

Conservation and Evaluation of Genetic Resources for Forage and Pasture in Morocco



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Summary

Morocco, which covers 712,300 km², is climatologically, topographically and biologically diverse, at both the ecosystem and flora levels. The total number of flowering plants is about 4,500 species of which >15% are endemics. In addition, the country is considered to be a centre of diversity for a number of cultivated crop plants and wild relatives. This diversity, however, is undergoing genetic erosion due to several factors, including: overgrazing of pastoral resources; deforestation caused by demographic pressure; irregular rainfall distribution; and changes in cultural practice. To counter this trend, genetic resources activities such as collecting, evaluation and conservation have been undertaken by scientists in national and international institutions. Many of the species currently under study are exploited in micro-zones and are considered as useful but under-utilised. They represent a great potential for food diversification and multiple uses, and could enhance future agricultural development and income generation. This paper presents an overview of the effort undertaken by national institutions in Morocco in plant genetic resource conservation and evaluation.

Introduction

Morocco is located in the north west of Africa between latitudes 21 and 36°N and longitudes 11 and 17°W, and covers 712,300 km². It is situated at the meeting point of three distinct geographical zones: the Mediterranean Sea to the north, the Atlantic Ocean to the west and the Sahara desert to the south-east. The Atlas Mountains represent a natural barrier between the sea and saharan environmental influences. The climate is of Mediterranean type, with mild winters and hot dry summers. Precipitation varies from 50 mm in the Sahara to 2000 mm in the high Rif mountains.

The agricultural sector in Morocco plays an important role in the country's economy since it contributes 17% of the Gross Domestic Product (GDP) and occupies nearly half the active labour force. However, agricultural production varies with the climatic conditions. Land classification in Morocco shows that 78% of the area (56 million ha) is located in the desert and dry zone (annual average precipitation <250 mm per annum), 15% (10 million ha) in the semi-arid zone (250 to 500 mm rainfall per annum) and 7% in the sub-humid to humid zones (>500 mm rain per year). Arable land represents 12% (or 8.5 million ha) of the land area, of which 1.2 million ha are irrigated, 12.5% is forest, 36% is pasture and 39% is land for other use.

Plant Genetic Resources Diversity of Morocco

The diversity in relief and climate confer on Morocco a rich biodiversity with a large number of ecosystems and a rich flora. The latter includes over 4,500 species of higher plants, in 135 plant families and 940 genera. Over 600 plant taxa are endemic and about 200 species are considered to be rare or threatened.

Increasingly, the country is considered to be a centre of diversity for a number of cultivated crop plants and their wild relatives. The best represented genera are: *Avena*, *Medicago*, *Lupinus*, *Trifolium*, *Aegilops*, *Phalaris*, *Hordeum*, *Triticum*, *Lathyrus*, *Ononis*, *Vicia*, *Astragalus*, *Bituminaria*, *Lotus*, *Stipa*, *Eragrostis*, *Beta*, etc. This diversity, however, is undergoing genetic erosion due to several factors: overgrazing of pastoral resources; deforestation caused by demographic pressure; irregular rainfall distribution; and changes in cultural practice. Studies conducted during the last decade have concluded that several forage species are threatened by genetic extinction (Rumbaugh and Graves, 1983; IBPGR, 1985; Graves, 1985; Francis, 1987; Bounejmate *et al.*, 1992a). Hence, genetic resources activities - such as collecting, evaluation and conservation - have been undertaken by scientists in national and international institutes. National institutions working in this field are the National Agronomic Research Institute (INRA), the Agronomic and Veterinary Institute Hassan II (IAV Hassan II), and the Centre de Production des Semences Pastorales (CPSP) of the Livestock Department of the Ministry of Agriculture. Table 53.1 summarises the plant genetic resources activities of each institution.

Table 53.1 Distribution of forage and pastoral plant genetic resources activities among national institutions

Institution	Collecting	Conservation	Evaluation	Selection	Training	Documentation
INRA Forage & pastoral species	+	+ (<i>Ex situ</i>)	+	+	–	+ Partly computerised
IAV Hassan II Forage & pastoral species Wild Flora	+	+ (<i>Ex situ</i>) Herbarium	+	+	+ (Plant Breeding., PGR, Botany)	+ Partly computerised
DE (CPSP) Forage & pastoral species	+	+ <i>Ex situ</i> (CPSP) + <i>In situ</i> (pastoral zones)	+	+	+	+ Computerised

+ Activity conducted, – not conducted.

Forage & Pastoral Plant Genetic Resources Activities

1. Collecting Expeditions

Forage and pasture research has been conducted in Morocco since 1920. Due to the great importance of species and variety selection for pasture development, hundreds of species have been tested. However, all the early programmes focussed on introduced, foreign cultivars. Expeditions to collect local forage material have been conducted since 1950 by foreign institutions and sometimes in collaboration with national institutions. These missions, were, however, undertaken with the aim of utilising such resources in foreign plant breeding programmes. A summary of all these expeditions has been reviewed by Bounejmate (1997) and Tazi (1995).

Since the early 1980's, collecting activities have been conducted mainly by the trained scientists of national institutions in collaboration with international centres and institutes, such as the International Board for Plant Genetic Resources, IBPGR (now the International Plant Genetic Resources Institute, IPGRI) and the International Center for Agricultural Research in Dry Areas, ICARDA, and institutions from developed countries, e.g., USA, Great Britain, Canada, France, Australia, etc. During the last decade, expeditions have been frequent (Table 53.2) and were conducted in a systematic manner in relation to national genetic resources and breeding programme priorities. Special emphasis was put on forage legumes, particularly of the genus *Medicago*. Lately, expeditions to collect fodder shrubs (e.g., *Atriplex*, *Acacia*, *Salsola*) have been conducted in the arid and Saharan zones by the Livestock Department and the IAV Hassan II (Birouk *et al.*, 1991).

2. *Ex Situ* Conservation

National *ex situ* conservation is implemented through both seed and plant collections. The latter are preserved in field genebanks at the Centre de Production des Semences Pastorales in El Jadida.

The seed collections, mainly of forage and pasture species and totalling 10,187 accessions, are stored at three different institutions, i.e., the National Agronomic Research Institute (INRA), the Agronomic and Veterinary Institute Hassan II (IAV Hassan II) and the Livestock Department (CPSP) (see Table 53.3). They are preserved as active collections, at + 4°C, and base collections, at -18°C. The seeds are stored in aluminium packs according to international recommendations for seed conservation. Unfortunately, however, there is no guarantee of long-term reliability of storage due to maintenance and electricity problems. A need for a national gene bank still exists. Following the signing of the recent 'International Undertaking on Plant Genetic Resources', a project proposal for the establishment of the national gene bank was developed in collaboration with the Food and Agriculture Organisation of the United Nations, FAO and IPGRI.

Table 53.2 Principal forage and pastoral species collecting expeditions conducted during the last decade in Morocco

Year, Participants	Prospected regions	Species collected (number of populations)	Site of conservation
1990– M.Tazi (CPSP), A. Birouk & J. Lewall (IAV Hassan II) & H. Prendergast (KG)	El Jadida, Settat, Azilal, Marrakech, Essaouira, Agadir, Ouarzazate, Saharan Provinces	Legumes (188), Grasses (85), Shrubs (73),	CPSP KG
1990– B. Buirchell (WADA) & INRA	Régions de Tafraout, Amizmiz, Béni Mellal, Rabat, Khénifra, Fès, Chefchaouen	<i>Lupinus</i> spp. (48), <i>Medicago</i> spp. (24), <i>Trifolium</i> spp. (3), <i>Vicia</i> (2), <i>Pisum</i> (2)	SCPF
1992– C.P.West (UA) & INRA	Middle et High Atlas	<i>Acremonium coenophialum</i> (51) – a fungus	
1993– L. Robertson (ICARDA) C.M. Francis (WADA) & INRA	Middle & High Atlas, littoral & Rif	<i>Vicia</i> , <i>Lathyrus</i> (450)	ICARDA SCPF
1994– L. Robertson (ICARDA) C.M. Francis (WADA) & INRA	Chefchaouen, Al Hoeima, Taza, Fès, Marrakech & Béni Mellal	<i>Vicia</i> , <i>Lathyrus</i> (209)	ICARDA SCPF
1994– P.J. Cunningham (DAV), W. Graves (UC) & INRA	Middle & High Atlas	<i>Lolium</i> , <i>Festuca</i> , <i>Dactylis</i> , <i>Phalaris</i> , <i>Trifolium</i> (226)	SCPP CPSP
1995– A. Birouk (IAV), M.Tazi (CPSP) & M.Van Slageren (KG)	Ouarzazate, Figuig, Taza, Rif, Middle Atlas	Pastoral species (73) Medicinal & others (129)	KG CPSP
1995– S. Saidi, C. Al Faiz & M.Taoufiq (INRA)	Rif, Middle Atlas	<i>Avena</i> (17), <i>Aegilops</i> (19), Grasses (18), Others (28)	SCPF
1997– A. Birouk (IAV), M.Tazi (CPSP) & M.Van Slageren (KG)	Agadir, Tan Tan, Laâyoune	Pastoral species & others (35)	KG CPSP
1998 A. Birouk(IAV) & K. Mokhtari	Ziz and Draa Valleys	<i>Medicago sativa</i> from saline reas (32)	IAV
1999 A. Birouk (IAV), M.Tazi (CPSP) & M.Van Slageren (KG)	South of Morocco, High Atlas	Pastoral and wild species	KG CPSP

CPSP : Centre de Production de Semences Pastorales, Direction de l'Elevage, El Jadida, Morocco.
 DAV : Department of Agriculture, Victoria, Australia.
 ICARDA : International Center for Agricultural Research in Dry Areas, Aleppo, Syria.
 IAV Hassan II : Institut Agronomique et Vétérinaire Hassan II, Morocco.
 INRA : Institut National de la Recherche Agronomique, Morocco
 KG : Royal Botanic Gardens, Kew, United Kingdom.
 SCPF : Station Centrale des plantes Fourragères, INRA, Morocco.
 UC : University of California , San Diego, California, USA
 WADA : Western Australian Department of Agriculture, Australia.
 UA : University of Arkansas, Fayetteville, Arkansas, USA

Table 53.3 Forage and pastoral ex situ collections maintained by different institutions

Institution Department/Research Programme	Number				Type of ⁽¹⁾ Collection
	Species	Varieties	Populations	Total accessions	
INRA – Forages	270	27	8130	8157	MT, LT
IAV Hassan II – Forages (alfalfa,..)	7	55	835	890	MT, LT
Direction de l'Élevage – CPSP (Forage & pastoral species)	192	166	974	1.140	MT, LT
Total	469	248	9.939	10.187	

⁽¹⁾ MT: Medium-term conservation, LT: Long-term conservation

3. Germplasm Evaluation and Regeneration

Characterisation and evaluation is done by breeders, plant selection specialists and by research associates. Sixty per cent of forage and pasture accessions collected in Morocco have been characterised. Evaluation is mainly conducted for agronomic characters which are of interest for agricultural development, i.e., productivity, disease resistance, etc.

Evaluation programmes for pastoral species have been initiated, in particular on annual medics, clovers, perennial grasses and some shrubs (Bounejmate *et al.*, 1989; Cremer-Bach, 1990; Derkaoui, 1990; El Mossadik, 1988; Mattahaus, 1990; Prendergast *et al.*, 1992; Tazi *et al.*, 1989). IPGRI descriptors are generally used. Other ecological studies regarding the establishment of local species have been conducted at the IAV Hassan II. These concern *Artemisia herba-alba* (Berkat, 1986), *Cymbopogon schoenanthus* (Berkat and Kabak, 1986), *Stipa* spp. (Benjelloun, 1994) and *Acacia* spp. (Layachi, 1994).

Regeneration of seed accessions is undertaken when the viability decreases below 85%. Regeneration and multiplication of collections is, however, a bottleneck for most institutions within the country since it requires large amounts of labour and funds.

All the collected materials are well documented and the information is partially computerised (passport, storage, characterisation and evaluation data). Although characterisation, evaluation and documentation are at an advanced stage of development, much more effort and international assistance is still needed in the country.

4. Plant Genetic Resources Documentation

Most of the institutions holding *ex situ* collections have their information documented. However, computerisation of data varies from one institution to another and even between programs within the same institution (Tazi *et al.*, 1999). Information is computerised particularly for forage and food legumes species. For other crop species, documentation is not in place yet or there is only partial computerisation.

5. Forage and Pastoral Plant Genetic Resources Utilisation

Forage and pastoral genetic resources from Morocco have been widely used in breeding programmes around the world to develop commercial cultivars (Table 53.4). Traits and characters that are looked for are: summer dormancy, winter growth, and disease and insect resistance, in perennial grasses (e.g., *Festuca*, *Dactylis*, *Phalaris*); and hardseededness in annual legumes (e.g., *Medicago* spp. and *Trifolium subterraneum*). Also, local ecotypes of *Lupinus angustifolius* have been shown to be resistant to *Phomopsis leptostromiformis*. Resistance to several diseases has been found in local wild oats, and the endemic species *Avena maroccana* has been shown to have high protein content. This useful trait has been incorporated into two new *Avena* varieties that have been selected and registered by INRA in recent years. Landraces of alfalfa (*Medicago sativa*) are known to have a high salt tolerance, and selection of new varieties is presently underway by INRA and IAV Hassan II.

In annual medics, great variability for several traits and characters has been found within local ecotypes, such as early flowering, favourable leaf size, high dry matter and seed yields, and adaptability to acid soils. As a result of selection, six varieties of annual medics have been developed by INRA and CPSP and are now registered in the national catalogue.

Ecotypes of pasture and range species, particularly fodder shrubs such as *Acacia raddiana*, *Atriplex halimus*, *Nitraria retusa*, *Nucularia perrini*, *Salsola longifolia* and *Salsola tetrandra* are under evaluation at the CPSP in a joint programme with the IAV Hassan II (Tazi, 1994). Adaptability trials show that local material has a potential for rangeland rehabilitation in arid zones in the region.

Table 53.4 Main cultivars developed using local material collected in Morocco (Bounejmate, 1997)

Species and cultivar	Collecting site	Institution and year	Selection criteria
<i>Dactylis glomerata</i> (Berber)	Anti & High Atlas 230–460 mm, 760–1100 m	Waite Institute, Australia, 1967	Winter growth & summer dormancy
<i>Dactylis glomerata</i> (Kasba)	West of Imfout Dam 270 mm	Waite Institute, Australia, 1970	Winter growth, summer dormancy & rust resistance
<i>Phalaris aquatica</i> (Sirocco)	Kénitra 590 mm, 25 m	CSIRO-Canberra, Australia, 1967	Winter growth & summer dormancy
<i>Phalaris aquatica</i> (El Golea)	Amizmiz 200–250 mm	CSIRO-Canberra, Australia, 1977	Winter growth & summer dormancy
<i>Festuca arundinacea</i> (Maris Kasba, Maris Jebel)	Anti & High Atlas 230–460 mm, 760–1100 m	Pl. Breed. Institute, Cambridge, UK, 1976	Winter growth & summer dormancy
<i>Medicago sativa</i> (Demnat)	Demnat 525 mm, 950 m	CSIRO-Canberra, Australia, 1970	Winter growth
<i>Medicago tornata</i> (Rivoli)	10 km South of Kénitra	South Aust. Dept. Agri., Australia, 1990	Good establishment and regeneration
<i>Ornithopus compressus</i> (El Gara)	40 km S–W of Rommani	NSW Agri. Fish. Australia 1989	Precocity and persistence on infertile soils
<i>Ornithopus pinnatus</i> (Jebala)	28 km South of Tanger	West. Aust. Dept. Agri., Australia, 1989	Persistence on infertile soils

Conclusion

In recent years there has been an increasing interest in plant genetic resources preservation, particularly of forage and pastoral species. This has been expressed through concrete activities by different institutions (INRA, IAV Hassan II, Direction de l'Élevage). These efforts should, theoretically, be reinforced since the country has ratified the Convention on Biological Diversity and has also signed the Convention to Combat Desertification.

Collecting expeditions should be extended to all the ecological regions in the country. For each environment, collecting missions should be undertaken in order to ensure effective sampling of the genetic variability of the available material. Priorities can be defined for collecting and evaluation activities of several forage and pasture genera, such as *Medicago*, *Trifolium*, *Avena*, *Phalaris*, *Festuca*, *Dactylis*, *Lolium*, *Hedysarum*, *Lupinus* and *Ornithopus*. Moreover, it is urgent that the collecting and evaluation activities for fodder shrubs used in range rehabilitation (e.g., *Atriplex*, *Acacia*, *Salsola*) is reinforced.

In order to ensure better utilisation of plant genetic resources in general, *ex situ* conservation should be complemented by *in situ* conservation of species in their natural habitat. The success of any plant genetic resources conservation and utilisation programme is dependent on the employment of permanent and qualified scientific and technical personnel. Hence, training activities in plant genetic resources and related fields should be reinforced within the country and at the regional level. Moreover, all these programmes and activities should be reinforced through fruitful collaboration with international centres and organisations, such as IPGRI, ICARDA, the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), FAO, the United National Development Programme (UNDP), and projects, such as the Millennium Seed Bank Project of the Royal Botanic Gardens, Kew.

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