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A PLAN OF ACTION FOR

FOR FORAGE GENETIC RESOURCES

By

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IBPGR Secretariat
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The International Board for Plant Genetic Resources (IBPGR) is an autonomous international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The IBPGR was established by the CGIAR in 1974 and its Executive Secretariat is provided by the Food and Agriculture Organization of the United Nations. The basic function of the IBPGR is to promote an international network of genetic resources centres to further the collection, conservation, documentation, evaluation and use of plant germplasm and thereby contribute to raising the standard of living and welfare of people throughout the world. The Consultative Group mobilizes financial support from its members to meet the budgetary requirements of the Board.

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PREFACE

When the IBPGR agreed to its priorities among crops and regions in 1976 a number of groups of crops were designated for further study. One of these was forages. Subsequently the IBPGR embarked on an exercise to gather information. This included the convening of several meetings and the appointment to the Executive Secretariat of a Forages Officer.

By the end of 1982 sufficient data had been gathered to permit the IBPGR to consider a preliminary report which would lead to world-wide action.

This report is an abstract of a working document considered and endorsed by the IBPGR at its tenth meeting in February 1983. Further reports will be issued from time-to-time.

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SUMMARY

This report is an abstract of an interim document presented and endorsed by the IBPGR in February 1983.

1. The present state of forage germplasm resources is reviewed and the main repositories listed (Tables 1&2).

2. It is concluded that for priority and operational purposes three areas should be listed (Table 3):

(i) Mediterranean and adjacent semi-arid/arid areas
The arid areas were given high priority by IBPGR in 1980.

(ii) Tropical and sub-tropical areas
There are also semi-arid/arid areas in these regions.

(iii) Temperate areas
Significant parts of these areas are in developed countries.

3. Working groups covering (i) and (ii) should be convened to rationalize a work programme. European countries can join the European Cooperative Programme/Genetic Resources (ECP/GR) which has been the responsibility of IBPGR since January 1983.

4. A Forage Crop Advisory Committee is proposed to coordinate overall forage germplasm resources.

5. IBPGR should continue to encourage computer storage of data and should, when possible, compile a data base for forages.

6. IBPGR whould continue to hold training courses for workers involved with forage germplasm.

1.0 INTRODUCTION

Animal husbandry makes an important contribution to human food supply in large areas of the world and also provides draft power and transportation for cropping systems. These animals derive their own food from pastures, fodder crops and crop residues. Although it can be shown in theory that cropping systems are more efficient in providing human food than animal production, large areas of land are unsuitable for cropping. Other areas need a fallow or rotation in order to maintain soil fertility.

With an increasing population there is pressure to bring more land into cultivation and to shorten fallow periods. This puts greater pressure on the remaining lands, which results in over-grazing and leads to subsequent desertification, especially in arid and semi-arid areas. One way to halt this trend is to increase productivity of the forage areas and especially through the use of legumes to build up soil nitrogen status. Thus fallows cropped with forage crops can increase the cash returns from animal production, which allows increased inputs of fertilizers etc., into the cropping systems.

Forages, therefore, have an important part to play in raising cash returns and reversing and stabilizing some of the detrimental changes now taking place. Compared with other crops which are directly used as food for humans, the conservation of forage germplasm has been relatively neglected.

Since the 1970s the IBPGR has been considering action on forages. The IBPGR convened a workshop in CIAT of South American forage workers in 1978. A Symposium and a Working Group was convened by the IBPGR and CSIRO's Division of Tropical Crops and Pastures (TCP) at Townsville, Australia in 1979, to report to the Board on the need for action.

The Working Group considered many topics associated with genetic resources including genetic erosion, in situ and ex situ conservation; suggested priorities for regions and genera; recommended the appointment of an Advisory Committee and the compilation of an inventory of genetic resources held in collections. The Board's Executive Committee agreed that an inventory of stocks should be prepared and further agreed to take advice on how an action programme might be developed.

Subsequently a Forages Officer was appointed to the IBPGR to undertake this task, with the following duties :

1. To assess the present state of germplasm collections of forages with regard to their representation, adequacy, evaluation and documentation;

2. To establish priorities for collection and conservation;

3. To visit important institutes to stimulate genetic resources activities;

4. To devise a rolling global five-year plan of action for the IBPGR to implement taking into account ongoing work and to determine the necessary balance between work in tropical, sub-tropical and arid/semi-arid zones;

In the interim period the IBPGR has published a Directory of Forage Genetic Resources. The Board has also supported collecting missions in several countries, although the total input on forages has been a very small percentage of overall expenditure.

This report represents the first step in producing a rolling global five-year plan.

2.0 The Present State of Germplasm Resources

In recent years information has been collected on forage germplasm resources available in various genebanks and collections around the world. A questionnaire was sent to institutions and/or individuals and, in general, the response was good. However, information is still lacking on a few collections known to exist. Information was sought on numbers of species in each collection, geographical representation, documentation and evaluation, as well as storage conditions.

Some data were received in machine readable form on magnetic tape, some in the form of computer print-out catalogues but most of the data were received in manual format.

Summarized data from this survey are shown in Table 1. They are classified into three groups :

a. Mediterranean and adjacent semi-arid and arid areas
b. Tropical and sub-tropical areas
c. Temperate areas

(Some overlap in this classification occur because some collections maintain material from outside their eco-climatic zones.)

2.1.a Mediterranean and arid/semi-arid regions (Table 1-a)

There are three sizeable collections listed, viz. that in ICARDA, Syria and two in Australia at Adelaide and Perth. The latter two collections reflect the importance given by Australia to collecting indigenous forage legumes in the Mediterranean basin over the past twenty years. In the Australian national network, the South Australian Department of Agriculture at Adelaide has been nominated to be the main repository for *Medicago* (medics) in Australia while the West Australian Department of Agriculture at Perth has a similar responsibility for annual *Trifolium*. The latter's collection of *Trifolium subterraneum* is the most comprehensive in the world and except for a few countries, is said to be fairly complete, covering the whole distribution of this annual clover.

There is also a sizeable collection of range species for saline and arid environments, shrubs and grasses, mainly of *Atriplex* and *Puccinellia*.

The ICARDA collection has been built up by acquisition from other genebanks and collections and also by some actual collecting in the field. It also contains several genera which would normally be considered as grain crops but are here used for forages and hay, e.g. *Pisum*, *Vicia*, *Hordeum* and *Triticale*. This also applies to some extent to the collection at Bari, Italy, and Izmir, Turkey.

Table 1-a. Approximate Numbers of Samples in Principal Forage Collections-Mediterranean/arid/semi-arid regions

Country	Location/ Institute	LEGUMES								GRASSES						Other species		TOTAL
		No. of samples	Medicago		Trifolium			Pisum	Vicia	No. of samples	Lolium	Dactylis	Hordeum	Triticale	Avena	No. of samples	Atriplex	Total
			A	P	subt.	other A	other P											
Australia	Adelaide	9601	7495	1650	57	199												9600
"	Perth	9300	2300		5000	2000				350	x		x			900	x	9650
Italy	Bari	3006	440						2300	717	197	180						3720
Portugal	Elvas	690	[175]		183	336			103	250	30	110	12	30	26			940
Spain	Badajoz	3000			3000													3000
Syria	ICARDA	11330	2500	800	747	32		2742	2611	89		59	1395	1544	529	40		15220
Turkey	Izmir	2280	[370]			[870]			710	1190	190	200			410	90		3560

Key :
A = annual
P = perennial
subt = Trifolium subterraneum
x = included in total but number in genus/class not known
[ ] = information received not subdivided into annual/perennial

The three smaller collections at Bari, Izmir and at Badajoz in Spain mostly have indigenous introductions from the Mediterranean region. The one at Badajoz is a specialist Trifolium subterraneum collection. There are also small collections at Elvas, Portugal and at Perugia, Italy, the latter not listed in Table 1a.

2.2 Tropical and sub-tropical regions (Table 1-b)

The two major collections of forage species are located in CSIRO, Brisbane, Australia and CIAT in Colombia. These resources, which have been built up as a result of active collecting and exchange of samples, are comprehensive collections of tropical forage species. The one at Brisbane is comprised of 405 genera and over 2000 species. The CIAT accessions are almost exclusively wild species, with the legumes originating mainly in tropical America and to a lesser extent in tropical Asia and Africa. The grasses, on the other hand, are almost exclusively from tropical Africa.

Most of the national collections comprise indigenous material collected in their own or adjoining countries during the last decade, a reflection of the growing impact of the new national genetic resources centres. The collection at the Indian Grassland and Fodder Research Institute is an exception being largely comprised of materials obtained from other genebanks. Of the two collection in Africa, that in Kitale, Kenya contains a good sample of Kenyan forage species while that in the Ivory Coast is of Panicum maximum the seeds of which are stored in France.

In addition to the CIAT collection there are also genebanks of forages in EMBRAPA, Brazil and Salta, Argentina. The latter contain sizeable collections of indigenous forage species from their respective regions.

There is a large collection of Leucaena mainly L. leucocephala in the Department of Horticulture, University of Hawaii and smaller ones at the National Plant Genetic Resources Laboratory, Los Banos in the Philippines and Experiment Georgia, USA.

2.3 Temperate regions (Table 1-c)

There are a large number of collections of temperate species, which are with few exceptions, located in developed countries. The four largest collections are those in USA, New Zealand, USSR and Canada. There are significant collections in eleven European countries (excluding Italy and Portugal, already listed in the Mediterranean grouping). The two remaining countries on which there is some information are Argentina and Japan.

The main genera held in collections :
(a) forage legumes - Trifolium, Medicago, Lotus, Onobrychis
(b) grasses - Lolium, Dactylis, Festuca, Phleum, Poa, Phalaris, Agropyron and Bromus.

Table 1-b. Approximate Numbers of Samples in Principal Forage Collections-Tropical/sub-tropical

		LEGUMES									GRASSES							TOTAL
Country	Location/ Institute	No. of samples	*Stylosanthes*	*Desmodium*	*Centrosema*	*Aeschynomene*	*Macroptilium*	*Indigofera*	*Zornia*	*Leucaena*	No. of samples	*Pennisetum*	*Panicum*	*Paspalum*	*Cenchrus*	*Digitaria*	*Chloris*	Total
Argentina	Salta	1030									850							1880
Australia	Brisbane	11420	1700	1100	1100	400	800	400	180	700	3280	120	570	330	500	370	200	14700
Brazil	EMBRAPA	15800	3046	835	1100	408	281	140	897	136	2128	77	680	433	125	101	40	18000
Colombia	CIAT	9526	2366	1278	1015	513	739*	143	758	140	843	4	368	20	39	10	3	10340
India	Jhansi	1030	41	33							1570	970			26			2600
India	Jodhpur	100									494		89		175			590
Ivory Coast	Adiopodoume										570		570					570
Japan	Tochigi										1230		310				110	1230
Kenya	Kitale	918	90	34				100			2215	53	329		171	87	372	3133
Philippines	Los Banos	590	49	62	53	45			2	226								590
U.S.A.	Experiment, GA	2420	119	230						405	4426	436	560	636	748	593	191	6840
U.S.A.	Hawaii	740								740								740
U.S.A.	Tifton GA.										1196	743		453				1190
Uruguay	Montevideo	17									560		13	97		14		569

* includes *Vigna* and *Phaseolus*

Table 1-c. Approximate Numbers of Samples in Principal Forage Collections - Temperate Regions

		LEGUMES						GRASSES										
Country	Location/ Institute	No. of samples	Trifolium	Medicago	Onobrychis	Lotus	Vicia	No. of samples	Lolium	Dactylis	Festuca	Phalaris	Phleum	Poa	Agropyron	Bromus	Other spp.	Total
Argentina	Pergamino	100	19	19				360	32	26	21	9			12		10	470
Bulgaria	Plovdiv	5360	420	1330	400	50		860	180	410	90		40	80				6220
Canada	Ottawa	6080	1260	3800	275	450		6200	50	200	870	250	450	1350	1250	250		12280
Czechoslovakia	Prague	1410	730	160			280	730	190	60	120			80				2140
France	Provins	1820	630	1140		45												1820
Germany FR	Braunschweig	250	120	90			35	640	260	20	35		35	80				890
Germany FR	Weihenstephan	65		25		40		460	130	100			120	80				525
Greece	Larissa	1090	180	120			110	90	29	18	20							1180
Hungary	Tapioszele	2390	1110	440				1820	110	150	280			120		80		4210
Japan	Tochigi	50						460	38	400	12		17					460
New Zealand	Palmerston N	12450	7900	1000		1700		12130	4100	1200	1000	780	300	500		980	70	24750
Poland	Radzikow	2790	100	60				4330	620	1400	1110		590	310		90		7120
Romania	Cluj	788	534		73			250										1030
Spain	Zaragoza	710		130	25		560	50		50								760
Sweden	Nordic G.B.	200	200					620	30	30	160		140	130				820
USSR	Leningrad	7900	4190	2260	460	270		5720	800	670	1080		690	990		380	680	14300
USA	Pullman WA	980			460			7490	620	860	1240	520		540	1260		90	8560
USA	Ames IA	2200		1120				1880				160				770		4080
USA	Geneva NY	x	1250			x		x					x					1250
USA	Logan UT							940							320			940
USA	NSSL CO	4780	1140	1240	69	400	80	5900	400	820	1050	220	300	340	630	210	830	10680
UK	Aberystwyth	700	310	180	10	50		3404	1070	930	590							4104
UK	Kew	848	328	90	15	40	79	572	15	28	40		40			68		1420

x = numbers not known

2.4 Adequacy of collections

Information on which to base a judgement on the adequacy of existing collections is not readily available; details on the exact origin of the samples are first needed. This report is therefore dependent upon the opinions of experienced observers - and there are few of these available.

At one extreme is a species like Trifolium subterraneum (subclover), which has a restricted, well-defined distribution in the Mediterranean basin and which has been the subject of extensive and systematic collection over the past 20 years by Australian scientists. The opinion has been expressed that the greater part of variation for this species has already been collected and there remain just a few smallpockets to be explored. There are over 5000 samples of this species in the Western Australian collection and over 3000 in the Badajoz genebank in Spain.

On the other hand, systematic collection over the vast expanse of the African continent has taken place only in a minute fraction of the total area.

Another factor affecting adequacy is the loss of material in genebanks that occurs through lack of regeneration or replacement. In CSIRO Brisbane it was estimated that 50% of the older material had been lost but recently the figure was reduced to less than 20%. A recently published Index Seminum from Izmir of collections made 1970-80, indicated that in only 2% of forage legumes was seed available for exchange but 20% existed in small quantities. The remainder may be presumed lost.

It is therefore, not merely sufficient to know the number of samples in a collection but to also have an intimate knowledge of the efficiency of maintenance and regeneration in order to assess the adequacy of the holding.

2.5 Evaluation

The extent of characterization and evaluation carried out on the collections covers the whole range from where none has been done (or even contemplated), to where a start has been made, to finally where detailed descriptor data have been collected and published, (Table 2). Priority has been given to species deemed to be of the greatest economic importance, while the others are pending.

Generally, there is increasing awareness of the importance of evaluation and other data collection and that it is proceeding, albeit at a slow pace.

The evaluation of forage germplasm presents special problems and it is difficult to obtain a consensus on what is required. Breeders are

mainly interested in characters of agronomic importance and do not attach much importance to detailed morphologic data which are of interest to curators to use in sorting out redundant duplication and assessing ranges of variability (and variety rights offices).

At least three groups have been concerned with developing descriptor lists for forages. There is general agreement on passport data following the IBPGR guidelines; the IBPGR and the EEC sub-group will jointly publish descriptors on grasses and legumes. The South-east Asia region has proposed a forage legume descriptor list as a result of a workshop meeting. The Alfalfa Crop Advisory Committee of the USDA has proposed a list with three priority ratings, and has placed special emphasis on screening data for certain specified pests and diseases.

2.6 Documentation

Most of the larger collections, on which information is available, now have computerized documentation. Some smaller collections are also beginning to computerize but most depend on manual records.

The most advanced system is that in USA where each of the P.I. Stations developed their own computing facilities and published catalogues of their holdings and evaluation data, e.g. in Pullman Washington, Ames Iowa and Experiment Georgia. These data are now being transferred to a central Prime computer housed at USDA, Beltsville, Maryland via an access terminal at each station and elsewhere. Eventually the user community will be able to query the central computer on the actual holdings in the US germplasm system, and for relevant characterization and evaluation data.

In Perth, Western Australia a Primecomputer using Info software is being used to document the annual medic collection from Libya.

A global data base of forage genetic resources, if established, would contain information from national and regional genebanks; it would facilitate analysis of the overall situation. The task of compiling such a data base and keeping it up to date would need considerable resources. Since many of the major forage genebanks now have fairly well organized data bases it woud seem appropriate for IBPGR to make an early start on the global forage data bank.

2.7 Storage conditions

The storage conditions under which the samples are kept are shown in Table 2. Information is lacking on some of the larger collections but most banks now appear to have at least medium term storage temperatures. There are however a number of collections where seed is still stored at ambient temperatures and this apparently includes at least part of the large Australian collection at Perth as well as some of the smaller collections.

Table 2. Summary of State of Evaluation, Documentation and Storage Conditions in Forages Genebanks

Country	Location/ Institute	No. of samples	Evaluation	Documentation	Storage Temperature			
					Ambient	Medium	Long term	Package
Mediterranean								
Australia	Adelaide	9600	full for medics	computerized, pt. manual		2°C		sealed foil
Australia	Perth	9650	full for priority spp	pt. computerized, pt. manual	20°C	2°C pt		
Italy	Bari	3720	pt in progress	pt. computerized		0°C	-10°C	tins, sealed
Portugal	Elvas	940	agronomic	manual	cool			
Turkey	Izmir	3560	nil ?	pt. computerized		0°C	-15°C in secure deep freeze cabinets	
Syria	ICARDA	15220	agronomic	manual, to be computerized	*			
Spain	Badajoz	3000	80% evaluated	being computerized	+			
Tropical/ sub-tropical								
Argentina	Salta	1880	physiologic	computer available	+			
Australia	Brisbane	14700	full	computerized, pt.manual		5°-10°C	-20°C	
Brazil	EMBRAPA	18000	descriptors	computerized		-1°C	-18°C	
Colombia	CIAT	10340	full for priority spp.	computerized catalogue		6°-8°C	-4° to -1°C	
India	Jhansi	2600	?	?		?	?	
Ivory Coast	Apiopodoume	570	agronomic	published	living plants			
Japan	Tochigi	1230	agronomic	manual		3°C		
Kenya	Kitale	3133	detailed for some spp.	manual, computerization in progress		5°C		
Philippines	Los Banos	590	agronomic	manual		4°C	-15°C	
USA	Experiment, GA	6840	agronomic	computerized		4°C		
USA	Tifton, GA	1190	?	manual		4°C		
USA	Hawaii, HI	740	selected characters	partial				
Uruguay	Montevideo	567	start with Bromus	manual	+			small bags 5% mc
India	Jodhpur	590	plant characters	full manual	+			

Table 2. Summary of State of Evaluation, Documentation and Storage Conditions in Forages Genebanks (Continued).

Country	Location/ Institute	No. of samples	Evaluation	Documentation	Storage Temperature			
					Ambient	Medium	Long term	Package
Temperate								
Argentina	Pergamino	470	?	computer inventory	?			
Bulgaria	Plovdiv	6220	20 characters	manual	9°-15°C			
Canada	Ottawa +	12280	by breeders	not centralized yet		4°C	-20°C	
Czechoslovakia	Prague	2140	agronomic	manual, partial	15°,7-25°		-25°C	
France	Provins	1820	agronomic	manual, partial		6°C		
Germany FR	Braunschweig	890	agronomic part	computerized		3°C	-10°C	tins, 5-6% mc
Germany FR	Weihenstephan	525	agronomic	manual	+			
Greece	Larissa	1180	start descriptor	?	15-18°C		-22°C	
Hungary	Tapiozele	4210	complete, pt.in progress	computerized partially		0°C,4°C	-20°C	glass,sealed
New Zealand	Palmerston N	24750	not systematic	pt. computerized		0°C		
Poland	Radzikow	7120	?	manual	?			
Romania	Cluj	1030	partial	partial	+			
Spain	Zaragosa	760	agronomic	manual, partial		2-4°C		
Sweden	Nordic Gene-bank	820		computerized			-20°C	
UK	Aberystwyth	4140	descriptors/ agronomic	manual, computerized		0°C	-23°C	
UK	Kew	1420	only germination	computerized			-20°C	sealed 5%mc
USA	Pullman WA	8560	descriptors/ agronomic	computerized catalogue		4°C		
USA	Ames, IO	4080	" "	"		4°C		glass bot
USA	Geneva, NY	1250 +				4°C		
USA	Logan, UT	940	cytogenetic	manual		-1°C		
USA	NSSL, CO	10680	at regional PI station	computerized passport data		4°C	-20°C	sealed, 4-7%mc
USSR	Leningrad	14300	?	?		4.5°C	-10°C	

* = Cold store being build
\+ = Stored locally by individual breeders
pt = Partial

3.0 Priorities for collection

3.1 The IBPGR criteria for establishing priorities among crops are as follows :

1. The danger of genetic erosion;
2. The economic and social importance of the species;
3. The recognized requirements of plant breeders and researchers;
4. The size, scope and quality of existing collections.

Regions have been selected for attention and assigned priority according to the following criteria:

(a) That they contain significant genetic diversity of one or more crops;
(b) That change and development in agriculture or change in land use, are occurring in them at such a rate that if nothing is done, genetically diverse materials are likely to be lost;
(c) That widespread crop failures have occurred, with the same outcome as in (b).

Since 1978 several groups have considered the question of priorities for forages and produced lists of genera/species. The first was the Workshop at CIAT in April 1978, (see Appendix I). Subsequently in 1979 the Townsville Workshop identified a number of regions with a high priority for collection (see Appendix IIa). The Working Group pointed out that their report did not benefit from advice on the situation in the USSR, East Asia (China, Japan and the Koreas) and Southwest Asia (from Arabia/ Syria through to Pakistan/Afghanistan). Further consultation and advice was thought necessary to determine detailed targets and arrangements for collecting missions.

A review of the Report by the FAO Grassland and Pasture Crops Group noted that although there were risks of genetic erosion, neither the species nor the situation had yet been properly identified and added to the list of important genera (see Appendix IIb).

FAO favoured a national approach through local institutions utilizing workers with an intimate knowledge and experience of the local scene.

The IBPGR came to the conclusion that there was insufficient information on the present collections of forage germplasm to determine what important gaps needed to be filled and requested the IBPGR Secretariat to gather information on existing collections. Subsequently various IBPGR Regional Meetings have considered the question of crop priorities. During 1980 the IBPGR agreed to assign a high priority to forage plants in arid and semi-arid zones. As a result, forages have a high priority in at least half of the IBPGR regions, viz. Mediterranean, Southwest Asia, Central Asia, Southeast Asia, East Asia, Central America, the Andean region and Europe. In Brazil there is considerable activity on forages under the auspices of EMBRAPA. Of the other regions information is lacking in sub - Saharan, Africa,

although germplasm work is proceeding in Ethiopia (ILCA), Kitale Kenya and West Africa, Adiopodoume Ivory Coast.

3.2 Priorities for genera/species

An outstanding problem relating to forage plants is the large number of genera/species that can be used for forage purposes, which may be numbered in thousands. Since it would be a mammoth and expensive task to maintain representative collections of such numbers, a choice must be made. Few criteria exist for making a rational choice since little is known about the biology, and even less about the agronomical potential of many species. Even widely used species have been subjected to selection and breeding procedures over only a short time span so that there is often little morphological difference between a wild and a cultivated species.

Some genebank curators may also wish to collect related species and possibly genera in order to clarify the taxonomy of the genus, so that accessions can be correctly named. Such material is also required by the cyto-geneticist to establish inter-specific relationships and evolutionary trends and by other specialists. This information is useful to the breeder searching for characters lacking in the cultivated species, e.g. disease resistance.

The following lists include those genera which have shown potential usefulness. Tentative priority attention is assigned on eco-geographical grouping. Current activities are provided in Appendix III.

Priority 1. Mediterranean, and adjacent arid/semi arid areas

(a) Forage legumes

Medicago	annual spp :	M. truncatula, M. littoralis, M. rugosa etc.
	perennial spp :	M. sativa and its subspecies
Trifolium	annual :	T. subterraneum, T. hirtum, T. cherleri
	perennial:	T. fragiferum
Vicia		V. sativa
Onobrychis		O. viciifolia
Astragalus		A. hamosus
Hedysarum		H. coronarium
Ornithopus		O. sativus

(b) Grasses

Lolium	L. multiflorum, L. rigidum
Dactylis	D. glomerata subsp. hispanica
Festuca	F. arundinacea
Phalaris	P. aquatica
Agropyron	A. desertorum, A. intermedium
Bromus	B. tomentellus
Arrhenatherum	A. elatius

Priority 2. Tropical and sub-tropical species:

(a) Forage legumes:

Centrosema	C. pubescens, C. brasilianum, C. macrocarpum
Desmodium	D. uncinatum, D. intortum, D. ovalifolium
Stylosanthes	S. guianensis, S. humilis, S. hamata, S. capitata
Macroptilium	M. atropurpureum
Aeschynomene	A. falcata
Vigna	V. radiata
Alysicarpus	
Puereria	P. phaseoloides
Dolichos	D. lablab
Calopogonium	
Crotalaria	
Desmanthus	
Leucaena	L. leucocephala
Glycine	
Phaseolus	P. adenanthus
Zornia	Z. latifolia, Z. brasiliensis, Z. myriadena

(b) Grasses

Brachiaria	B. decumbens, B. humidicola, B. dictoneura
Botriochloa	B. insculpta
Cenchrus	C. ciliaris
Chloris	C. gayana
Andropogon	A. gayanus
Paspalum	P. plicatulum, P. scrobiculatum, P. dilatatum
Panicum	P. maximum, P. virgatum
Pennisetum	P. purpureum, P. glaucum, P. clandestinum
Haemarthria	
Axonopus	A. compressus
Urochloa	U. mosambicensis, U. pullulans
Sorghum	S.x almum, S. bicolor
Setaria	S. sphacelata

Priority 3. Temperate areas

(a) Forage legumes

Medicago	M. sativa & subspecies
Trifolium	T. pratense, T. repens
Lotus	L. corniculatus, L. uliginosus
Onobrychis	O. viciifolia
Vicia	V. sativa

(b) Grasses

Lolium	L. perenne, L. multiflorum
Dactylis	D. glomerata
Phleum	P. pratense
Festuca	F. arundinacea, F. pratensis, F. rubra
Bromus	B. inermis
Agropyron	A. cristatum, A. desertorum, A. intermedium
Poa	P. pratensis
Agrostis	A. tenuis

The above is not an exhaustive list but includes most of the economically important genera. Relevant Rhizobium for legumes should also be collected.

The comments of Prof. A.H. Bunting, founder member of the IBPGR on Andean forage collection (1982) are relevant : "Before further collections are undertaken it should be clear who will care for the collections and how they will be evaluated and where.... what will be done with the collected material - who will work on it, conserve it, evaluate it, document it and ultimately use it, and for what purposes. To collect material which no-one is able to study, conserve, evaluate and document, and which is unlikely ever to be used, is not the best way of spending money, and is therefore at risk in periods of economic recession. "

It should be noted, however, that grant support for the whole process from collection to utilization is seldom given by organizations including the IBPGR. Certainly conservation of the material is a basic necessity. If there is a strong probability that the material would be useful in the future then it should be collected when the opportunity arises. Bunting commented further, " at the end of the day, genetic resources work is for economic and social development. It cannot be based principally on the wish (which I share) to conserve diversity against genetic erosion." In this respect in situ conservation is important.

3.3 In situ conservation

The Townsville Working Group recognized that in a number of situations conservation in situ would be the best means of preserving genetic diversity. As an example they noted the large areas of intensively grazed grasslands in Europe and rangelands in many parts of the world. In the case of the former, however, a change in management practice, e.g. application of heavy dressings of nitrogen, can lead to the virtual elimination of susceptible species, e.g. white clover.

The IBPGR in 1980 concluded that in situ conservation could be the principal, most effective and economical means of conserving

forage germplasm resources. There were, however, several circumstances where collecting must be given priority, e.g. (a) in emergencies, (b) where no in situ conservation can be set up, (c) to preserve landraces and (d) to increase the range of variability for the breeder.

It is concluded that collection will be the major method of conservation in the priority arid and semi-arid areas. In tropical and sub-tropical areas there is a need for greater variation for use in plant breeding programmes hence selective collection, will be needed.

4.0 Proposal for a forages crop advisory committee

The appointment by the IBPGR of a Forages Crop Advisory Committee, as recommended by the Townsville Working Group, would assist in developing and coordinating the germplasm resources programme. It is essential that the membership consist of active workers in this field and/or have considerable experience in this activity. The committee's constitution should provide representation for the major geographic regions and the significant climatic zones.

Prior to the convening of the Committee two specialist Working Groups should meet to consider details for Mediterranean and adjacent semi-arid/arid zones and tropical/sub-tropical zones.

When convened the Committee could meet at the same time as the international Grassland Congress which meets every four year.

5.0 Five-year plan of action

There are a number of basic difficulties in devising a rolling five-year global plan of action for the IBPGR. The mode of operation of IBPGR is largely "pump-priming" but before any genetic resources work is undertaken there must be an infra structure on which to build a programme. There is a lack of information about the extent of forage genetic resources activities in a large number of countries, as can be seen from the response to the request for information:

	No information received	No activity	Operating genebanks	Total
Number of countries	42	14	36	92

About 30 out of the 36 countries have significant germplasm activities, but the stage of development and sophistication reached also varies considerably.

Three of the IARCs have mandates which include forage crops and cover areas of high priority. In addition to having agreements with the countries in which they are located some have agreements with

other governments within their mandated area. This allows access to facilities in these countries and provide a platform on which to launch a programme. There is also a reasonable chance that finance for genetic resources within IARCs would be on a longer term basis than is possible for a national project dependent upon short term grants.

Two of the IARCs already have comprehensive on going programmes for forage genetic resources, which include general conservation activities linked with selection and breeding of potential varieties. These are ICARDA in Syria with a mandate spreading over 22 countries from Pakistan to Morocco in the arid and semi-arid areas of the Mediterranean and the Middle East, and CIAT in Colombia whose mandate covers acid infertile soils for tropical America. The third, ILCA in Ethiopia will develop a germplasm capability to cover forages within its area of operation in humid tropical, arid and semi-arid areas of sub-Saharan Africa. It is important for IBPGR to integrate its work with these centres.

Taking into account the plans of existing centres a plan for the IBPGR is shown in Table 3.

Table 3 - Proposed financial estimates for five-year forages germplasm (1000 US$ terms-1983)

	1983	1984	1985	1986	1987	1988
Priority One : Mediterranean, and adjacent semi-arid, arid						
-Working group meeting			20		25	
Collection		)				
Characterization and evaluation		)50	120	105	100	135
Documentation		)				
Conservation		)				
-Support for ICARDA programme 1983-4	20	20				
-On going national programmes	10	10				
Priority Two : Tropical and sub-tropical						
-Working group meeting		25			30	
Collection		)				
Characterisation, evaluation		)				
Documentation		)35	80	75	75	90
-Support for field work contracted by IBPGR to CIAT	9	)	(taken over by CIAT core)			
-Support for field work contracted by IBPGR to ILCA	10	)20	(taken over by ILCA core)			
		)				
Priority Three : Temperate		10	10	10	10	
Crop Advisory Committee			25			
Documentation-Global Data base [1]		30	30	30	30	
Training Courses [2]	-	45	-	45	-	-
Publications-Directory etc	5	5	5	5	5	
Staff costs	70	70	70	70	70	
Miscellaneous costs	40	40	40	40	40	
Contingency	20	20	20	20	20	
Total Budget		380	420	400	400	

1. That IBPGR should compile a global data base of forage genetic resources (including temperate areas) and should assist national centres to computerise their own data and continue to update its own directory.

2. That training courses be held to cater for the specialist requirements of workers in forage genetic resources.

Appendix I

Priorities agreed at a Workshop on Forage Plant Genetic Resources of South America, CIAT 1978

Tropical South America

Priority 1 - Legumes :

Stylosanthes, Centrosema, Zornia, Phaseolus, Macroptilium, Aeschynomene, Clitoria, Vigna, Leucaena, Desmodium, Calopogonium, Crotolaria, Indigofera

Priority 2 - Grasses :

Brachiaria, Hemarthria, Digitaria, Rottboelia, Axonopus

Temperate South America

Priority 1 - Grasses :

Bromus auleticus, Paspalum dilatatum, Bromus catharticus, Agropyron scabrifolium

Priority 2 - Grasses :

Paspalum notatum, Bromus brevis, Poa lanigera, Elymus patagonicus Setaria fiebrigii, Sorghum almum, Trichloris crinita, Paspalum urvillei, Sorghastrum pellitum

Priority 3 - Legumes :

Desmodium, Trifolium, Vicia, Lathyrus

Appendix IIa

Priorities for collection agreed at Working Group on the Genetic Resources of Forage Plants, Townsville 1979

A. HERBACEOUS LEGUMES

1. For Tropical and Sub-Tropical Climate Regions

Region for Collection	Priority	Principal Taxa
Tropical South America	1	*Stylosanthes*, *Macroptilium* *Aeschynomens*, *Desmodium* *Centrosema*, *Phaseolus*, *Arachis*, *Leucaena*
Mexico and Central America	1	*Phaseolus*, *Macroptilium*, *Desmanthus*, *Desmodium*, *Stylosanthes*, *Centrosema*, *Leucaena*
Africa (East)	2	*Glycine*, *Clitoria*, *Lablab*, *Vigna*, *Lotononis*, *Trifolium* *semipilosum*, *Dolichos*
Tropical Asia	2	*Pueraria*, *Desmodium*, *Vigna*, *Stylosanthes*, *Glycine*, *Alysicarpus*
Australia	3	*Glycine*, *Vigna*, *Trigonella*, *Desmodium*

2. For Mediterranean Climate Region

Mediterranean	1	*Medicago*, *Trifolium*, *Vicia*, *Melilotus*, *Ornithopus*, *Onobrychis*
Southwest Asia	1	*Medicago*, *Trifolium*, *Vicia*, *Onobrychis*
Australia (Southern)	2	*Trifolium subterraneum* and annual *Medicago* spp. - local ecotypes

3. For Temperate Climate Regions

Europe	1	*Trifolium*, *Medicago*, *Lotus*, *Melilotus*, *Onobrychis*, *Vicia*

Appendix IIa. (cont.)

Southwest Asia	1	Medicago, Trifolium, Vicia, Onobrychis
Mediterranean	2	Medicago, Trifolium

B. GRASSES

1. For Tropical and Sub-Tropical Climate Region

Africa	1	Setaria, Panicum, Cenchrus, Chloris, Eragrostis, Cynodon Brachiaria, Digitaria, Andropogon, Pennisetum Urochloa
Asia	2	Cynodon, Cenchrus, Bothriochloa, Panicum, Pennisetum, Setaria
South America	2	Paspalum, Axonopus, Tripsacum, Eriochloa
Mexico and Central America	3	Axonopus, Tripsacum, Eriochloa

2. For Mediterranean Climate Regions

Mediterranean	2	Lolium, Festuca, Phalaris Bromus, Agropyron, Cynodon

3. For Temperate Climate Regions

Europe	2	Lolium, Dactylis, Festuca, Bromus, Phleum
Temperate South America	2	Paspalum, Bromus, Poa

C. FODDER SHRUBS AND OTHER FORAGES

Although a number of species are known to be important, there is insufficient knowledge available to provide a firm basis for determining priorities in forage plants other than herbaceous legumes and grasses. Among the important taxa identified were Atriplex, non-thorny Acacias, Leucaena, Prosopis and Codariocalyx.

Appendix II.b

Additional Genera Recommended by FAO Grassland and Pasture Crops Group

1. Legumes

   (a) Africa (East) - *Alysicarpus scatanus*, *Crotalaria*, *Phaseolus*, *Indigofera*, *Stylosanthes*, *Tephrosia* and *Zornia*

   (b) Mediterranean - *Anthyllis*, *Astragalus*, *Hedysarum*, *Lathyrus*, *Lotus*, *Psoralea*

   (c) Southwest Asia - *Lathyrus*, *Lotus*

2. Grasses

   (a) Africa - *Aristida*, *Echinochloa*, *Lasiurus*, *Melinis*, *Stipa agrostis*

   (b) Mediterranean - *Agrostis*, *Alopecurus*, *Arrhenatherum*, *Stipa*, *Trisetum*

3. Fodder shrubs and trees

   Balanites, *Cadaba cardanxia*, *Naerua*, *Tamarindus*, *Tecoma* and *Ziziphus*

Appendix III.

DETAILS OF CURRENT ACTIVITIES

First Priority : Mediterranean and adjacent semi-arid/arid zones

The IBPGR designated these zones as areas of high priority in 1980. These are areas where it is not unusual to find over-grazing, the encroachment of cultivation into grassland and the general depletion of soil fertility and structure; all factors which contribute to the reduction or obliteration of plant variability. Genetic erosion of woody shrubs, which are also palatable to grazing animals and are cut for fuel, is continuing to take place.

Arid and semi-arid zones are to be found in the following regions: Mediterranean, South-west Asia, Central Asia, Africa, India and south South America. Two-thirds of the land area of Mexico is classified as arid or semi-arid, and the above list contains 9 out of the 14 regions so far recognized by the IBPGR. In addition there is a large area of arid and semi-arid land in Australia, USA and USSR.

1. One of the IARC's with a mandate for forage crops, ICARDA covers a large segment of the arid and semi-arid zone from Pakistan in the east, including the South-west Asia and Central Asia regions and along the north coast of Africa as far as Morocco - a total of 22 countries. Work on genetic resources has been strengthened by the establishment of a new department for this purpose, with Dr. B. Somaroo as its head.

The IBPGR has supported genetic resources work at ICARDA with a grant for cold storage facilities and has had a technical officer stationed there (until March, 1983). It would be prudent to continue to support suitable projects because of its growing commitment to germplasm work. ICARDA already has a large collection of forage species and new laboratory and cold storage facilties are being provided. Evaluation is being carried out as an integral part of the improvement programme and a computerized data base is available. ICARDA also has working agreements with several governments in its area.

The IBPGR's recent joint projects in the Southwest and Central Asian regions have, with the exception of those in Pakistan and Turkey, met with severe setbacks, due to political action.

2. Two Australian State Departments of Agriculture have amassed very large collections of annual forage legumes over the past 20 years mainly from the Mediterranean basin. One of these in South Australia holds the largest collection of annual medics while the other in Western Australia has the largest and most complete collection of subterranean clover (Trifolium subterraneum) in the world.

Since to date greater emphasis has been placed on exploitation of genetic resources rather than on their conservation, the seed storage conditions, especially at Perth, are inadequate. With the setting up of the Australian Network of Plant Genetic Resources Collections improvement is expected in the near future.

The Western Australian Overseas Project Authority has been a partner in an interesting innovation whereby it has arranged a short term contract with the Libyan Government to evaluate annual medics. These medics were part of the Libyan collection of 1978 and 1979, which was supported by IBPGR and stored in Bari, and of earlier Australian collections. Evaluation is carried out in Australia during the growing season and subsequently in Libya, taking advantage of the different seasons in the two hemispheres. Australia provides the technical direction and three Libyans are also being trained on the project-two of whom accompany the material to be grown in the Libyan season. Documentation is on a Prime computer using an Info programme. It is expected that at the completion of the project the Libyans who have received training will complete the evaluation and will develop the superior lines that have already been isolated for farmer use. This arrangement seems to benefit both parties. A serious limitation is the lack of satisfactory seed storage facilities at either location. A similar bilateral contract is in operation between Australia and Iraq; Australia seeks to develop similar arrangements with other countries in the Mediterranean.

It is desirable that these large and comprehensive collections of forages are included into the IBPGR network, together with the expertise of the personnel associated with this work. Medium-term storage facilities are available at Adelaide, Australia but improvements are planned at these facilities at both locations in the near future. It is hoped that the Commonwealth Government will make available $1.2 million (Australian) over the next five years from 1983/84 to provide capital items, buildings or major equipment for the eight plant genetic resources centres.

3. Mediterranean Countries. Several Mediterranean countries including Spain, Italy, Greece and Libya are actively developing national programmes for forage genetic resources. As a result of an IBPGR liaison officers meeting in December 1981, Italy agreed to undertake a regional responsibility for forages and Spain for forage legumes. This was subsequently endorsed by the Board.

Second priority : Tropical and sub-tropical zones

The tropical and sub-tropical zones have a range of climates from humid to sub-humid, through semi-arid to arid areas and even to temperate at high elevations e.g. the Ethiopian highlands.

The two leading institutes concerned are CIAT in Colombia and the Division of Tropical Crops and Pastures (TC&P) in Australia. Both have built up large and comprehensive collections, by exchange but largely through collecting expeditions, mounted in tropical areas of the world. They thus have well developed on-going plant introduction programmes of collection,characterisation, evaluation, documentation and storage, linked with the more detailed evaluation, selection and breeding of the most promising lines carried out by the breeders.

Recently TC&P have inaugurated a $500,000 (Australian) facility named Controlled Pollination Unit (CONPOL) which enables cross pollinating populations to be multiplied in isolation. Filtered air is blown through the 36 compartments, which have artificial light and controlled temperatures for use throughout the year. Out-crossing is reduced to a minimum. Both CIAT and TC&P have made agreements to store some of each other's seed stocks and to rationalize their holdings.

Africa also has a large area of tropical grassland. The Kenya project set out to collect and conserve populations of grasses, legumes and shrubs. A large collection was made and populations were evaluated and the agronomically most promising were advanced. However, at this moment there is some uncertainty about the condition of the original collection and how much of it is available for exchange. In West Africa a collection of Panicum maximum was being maintained in the Ivory Coast and the seed stored by ORSTOM in France. Desertification is proceeding at a rapid rate in sub-Saharan Africa. Over 520 million ha (72% of total area) are suitable only for grazing and carry 57% of the ruminant livestock of Africa. All these pastoral areas are under pressure due to the expansion of cropping at the expense of the dry-season grazing areas and to increasing human populations. Stocking densities in these pastoral zones have now brought many of the systems to the point where their viability is in jeopardy.

An FAO project started in 1974, Ecological Management of Arid and Semi-arid Rangelands (EMASAR), has several on-going projects in countries in the Sahel including Mali, Niger, Nigeria and Upper Volta which includes some collection, testing and evaluation of forage species.

The International Livestock Centre for Africa (ILCA) has a mandate which includes the Sahel. Recently it started a collection of indigenous Trifolium spp in the temperate Ethiopian highlands as a start for its expanded legume programme. In the semi-arid area of Mali, testing has indicated that only annual forage legumes are productive and forage cow pea (Vigna spp) lines are being screened. In the arid parts of the Rift Valley in Ethiopia perennial forage legumes are being tested under extensive grazing. ILCA will increase its collaboration with ICRISAT at the latter's West African Sahelian Centre near Niamey, Niger and move the Mali programme to this centre. In Ibadan, Nigeria ILCA is collecting and screening native leguminous browse species and exotic herbaceous legumes and at Kaduna in northern Guinea, leguminous species, particularly Stylosanthes, are being screened. ILCA will be developing a germplasm capability based on collection,

acquisition, storage and multiplication. Africa is an important source of fodder legumes such as, Aeschynomene, Desmodium, Indigofera, Lotononis Neonotonia, Trifolium and Vigna. Browse species, of particular interest for more arid areas, have received little systematic attention; over 90 species have been recorded in West Africa and are being collected.

The IBPGR has supported the collection of forage legumes in Ethiopia and this support should continue. ILCA has most of the basic facilities and is expected to provide the long term continuity essential for this work. For the time being cold storage facilities at the Plant Genetic Resources Centre at AddisAbaba, Ethiopia will be used.

It is envisaged that these three institutions TC&P, CIAT and ILCA could form a nucleus for genetic resources work on tropical forages around which other institutes could join. These would include EMBRAPA in Brazil, Salta in Argentina, Kitale in Kenya, Adiopodoume in the Ivory Coast, Jhansi in India, institutes in the IBPGR South-east Asia region and the Southern Plant Introduction Station in Georgia, USA.

One concern to both CIAT and TC&P is the high cost of providing seed samples of forages to those requesting them. This seed is very expensively produced, particulary if multiplication is carried out in purpose-built facilties. For example, the Australian CONPOL has 36 compartments and cost $500,000 (Australian).

The question of financing can be addressed in two ways: one view is that since supply of seed samples is an international commitment, it should be financed from international sources. Another suggestion is that a nominal charge be made to cover costs of packaging, postages, health certificates, etc.

In TC&P, Australia this activity is now financed by the Australian Development Assistance Bureau (ADAB) on a short term basis, but this support is not expected to continue indefinitely. This task may be off loaded to some other organization e.g. ILCA, but not until the latter is in a position to undertake it.

Third priority : Temperate regions

As already indicated most of the countries in the temperate zones are developed countries. These include Australia, Canada, Europe (with a few exceptions), New Zealand and USA. There remain southern South America, China and Mongolia.

In the European Cooperative Programme for Genetic Resources, forages are one of the first priority crops in Phase II of the programme and a preliminary meeting to discuss possible action was held in UK in

September 1982 and a Working Group met in 1984.

At USDA there is an active Alfalfa Crop Advisory Committee (CAC) which suggests collecting missions for Medicago and has drawn up germplasm evaluation and enhancement proposals. A USDA Clover and Special Purpose Legumes CAC has also been constituted. The Grass Breeders Planning Conference meeting in Pennsylvania State College in July 1982 recommended the establishment of four Forage and Turf CAC's : arid/cool, arid/warm, humid/cool, and humid/warm.

The USA continue to send collecting expeditions to various parts of the world, including missions to collect grasses and clovers in USSR (1982), China (1980) and Medicago in Turkey (1981) and South America (1980 and 1981).

The American forage collection in China (1980) produced 207 accessions, 169 of which were grasses and 38 of legumes. This was the first access to China since 1949 to obtain forage germplasm resources and carried out under the China/US Germplasm Agreement. The delegation was in no doubt that China has a vast reservoir of germplasm, especially in two large groups of economically important grasses, Agropyron (wheat grasses) and Elymus (wild rye grasses). Northern and western China appeared to be valuable sources of several legumes in the following genera : Medicago, Hedysarum, Astragalus, Vicia and Trifolium.

DOCUMENTATION

Earlier in this report it was suggested that a global forage data base should be compiled from data in national genebanks. However, in many instances lack of availability of data appears to be a bottleneck. Every encouragement should be given to complete this task but this need not necessarily delay a start on the global data base.

As a first step this should be limited to passport data for which there appears to be general agreement. There is a lack of concensus on characterization and preliminary evaluation characters. The quality of the stored data should also be considered as it is wasteful to store data which are of little intrinsic value.

IBPGR should encourage the computer storage of data and should compile a data base for forages.

TRAINING

Because the techniques of handling forage germplasm are different from those of other crops due to cross pollination, large amount of variability, perenniality, method of growing, etc. it is desirable to hold 2 or 3 training courses during the next quinquennium. Such courses should be held in centres of excellence where a complete range of genetic resources activity is carried out.

Appendix IV

ACRONYMS USED IN THIS REPORT

ADAB	- Australian Development Assistance Bureau
CIAT	- Centro Internacional de Agricultura Tropical - CGIAR
CONPOL	- Controlled Pollination Units
CSIRO	- Commonwealth Scientific and Industrial Research Organization (Australia)
ECP/GR	- European Cooperative Programme for Conservation and Exchange of Crop Genetic Resources - UNDP/FAO
EEC	- European Economic Community
EMASAR	- Ecological Management of Arid and Semi-arid Rangelands in Africa and the Near and Middle East
EMBRAPA	- Empresa Brasileira de Pesquisa Agropecuaria (Brazil)
FAO	- Food and Agriculture Organization of the United Nations
IARC	- International Agricultural Research Centre
ICARDA	- International Centre for Agricultural Research in the Dry Areas - CGIAR
ICRISAT	- International Crops Research Institute for the Semi-Arid Tropics - CGIAR
ILCA	- International Livestock Centre for Africa - CGIAR
NSSL	- National Seed Storage Laboratory (USA)
ORSTOM	- Office de la Recherche Scientifique et Technique Outre-mer (France)
TCP	- Tropical Crops and Pastures CSIRO (Australia)
USDA	- United States Department of Agriculture (USA)