CONTRIBUTION OF THE NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH TO THE CONSERVATION OF PLANT GENETIC RESOURCES IN MOROCCO

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SUMMARY

The potential value of the Moroccan plant genepool is well known. Local species and ecotypes have developed adaptative strategies to cope with prevailing conditions. Hardseededness, high winter growth and disease tolerance are some examples of characters associated with Moroccan germplasm. This large genetic diversity is, however, at risk. Available data clearly indicate that genetic erosion is occurring in many species.

In recent years, there has been an increasing awareness in Morocco that conservation and sustainable use of local plant genetic resources is essential to agriculture. Therefore, conserving plant genetic resources has received considerable attention. Several national and international research institutions are now working to produce the knowledge required to conserve and make better use of local plant genetic resources. This paper reviews the contribution of the "Institut National de la Recherche Agronomique" (INRA) to a better understanding of the value and uses of Moroccan germplasm.

To collect local germplasm, comprehensive surveys were conducted. Geographical features, climatic factors and soil characteristics of collection sites were documented. Distribution studies have determined species/ environment relationships and have been used to identify species and ecotypes best adapted to a given environment.

The facilities for long term storage of plant germplasm in Morocco have been greatly improved. Now, more than sixteen thousand accessions are stored at INRA genetic resources units.

Evaluation of local plant material started with several genera such as *Hordeum*, *Triticum*, *Medicago*, *Trifolium*, *Lupinus* and *Avena*. This evaluation has established the range of adaptability of these species and ecotypes. It also

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provided information to assist in developing strategies to select cultivars adapted to the various regions of Morocco.

Research efforts to conserve and use local genetic resources should continue in the future as an integral part of agricultural research. Morocco's rich flora is far from being adequately sampled, completely preserved and characterized. Further collection and evaluation are needed. Efforts should also continue to improve storage conditions and to establish duplicate collections.

Key words: Collection, conservation, evaluation, Institut National de la Recherche Agronomique, Morocco, plant genetic resources.

RESUME

La valeur potentielle élevée du pool génétique marocain est bien connue. Les espèces et écotypes locaux ont développé des stratégies pour s'adapter aux différentes situations écologiques existantes. La dureté des semences, la croissance hivernale élevée et la tolérance aux maladies sont des exemples de caractères associés avec le matériel végétal marocain. Cette large variabilité génétique est cependant en danger d'extinction. Les données disponibles montrent clairement que l'érosion génétique est en train de se produire pour plusieurs espèces.

Au cours des dernières années, la conservation et l'utilisation durable du matériel phytogénétique local ont reçu une attention considérable. Plusieurs institutions nationales et internationales de recherche oeuvrent pour produire les connaissances nécessaires pour une meilleure conservation et utilisation des ressources phytogénétiques locales. La présente communication donne un aperçu sur la contribution de l'Institut National de la Recherche Agronomique (INRA) dans ce domaine.

Des missions exhaustives ont été effectuées pour la collecte du matériel végétal local. Les traits géographiques, les facteurs climatiques et les caractéristiques des sites de collecte ont été recueillis. Des études de distribution ont permis d'établir des corrélations entre les espèces et les conditions de l'environnement et ont été utilisées pour identifier les espèces adaptées à un environnement donné.

Les techniques de stockage à long terme se sont nettement améliorées. Actuellement, plus de seize mille échantillons sont conservés dans différentes unités de l'INRA.

Les travaux d'évaluation ont commencé avec plusieurs genres tels que *Hordeum, Triticum, Medicago, Trifolium, Lupinus* et *Avena*. Ces études ont permis de mieux définir les conditions potentielles pour l'utilisation optimale des espèces et écotypes appartenant à ces genres. Elles ont aussi permis de fournir des informations utiles au développement de stratégies de sélection de cultivars adaptés aux différentes régions du Maroc.

Les efforts de conservation et d'utilisation des ressources phytogénétiques locales doivent se poursuivre comme partie intégrante de la recherche agricole. La flore du Maroc est loin d'être totalement échantillonnée, complètement conservée et évaluée. Des efforts supplémentaires sont nécessaires pour la collecte, l'évaluation, l'amélioration des conditions de stockage et l'établissement de doubles des collections existantes.

Mots clés: Collecte, conservation, évaluation, Institut National de la Recherche Agronomique, Maroc, ressources phytogénétiques.

1. INTRODUCTION

Morocco harbours one of the richest flora in the western Mediterranean. The different soil, climate and management systems accross Morocco interact to provide a wide range of ecological situations resulting in a diverse flora (Sauvage 1975).

This flora, is however, threatened with extinction. It is widely contended that loss of agriculturally useful species and ecotypes is occurring in Morocco (Rumbaugh and Graves 1983; Perrino *et al.* 1984; IBPGR 1985; Francis 1987). Population increases have generated tremendous pressure on these resources through urban development, increased hectarage of land under tillage, changes in agricultural practices, introduction and distribution of improved cultivars, and a greater animal numbers grazing fewer hectares.

The challenge is clear. Plant genetic resources in Morocco are under an ever increasing pressure. It is therefore of prime importance that research and extension institutions do all in their power to safeguard at least a portion of Morocco's genetic resources for future generations.

To this end, the Institut National de la Recherche Agronomique has been taking a lead by initiating genetic resources projects to preserve, evaluate and develop locally adapted cultivars using indigenous germplasm. The present communication highlights some achievements in this area.

2. ASSESSMENT OF THE MOROCCAN FLORA

2.1. Richness

The flora of Morocco is known for its high genetic diversity. With about 3,700 species, it is the richest flora in the Maghreb. More importantly, it possesses a high number of endemics (650 species known to date) and several species show ecotypic differentiation (Sauvage 1975).

Several factors explain this richness of the Moroccan flora. Geographically, Morocco is located between two seas, is next to the Sahara and has a topography which includes high and low plains and high mountains. Morocco also offers an almost complete range of mediterranean climates, from the driest ones of the Sahara to the wettest ones in the Rif, from mild coastal conditions to very cold temperatures in the mountain environment. In all these environments thrive an associated and adapted flora. Also, the high Atlas mountain barrier isolates some zones from external influences. These protected and undisturbed areas represent ecological zones of particular interest where hundreds of endemics are found. Furthermore, an important tropical flora still persits in southern Morocco due to migrations from tropical zones during the tertiary and the quaternary periods.

2.2. Agronomic value

It is well established that natural selection directs evolution in a way that survivors are better adapted to their local environments, and that responses of plant species to environmental factors are closely related to their geographic origin (Lorenzetti *et al* 1971; Cocks and Ehrman 1987; Bounejmate 1992). Species and ecotypes of the Moroccan flora have developed adaptive strategies to cope with prevailing conditions and several useful agronomic characters are associated with Moroccan germplasm.

Adaptive features include summer dormancy in perenial grasses. One of the striking aspects of the climate is the low summer rainfall coinciding with a period of high temperatures. Dormancy enables plants to grow during the winter and survive the summer. In a mediterranean environment, plant survival during the summer was 97% for Moroccan families of *Dactylis glomerata* compared to 59% for the purely European families (Knight 1966).

Hardseededness is another important feature developed by annuals legumes to cope with the erratic Moroccan climate. For example, Moroccan

strains of *Trifolium subterraneum* (Gladstones *et al.* 1981) and annual *Medicago* species (Crawford 1985) are a source of hardseededness.

Several other ecological and agronomic characters are found in indigenous plant material. In *Festuca arundinacea*, ecotypes collected in Morocco had higher winter growth and disease tolerance than European ecotypes (Gillet 1964; Jadas and Gillet 1978; Robson and Jewiss 1968). Strains of alfalfa collected from the Draa River were as salt tolerant as the most salt tolerant germplasm known in the United States (Rumbaugh and Graves 1983). Wild types of *Lupinus angustifolius* carry a useful degree of resistance to *Phomopsis leptostromiformis* (Gladstones *et al.* 1981). Resistance to various diseases has been found in a number of wild oats (Davis *et al.* 1973) and the endemic *Avena maroccana* has a high protein content (Ladizinsky and Fainstein 1977).

At the species level, the performance of ecotypes varies considerably as one considers more local environments. This was demonstrated at Aberystwyth, Wales, when a tall fescue collection from the Atlas Mountains of Morocco was subjected to a severe winter without snow cover. Superior winterhardiness (Table 1) was associated with ecotypes obtained from regions of higher altitudes (Breese 1964).

Table 1: Survival percentages of tall fescue tillers introduced from the Atlas Mountains of Morocco and exposed to natural environmental conditions existing at Aberystwyth, Wales during the winter of 1962-63. After Breese (1964).

Altitude of collection site (m)	Origin				
	Moyen-Atlas			Haut-Atlas	
	North	South	West	West	Central
914-1219	4	-	27	13	-
1219-1523	3	4	49	14	-
1523-1828	23	40	59	47	-
1828-2133	93	73	-	89	71
2133-2437	-	-	-	100	94
2437-2742	-	-	-	-	94

Many of the ecological and agronomic characters identified in Moroccan plant material have been exploited by plant breeders. Several ecotypes of grasses and legumes collected in Morocco have been used as such to produce commercial cultivars (Table 2). Also, several cultivars developed for use in Moroccan conditions have been found to carry useful characters. These have been successfully incorporated into existing varieties in many countries (Table 3).

Table 2: Main forage cultivars developed from Moroccan germplasm

Species and (cultivar)	Site of collection	Institute and year	Selection criteria
Dactylis glomerata (Berber)	Atlas mountains 230 - 460 mm 760 - 1100 m	Waite Institute Australia 1967	Winter growth Summer dormancy
(Kasba)	West of Dam Imfout, 270 mm	Waite Institute Australia 1970	Winter growth Summer dormancy Rust tolerance
Phalaris aquatica (Sirocco)	Kénitra 590 mm 25 m	CSIRO - Canberra Australia 1967	Winter growth Summer dormancy
(El Golea)	Amizmiz 200 - 250 mm	CSIRO - Canberra Australia 1977	Winter growth Summer dormancy
Festuca arundinacea (Maris Kasba) (Maris Jebel)	Atlas mountains 230 - 460 mm 760 - 1100 m	Pl. Breed. Inst. Cambridge 1976	Winter growth Summer dormancy
Medicago sativa (Demnat)	Demnat 525 mm 950 m	CSIRO - Canberra Australia 1970	Winter growth
Medicago tornata (Rivoli)	10 km south of Kénitra	South Aust. Dept of Agriculture Australia 1990	Good establishment and regeneration
Ornithopus compressus (El Gara)	40 km south west of Rommani	NSW Agri. Fisherie Australia 1989	Earliness and persistence in infertile soils
Ornithopus pinnatus (Jebala)	28 km south of Tangiers	West. Aust. Dept. Agric. 1989	Good persistence in infertile soils

Table 3: Germplasm developed in Morocco and used in foreign breeding programs

Crop	Germplasm	Characters	Foreign Program
Barley	071 - 077 - 628	Resistance to cyst nematodes	Australia
Bread wheat	Nesma, Fartass Charquia	Productivity	Jordan, CYMMIT
Durum wheat	0126 - 1658 272 - 2902	Resistance to Hessian fly and Russian Aphid	USA (Kansas)
Maize	North African collection	Earliness	CYMMIT
Oat	Avena maroccana Avena agadiriana	Resistance to various diseases	Aberystwyth (Wales)

2.3. Extent of genetic erosion in Morocco

During the past 20 years, concern has been expressed that genetic erosion has been taking place in the Mediterranean region. Hence, there is a clear need to assess the extent of genetic erosion in Morocco.

Available data suggest genetic erosion is occurring in Morocco. From most - if not all - collections undertaken in Morocco over the last ten years, it has been widely contended that rapid changes in agricultural practices have resulted in the loss of agriculturally useful species and ecotypes:

"Genetic erosion in general and especially for wheat was found to be higher than was originally thought" (Perrino *et al.* 1984).

"The grazing pressure is causing genetic erosion especially for vulnerable species like *Lupinus* and *Vicia*" (Francis 1987).

"The collection team concluded that the potential for genetic erosion of Morocco's legume flora is high" (Beuselink *et al.* 1989).

"Results suggest that genetic erosion is occurring but occasional sites can be found where medics are abundant" (Bounejmate *et al.* 1992).

Although we know of no critical study supporting or quantifying this contention, some attempts have been made to assess whether genetic erosion has taken place during recent times. The case of the annual *Medicago* species is given as an example.

A collection made in 1988 was used to assess changes at the level of species by comparing their occurrence in the different collections (Bounejmate 1992). Only 11 out of the 18 species recorded in previous collections were found. While it can never be said that any of these species no longer occur in Morocco, they are certainly not readily found. Their loss, particulary that of the endemic *M. sauvagei*, would be unfortunate since they might carry useful genetic characters.

3. CONTRIBUTIONS OF INRA TO MAINTENANCE OF LOCAL PLANT GENETIC RESOURCES

3.1. Progress in collection

The problem of conserving genetic resources in Morocco has received considerable attention in recent years. Table 4 summarizes the main plant collections made in Morocco and clearly shows the growing interest by national institutions to indigenous plant material. Before the 80's, plant collection and evaluation were made mainly for the needs of foreign programs. Since 1980, all collections were undertaken with the participation of national institutions and several were made for the needs of national programs.

The Institut National de la Recherche Agronomique (INRA) was involved in more than 20 plant collection missions. Many of these were carried out meaningfully in the context of a plant breeding program where objectives were properly formulated. This was the case for annual *Medicago* species, *Trifolium subterraneum* and *Avena*. Other surveys were undertaken to collect species at risk such as *Lupinus* and *Vicia*. Prospections were not limited to plants, in a few cases, rhizobia were also collected.

The progress made in collection procedures is of noteworthy. All recents surveys conducted by INRA to collect forage and pasture species have used Marshall and Brown (1983) techniques to maximize genetic diversity. Furthermore, geographical features, rainfall, temperature, soil characteristics and grazing pressure have been comprehensively documented.

Table 4: Main plant collections made in Morocco

Year of collection and collectors*	Areas prospected	Species collected (no. of populations)
1954 - C.A. Neal-Smith (CSIRO)	Agadir, Marrakech, Casablanca, Rabat, Kénitra, Fès, Ouezzane	Phalaris aquatica (38) Dactylis glom. (35) Phalaris minor (11) Lolium rigidum (25)
1962 - WPBS	Taroudant, Aït Ourir, Khénifra, Midelt and Ifrane	Festuca arundinacea Dactylis glomerata
1964 - T. Rajhathy, F.J. Zillinsky (CDA), J.D. Hayles (WPBS)	Rabat, Tiflet, Meknès Ifrane, Oulmès, Sefrou, Fès, Tanger	Avena (38)
1968 - WPBS	Haut-Atlas, Anti-Atlas	Festuca arund. (25) Dactylis glomerata (9)
1973 - J.S. Gladstones (CSIRO)	Rabat, Marrakech, Agadir Tiznit, Tafraout, Azrou, Tantan, Tanger, Tétouan Al Hoceïma	Lupinus spp. (45) Ornithopus spp. (32) Trifolium subt. (25) Medicago spp. (37)
1979 - B. Sali and H. Sobhy (INRA)	Chaouia, Doukkala, Abda Rehamna, Chichaoua	Maize (120)
1982 - A. Birouk (IAVHII)	Tafilalet, Draa, Haut and anti-Atlas, Demnate	Medicago sativa (153)
1983 - B.H. Somaroo, W. Boumoghlabi (ICARDA) with INRA	Rabat, Casablanca, Marrakech, Azilal, Béni Mellal, Settat	Medicago spp. (293)
1983 - M.D. Rumbaugh (U.U) and W.L. Graves (UC) with INRA	Rabat, El Jadida, Marrakech, Taroudant, Ouarzazate, Errachidia, Taza, Al Hoceima, Chefchaouen, Tanger	Medicago sativa (155) Medicago spp. Dactylis glom. (23) Festuca arund. (10)
1984 - J.Jadas (SAPF) with INRA	Fès, Meknès, Ouazzane, Tétouan, Souk El Arba, Sidi Kacem	Festuca arund. (43)
1984 - P. Perrino (IG) G.B. Polignano (IG) J. Sui-Kwong (ICARDA) M. Khouya-Ali (INRA)	South Morocco, from Rabat to Tafraout	Hordeum vulgare (91) Triticum aestivum (27) Triticum turgidum (28) Others (160)
1985 - B. Sali, L. Rena H. Sobhy and A. Slimani (INRA)	Moyen and Haut-Atlas	Maize (129)

Table 4: Continued

1985 - M. Sadiki (IAVHII)	Most agricultural zones	Vicia faba (400)
1985 - W. Graves (UC) with INRA and CPSP	Béni-Mellal, Azilal, Marrakech, Ouarzazate, Errachidia, Midelt	Astragalus, Medicago, Lotus, Onobrychis, Trifolium, Dactylis Phalaris (219)
1985 - M.Leggett (WPBS) with INRA	Rommani, Ben Slimane, Agadir, Tiznit, El Jadida Béni Mellal, Tanger	Avena spp. (24)
1986 - S. Sato and K. Tsurumi (KNAES) with INRA	Ourika, Oukaimeden, Béni Mellal, Azrou, Ifrane, Taroudant, El Ksiba	Festuca (18) Dactylis (13) Avena (12)
1986 - A. Birouk, A. Hilali and M. El Haddioui (IAVHII)	East Morocco and Sahara	Medicago sativa (99)
1987 -B.Sali, A. Riffay (INRA), M. Atir (FT)	Northern Morocco	Sorghum (36)
1987 - C.M. Francis (WADA) with INRA	Rabat, Béni-Mellal, Azilal, Demnat, Settat and Moyen-Atlas	Medicago spp. (299) Trifolium spp. (78) legumes (42)
1987 - M. Tazi (CPSP) A. Birouk, Z. Fatemi, P. Heiffer (IAVHII)	Tafilalet, Draa, Haut-Atlas, Moyen-Atlas, Fès, Chefchaouen and Ouazzane	Dactylis, Festuca and Stipa (79) Medicago and Trifolium (88)
1988 - M. Bounejmate - (INRA) and P.E. Beale (ICARDA)	Oujda, Marrakech, Béni-Mellal, Settat, Tanger and Moyen-Atlas	Medicago spp. (386) Trifolium spp. (363) legumes (390)
1988 - D. Matthäus INRA	Morocco except Oujda Area and South of Ouarzazate	Trif. subter. (700)
1988 - A. Arif INRA	Haute Chaouia	Perennial grasses
1988-J.M.Legget(WPBS) M. Obanni (IAVHII) S.Saïdi (INRA)	Rabat, Essaouira,Tiznit, Marrakech,Ifrane, Chefchaouen	Avena (64)
1988 - M. Cremer INRA 1988 - M.Baumann INRA	Sols acides Midelt, Guercif, Oujda and Tendrara	Medicago spp. (411) Medicago spp. (270)
1989 - P. Beuselink, J. Kirkbride (USDA/ARS), W. Graves (UC), C. Roberts (UM) with INRA	Agadir, Tiznit,Tafraout, Marrakech, El Jadida, Settat, Azrou, Ifrane, Oued-Zem, Chefchaouen, Fès, Taza,Guercif,Oujda	Lotus spp. (76) Medicago spp. (36) T. subterraneum (9) F. arundinacea (16) Others (14)

Table 4: Continued

1989-1990 - A. Birouk et J.Lewalle (IAVHII) H. Prendengast (KG) M. Tazi (CPSP)	Provinces of Oued Eddahab Boujdour, Essmara, Tantan Guelmim, Assa, Tata	Pasture species	(197)
1989 - C. Al Faïz and A. Souihka (INRA)	Zaërs, Gharb, Tangiers, Rif, Moyen-Atlas, Souss	Avena spp.	(812)
1990 - B. Buirchell (WADA) with INRA	Vicinity of Tafraout, Amizmiz, Béni-Mellal, Rabat, Khénifra, Fès, Chefchaouen	Lupinus spp., Medicago spp. Trifolium spp. Vicia (2), Pisum	(48) (24) (3) (2)
1990 - A. Birouk, M. El Haddioui and M. Essafi (IAVHII)	Valley of Draa Saline soils	Rhiz. meliloti	(38)
1991 - L. Guarino and A. Bari (IBPGR) with CPSP and IAVHII	Atlas mountains	Cicer atlanticum and other endemic legumes	(17)
1992 - C.P. West (UA) with INRA	Moyen and Haut-Atlas	Acremonium coen.	(51)
1993 - L. Robertson (ICARDA), C.M. Francis (WADA) with INRA	Moyen and Haut-Atlas, coastal area and Rif	Vicia, Lathyrus	(450)
1993 - A. Amri and M. El Haïla (INRA)	Barley grown areas	Barley	(771)
1994 - L. Robertson (ICARDA), C.M. Francis (WADA) with INRA	Chefchaouen, Al Hoceïma, Taza, Fès, Marrakech and Béni-Mellal	Vicia, Lathyrus	(209)
1994 - P.J. Cunningham (DAV), W. Graves (UC) with INRA	Moyen and Haut-Atlas	Lolium, Festuca, Dactylis, Phalaris, Trifolium fragiferum Trifolium repens	(226)

* Available collection missions reports are cited in references.

CDA: Canadian Department of Agriculture, Canada
CPSP: Centre de Production des Semences Pastorales, Khémis M'touch, Province of El Jadida
CSIRO: Commonwealth Scientific and Industrial Research Organization, Australia
DAV: Department of Agriculture, Victoria, Australia
FT: Faculty of Tétouan, Morocco
HI: Pastoral and Veterinary Institute, Hamilton, Australia

IAVHII:	Institut Agronomique et Vétérinaire Hassan II, Rabat, Morocco
ICARDA:	International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria
KG:	Royal Botanic Gardens Kew, United Kingdom
KNAES:	Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto, Japan
SAPF:	Station d'Amélioration des Plantes Fourragères, Lusignan, France
UA:	University of Arkansas, Faytteville, AR 727003, USA
UC:	University of California, San Diego, CA 92123, USA
UM:	University of Missouri, Columbia, MO, USA
USDA/ARS:	United States Department of Agriculture, Agricultural Research Service
UU:	Utah State University, UMC 63, Logan, UT 84322, USA
WADA:	Western Australian Department of Agriculture, Australia
WPBS:	Welsh Plant Breeding Station, Aberystwyth, Wales

3.2. Distribution studies

Along with safeguarding of local material form extinction, INRA recognized the importance of the knowledge of adaptation and distribution of species. Thus distribution patterns of some species have been determined from the collections made.

Several comprehensive distribution studies have been undertaken. These include annual legumes (Beale *et al.* 1991), annual *Trifolium* species (Beale *et al.* 1993), annual *Medicago* species (Bounejmate *et al.* 1992a; Bounejmate *et al.* 1992b; Cremer-Bach 1992; Feniche 1993), *Trifolium subterraneum* (Matthäus 1992), *lupinus* (Buirchell 1992; Bounejmate *et al.* 1993), and *Vicia* and *Lathyrus* (Francis *et al.* 1994).

These distribution studies have helped to establish the potential agricultural range for the successful use of species and ecotypes in the various regions of Morocco. The potential of annual *Medicago* species is now discussed as an example.

Investigations demonstrated that there is considerable scope, through cultivar release from a broader range of species, for extending the range of climatic and edaphic conditions where annual *Medicago* species can be successfully grown. They also provided a clear indication of the species deserving more attention. Annual *Medicago* species are naturally distributed

over a very wide environmental range, and whitin this, there were distinct ecological preferences of different species.

Medicago polymorpha is the most widespread of all the medic species, although very rare on sandy soils in low rainfall areas, and is therefore a promising species. Unfortunatety, no spineliness genotypes were found in Morocco. *M. scutellata*, found in high rainfall areas on soils of high clay and phosphorus contents, is of low priority because of its rarity and very low density. *M. truncatula* is distributed over a much wider range of soil types and climate than previously believed. This species offers alternative possibilities for annual *Medicago* use on mildly acid soils where acid tolerant species are agronomically unsuitable.

Of particular interest is the occurrence of certain species at the extremes of the range of edapho-climatic stresses. *M. tornata* and *M. murex* may have a role in low fertility soils, as these two species occupied sites with lower pH, phosphorus, calcium carbonate content and clay content than other species.

The adaptation of non commercial species is noteworthy. *M. aculeata* is very widely distributed and was the most common of all species in low winter temperature areas. This species, associated with fertile clay soils has a certain ecological nich. *M. orbicularis* occupied a similar range to *M. aculeata* and was found also on shallow stony soils on more arid land. Because of its adaptation to low temperature and low rainfall, this species merits attention. *Medicago intertexta* could also be of value for certain niches. This species, associated with zones with a mild winter, a mild summer and high rainfall, is also known to persist better than most medic species on poorly drained and saline soils. *M. laciniata* is another promising species as it is restricted to and was the most abundant in the driest areas.

3.3. Progress in conservation

Historically and up to the 1980's, working collections were the only mean of conservation of genetic material used in Moroccan breeding programs. Large areas of land and massive work were needed to rejuvenate fresh seed. As plant breeders invariably have restricted resources, only a limited number of species and accessions were given necessary care. Thus, part of the genetic material was inevitably lost, e.g. accessions collected during a joint ICARDA/ITALY/MOROCCO collection mission were lost.

With the development of genetic resource programs, the facilities for long term storage have been greatly improved. Facilities of international standard required for conservation and storage of collected material have been built. For example, the INRA Forage Program, where more than ten thousands accessions are stored (Table 5), has the following:

- 1 seed/laboratory
- 1 laboratory for rhizobia conservation and multiplication
- 1 drying room: 17 ± 2°C et 20 - 40% relative humidity
- 1 short term storage room: 10 - 15°C and 30% R.H.)
- 4 refrigerators of 460 l each: 4°C
- 3 freezers of 360 l each: -18°C
- 1 oven for germination tests
- 1 computer for data management

Substantial efforts are currently deployed for the establishment of a National genebank.

Table 5: Main species conserved at INRA (live collections or seed).

Crop	Number of accessions
Forage and pasture	> 10,000
Cereals	3,000
Almond trees	100
Olive trees	82
Peach trees	3
Apricot tree	47
Date palm	3,000

3.4. Progress in evaluation

Comprehensive studies have been taken by different INRA programmes to evaluate local plant germplasm. These studies have demonstrated that there is considerable scope for selecting cultivars adapted to the different environments of Morocco from within local germplasm.

Screening of local populations of maize collected from arid and semi-arid zones led to the registration of 2 varieties: Doukkalia and Mabchoura.

Under rainfed conditions, these varieties significantly outyielded available commercial cultivars.

The potential value of Moroccan populations of olive, almond and apricot trees has been successfully exploited to release improved cultivars (Table 6).

Table 6: Examples of fruit trees developed in Morocco

Crop	Clone	Characters	Cultivar
Olive tree	C6 C27	- High productivity - High oil content - Tolerance to tuberculosis - Tolerance to Cycloconium	HAOUZIA
	C6 H17	- High productivity - High oil content - Tolerance to Cyclonium	MENARA
Almond tree	AT8	- Earliness of flowering - Tolerance to moniliose	AT8
Aprico tree	Marouch 4	- High productivity - Early maturity (2 weeks earlier than Canino) - Good fruit quality	BAKRI
	INRA-CP	- High productivity - 2 weeks earlier than Canino - Good fruit quality	LOUDAYA

Moroccan populations from annual *Medicago* species showed large genetic variability (Bounejmate 1992; Cremer-Bach 1992). For instance, there was a significant intra-specific variation in the ability of *M. truncatula* to nodulate and grow in acids soils and acid solutions. There was also a clear relationship between response of medic ecotypes to environmental factors and their geographic origin. Nodulation in the presence of nitrate, response to phosphorus, and response to temperature and frost were related respectively to soil nitrogen content, soil phosphorus content and winter temperature at site of collection. Coumestrol content, flowering time, leaf size and seed production also varied greatly among ecotypes. This work resulted in the selection of several populations adapted to specific environments. So far, six ecotypes have been submitted for registration. These are: *Medicago polymorpha* 124 and 384,

Medicago tornata 196, *Medicago truncatula* INDA 3, *Medicago orbicularis* INDA 2, and *Medicago aculeata* INDA 1.

4. FUTURE PROSPECTS

The research efforts during the last 10 years have resulted in a better knowledge of the distribution of native species in Morocco. Some germplasm has been preserved from extinction and information on the the value of Moroccan plant material is accumulating. More efforts are needed, however, to preserve the genetic variability in Moroccan material and to exploit it for the development of cultivars adapted to various regions of Morocco.

Further collection is clearly needed. Morocco's rich flora is far from being adequately sampled and completely preserved. Morocco has a diverse range of winter and summer temperature, rainfall and soil type. Grazing pressure, which plays a major role in distribution of species, also varies between and within regions. Therefore, definition of distinct groups of environments is required as well as mapping of original locations of samples in order to identify gaps in collections. Priorities have been established by National Working Groups. Those related to forage and pasture species are outlined in Table 7.

Table 7: Priorities for collection and evaluation of local forage germplasm

Species	Collection and conservation	Evaluation
	+ + +	+ + +
Alfalfa	+	+ + +
Medics	+	+ +
Subclover	+	+ +
Oat	+ + +	+ + +
Lupin	+ + +	+ + +
Other legumes	+ + +	+ +
Annual grasses	+ + +	+
Perennial grasses	+ + +	+
Schrubs	+ + +	+
Trees	+ + +	+
Arganier	+ + +	+ +

+: low priority
+++: high priority

Efforts should also continue to improve storage facilities. In this respect, the need for systematic duplication of available collections needs to be stressed. We hope that the establishment of the National Genebank will enhance the creation and maintenance of a working database and provide information for potential national and international users.

More training is needed in diverse aspects of genetic resources management. The training needs for plant taxonomy is also of high priority.

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