

In the recent 5-year period, emphasis was not on expanding, but rather on consolidating the existing germplasm collection. Acquisition of new germplasm was strategically focused on filling in geographic and genetic gaps, and in response to international requests to specific needs. Much emphasis was given

in collecting *Arachis pintoi* and other *Arachis* species with forage value, in collaboration with EMBRAPA/ CENARGEN. A new seed storage facility began operation in early 1990. The facility includes a long-term storage room with a temperature of -20°C, a short-term storage room with a temperature of 5-8°C and 35% r.h., and a seed drying room at 20°C and 15% r.h. During the transfer to the new facility, a complete inventory of germplasm conserved was carried out. Multiplication average about 2000 accessions per year. About 25% of the collection was put into the base collection under long-term storage conditions. More than 50% of the collection maintained at CIAT is actively duplicated with various institutions.

During characterization, recent emphasis lay on establishing differences among accessions by morphological characterization. In addition, to better understand patterns of genetic diversity of important genera and species maintained in the collection, biochemical characterization by electrophoresis of isozymes and seed proteins is being carried out with emphasis on *Arachis, Stylosanthes* and *Brachiaria.*

Because little is known about reproductive biology of most of the species held in the tropical forage germplasm collection, research on reproductive biology was initiated. The reproductive mode of a large collection of *Brachiaria* was determined for increasing the use of sexual accessions in the CIAT breeding program. Legume species were investigated for morphological markers, which may assist in determining the outcrossing rate to improve germplasm management.

Information management and documentation. Management of registration, post-entry phytosanitary follow up, increase in field and screenhouse, conservation, distribution, and the herbarium are fully computerized. The relational database management system, ORACLE, has been recently implemented. In collaboration with international taxonomists, identification of species was strongly emphasized. The herbarium was reorganized and maintains currently specimens of almost 50% of the accessions.

Because most of the legume and grass germplasm maintained at CIAT originated from direct collection, the proportion of germplasm with complete passport data is high. Computerized data management of the tropical forage germplasm collection was implemented at CIAT in 1980. The first computerized catalog was published in 1987. Recently, passport data are being revised and completed by country of origin of the germplasm. Important institutions with which CIAT has jointly collected or exchanged a large proportion of germplasm, such as ILCA, EMBRAPA/ CENARGEN, CSIRO, and the University of Florida, have been contacted, and passport data are being exchanged. Regional germplasm catalogs, which contain complete geographic and some ecological information of collection sites, have been published for almost 60% of the germplasm.

Distribution and utilization. Besides the distribution of germplasm to participants of the forage evaluation networks RIEPT (Red Internacional de Evaluación de Pastos Tropicales), RABAOC (French acronym for West and Central African Forage Network), and recently SEAFRAD (Southeast Asian Forage Research and Development Network), the role of the CIAT collection became wider: material was distributed internationally for more purposes. Because of its nature, the tropical forage germplasm is not only used in pasture improvement but also as an important component for sustainable crop production systems, e.g.,

ground cover, green manure, and erosion control.

Key genera in distribution were the legumes *Stylosanthes*, *Centrosema*, *Desmodium* and *Leucaena*, and the grasses *Brachiaria* and *Panicum*. Based on extensive multi-locational evaluation, cultivars have been released in various countries in tropical America. The grass *Andropogon gayanus* accession CIAT 621 has been registered in the most countries. In the 1990s, the legume *Arachis pintoi* accession CIAT 17434 has become important and is now released in Colombia, Honduras and Costa Rica.

CSIRO-ATFGRC

Current holdings of seed by the ATFGRC exceed 21,000 accessions. About 10,000 accessions are from Central and South America and 4,500 are from Africa. The largest collections are, amongst the legumes, *Stylosanthes* (2,277), *Desmodium* (1,531) and *Centrosema* (1,231), and amongst the grasses, *Panicum* (632), *Cenchrus* (536) and *Digitaria* (425).

Base collections of *Centrosema*, *Desmodium*, *Stylosanthes* and *Macroptilium* and the grasses *Cenchrus*, *Digitaria* and *Urochloa* are being maintained, in accordance with the agreement of the 1984 working group.

The last five years has been a period of consolidation for the ATFGRC, with relatively few collecting missions. A collection of potentially cool-tolerant *S. hamata* was made in Venezuela and there have been two collecting trips to South Africa, seeking grasses tolerant of heavy grazing. A short mission to Paraguay is planned for mid-1994, focusing on cool-tolerant legumes.

Further developments with the database management system have made it a powerful tool which is an essential part of the operation, helping to ensure that clients are promptly provided with appropriate genetic material.

Characterization studies are proceeding on a continuing basis, frequently in conjunction with scientists of the Queensland Department of Primary Industries. Genera covered include the legumes *Aeschynomene*, *Alysicarpus*, *Macoptilium*, *Macrotyloma*, *Rhynchosia* and *Teramnus*, and the grasses *Bothriochloa*, *Cenchrus* and *Urochloa*.

Over the 5-year period to February 1994, 14,000 samples of seed were distributed to clients, 3,900 being to overseas clients. 950 samples were sent to Asia, 680 to Africa, 550 to Europe and 530 to South America.

Large sets of forages are processed through a quarantine glasshouse each year. Over 1993-1994, 391 accessions were processed, 266 being grasses. Numbers vary from year to year—the high proportion of grasses during 1993-1994 was associated with a current emphasis on grasses capable of withstanding heavy grazing.

Biological research is an increasing component of the activities of CSIRO-ATFGRC. With the incorporation of the RNB germplasm in the group, there are studies on RNB adaptation to host and environment and persistence after inoculation. Methodology is being developed for characterization using agronomically meaningful attributes, such as tolerance of water stress. In an extensive literature survey, attempts are being made to align species more closely with habitat preference, to improve opportunities for germplasm selection.

In a new program, molecular marker techniques are being developed for recognition of genetic diversity and identifying core sets in *Stylosanthes* spp. Taxonomic research has improved understanding of relationships in *Macroptilium*. In an industry-targeted study, attempts are being made to develop forages suitable for revegetation of Central Queensland coalspoils.

In conjunction with CIAT, ATFGRC has a program aimed at developing forages for several countries in Southeast Asia.

EMBRAPA/CENARGEN

Brazil is one of the most important centers of diversification of plant species of interest and, particularly, of wild legumes of importance as forage plants. Research on a number of genera of leguminosae of actual or potential value has been carried out by EMBRAPA/CENARGEN in close cooperation with other EMBRAPA research units, as well as other institutions and universities. Research activities include an extensive nationwide germplasm collecting program, in collaboration with CIAT, CSIRO and Royal Botanic Gardens, Kew, UK.

Since 1975, with EMBRAPA/ CENARGEN as the research unit responsible for the coordination and organization of all activities related to genetic resources in Brazil, EMBRAPA started to develop an ambitious program on native forage genetic resources. This program has not only responded to the demands for germplasm at the national and international levels, but also to the need to conserve those genetic resources in view of growing evidence of genetic erosion.

So far, nearly 6,000 accessions are undergoing botanical and agronomical characterization and evaluation. These samples have resulted in a total of 39 native forage collecting expeditions, of which 22 have been aimed at collecting material of forage plants of tropical areas of Brasil and 17 have been carried out in subtropical areas. As a result, all states of the Brazilian Federation have been covered, many of them several times, and close to 5,400 accessions of germplasm of tropical legumes and nearly 500 of subtropical regions have been obtained, for a total of 5,816 accessions in the period 1975-1993. Parallel efforts have been undertaken to collect native forage grasses germplasm with a growing number of accessions of species suitable for forage use made available.

Documentation available at EMBRAPA/ CENARGEN regarding tropical and subtropical legume germplasm includes the following:

- Inventory of all germplasm available at various forage genebanks carrying out research on these products;
- Up-dated lists of accessions sent to genebanks, as well as of germplasm currently available;
- Catalog of germplasm available throughout the world, including the identification of duplicated accessions in different countries and institutions.

Germplasm is being kept at EMBRAPA/ CENARGEN for long term storage under controlled conditions at -18°C. Subsamples are distributed to genebanks for multiplication, characterization and preliminary agronomical evaluation, at local, regional, national and international levels.

In order to maximize the use of available resources, a good balance has been achieved between the collection of genetic material and the preparation of herbarium vouchers. Duplicates are

distributed to specialists, collaborators and representative herbaria worldwide.

The improvement of available genetic variability is done mainly on the basis of collecting expeditions. About 90% of the germplasm available either at EMBRAPA/ CENARGEN or at the genebanks has been obtained through the nationwide germplasm collecting program. A significant number of accessions (about 10%) was introduced, however. Considerable work has already been done by EMBRAPA/CENARGEN, in Brazil, to increase the available genetic variability of many forage legumes such as *Adesmia, Arachis, Centrosema, Chamaecrista, Cratylia* and *Stylosanthes*.

A number of cultivars have been successfully released by several EMBRAPA research units in Brazil, and by NARS in other latin American countries in the last few years, using genetic materials gathered under the successful collecting program coordinated by EMBRAPA/ CENARGEN.

In addition, in the last years EMBRAPA/CENARGEN has made many efforts to integrate the conservation of biodiversity with the conservation of genetic resources - with special emphasis to native forage grasses and legumes) by creating *in situ* genebanks (genetic reserves). For logistic reasons high priority is being given to existing protected areas (conservation units) at Federal level. Research to define specific methodology for *in situ* forage genetic resources conservation is much needed.

Finally, it is suggested that much information useful for genetic studies of genera of economic importance could derive from this wealth of selectively collected and well documented material of wild Brazilian leguminosae available to the international scientific community.

ILCA-FGRC

Background and justification. Sub-Saharan Africa is rich in plant genetic resources, including many important indigenous forages, especially grasses. This indigenous base of forage biodiversity is being eroded by over-utilization of resources, destruction of habitat and introduction of exotic germplasm. Forage genetic resources must be sustainably managed, used and preserved to secure them for future generations.

Feed shortages and poor feed quality are among the major limitations to increasing livestock production in the region. Forages are an important feed resource, but lack of forage seeds is an important limitation to increased forage production.

ILCA is addressing these constraints through the conservation of a large forage germplasm collection, which is available for utilization and development of livestock feed and through the promotion of forage seed production and training. An integrated project in forage germplasm, covering collection, conservation, characterization, seed production and evaluation for utilization as livestock feeds is serving the needs of NARS through provision of germplasm and seeds. Targeted germplasm evaluation and coordination of research results are essential to select forages with wide adaptability for use in sustainable farming systems.

Objectives. To promote the conservation and utilization of forage genetic resources, and the evaluation and selection of germplasm for use by small-holder farmers in the development of sustainable crop-livestock farming systems for increased food production in sub-Saharan Africa.

ILCA's forage genetic resources project. The ILCA genebank holds more than 12,000 accessions from 840 species of 227 genera with a wide representation of the major genera identified for potential forage use (Table 2). The ILCA genebank holds both an active collection for research and distribution of seeds and a base collection for long-term security storage. Seeds are stored at 5% moisture content in laminated aluminium foil bags at 8°C in the active genebank and at -20°C in the base genebank.

All seeds in the ILCA genebank are freely available in small quantities to *bona fide* forage research workers. This is done both directly and through networks, such as the African Feed Resources Network. Each year more than 3000 samples of seeds are distributed on average in response to requests, mostly in sub-Saharan Africa. ILCA began a program on germplasm health in 1994 to screen the material for major virus and fungal pathogens to ensure that clean seeds are distributed from the ILCA genebank.

Since 1988, the priority in the genetic resources work has changed from the collection and acquisition of forage germplasm more towards the adequate characterization and evaluation of the existing collections, e.g., the large collection of *Sesbania* maintained at ILCA was characterized for selected morphological and phytochemical characters in 1993.

Table 2. ILCA's germplasm resource (number of accessions).

Forage type	Indigenous African germplasm	Introduced germplasm	Total
Browse	785	1037	1822
Grass	1771	1439	3210
Legumes	3148	3773	6921
Other forages	77	186	263
Total	5781	6435	12216

Although conventional management of forage germplasm relies on seeds, some important species of forage grasses rarely produce seeds and other slow growing trees may be out-crossing or take several years to produce seeds, thus inhibiting rapid dissemination of selected germplasm. Plant *in vitro* culture techniques have provided solutions and alternative approaches to overcome constraints in the management of these genetic resources.

Research at ILCA has shown that cultures can be initiated from nodal cuttings, axillary buds and meristems of *Cynodon aethiopicus, C. dactylon, Digitaria decumbens* and *Pennisetum purpureum*. These cultures can be multiplied and stored for 18 months in an *in vitro* active genebank at 15°C. Appropriate technology techniques have also been developed for field collection of *C. dactylon*. Research on some selected browse species has shown that cultures of

Sesbania sesban, *Erythrina brucei*, *Leucaena leucocephala* and *Faidherbia albida* can be established from nodal cuttings and methods for adventitious regeneration have been developed. Methods for re-establishment of these species using appropriate technology have also been developed. Research on *in vitro* culture of multipurpose trees was supported by IDRC.

Another constraint to provision of forage germplasm is the lack of information on breeding systems, which is essential for the development of appropriate regeneration techniques for germplasm maintenance of selected accessions and for seed production for further utilization. Information is either scattered through the literature or lacking for many forage species. A literature review was undertaken and a data base established to hold information on breeding systems. Experiments on interspecific relationships was commenced to obtain information for the development of appropriate seed multiplication techniques for species of *Sesbania* and *Trifolium*. Research on *Sesbania sesban* has shown that flowers from different accessions are self-compatible, but that tripping by insects is probably necessary for pollination and seed set. A similar project on *Trifolium* species showed that *T. tembense*, *T. steudneri*, *T. lugardii*, *T. multinerve*, *T. pichisermollii* and *T. baccarinii* appear to be self-compatible and produce seeds without tripping.

The germplasm is evaluated at three sites in Ethiopia and one in Nigeria in West Africa by ILCA. Temperate materials are evaluated at the ILCA Headquarters site at 2350 m.a.s.l. during the long rainy season from June to September. Tropical and sub-tropical materials are evaluated in the Ethiopian Rift Valley at Debre Zeit (soil ph 7; 1930 m.a.s.l.) under irrigation and at Soddo (soil ph 4.5; 1850 ma.s.l.) under rainfed conditions. In West Africa, evaluation is done at Kaduna in the ILCA sub-humid zone program on red acid soils.

Appendix III - Statement from ICRAF

On our interest in tropical and sub-tropical forage genetic resource

The purpose of this statement to members of the working gorup on tropical and sub-tropical forage genetic resources is to indicate ICRAF's position and interest in germplasm resources of multipurpose fodder trees. Although we cannot be here, we wish the working group every success and look forward to the outcome ot the meeting.

ICRAF's mission statement is "to increase the social, economic and nutrinional well-being of peoples of developing countries through the use of research and related activities to integrate woody perennials in farming and related land-use systems in order to increase productivity, profitability, sustainability, diversity of output and conservation of natural resources". This implies that our special interest would be in MPT fodder trees in specific agroforestry technologies, e.g., tree fodder banks, etc. This issue of tree use in particular technologies is important to us.

ICRAF has collaborative research programmes in Africa, SE Asia and Latin America. Of these, the African programme is the best developed through the Agroforestry Research Networks in Africa (AFRENAs). The four AFRENAs in Africa are East Africa Highlands (bimodal rainfall), Southern Africa (unimodal rainfall), Humid Lowlands of West Africa and Semi-Arid Lowlands of West Africa (Sahelian zone). Fodder trees/shrubs feature prominently in this research, particularly in the Sahelian zone and eastern Africa. ICRAF's Central and South American research work will focus on trees for pasture improvement and live fences, among others.

Current ICRAF research on MPT fodder is mainly restricted to screening and evaluating growth potential of a number of MPT fodder legumes, e.g., *Leucaena, Calliandra, Gliricidia* and *Sesbania*. Although we have completed limited research in feeding trials, we have little comparative advantage in this area, compared with ILCA and CIAT.

In terms of genetic resources in fodder trees, ICRAF has recently made unique collections of *Prosopis africana* and *Balanites aegyptiaca* from the Sahel. Our research in the Sahel will involve farmer paticipation (indigenous knowledge) in the identification of good "Parkland" *P. africana* fodder trees, and in southern Africa, we hope to screen accessions from our recently concluded *Sesbania* collections, for crude protein content as part of the characterisation process. The Sahelian work on *P. africana* involves collaboration with ILCA scientists and will include examination of anti-nutritional factors after repeated browsing (artificial) damage.

For forage germplasm, ICRAF has assembled over 500 unique individual tree accessions of *Prosopis africana* from the Sahel and about 90 population accessions of *Sesbania* from southern Africa. The *Sesbania* accessions are now being evaluated and characterised. In separate collections, ICRAF has available material from Kenya, which is being improved mainly for stem straightness to produce good quality stakes. Overall our main interest in *Sesbania* is directed towards soil improvement, using the species for improved fallows.

Our future focus on genetic resources will be more towards tree species with higher income potential, e.g., fruits, fodder, gums, medicines, etc. In principle, therefore, we would like to become a member of the proposed network on tropicl and sub-tropical forage genetic resources and to exchange germplasm where appropriate. We would hope, in future, to contribute more actively towards the network.

(D. Boland, ICRAF, 9 March 1994)

Appendix IV - Promising legume genera (includes trees and shrubs) and grass genera

Legumes

Acacia
Aeschynomene
Albizia
Arachis
Calliandra
Centrosema
Chamaecrista
Clitoria
Codariocalyx
Cratylia
Desmanthus
Desmodium
Galactia
Gliricidia
Lablab
Leucaena
Lotononis
Macroptilium
Macrotyloma
Neonotonia
Pueraria
Prosopis
Sesbania
Stylosanthes
Teramnus
Trifolium
Vigna
Zornia

Grasses

Andropogon
Brachiaria
Bothriochloa/Dichanthium
Cenchrus
Chloris
Cynodon
Digitaria
Echinochloa
Panicum
Paspalum
Pennisetum
Setaria
Urochloa

Appendix V - Short-term work plan

Acquisition

The Group considered priorities for collection in terms of key species, areas not covered, species distribution and threat, and participating institutions expressed their interest in collection. Further collection will depend on priorities set by the Working Group.

Main reason for collection	Genera and region	Institute
Needs:	*Cratylia, Arachis* *Stylosanthes* sp. aff. *scabra* Forage grasses Cold tolerant legumes *Calliandra* and other shrubs *Sesbania* (Uganda)	CENARGEN - CIAT CENARGEN - CSIRO ARC S. Africa - CSIRO CSIRO CIAT - CENARGEN ILCA - ICRAF
Coverage:	Slopes of the Andes in Bolivia	
Threatened areas or taxa:	Cerrados in Brazil *Leucaena* in Central America	
Exchange:	Documentation	
Short-term collection plans for 1994/1995:	Legumes in Paraguay *Cratylia, Arachis* in Brazil Legumes in Brazil	CSIRO - PRONIEGA CIAT - CENARGEN CENARGEN - R.B.G. KEW

Characterization

The results of this work will become available through the network and lead to a better understanding of the variation in large germplasm sets from several institutes. Useful lists of descriptors will be developed for characterization of selected species or groups of species.

Genus, species	Priority	Institute
Arachis	H	CENARGEN - CIAT
Centrosema		EMBRAPA/CNPGC
Calliandra		OFI
Galactia	M	CIAT
Sesbania	H	ICRAF - ILCA
Stylosanthes sp. aff. *scabra*	H	ATFGRC
Stylosanthes guianensis	M	
Vigna	L-M	
Zornia	L-M	ATFGRC

Conservation

Each Center will need to define its own position and identify priorities. All institutes should be encouraged to duplicate their collections for safety. The Working Group will prepare a status report of the activity and commitment of base collections defined in 1984. All institutes should be encouraged to monitor and regenerate their collections to make them available.

Short term activities for 1994-1995

CIAT - ILCA	will duplicate ("black box") mutually accessions not yet duplicated
CSIRO	will maintain back-up collection ("black box") in Australia
CENARGEN	will compile a status report on active duplication
ILCA	will hold ICRAF material until its genebank is operational

Distribution

The underlying costs of distribution are very high. The Group agreed that there should be free access to forage genetic resources without charge for use as germplasm. Samples distributed for such purposes would comprise small lots generally not exceeding 100 seeds. Institutes should assemble core sets within major taxa for distribution. Core collections should cover the diversity within the species and be a good geographic coverage of the collection. Molecular marker techniques were recognized as being of potential value in delimiting core sets. Those responsible for the base collection of each species should assemble and identify the core collection.

Documentation

The following are required:

- Complete documentation of passport/characterization data and identify a minimum set of data (CIAT - CENARGEN)
- Identify duplicates
- Produce Working Group inventory of species

A minimum list of descriptors for a germplasm catalog is:

Accession data	Collecting data	
- institute accession number - scientific name - other numbers	- collector number - collection site - geographic coordinates - altitude - sample size (no. individuals) - sample type (vegetative/ seed)	- soil (texture, salinity, pH) - run-on or run-off - annual rainfall - rainfall distribution - abundance of targe species - vegetation type

Appendix VI - Development of the Tropical Forages Network

Activities for establishment of the active network

- Update the IPGRI forage directory to identify collaborators and compile list of possible collaborators;
- Contact other forage genetic resources programs through existing newsletters and personal contacts;
- Confirmation of interest and acceptance;
- Seek funding for a workshop to establish network to be held with IGC June 1997;
- Develop operational plan;
- Develop funding proposal;
- Plan for workshop including contact of organizing Committee of the IGC;
- Hold workshop in conjunction with IGC;
- Formulate an agreement on mode of operation.

The outputs of establishing such a network will be

- An effective communication system developed to disseminate information
  - coordinator appointed
  - regular electronic mail communication
  - activities published through a newsletter
  - linkages established with other networks
  - international journal of forage genetic resources established
- More effective characterization and conservation
  - information on status of collections more readily available
  - priorities for forage genetic resources established
  - genetic diversity in target species characterization
  - core sets identified
  - existing collections duplicated and hence secure
  - *ex situ* and *in situ* conservation systems integrated

Inputs

- Address lists should be compiled by July 1994
  - CIAT: South America/Southeast Asia
  - ILCA: Africa
  - CSIRO: from ATFGRC News listing
  - In addition ATFGRN, RIEPT, IPGRI, ICARDA and AFRNET newsletters - CSIRO to develop information for this.
- CIAT and ILCA will develop operational draft plan of network and send out to those who express interest. CIAT to develop the funding proposal and seek donor support.
- CENARGEN and CIAT will develop plans for the workshop and contact ICG committee.
- IPGRI to establish links with other networks and develop research proposals for *in vitro* conservation.
- CSIRO to establish journal.
- All participants to work together to clarify status of collections and amount of active duplication and publish inventory by Nov 1995.
- All participants will collaborate on characterization of existing collections.

Appendix VII - Acronyms and abbreviations

AFRENA	Agroforestry Research Networks in Africa
ARC	Agricultural Research Centre, South Africa
ATFGRC	Australian Tropical Forages Genetic Resources Centre, Brisbane, Australia
CAAS	Chinese Academy of Agricultural Sciences, Beijing, China
CENARGEN	Centro Nacional de Pesquisa de Recursos Genéticos e Biotecnologia/EMBRAPA, Brasília, Brazil
CGIAR	Consultative Group of International Agricultural Research, Washington, USA
CIAT	Centro Internacional de Agricultura Tropical, Cali, Colombia
CIP	Centro Internacional de la Papa, Lima, Peru
CNPGC	Centro Nacional de Pesquisa de Gado de Corte/ EMBRAPA, Campo Grande, Brazil
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brazil
FGRC	Forage Genetic Resources Centre at ILCA
GBK	Genebank of Kenya, Muguga, Kenya
GRC	Genetic Resource Centers
IBPGR	International Board of Plant Genetic Resources, Roma, Italia
IDRC	International Development Research Centre, Ottawa, Canada
ICRAF	International Centre for Research in Agroforestry, Nairobi, Kenya
IFAS	Institute of Food and Agricultural Sciences of the University of Florida, Ft. Pierce, USA
ILCA	International Livestock Centre for Africa, Addis Ababa, Ethiopia
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina
IPGRI	International Plant Genetic Resources Institute, Roma, Italia (formerly: IBPGR)
IIRSDA	Institut International de Recherche Scientifique pour le Développement en Afrique, Abidjan, Côte d'Ivoire
MPT	Multiple purpose tree

NARS	National Agricultural Research System
NBPGR	National Bureau of Plant Genetic Resources, New Delhi, India
NFTA	Nitrogen Fixing Tree Association, Hawaii, USA
OFI	Oxford Forestry Institute, Oxford, England
PRONIEGA	Programa Nacional de Investigación y Extensión Ganadera, Paraguay
RABAOC	French acronym for West and Central African Forage Network
RIEPT	Red Internacional de Evaluación de Pastos Tropicales
RNB	Root nodule bacteria (*Rhizobium* and *Bradyrhizobium* spp.)
R.B.G.	Royal Botanic Gardens, Kew, England
r.h.	relative humidity
SADC	Southern Africa Development Community, Gabarone, Botswana
SCATC	South China Academy of Tropical Crops, Hainan, China
SEAFRAD	Southeast Asian Forage Research and Development Network
USDA	United States Department of Agriculture, USA
WANA	West Asia and North Africa