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CONSERVATION AND PROPAGATION OF RANGE PLANT GENETIC RESOURCES IN THE NORTH AFRICAN COUNTRIES

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SUMMARY

The region of North Africa includes five countries bordering and extending into the Great Sahara Desert from the North. These are, Morocco, Algeria, Tunisia, Libya and Egypt; Mauritania, on the other hand borders the desert from the South. The surface area of this region totals about 7 million km^2, with natural borders formed by the Atlantic Ocean, the Mediterranean Sea and the Red Sea from the west, north and east, respectively.

North Africa, except for Mauritania, is influenced by the Mediterranean sea climate and all Mediterranean bioclimatic belts (*étages*) are represented in the region. Aridity, however, dominates the greatest portion and areas receiving less than 400 mm of rainfall per annum cover about 96% of the region's territory. Rangelands cover more than 130 million ha and provide 30 to 60% of the feed requirements of the local animal populations. These rangelands support thousands of plant species that form and shape the grazable plant cover, which in turn is the most important renewable natural resource.

Many of these plant species are quite important in terms of forage production, while others possess specific economic uses: medicinal, industrial or fuel wood production. These species also conserve the ecological balance of the fragile ecosystems and control soil erosion. Trees and shrubs provide wildlife refuge, while psamophytes fix sand dunes. The combined effect of the North African xerophytic flora will yield quite effective measures to counter the threatening desertification in the region. Furthermore, many of these species bear strategic importance, being the breeding base for new types and varieties with desired properties, mainly the high yielding qualities, pest and disease resistance as well as high tolerance to environmental stress.

All economic studies and indicators in the region confirm the current status of the continuous degradation of rangelands. The main causes are: (1) horizontal expansion of agriculture over the richest range sites; (2) overgrazing caused by the imbalance between the increasing livestock population and their feed requirements; (3) the decreasing productivity of the depleting rangelands; (4) uprooting of shrubs for fuel; (5) cutting of trees and shrubs for the construction of fences and animal shelters; and (6) harvesting plants for medicinal or industrial uses.

The environmental and economic consequences of these factors are immense. Many plant species become either distinct or threatened in many sites. The last phenomenon termed genetic erosion, will lead to serious effects in the near future on both the ecological balance and on the efficiency and net return of the ecosystem.

Since their independence, the countries of North Africa have exerted great efforts and spent large amounts of money to arrest this dangerous ecological trend and to face the continuous degradation of rangelands, especially in terms of range management and improvement and desertification control. The main efforts have been directed toward: (1) reseeding, (2) plantation of forage shrubs, (3) erection of enclosures, (4) development of water points (wells and cisterns), (5) sand dune fixation, (6) issuing and observing regulations and laws to achieve rational management of arid zone natural resources, (7) carrying out research and studies, (8) organization of rangeland societies.

In spite of all these efforts, rangelands are still facing continuous degradation. This is caused by ecological factors – mainly, the repeated drought, and socio-economic factors, the rangeland ownership and grazing patterns. The technical issues, however, are as important as the former ones. They are, in fact, the main obstacles which have been hindering range improvement programmes to achieve their goals. The most important technical issue is the scarcity or unavailability of local plant species seeds that are necessary for revegetation and desertification control. Native xerophytic plant species seeds would be utilized efficiently in

the improvement programmes and would compensate for the currently demanded introduced or reintroduced seeds. Needless to say, North Africa was the main ground in which many of the reintroduced species were produced, through breeding in the technically advanced countries for improved production qualities and pest control but not for stress tolerance prevailing in the local arid zone environments.

The drive for the production of the local seed species in the region is a multidimensional endeavor, but current problems can not be solved unless specific conditions are met. These include: (1) availability of genetic resources having the desired characteristics and qualities that enable them to be domesticated and cultivated on the widest possible scale, (2) availability of an organization and a legal system which would regulate, promote and commercialize the produced seeds, (3) availability of the proper ecological conditions, facilities, machinery, storage capacities, and the required capabilities for seed production, and (4) availability of trained and specialized manpower.

These qualifications are needed more rigorously in the field of range plant seed production, in comparison with cultivated ones. This is due to the ecological and socio-economic peculiarities of the rangelands as well as the peculiarities of the range plants themselves, of which neither their autecological strategies nor their propagation systems are known to a large extent.

In the light of the above conditions, situations and the subjectivity of the range plant species to genetic erosion risks, the concerned seed propagation programmes should give greater attention to: (1) surveying, exploration and collection of physiological races, ecotypes, varieties of the endangered, threatened and economically important plant species of the arid areas, (2) evaluation and characterization of the germplasm collected and application of rigorous selection to select the fittest and the best, (3) development of schemes for the proper propagation techniques for both seed production, revegetation and cultivation, and (4) training of specialized technical staff to fulfill these tasks.

Cooperation and integration between all countries of the region in this subject matter are essential. The reasons are: (1) large quantities of diversified range plant seeds are needed, (2) the ecological habitats to be reseeded are quite diversified, (3) institutions active in the field of range improvement are many but act separately, (4) the presence of huge but unutilized human resource capabilities, and (5) the ventures to perform the multitudinous tasks in the field are extensive and costly, yet the resources needed to perform them are not available to the majority of the local institutions.

Cooperation and integration in the region are possible through systematization and coordination between various efforts at several levels. The most important of which are: (1) establishment of a regional gene bank to store all native plant seed samples; (2) carrying out systematic seed collection by specialized working groups supervised by a joint steering committee of specialized scientists at a regional level; and (3) carrying out evaluation research and adaptation trials on the prominent and promising species in the specialized national centres, to select superior genetic resources and to experiment and identify appropriate techniques for seed propagation. Seed collection and propagation assignments should also be undertaken in cooperation with the private sector, seed companies and native citizens. Incentives, mainly financial assistance and/or supplies should be made available.

Nevertheless, Hemmas, protected areas and in situ conservation sites should be fully preserved by all possible means. They constitute living gene banks and a persistent source of seeds.

INTRODUCTION

North Africa is an extensive and ecologically very diversified region. It covers from the Red Sea in the east to the Atlantic Ocean in the west, about 7 million km^2. Its countries, Egypt, Libya, Tunisia, Algeria, Morocco and Mauritania border and embrace a great portion of the Sahara desert. The northern natural borders of the region, except for Mauritania, are formed by the Mediterranean Sea, with its coasts extending from Egypt to Morocco, over thousands of kilometers.

The region, by its location, forms a peculiar geographic unit, with diverse climates, topography and landscape. It is influenced, generally, except for Mauritania, by the Mediterranean climate. All Mediterranean bioclimatic zones (*étages*), Saharan, arid, semi-arid, semi-humid and humid are found in North Africa (Emberger 1956). Precipitation in such bioclimates is concentrated in the cold period of the year, while summer is hot and dry. The greatest portion of the region, however, is dominated by the Saharan bioclimates characterized by very low precipitation, where

several years may elapse without a single rain storm. The thermal regimes, in such areas are quite continental. They show great thermal differences between summer and winter and day and night, respectively.

Climatic regimes may interact in many places. For instance, the Al-Hoggar Mountains, in the Algerian Sahara, are influenced by both the Mediterranean and the Tropical rain storms. Parts of Morocco are influenced by the Atlantic Ocean, while Mauritania is dominated by the Swahilian bioclimates, with summer rainfall and dry winters.

Generally, drought dominates the greatest portion of the region and 96% of its terrains receive less than 400 mm of rainfall per annum. Consequently, rangelands are extensive and expand over more than 130 million ha.

North Africa is considered one of the main centres of drought-resistant plant biodiversity. It has more than 5 000 plant species, 2 000 of which are xerophytes and well adapted to the arid and Saharan areas. Even in a small country like Tunisia, nearly 1,300 xerophytic species are recorded in 140 thousand km^2, that represent the semi-arid areas.

The diversity of the ecosystems, all over the region, in terms of precipitation, climatic variations, topographic features, soil types and salinity gradients are great and have structured the evolution of their biodiversity. As a result, the native plant cover though fragile, becomes one of the most important renewable natural resources. The plant cover of the rangelands forms a wide desertification control front, plays a major role in the ecological equilibria, conserves soil, provides wildlife refuge, offers the greatest portion of forage and the needed fuel wood and shapes the socio-economic life of the inhabitants. Many arid zone plants are also utilized for medicinal purposes as well as for industrial and agricultural use. In summary, range plants are a symbol of life in the marginal and arid areas of the region and as plant cover is progressively increased the human activities are increased and vice versa.

Wild plants possess wider genetic bases and have accumulated richer biodiversity. Their evolution in terms of adaptation to changing environments and ecological variations is more active as compared to many domesticated plants. Consequently, they hold future strategic importance for breeding and production of new types and varieties having the required characteristics, mainly high productivity and stress and pest tolerance.

All studies that ahve been reviewed indicate that North African rangelands have been increasingly exposed to severe deterioration since the beginning of the 20th century. This was caused by overgrazing, the cutting of trees and shrubs for heating and cooking purposes, horizontal expansion of crop cultivation, mainly cereals, into the marginal lands, sloping terrain, and shallow and sandy soils, all of which have low productivity and are highly susceptible to erosion.

Degradation levels in many areas have reached the state of desertification. This has been expressed ecologically in the form of soil erosion, genetic erosion, loss of palatable plant species and extreme reduction of plant biodiversity. Economically it has been expressed by low ecosystem productivity, increased protection and maintenance costs for establishments and infrastructures, especially against sand encroachment.

Degradation and desertification have consequently reduced the income of range users, mainly livestock producers, creating mass immigration waves into cities, thus, creating in turn social and economic difficulties.

The countries of the region have exerted great efforts, during the last decades, to conserve and improve rangelands. These efforts have been demonstrated by the plantation of forage shrubs, mainly *Atriplex* and *Acacia* spp., introduced from ecologically equivalent areas of the world. The

main reasons for the dependency of national programmes on the introduced species are the following:

- lack of the necessary information on breeding, plantation and management of local range plants;
- the relative ease of raising and propagating the introduced plant species and their rapid growth in comparison with local plant species; and
- unavailability of local range plant seeds in large enough quantities to satisfy the requirements of the rangeland development programmes.

With time, rangeland specialists have recognized the importance of the local range plants. Consequently, several specialized research establishments were created, conferences organized and many exploration trips carried out to survey range plant genetic resources in the countries of the region.

Current range improvement programmes are still dependent, to a large extent, on introduced species, shrubs and herbaceous plants for the arid and semi arid areas, respectively. This trend is still growing, in spite of the value and importance of native wild range plants and rangelands, and in spite of the growing interest in the concerned countries to develop their range resources. This is expressed in the increased range improvement and revegetation activities, or in the fields of scientific research.

The introduction of exotic plants creates many constraints and drains part of the developmental foreign stocks, thus accelerating the process of genetic erosion and loss of genetic biodiversity.

The foregoing discussion stresses the importance of the conservation of range plant genetic resources, not merely for economic reasons, but rather for their importance in the ecological equilibria and desertification control in the countries of the region.

The collection, conservation, description and evaluation of plant genetic resources require huge and costly efforts which are not available to concerned local institutions. The formulation of joint bases to coordinate efforts in a sub-regional programme would help achieve the above targets. The programme should aim to achieve the following objectives:

Immediate objectives:

1. Conservation and protection of range plant genetic resources in the countries of North Africa and storage of their seeds in a semi-regional seed bank.
2. Evaluation, characterization and documentation of the important range plants and identification of their ecological requirements.
3. Production and utilization of the improved range plant seeds to revegetate deteriorated rangelands by the national programmes and to create seed self-sufficiency.
4. Coordination of efforts and utilization of the local experiences and seeds at national and regional levels.
5. Training and recruiting of specialized staff in the field of collection, evaluation and conservation of plant genetic resources and seed production.

Long-term objectives:

1. Conservation of soil surface and protection of rangelands against desertification by maintaining proper plant covers.

2. Enhancing the efficiency of rangeland productivity.
3. *Improvement of* livestock production and revenues from the rangelands.
4. Improvement of the microclimate and rehabilitation of the arid zones ecosystems and their wildlife productivity.

RANGELANDS OF NORTH AFRICA

General information

Estimations of the rangeland areas in North Africa have varied between different sources and references. Al-Haddari (1992) attributed such differences to the lack of a unified terminology for the rangeland term itself. Rangeland statistics have not been substantiated or verified, and many rangelands are continuously converted into cultivated areas. However, if the current rangelands are grouped together with permanent fallow lands in areas in between the 400 mm of rainfall per annum isohyet and the desert, then rangelands would total about 130 million ha.

Table 1. Rangeland areas in the countries of North Africa.

Country	Total area Km^2	Rangelands (1000 ha)	Reference
Egypt	1,002 000	4 000	Al-Shorbagi (1988)
Libya	1,760 000	22,325	Ben-Mohamed (1990)
Tunisia	165 000	5,500	Ben-Mohamed (1992)
Algeria	2,381,740	31,615	Al-Shorbagi (1988)
Morocco	659,970	28,093	Al-Haddari (1992)
Mauritania	1,131 000	40,025	Weld-Ali (1989)

Rangelands in North Africa are mainly steppes, dominated by shrubs and sub-shrubs of no more than 1 metre in height. Exceptions are found in wadies, where flood waters accumulate or at higher elevations where precipitation increases and livestock numbers decrease. In Mauritania, however, plant cover, especially in the south is formed of a thorny savanna or a savanna type dominated by *Acacia* spp.

Plant cover and number of species in North Africa decreases with the gradual decrease of precipitation from north to south, until plant cover vanishes on the mobile sands or on the desert skeletal soils, al-Hammada-type. The reverse, however is true in Mauritania, where precipitation and plant cover increase from north to south. The Al-Hoggar mountains in the middle of the Algerian Sahara support a northern and southern transitional plant life and flora. Arboreal elements and relics are found at high elevations. The Al-Hoggar mountains have few rainy thunder storms either of Mediterranean or Monsoon origins.

In addition to the direct influence of precipitation on vegetation composition and plant cover, other ecogeographical influences are exerted in specific belts, or areas. The most important of which are maritime influences of the Mediterranean sea, Atlantic Ocean and Red Sea, that are mainly illustrated by relatively higher humidity and favorable thermal regimes. An example of such influences, on tree distribution, is *Argania spinonsa* distribution, southwest of Morocco, which is strongly influenced by climatic factors that are directly related to the Atlantic Ocean effects.

The nature of the soil and its types, patterns of flood water and topography play a major role in the characterization of vegetation types and plant cover productivity. Generally, vegetation is sparse in the hills having skeletal or shallow soils, but becomes dense, taller, diverse and productive in wadies, basins and low laying lands. In saline soils and saline sinks vegetation becomes dominated by salt tolerant plants and halophytes, respectively.

Seasonal and yearly fluctuations in precipitation and other correlated weather components also make rangeland productivity quite variable, ranging between 50 to 150 and 250 to 350 kg/ha in the arid and semi-arid areas, respectively.

In addition to the above factors and influences, plant cover and productivity are modified successively by humans and livestock, utilization types, seasonal grazing patterns and intensities. Areas which are more subjected to human and livestock pressure have deteriorated greatly in comparison with similar areas subjected to low utilization intensity regimes. Generally, degradation at its extreme limits is noticed in the vicinity of populated centres that are located in more favourable areas, mainly in the coastal regions, mountains with good rainfall and areas with ample water resources.

The important vegetation types

The vegetation types in the region result from the positive and negative interactions between all the factors mentioned earlier, and many others. This would explain the enormous variation in plant cover types, their nature, structure, function, and dynamics. The most important plant cover types in the region are:

- The woodland vegetation types:

  These types form a mosaic of successional stages, resulting from various types of overuse that has occurred over centuries in the forests. These types, however, still include tree components, mainly *Pinus halepensis*, *Juniperus phoenicia*, *Pistacia atlantica*, *Olea europaea*, *Acacia tortilis*, *Quercus* spp. or *Argania spinosa*. The last tree species, covers the coastal semi-arid and arid areas, south-west of Morocco, occupying about 1.5 million ha.

- The steppe vegetation types:

  These vegetation types characterize rangeland areas that receive less than 400 mm of rainfall per annum. The most important types of which are:

  Stipa tenacissima steppe:
  This steppe extends over wide stretches of lands: undulating plains, plateaus, and mountain foothills and slopes at elevations varying between 100 and 800 metres above sea level, in areas that vary between the 100 and 300 mm precipitation isohyets. *Stipa tenacissima* steppe lands stretch from the east of Morocco to the Nafoussa Mountains in Libya.

The most important plant species of this degraded vegetation type are: *Atractylis serratuloides*, *Noaea mucronata* and *Plantago albicans*.

Artemisia herba-alba steppe:
This vegetation type is found at the higher plateaus in Morocco, Algeria, Tunisia and Libya. It grows in clay loam and silty clay soil types. The following species are associated with *Artemisia herba-alba*; *Stipa tenacissima* and *Lygeum spartum*. Presence of *Hammada scoparia* (*Haloxylon articulatum*) is considered a degradation indicator in this vegetation type.

Rhanterium suaveolens steppe:
This vegetation type flourishes in the Mediterranean-type very arid areas (100-200 mm rainfall per annum) with warm or hot winters, on calcareous silty soils, overstrated by a sandy layer, having different depths. *Rhanterium suaveolens* is associated with the following species:

Helianthemum lippii var. *sessiliflorum*, *Stipa lagascae*, *Salsola* and *Thymelaea microphylla*. If this vegetation type is disturbed, the sandy surface becomes eroded and the skeletal soils that are left are sparsely covered by plant invaders such as *Artemisia campestris* and *Astragalus armatus*. In areas of sand accumulation and dunes, psammophytes, mainly *Stipagrostis pungens* and *Retama raetam* thrive sporadically.

Hammada schimittiana and *Anthyllis henoniana* steppe:
This vegetation type is found on sandy soils overlaying a calcareous stratum in the lower arid and upper Saharan areas. The most important plant species that grow in this vegetation type are: *Stipa* lagascae, *Farsetia aegyptiaca* and *Gymnocarpos decander*. The first and the third species are palatable.

- The gypsaceous range types:

  Several vegetation types originate from either *Stipa tenacissima*, *Rhanterim suaveolens* and *Hammada schmitiana* or *Traganum nudatum* steppe are found on the present day eroded gypsaceous soils. *Lygeum spartum* is the main component of these types.

  A gypsophilous species, *Anarhinum brevifolium* is endemic to the Tunisian arid areas and it is well associated with these vegetation types, which were characterized by the following species: *Traganum nudatum* and *salsola vermiculata* var. *villosa* which are good browse plants. The palatable species are replaced by unpalatable plants, mainly *Zygophyllum album* and *Reaumeria vermiculata*.

- Arid gypsiferous sandy range types:

  These are dominated by a chenopodiaceous shrub, *Salsola sieberi* (*S. zygophylla*). This species may dominate the skeletal soils as well.

- Saline soil range types:

  These range types are characterized by the following shrubs: *Suaeda fruticosa*, *Atriplex halimus*, *Limoniastrum guyonianum* and *Salsola tetragona*.

- Highly saline soil plant communities:

The most important halophytes of these plant communities are: *Salicornia arabica*, *Arthrocnemum indicum*, *Halocnemum strobilaceum* and *Atriplex mollis*.

- Sandy soil rangeland vegetation: These are divided into several vegetation subtypes. The most important of which are:

  Calligonum spp. subtype:
  It is characterized by the presence of two *Calligonum* spp., *C.azel* and *C.arich*. Both species grow on sand dunes or mobile sands.

  Stipagrostis and *Ephedra* subtype:
  It is characterized by the presence of a perennial grass, *Stipagrostis pungens*, and a shrub, *Ephedra alata*. These grow on sands covering a rocky substratum. *Genista saharae* may be found in this subtype as well.

  Calligonum comosum and Helianthemum brachypodium subtype:
  It is found on rocky lands covered with sand. The following species are the main components of the vegetation: *Calligonum comosum*, and *Oudneya africana*.

- Wadies rangelands:

  Many wadies collect run-off water from large catchments at a rate that varies between 3 to 10 times higher or more than the actual precipitation of the area concerned, at spaced intervals. Wadis consequently, support arboreal, shrubs and grass rich vegetation. The most important

tree elements in the wadies' vegetation are: *Acacia tortilis Acacia seyal*, *Maerua crassifolia* and *Balanites aegytiaca*. The last three tree species grow in Mauritania more than in other North African countries. The shrubs' elements are composed mainly from *Rhus tripartita*, *Retama raetam*, *Ziryphus lotus* and *Artriples halimus*.

- Mauritanian rangelands:

  Because of tropical climatic affinity and differences, the tropical desert and arid rangeland vegetations of Mauritania are quite different from those found in the other North African countries. The major soil groups are different as well, being sandy with variable substrata, and subject to severe wind erosion.

  The dominant and prominent tree species are, *Acacia tortilis* subsp. *raddiana*, *A. senegal*, *A. seyal* , *A. flava*, *A. nilotica*, *A. albida*, *Hyphane thebaica*, *Salvadora persica*, *Balanities aegyptiaca*, *Maerua crassifolia* and *Commiphore africana*. There are many shrubs, the most important of which are: *Capparis decidua*, *Euphorbia balsamifera*, *Leptadenia phyrotechnica*, *Zizyphus mauritanica* and *Grewia tenax*. Tree understory and gaps are dominated by many perennial and annual grasses: *Panicum turgidum*, *Cenchrus ciliaris*, *Stipagrotis pungens*, *Stipagrostis plumosa*, *Lasiurus hirsutus*, *Schoenefeldia gracilis*, *Enneapogon desvauxii* are just examples. These grasses are replaced as a result of overgrazing in the degraded rangelands by a short living and harsh annual grass, *Cenchrus biflorus*.

THE DEGRADATION OF RANGELANDS: CAUSES AND EFFECTS

Al-Shobagi (1988) estimated that 70% of the Arabian rangelands had been destroyed or had become very degraded, while the productive rangelands were no more than 30%. Ratios of degraded and productive rangelands would agree with the former accounts, and all studies and eco-indicators in the region confirm the current status of continuous degradation. The causes of such degradation are:

- horizontal expansion of agriculture over the richest range sites, without adoption of the proper mechanization techniques;
- overgrazing; and
- uprooting of shrubs, cutting of trees and uncontrolled fires.

1. *Horizontal expansion of agriculture*: The settling of an increasing number of bedouins and marginal land users having strong motives toward land ownership with an increasing desire toward consumption and merchandise acquisition have led to a massive horizontal expansion of agriculture on the most productive rangelands. Expansion of agriculture and mechanization have accelerated the eradication rates of range plants. For example, agriculture had extended into the marginal lands between 1890 and 1975 over 270 000 hectars in Tunisia, while in Morocco it widened from 70 600 to 83 000 km^2 between 1960 and 1985, respectively. This represents an 18 % increase during a quarter of a century.

Cultivation expansion increases usually during wet years, and it extends further and further to increasingly marginal lands to compensate for the decreasing agricultural return.

In addition to these negative effects of agricultural expansion into the marginal lands, especially the sandy and erodible habitats, such practices would cause a continuous decrease in plant biodiversity and cover (Table 2).

Table 2. Plant cover and species number in *Rhanterium suaveolens* steppe before and after cultivation (Floret & Pontanier 1992).

Number of native plant species	Rhanterium cover (%)	Cereals cover (%)	Plant cover (%)	Cover and *species number* Utilization type
39	17	0	25	Grazing
13	2	0.5	5	Cultivation

2. *Overgrazing*: Rational rangeland management requires a visible balance between livestock feed requirements and the available forage and feed resources. However, it is not an easy task to substantiate or confirm the balanced feed budget in the desert, arid and semi-arid rangelands. Several factors contribute to such difficulties. The most important contributing factors are: (a) social, namely the nature of land ownership (private, socialistic, governmental, etc.,), (b) grazing patterns (sedentary, transhumance, nomadic, etc.), (c) ecological, namely precipitation fluctuations which make productivity estimation of rangelands rather difficult, and (d) interactional. The last factor represents the extent that forest lands and other feed resources would contribute to such budget. Mobility of flocks in time and space is an additional factor to be considered in the calculation processes.

Rangelands in North Africa are increasingly subjected to overgrazing pressure as many studies have indicated. This is because rangelands are decreasing in area while livestock numbers are increasing. Sheep numbers for instance, have increased by 40%, during 1966 and 1980, in Tunisia, Algeria and Morocco. Libya represents a peculiar case, where sheep numbers have doubled 10 times during 1943 and 1980. Cattle numbers in Mauritania have increased from 0.25 million since independence to 2.3 million in 1968. As a result of the increasing imbalance between feed requirements and the decreasing range production, the feed gap is widening. The shortages, however, vary between countries, areas and sites within each country and within years. Shortages are minor in wet years, but they increase a lot during dry years.

As indicated before, overgrazing leads to a continuous decrease in plant cover and size. Palatable plants, decrease gradually from the rangeland till they vanish as overgrazing reaches critical levels. They are replaced by groups of invading plant species, which are low in productivity, size, and plant cover (Table 3). Many invaders are spiny: *Astragalus armatus*, *Atractylis serratuloides* and *Calicotome villosa* are examples. Others may have low palatability, namely, *Cleome ambylocarpa*, *Hammada scoparia*, *Hertia cheirifolia* and *Asphodelus microcarpus*.

Table 3. Biomass and biodiversity in response to grazing and state of degradation in *Rhanterium suaveolens* steppes. (PNUD/FAO 1979).

Type of steppe Index	Biomass (dry matter) kg/ha	Number of range plant species	Number of unpalatable plant species
Steppe in good condition	1,312	83	17
Steppe in poor condition	415	59	41

Other invading plant species are poisonous such as Calotropis procera, Hypericum triquetrifolium, Solanum nigrum and Thapsia garganica.

3. *The cutting of trees and uprooting of range plants*: Cutting and uprooting of range plants are increasingly practiced to secure, (a) fuel wood for heating and cooking purposes, (b) wood and shrubs for the construction of fences and animal shelters, and (c) plants for medicinal and industrial uses.

Plant communities near populated areas and roads are more affected by the formerly mentioned degradation factors. Generally, woody plants are more subjected to cutting, uprooting and goat grazing than the herbaceous plants which are more subjected to sheep grazing.

Degradation factors affect both plant cover and soil, collectively and interactionally. Consequently, soils become increasingly open to erosion processes till they reach the state of no return – the state of desertification.

In spite of the degradation and large scale desertification that is affecting the North African rangelands today, confidence is increasing to revegetate and manage rangelands rationally to increase productivity, plant cover and soil conservation. Ibn Mohamed (1990) estimated that rational rehabilitation practices may reclaim more than 35 million ha in Morocco, Algeria, Tunisia and Libya (Table 4).

Table 4. Estimation of rangeland areas capable for improvement and rehabilitation in Mauritania, Morocco, Algeria, Tunisia and Libya (Ibn Mohamed 1990).

Location	Management and rehabilitation practices	Area (100 ha)
Central	*Stipa* steppe improvement	1 000
	Other types of steppe improvement	10 000
	Plantation of forage shrubs	5000
Southern	Improvement and management of desert and semi-desert rangelands	16 000
	Plantation of forage shrubs	2 000
	Plantation of forage shrubs in the saline lands	1 000
Total		**35 000**

MAJOR ACHIEVEMENTS IN RANGELAND DEVELOPMENT AND DESERTIFICATION CONTROL IN THE NORTH AFRICAN COUNTRIES

Since their independence the North African countries have exerted great efforts and made extensive investments to develop the degraded rangelands, control desertification and restore the ecological balance. The following summarizes the major accomplishments in this field.

Mauritania

The desertification control programme in Mauritania was finalized, as regards general principles, in 1986, following the discovery that more than 73 million ha were already desertified (Ben Mohamed 1992; Sankary 1994). An additional 10–15 million ha are threatened today as well, especially in areas receiving less than 200 mm of rainfall per annum. The first Mauritanian programmes to face droughts were started following the great Sahelian drought. At that time the Nouakchott green belt was initiated. Then several additional programmes have been initiated (Diam and Siaw 1986). The most important of which were: (a) afforestation of the formerly depleted *Acacia senegal* forests, (b) sand dune fixation and (c) the green belts and the green poles.

These projects were started in 1983 to reforest 1500 ha with gum arabic trees, *Acacia senegal*. The others have aimed at sand dune fixation around Nouakchott, in the interior, and near the road of hope. As a result, more than 18 sites covering about 450 ha were planted. Mechanical techniques and plantation of psammophytes were employed. The most important species which were utilized to fix dunes were: *Prosopis juliflora*, *Acacia* spp., *Euphorbia balsamifera*, *Leptadenia pyrotechnica*, *Stipagrostis pungens*, and *Panicum turgidum*.

Morocco

Revegetation achievements to restore plant cover in the depleted areas of Morocco were many. The following is a summary of the accomplishments:

- Afforestation of 424 000 ha, 25 000 ha of which were planted in the arid areas with forage shrubs.
- Fixation of sand dunes in the coastal areas over an area of 26 000 ha.
- Fixation of sand dunes in the interior and surroundings of the Oasis over an area of 318 ha.
- Application of several rangeland protection and management systems, especially against uprooting, plowing and overgrazing, over an area of 185 000 ha.
- Management and improvement of watersheds and slopes in the mountainous areas.
- Planting of browse and forage shrubs and improvement of many types of rangelands, in several bioclimatic areas.
- Reseeding of 25 089 ha of the semi-arid and depleted rangelands with legumes and perennial grasses, mainly *Agropyron* spp. in al-Aried region.

Algeria

An enthusiastic programme to establish a green belt in Algeria, extending 1,500 km, from the Moroccan to the Tunisian borders, across the Saharian Atlas Mountains and the steppe areas (200–300mm of rainfall/annum) has been initiated since 1970 (The Algerian Ministry of Water, Environment and Forests 1989). Efforts in the first decade were concentrated on the plantation of *Pinus halepensis* trees over an area of 150 000 ha. In spite of the importance of *P. halepensis* in desertification control, wood production and greening of the road sides in the semiarid areas, it is found that the other species possess higher economic importance. The last species is pyropyhte and slow grower and can be damaged by insects. Consequently, and following the evaluation of the project, a new and integrated strategy for the green belt project has been formulated. Attention has been paid in depth to the communities of the neighborhood of each section of the green belt as to their needs and wishes. New activities have been incorporated in the project as well. For instance, afforestation using multi-purpose trees has been stressed. These includes fruit trees (*Pistacia vera*, *Amygdalus amygdalus*, *Olea europaea*, etc., wild stock, and forest trees. Agricultural development, water harvesting and water resources development have also been incorporated in the project.

Tunisia

A national afforestation and desertification control strategy was formulated in Tunisia in 1986. The strategy has enabled the country to achieve several accomplishments. The most important of which are:

- Afforestation of 270 000 ha during the first 30 years after independence.
- Application of proper management practices on 433 000 ha of *Stipa tenacissima* steppe.

- Application of rational management and specific improvement techniques on 20 x 10 ha of watersheds and slopes in mountainous areas.
- Plantation of forage shrubs on an area of 53 000 ha.
- Application of protection and livestock exclusion systems on 180 000 ha to enable vegetation to regenerate and be stocked as forage reserves in the dry years.
- Application of protection and sand dune fixation systems on 100 000 ha of sandy areas to protect oasis, populated areas, roads, water points and coastal areas from sand dune creep. (Ibn Mohamed 1992; Shagroun 1989; and Jalal 1989).

Libya

About 25 desertification control, range management and afforestation projects have been initiated in Libya, since 1975. These projects are approaching various completion stages (Sankary 1975; Sankary and Baiyoumi 1983; al-Haddari 1992, and ACSAD 1990).

The main projects have been concentrated in the north in the following regions:

- *The western region*: includes al-Jefarah Plain, Gharian Highlands and Bir Ayyad watershed.
- *The central region*: includes Messratah area, Weshtatah, al-Hishah, Gulf of Sirt rangelands, and al-Assah project for range improvement and camel breeding.
- *The eastern region*: includes Benghazi Plain and al-Akhaddar Mountain projects.

The main accomplishments achieved during the first 7 years were the following:

- Plantation of 62 million forage shrubs on an area of 60 000 ha.
- Reclamation and preparation and plantation of 190 000 ha to fruit and forest trees.
- Erection of enclosures and fences for rangeland protection and improvement over an area of 39 000 ha. Since then these have been expanded to reach more than a million ha.
- Digging and construction of water points, cisterns, and various types of rangeland dams.
- Reseeding depleted rangelands with annual legumes and perennial grasses over several thousands of ha.

Efforts towards sand dune fixation were started as early as 1950. The total land area, which has been fixed and afforested by forest trees, mainly *Eucalyptus* spp. and *Acacia cyanophylla* species, reached about 95 000 ha.

All the former projects have been extensified and diversified during 1980–1990. In addition to all previously mentioned efforts and money spent on improving rangelands and halting desertification encroachments, we should not ignore many achievements which have been made in the field of research, studies, training of local technicians, scientists and administrators, and supporting laws and regulations and the various efforts that were directed toward the organization of bedouin and grazing communities, etc.

MAJOR OBSTACLES OF RANGELAND DEVELOPMENT IN THE NORTH AFRICAN COUNTRIES

Owing to the continuous extenuation of rangeland areas, overgrazing, uprooting, randomized and irrational utilization, all efforts and expenses have increased but are still unsubstantial to face desertification, due to the following constraints:

- The majority of rangelands are located in areas receiving less than 400 mm of rainfall per annum, combined with fluctuating rainfall regimes. Consequently, these rangelands are poor, fragile and have low and fluctuating productivity levels. These levels of productivity vary between seasons/years, and according to former management practices and the bioclimatic regions.
- Weather variation, soil diversity and fragility and the consequent irregularities of rangeland productivity, are the major constraints which make it difficult planning for rangeland management by policy makers, economists, administrators and even by the rangemen themselves.
- Soil type productivity potentials and land use criteria are bounded by many factors, mainly: topography, soil depth, stratification, texture, and the physical and chemical properties of the soil. Generally, productive lands are selected with time for agriculture, while the marginal lands that possess low productivity levels are left for grazing. Marginal lands include saline soils, sabkhas, mountain tops and slopes, plateau slopes, skeltal soils, rocky lands, etc.
- The imbalance is further aggravated by continuous exclusion of the productive soil types from range utilization to agricultural utilization, mainly for fruit trees cultivation.
- The negative imbalance between carrying and production capacities in the rangelands would lead in the short run to gradual reduction of the flock return, and eventually to the destruction of the plant cover. The Libyan statistics of 1978 showed that livestock overstocking in the Libyan rangelands had reached a level of 2.3 million sheep units. Feed subsidies and support in several countries of the region have been shown to have two effects: (a) they have allowed range peoples to raise flock numbers far above the increase needed to overcome the critical periods, mainly drought and severe cold; and (b) they have encouraged them to reach the production capacities of the rangelands concerned.
- Private flock ownership and communal and open rangeland systems have been the major cause for the randomized and irrational utilization of the rangelands resources. Rangelands, unfortunately, have been utilized as a mine, regardless of the degradation and desertification hazards, that face these important resources in the long run.

In spite of the increased desertification control, rangeland improvement activities and the multi-disciplined projects allocated in each country, the fact remains that these projects are still unable to satisfy the growing needs and demands, and are not competent enough to reverse the trends.

These threatening and warning situations have been attributed to the following factors:

1. The increased shortage of available financial support in relation to the growing size of the problem.

2. Lack of an integrated view of the problem and shortage of studies. Detailed investigations prior to the formulation of rangeland projects were generally poor. Rangelands in many cases were dealt with as separate issues, regardless of their links to forests, cultivated lands, desertification hazards and human and animal population growth. Consequently, all factors related to the subject matter should be reconsidered and viewed at several levels, (a) range people, especially, in relation to the prevalent socio-economic complexity of the area, (b) the ecological regions which are under consideration, their resources and the desertification hazards which they face, and (c) the dynamic situation of the country as a whole.

3. The limited capabilities or the inefficiency of the public and communal agencies, caused many projects, that were brought into operation, to fail or hindered the projects in achieving the targeted goals.

4. Many of the projects were terminated as soon as their proposed duration was concluded. This was because, (a) the aims of the rangeland populations and societies, who were directly concerned with the developmental process, had not been consulted during the programming and execution of the projects, (b) the overall views for rational management of improved rangelands were either defective or insufficient, and (c) the absence of the needed awareness among the range people themselves, who believe that investments in the field of rangeland improvement are necessary and that the production capabilities of the concerned rangelands are endless.

In addition to the above ecological and socio-economical causes and reasons, the technical issues also formed major obstacles that hindered the progress of the rangeland improvement programmes.

The earlier dependency of most programmes on the plantation of introduced species was one of the main reasons for its failure. It becomes clear that the introduced plant species have either poor or limited adaptation and tolerance qualities in the marginal and the arid areas as compared with the native plants. This confirms both the value and importance of the native plant species, which should be conserved and studied from different points of view, especially in regard to their autecological aspects and characteristics. Such studies would identify the proper breeding, propagation and cultivation techniques. Genetic improvement in all cases is deemed necessary especially for improvement of both fast growth characteristics and ample production features.

RANGE PLANT SEED PRODUCTION IN THE COUNTRIES OF THE REGION

Collection, evaluation and distribution

Collection of range plant seeds is considered one of the most important necessities in the region. This is because the majority of the rangeland improvement programmes depend largely on reseeding and cultivation of depleted or degraded areas. In the semi-areas, several grass and legume species are used, namely grasses that belong to *Festuca*, *Agropyron*, *Bromus* and *Lolium* genera, and legumes that belong to *Hedysarum*, *Medicago* and *Trifolium* genera. The majority of the needed seeds are still imported annually. On the other hand, revegetation efforts, in the arid and desert areas, have concentrated on plantation of introduced forage shrubs. Currently, shrub seeds are being collected from earlier shrub stands cultivated to proper sites, mainly in the semi-arid areas.

Countries of the region have only just recently paid attention to the local range plants. The first organized collection endeavors started in the 1980s. Few of the collected species have been utilized in revegetation and decertification control programmes, the most important of which are; *Periploca laevigata*, *Rhus tripartitum*, *Atriplex halimus*, *Atriplex mollis*, *Atriplex glauca*, *Acacia tortilis* subsp. *radiana*, *Retama raetam* and *Artemisia herba-alba*. Yet, all of these efforts, have been meagerly effective, and most of the countries continue to import the majority of their forage seed species in order to carry out the improvement programmes.

The following summarizes the available findings on the subject in the countries of the region.

Morocco

Range and forage seed production in Morocco is becoming a focus of concern to halt desertification among many institutions. The most important of these are:

- *Range plant seed production centre at Media*: This centre was established in 1976 in cooperation with FAO, at Media near Wazan to produce range and forage plant seeds, mainly grasses and legumes to enhance forage production in the forest areas. Rainfall at al-Media fluctuates

around 750 mm of rainfall per annum and seed production over an area of 600 ha varies between 4 500 to 20 000 kg/year.

- *Range plant seed production centre at Khamies Matouh, Godaidah*: This centre was established in 1982, over an area of 214 ha, 50% of which is irrigated. The centre enjoys a semi-arid climate and has fertile soils. About 60 ha of the centre is allocated for tree and shrub seed production, mainly *Robinia pseudoacacia*, *Chamaecytisus albidus* and *Medicago arborea*. This centre has important facilities. It includes cultivation, harvesting and cleaning machinery, laboratory equipment and a gene bank. The bank contains more than 1 000 forage and range species and cultivar seed samples.

The centre produced 100 000 kg of annual forage legume and perennial grass seeds. Yet, the production level is far below the demanded quantities. Seed shortages represent the main obstacle that face reseeding programmes. The five-year plan for 1978–1982 had anticipated the cultivation of 132 000 ha, out of which only 4 000 ha were actually cultivated. To fill the gap in this field, Morocco tended to import 10–80 000 kg/year (Tazi 1992). Many introduced forage legumes and perennial grasses showed poor adaptation. This fact encourages the local institutions to collect, evaluate and breed local types and varieties to fulfil the requirements. Examples of these concerned institutions are: the Forage Section at the National Institute for Agricultural Research, the Al-Hassan the Second for Agriculture and Veterinary Sciences and the Section of Rangeland Reclamation at the Water and Forest Directorate.

Short and long-term seed storage facilities are available at all of these institutions. These storage facilities include; cold storage rooms, refrigerators and freezers. The total storage capacity is estimated at around 4 000 and 1 000 samples for medium-term and long-term storage, respectively.

Algeria

Concern and interest in local range and forage plant species in Algeria dates back to the early 1970s, where several studies on range plants were carried out by the National Institute for Agricultural Sciences' research staff at al-Horace (Abdel Guerfi 1988). Seeds of many legume species of *Trifolium*, *Medicago* and *Hedysarum*, and grass species of the genera *Festuca*, *Dactylis* and *Lolium* were introduced in cooperation with international institutions and organizations, mainly the International Centre for Agricultural Research in the Dry Areas (ICARDA), the French National Institute for Agricultural Research and the Australian Ministry of Agriculture. Shrub plantation and reseeding of rangelands were not initiated till the institution of the High Plateau Municipality for Steppe Lands Development in 1987, at Djelfa. Several introduced grass species were seeded or transplanted in the experimental or idealistic villages and projects. Later, more than a ton of arid zone shrub species seeds were introduced from the Arab Centre for Studies of Arid zones and Dry Lands (ACSAD) in Syria, during 1988 –1992. The main introduced species were; *Atriplex halimus*, *Atriplex lentiformis*, *Atriplex undulata* and *Salsola vermiculata*. The same municipality, has established five seed production farms, 10 ha each, in the semi-arid and arid bioclimatic zones in Algeria.

Among other interested institutions in the field of preservation, collection and propagation of range plant seeds and studies, are: the General Directorate of Forests, the National Agency for Conservation of Nature, the National Institutes for Agricultural Sciences at al-Horach, the Technical Institute for Extensive Agriculture (I.T.G.C) and the Technical Institute for Cattle and Sheep (I.T.E.B.O).

Tunisia

Like other countries of the region, Tunisia imports its greatest portion of range plant and forage seeds from abroad. Importation percentage during 1989–1990 reached 90% of the allotment. In

the current decade (1990–2001), Tunisia is attempting to rationally manage more than 2 million ha and to plant forage shrubs over 600 000 ha. To meet these ambitious plans and the anticipated needs, efforts in this speciality, should be extended to support the establishments, institutions and projects involved, some of the most important being:

- *Seed Production and Nurseries Centre, Directorate General of Forests:* The centre is active in forest tree and forage shrub seed collection, consulting, storage and distribution. However, the majority of the distributed seeds are of introduced origin.
- *Range and Forage Seeds Improvement Programme:* This is operated by the Livestock Breeding and Range Affording Department. The programme expects to carry out the following activities:
    - collection and evaluation of range and forage plants, in cooperation with the specialized Tunisian research establishments.
    - production of the institution seeds that are selected from promising species by specialized research establishments, and making them available to propagation agencies.
    - technical supervision of seed production agencies, and on-job training to fulfil .
- The National Institute for Forestry Research: This institute is interested in seed collection of both forest trees and forage shrubs and running research studies on their subjects.
- Forage Production Laboratory: This is supervised by the National Institute for Agricultural Sciences and it holds many forage seed samples.
- Seed bank of the Institute of Arid Lands at Medenine: This is the most specialized and experienced establishment in the field of native range plant seeds, collection, conservation, characterization and evaluation, at both national and regional levels. The seed bank was initiated in 1986 in cooperation with UNDP and UNEP. Its activities have concentrated on studies of native arid and desert area species, both biologically and ecologically. Seed technology of the important species has also been studied. Seed collections are made generally, from bioreserves and protected areas and herbarium samples for more than 100 multipurpose and rare species have been collected and deposited at the gene bank herbarium. All collected seed samples, for instance, Periploca and Rhus tripartita are made accessable to the specialized establishments to improve the plant cover of the rangelands.

Libya

Native plant seed collection activities were initiated in Libya just a few years ago. Some 1,800 ecotype seed samples of annual *Medicago* spp. were collected from 560 different sites and 300 varieties then collected during 1980 and 1984 (Alidrissi 1993). Native seed collections in Libya are made by various rangeland programmes of the Agricultural Research Centre and the General Directorate of Forest, Soil and Range stationed in Tripoli.

Seeds of the following rangeland species are currently being collected: Atriplex spp. Acacia tortilis subpp. radiana, Medicago spp. Retama raetam, Ceratonia siliqua, Periploca laevigata, Rhus tripartita, Artemisia herba-alba and Hammada shmittiana, etc. However, utilization of native species in revegetation and range improvement programmes, is limited to few species only.

Among the establishments interested in the processes of range plant genetic resources is the Technical Centre for Environmental Conservation in Tripoli.

Egypt

The Desert Research Institute of the Ministry of Agriculture and Reclamation also carries out collection missions. It has already collected seeds of about 30 local species many of which are perennial species. The most important of which are: *Atriplex* spp., *Periploca angustifolia*, *Helianthemum lippi*, *Artemisia herba-alba* and *Pituranthos tortuosus*.

Mauritania

The aims of the revegetation projects in Mauritania are basically concentrated on the problems of sand dunes fixation. Many local and introduced species are utilized, mainly *Prosopis juliflora* from USA and local *Acacia* spp., *Balanites aegyptiaca*, *Leptadenia pyrotechnica*, *Euphorbia balsamifera*, *Panicum turgidum* and *Stipagrostis pungens*. Seeds of these species are either collected from their native habitats or from an earlier plantation.

Development of the arid zone seed sector, particularly for range and forage species, depends on fulfilling the following qualifications and conditions:

- availability of a species possessing particular combinations of characteristics which enables it to become revegetated on a largest possible scale;
- a satisfactory demand for its seeds to render it commercially viable;
- availability of a workable legal and organizational framework for the sector;
- availability of both, the suitable ecological conditions and the necessary capabilities for seed production; and
- presence of well trained specialized technical staff.

Meeting these qualifications and conditions, especially the first, are deemed necessary to develop and promote the native plant seed sector, which has been either neglected or has received little attention. In addition, many native species are either not known or are endangered. Consequently, it is important to overcome the first obstacle, which represents the first hindrance for all necessary actions required for the collection and evaluation of genetic resources and then to propagate the superior plant materials.

Domesticated plant species have generally varied a lot and genetically narrowed in comparison with the wild ones. Wild species possess, in many cases, a formidable array of characteristics, that make just dealing with their seeds a difficult endeavor through all working stages, i.e. collection, cleaning, reseeding, germination and establishment. To solve these problems, research is required in many fields.

The above discussion clearly shows, that the range plant propagation sector should be supported by the following programmes:

- surveying, discovery and collection of all kinds, botanical varieties and subspecies and establishment of a gene bank;
- characterization and evaluation of all collected plant materials in order to breed superior genetic makeups that meet demands and requirements;
- development of appropriate methodologies to propagate seeds of promising species;
- discovery of the best storage conditions that extend seed longevity and control gene erosion, and discovery of the best techniques for germination, seeding and establishment; and
- arranging for qualifications of specialized staff.

EXCHANGE OF RANGE PLANT SEEDS AND INFORMATION BETWEEN THE

COUNTRIES OF THE REGION

The exchange of information and seeds between countries of the region, except for a few species that are exchanged for research purposes, is too limited. Species exchanged are generally limited to *Medicago* spp. *Dactylis glomerata*, *Cenchrus ciliaris* and *Hedysarum* spp. Levels of seed exchange activities between the countries are very low compared with levels that occur between each of these countries and international and regional organizations and establishments. The same is true between these countries and other countries abroad, mainly Australia and USA.

The lack of seed and information exchange within and between the countries of the region has been attributed to the following causes:

- the majority of the North African countries import their greatest portion of range and forage seeds that are needed for range development programmes;
- surplus quantities of range and forage plant seeds, simply are not available;
- native plant seeds are not readily available, and the few which are available are only in small quantities and mainly for research purposes; and
- coordinated efforts are insufficient at both national and regional levels.

Nevertheless, many factors show the need for strengthening cooperation between the countries of the region, the most important of which are: (a) the immediate need for increasing the amounts of range and forage plant seeds, in the countries of the region, (b) the enormous diversity of the ecological habitats in the region, (c) the presence of many establishments which are concerned with rangeland improvement programmes, and d) the great availability of human resources.

To improve the former situation, it is possible to activate seed and information exchange through a well organized and capable regional steering committee, that incorporates country representatives to coordinate efforts and activities of various establishments, organizations and teams.

PROMISING RANGE PLANTS IN THE NORTH AFRICAN COUNTRIES

North Africa is considered one of the most important centres for heat and drought tolerance biodiversity. A few thousand native plant species inhabit the region, many of which are xerophytes and flourish in the semi-arid, arid and desert areas. Each species has specific present and future importance and their presence in such extreme and harsh environments is in itself considered a symbol of life. However, the study will consider the most important wild plants that have specific features relevant to the field of range improvement (Nafati & al. 1986; Ben Mohamed 1990; and Sankary 1977). Wild plants are those plants which grow and propagate themselves easily in nature without interference from humans, while range plants are a group of wild plants that are utilized by livestock and form the most important source of natural feed. Grazing values of range plants, however, do not contradict the presence of additional uses and values, mainly medicinal, aromatic, fuel, wood production, apiculture, raw materials for specific industries, etc. Exclusion other than range plants from the scope of this study, does not mean they are valueless either ecologically or economically. Even the poisonous plants show or may show specific values.

Attention in this text is given to the perennial plant species. Annuals, on the other hand, have token importance in terms of soil conservation and their productivity is closely linked with the

fluctuating, seasonal and yearly distribution of rainfall. Absence of rain in a specific month or a season, mainly at germination and establishment season, would make their presence rather a rare phenomena. Yet, many annuals are able to grow, whenever their autecological requirements are prevailed. Generally, annual seed species stay dormant in the soil for much longer periods in comparison with many perennial species such as *Hammada*, *Haloylon* and *Salsola* spp. (Sankary 1971; 1977). Furthermore, rangeland ecologists and specialists have proved that annual species dominance phenomena, either in shrub steppe rangelands or woodlands, are considered as a major indication of rangeland degradation.

A plant species should have a combination of the following characteristics, in order to be classified in one of the major range plant groups (Sankary 1977):

- good or acceptable palatability, high or required feed value in the grazing plant community and ample production;
- good competitive ability against invaders and good growth compatibility with the decreasers and the increasers;
- reasonable propagation efficiency combined with an easy dispersal mechanism, in order to compensate the deprived effects of grazing;
- adaptation to the local extreme stresses; climatic, edaphic and biotic;
- resistance to pathogens and pests; and
- tolerance to grazing effects and trampling. However, a few rare and endemic species, though unpalatable, are considered in this study, as well. For instance, *Cupressus dupreziana*, of the al-Hoqqar mountains in the Algerian Sahara, represents an important endemic tree genetic resource useful for afforestation of specific habitats in the arid areas.

In view of the preceding approach, a priority list of 100 important species was compiled to serve the tasks of future seed collections in the region.

RECOMMENDATIONS

The last three decades had observed an increased concern for conservation of range plant genetic resources. The importance of the subject is well recognized, locally and internationally, for its ecological, economic and social magnitude on the one hand and for the continuous decrease in the plant biodiversity on the other. Biodiversity is decreasing in the region as a result of increased pressure on the environment and the irrational management of the natural resources, especially in the arid areas and desert lands.

However, many genetic resources conservation methods have developed in the world (Homaid 1988), two of which could be followed in North Africa: (a) *in situ* conservation method, and (b) gene bank method.

- in situ conservation and preservation of plant genetic resources in North Africa

Protected natural areas, bioreserves and national parks play important roles in genetic resource conservation, maintaining the ecological balance and preserving representative samples of native habitats. Conservation, however, has additional economic, ecological and agricultural values and targets, such as tourism, recreation, and agricultural development. Other activities that do not disturb the ecological balance may be added.

Generally, bioreserves and protected areas have special importance, especially in the fragile arid and desert ecosystems that are increasingly subjected to overutilization, degradation and desertification.

In situ conservation technique is facilitated in North Africa by the presence of protected areas. This will serve the following purposes:

- protection of plant species, especially, endemics, rare and endangered ones, whose propagation and cultivation techniques are, not yet known. For instance, *Cupressus dupreziana* at Tassili Reserve, in the al-Quaqqar Mountains in the Sahara, south of Algeria is well preserved for future propagation and utilization in the region.
- preservation of an array of genetic resources of each conserved species. This would help maintain biodiversity and assure the continuity of the evolution processes in interaction with the prevailing ecological factors, especially in the cross-pollinated plant species.
- provision of a continuous source of the required seeds.
- protection of areas as useful sites for the required seed production for rangeland improvement and revegatation at minimum possible cost. The economic return from *in situ* seed production of *Acacia tortilis*, in Bou-Hadma's Reserve, in central Tunisia, is far superior than the return secured from artificial plantation.

  Nevertheless, the protected areas and bioreserves do not contain all available races and ecotypes of any species in its entire geographical distribution area. Consequently, such areas would conserve only a partial sample of the biodiversity.

  Protected areas and bioreserves, though practical, are subjected to many hazards, mainly fire, expansion of agriculture, and the limitations of laws and guarding capabilities. Such areas need to be protected by fences and guards and by issuing legal and legislative orders. The conservation of the areas should be complemented by the establishment of a genebank.

- Genebank establishment in North Africa

Genetic resources collection, conservation, characterization, evaluation and improvement require extensive and costly efforts that are not readily available to many local institutions in the countries concerned. Consequently, the coordination of efforts and information exchange between various concerned establishments in the region in the form of a gene bank is a must, in order to fulfill these tasks.

The genebank should contain the basic seed collections with the aim of providing a necessary seed reserve of native plants that possess actual and potential values, especially those plants that are either endangered or threatened with extinction.

Seed samples should be stored in the gene bank in sealed cans under thermal regimes of

-4°C and -8°C, for medium and long storage duration, respectively. Seed containers would be opened at 5–10 year intervals to test viability. All data and information obtained for each entry should be preserved for future consideration (Appendix No.3).

Living plant collections for all species which could be planted and improved should be established. These collections should emphasize more on those seed species that show either short longevity, storage difficulties, or genetic erosion during storage.

It is recommended that the location of the genebank should be carefully selected to fulfil the following requirements:

- availability of specific conditions, mainly the proper site or sites, irrigation water and facilities, trained labor and skilled technicians.
- availability of trained research staff, mainly in the field of genetic resources conservation, propagation and breeding. Professionals from all countries of the region could be selected and appointed on a competitive basis.

- availability of all conditions needed to ensure the continuity and functional efficiency of the genebank.

It is useful to situate the genebank in a country having a central position in the region.

Collection and conservation would not be sufficiently effective unless characterization and evaluation are carried out systematically to select the best types, then to breed and propagate them for proper utilization in the revegetation programmes.

It is true that all species to be propagated should undergo characterization, evaluation and selection stages (Crawford & Auricht 1993), but the urgent need to achieve substantial progress in the revegetation and desertification control programmes in the region requires an urgent propagation of the promising species in parallel at all stages.

It is important, however, to note that progress achievements in the breeding programme of any specific species should not mask the need for further research to find better species in terms of adaptation and economic value.

National centres should carry the task of selection and propagation of the superior genotypes within each country, and each should conserve active and eco-equivalent collections of the important species that are deemed necessary for plant cover improvement, in accordance with its own climatic characteristics. Each national Centre should also have living collections of the most important genetic resources, which could be utilized for diverse purposes, mainly research, tourism, etc.

Genetic resources collection and evaluation should progress at three levels, namely:

(1) survey completion and seed collection of all native plants of the dry areas. The collected seeds should be stored in a unified gene bank.

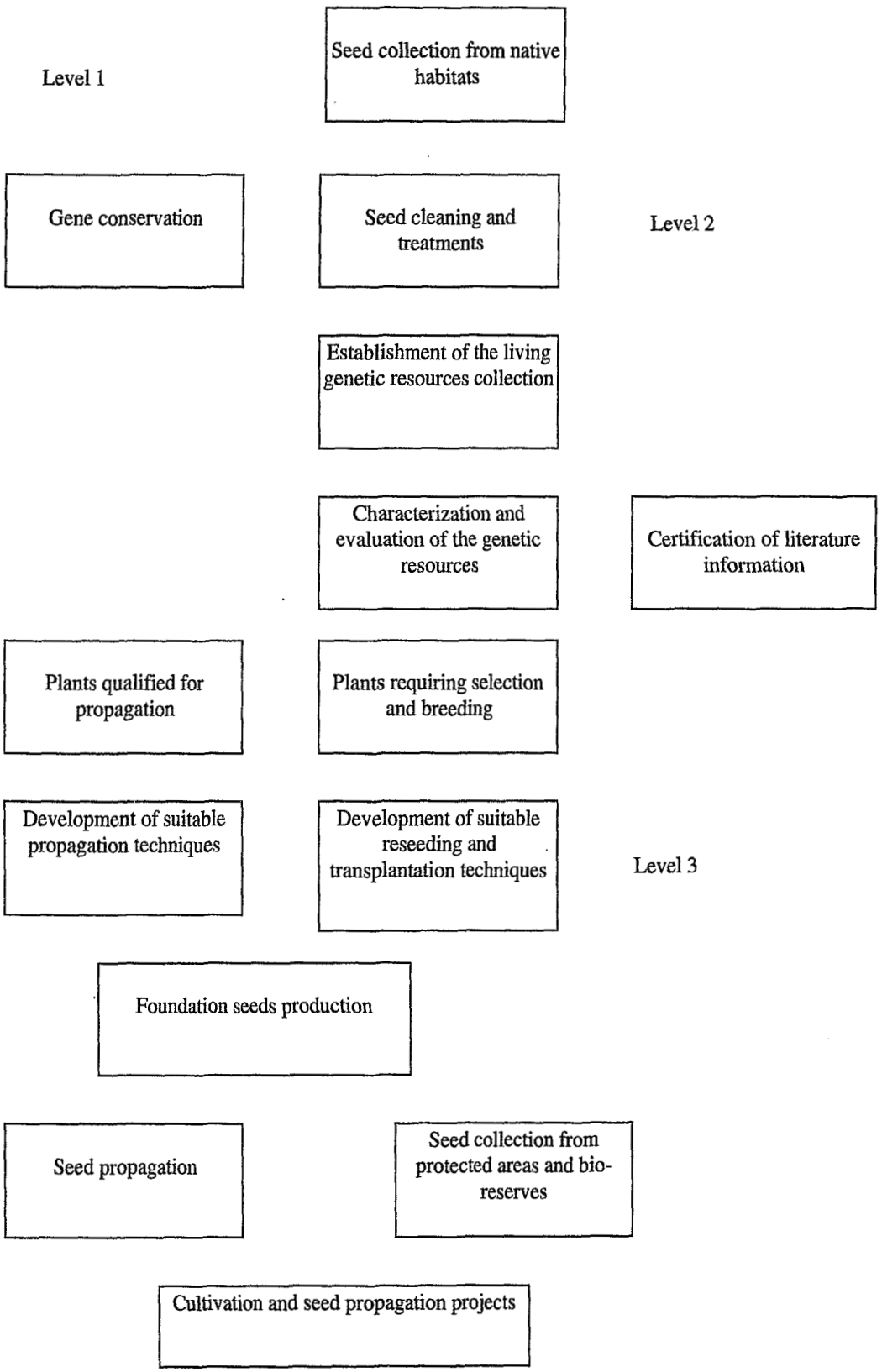
(2) research on the most promising species in each country's specialized national centres scientific tasks could be fulfilled as well, with the assistance of specialized subcontractors.

(3) selection and propagation of the evaluated and characterized superior genetic materials by the national centres, keeping the following in mind:

- range adaptability in correlation with the dominant local ecological factors;
- site evaluation for either seeding or transplantation and proper species combinations;
- optimal timing for seeding and transplantation, seeding depth and the simplest techniques for seed bed preparation;
- treatments or pretreatments that are necessary to hasten seed germination; and
- proper and rational techniques for improved range management.

It is possible to summarize the various collection and propagation stages diagrammatically as shown in Fig. 1.

FIGURE 1. Collection and Propagation Stages



The first and second levels of the programme would be achieved by specialized research institutions, but seed collection and propagation would be done with the help of the private sectors. This is to speed up the process and to provide it with the necessary dynamic actions, that are usually lacking in the governmental sectors. Generally, seed collections and propagation of the promising species could be managed by: (a) special seed offices or special units, (b) specialized companies, (c) private firms, and (d) range people and forage producers.

Incentives in the form of payments or food and feed grants should be provided by both seed collectors and farmers. Specialized institutions should supervise and control the procedures in order to prevent over collection from the native habitats and to provide the right ecological conditions to avoid genetic erosion.

The propagated plants would be used in the revegetation programmes, yet production of large quantities of seeds requires proper selection of the propagation sites, both in the semi-arid and marginal areas to fit the ecological requirements and to harvest the highest possible seed yields. Supplementary irrigation could be used in the dry years, only on mother plants, originally produced from harvests obtained from arid or very arid habitats and selected for their particular merits. All precautions should be taken and considered to avoid the genetic shifts.

Additional agricultural practices, mainly fertilization, weed control in specific cases to avoid unnecessary competition, and specific harvesting practices are required for high quantity and quality seed production.

The deposited seed samples in the gene bank, should primarily be collected by exploration teams, that explore the various fragile habitats of the region. National teams could carry out the tasks, yet coordination with the regional team is necessary to fulfill the gene bank objectives. Iso-samples, however, could be deposited in the national genetic resources centres, as well.

The exploration teams should collect seed samples, large enough to meet all the experimentation and cooperating agencies' needs. Size of the seed samples depends as well on the pollination mechanisms and the genetic homogeneity of the concerned ecotype.

Generally, genetic diversity increases as the size of the seed sample increases, but the storage capacity of the cooling units is the limiting factor that decides actually the sample size. According to (IBPGR 1995), a seed sample of a few thousand is satisfactory. The collection sheets should be filled directly during the collection trips. (Appendix No.3). Materials and tools for seed collection missions, and conditions necessary to make the missions successful are shown in Appendix No.5.

Initiation of a gene bank requires huge material and human capabilities. The exact manpower needed to run the gene bank, however, is difficult to estimate, but the supervising team should include researchers in the following fields:

- seed physiology and seed testing
- genetics and quantative genetics
- plant taxonomy
- computers
- plant pathology
- maintenance and repair specialists

The gene bank should have the following buildings and facilities:

- cooled storage rooms and refrigerators
- seed cleaning and seed treating chambers

- researchers' office and laboratory spaces
- seed drying chamber and store
- seed testing laboratories and a herbarium
- machinery, agricultural equipment and irrigation facilities.
- conditioned green house
- transportation, and trucking vehicles.

Buildings, storage rooms and laboratories should have the following safety and security measures:

- an additional electricity source that operates promptly at any power failure.
- additional cooling compressors that automatically operate in case of any cooling failure.
- precautions to prevent and control fire should be provided. Equipment to control lighting hazards should be installed as well.

Periodic maintenance should be carried out and a good supply of spare parts should be provided. Well trained and efficient technicians who are capable of using safety equipment and tools should be appointed.

Building designs and the installation of cold chambers should have specific and standardized specifications.

Protection from local environmental conditions, mainly direct sunlight flux should be considered during both design and installation.

Due to the physiological and morphological peculiarities of wild seeds, special attention to the selection and maintenance of seed treatments as well as to cleaning equipment and machines.

Seed management starting from collection, cleaning and treatment and ending with seeding or transplantation could be done manually by simple tools or mechanically by advanced and sophisticated machinery. Each management approach, the manual and the mechanized has its own advantages and disadvantages. Imported machinery, however, has been designed for different seed types than those native to North Africa. This imposes on the national researchers and designers the urgent task of inventing or remodelling the necessary machines to suit the native seeds.

The stages, equipment and tools that are necessary to prepare seeds for storage in the gene bank are summarized below:

- seed threshing: this process differs a lot among plant species. Seeds of many species are separated easily upon drying, while many others require either rubbing or filiating. Few species, however, require specific types of threshing machines or tools.
- seed drying: several methods are used to dry seeds (ISTA 1995: Homaid 1988). The selection of a method depends on the available techniques, sample size, dominant climatic condition, as well as the economic considerations. Nevertheless, reducing and controlling seed moisture contents are generally less expensive than to control seed temperature in stores.

Solar energy is abundant in the region. Consequently, seed drying facilities and equipment are not needed, except for seeds to be stored for long duration at the gene bank.

- seed cleaning: cleaning is possible because native seeds are well differentiated, each with specific morphological and physical peculiarities (weight, density and dimensions). Seed surfaces also between species.

Seed cleaning is achieved by one of the following means:

- cleaning by sieves according to the seed shape, dimensions and thickness.
- cleaning by automatic separating sieved cylinders or discs.
- cleaning according to specific weight separating principles with blowing air.

Several apparatus are used for this purpose: (a) aerial sieving cleaner, (b) separating belt cleaner and (c) spiral separators.

- seed preparation for storage: Following cleaning and drying, seeds are moved to a sterilization chamber for treatment by insecticides and fungicides.

Appendix 1. Range plant genetic resources of basic and primary importance for collection and propagation in North Africa.

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Acacia abyssinica	Leguminosae	Qaraz	Tree	Egypt	Medium	-	-	Very sporadic
Acacia ehrenbergiana	Leguminosae	Sammar	Tree	Egypt Algeria and Mauritania	Medium	-	Good	Sporadic
Acacia etbaica	Leguminosae	A'arad,	Tree	Egypt	Medium	-	-	Very sporadic
Acacia gummifera	Leguminosae	Santt, Talh, Adol	Shrub or tree	Morocco	Medium	July August	Fair	-
Acacia laeta	Leguminosae	Santt,	Tree Sammar	Egypt Algeria	Medium	-	-	-
Acacia mellifera	Leguminosae	Talh, Santt a'asali	Tree	Egypt	Good	-	-	Very sporadic
Acacia nilotica	Leguminosae	Talh nili	Tree	Southern belt of Egypt, Libya Algeria and Mauritania	Medium	July August	Abundant	-
Acacia orfata	Laguminosae	Aorfot	Shrub	Egypt	Low-medium	-	-	Very sporadic

Botanical	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection
Acacia senegal	Leguminosae	Talh Senegali, Haishab, Awarwar	Tree	Egypt, Mauritania	Medium good	-	-	-
Acacia seyal	Leguminosae	Seyal Talh, Qaraz	Tree	Egypt, Algeria, Morocco & Mauritania	Medium	July-August	Abundant	-
Acacia tortilis ssp. *raddiana*	Leguminosae	Sammar, Talh	Tree	The whole region	Medium	July	Medium	Insects may destroy more than 50% of the seeds
Anthyllis sericea	Leguminosae	Gazder	Shrub	The whole region except Mauritania (arid & Saharan bioclimates)	Good	June	Fair	-
Argyrolobium uniflorum	Leguminosae	Feddiah, Ragigah, Balgroun	Annual	The whole region except Mauritania	Very good	May-June	Fair	90% of the seeds are hard
Astragalus armatus	Leguminosae	Qatad	Sub-Shrub	The whole region except Egypt & Mauritania (Semi-arid & Saharan areas)	Very low & spring. Grazed by Camels & goats	June	Low-fair	Seed scattering
Calicotome villosa	Leguminosae	Qandoul	Shrub	The whole region except Mauritania (semi-arid, arid & Saharan.	Very low, grazed by Camels & goats	May-June	Low-fair	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Ceratonia siliqua	Leguminosae	Khroub	Tree	The whole region except Mauritania (semi-arid areas & rarely in the arid areas)	Fair	July-August	Low	-
Chamaecytisus albidus	Leguminosae	-	Shrub	Semi-arid & arid areas of Morocco	Medium	-	-	-
Coronilla minima var. fruticans	Leguminosae	A'aqrabiah	Annual	Semi-arid & arid areas of Algeria & Morocco	Medium	-	-	-
Coronilla valentina	Leguminosae	A'aqrabiah	Shrub in Tunisia, Algeria	Semi-arid areas and Morocco.	Medium	-	-	-
Ebenus pinnata	Leguminosae	-	Herbaceous	The whole region except Mauritania (semi-arid & arid areas)	Good	-	-	-
Genista monosperma	Leguminosae	-	Shrub	Semi-arid & arid areas of Algeria & Morocco	Good	May	-	-
Genista sharae	Leguminosae	Sadedah	Shrub	Libya, Tunisia, Algeria & Morocco	Medium	July	Low	-
Lotophyllus argenteus	Leguminosae	-	Herbaceous	Semi-arid & arid areas of Tunisia & Algeria	Medium	-	-	-
Lotus creticus	Leguminosae	Khaita	Herbaceous	Semi-arid & arid areas of the region except Mauritania	High	May-June	Medium to high	Seeds are hard need special treatment before germination

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Medicago arborea	Leguminosae	Fossa shogaireih	Shrub	Semi-arid areas of Tunisia, Algeria & Morocco	High	June	Medium	-
Retama raetam	Leguminosae	Retem	Shrub	The arid areas of the region	Medium	July	Medium	Contains hard seeds
Prosopis stephaniana	Leguminosae	Yanbut, Kharainebah	Shrub	Egypt & Tunisia	Medium	July-November	Low	Contains hard seeds
Hedysarum argentatum	Leguminosae	Fawh	Herbaceous sub shrub	Endemic to Morocco	Medium	-	Low	-
Crotolaria saharae	Leguminosae	Folah, Ismett	Herbaceous	Morocco & Mauritania	Abundant	-	-	-
Cenchrus ciliaris	Gramineae	Kara' al-Ghorab, Saham, Raqmaa Dhanoub, Dhanoub-awbar	Perennial, Hemieryptophyte	Semi-arid & Saharan areas in the region	High	June-November	Abundant	Low fertility
Cymbopogon schoenanthus	Gramineae	Shaarat al-Torab, Idhkhor	Perennial grass	Common in the Saharan areas	Medium	-	-	-
Dactylis glomerata	Gramineae	Isbaeiah-motagama'a Qalaibah	Perennial grass	Semi-arid & arid areas of the region except Mauritania	High	June-July	Medium	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Digitaria commutata	Gramineae	Sebtt-al-dheib	Perennial grass	Semi-arid & arid areas of the region	Medium	July	Medium	-
Hyparrhenia hirta	Gramineae	Lamedah, Hamrour	Perennial grass	Semi-arid & arid of the region	Medium	July	-	-
Lygeum spartum	Gramineae	Halfa-mahboula sennachs, senna	Perennial grass	Semi-arid & arid areas of the region except Mauritania	Low	-	Low	-
Oryzopsis miliacea	Gramineae	Seibous, Roziah	Perennial grass	Semi-arid & arid areas of the region except Muritania	High	-	Low	-
Panicum turgidum	Gramineae	Om Rokbah, Abou Rokbah, Thomam-Salb	Perennial grass (woody somehow)	Saharan areas of the	Medium	June-July	Low	-
Poa bullosa	Gramineae	Qabaa-bosaili (geophyte)	Perennial grass	Semi-arid & arid areas of the region except Mauritania	High	May-June	Medium	-
Stipa lagascae	Gramineae	Azam, Azami	Perennial grass	Semi-arid & upper Saharan areas except Mauritania	Medium	May	Low	Maturity variation
Stipa parviflora	Gramineae	Hashish- al-far Azam, Sagheir al-Azhar	Perennial grass	Semi-arid & upper Saharan areas except Mauritania	Medium	May	Medium	-
Stipa tenacissima	Gramineae	Halfa	Perennial grass	Common in the semi-arid & arid areas except Egypt & Mauritania	Low	Low	-	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Stipagrostis ciliata	Gramineae	Solian, Lamma, Aataf (Morocco)	Perennial grass	Arid & Sahran areas of the region	High	June	Low	-
Stipagrostis plumosa	Gramineae	Nosi-kal	Perennial grass	Arid & Saharan areas	Medium	June	Low	-
Stipagrostis pungens	Gramineae	Sebtt, Sebtt hadd	perennial and shruby grass	Semi-arid, arid & Sahran areas of the region	Low, but medium for Camels & donkeys	June	Abundant	-
Rhus pentaphylla	Anacardiaceae	Samaq- Khomasi alowraq, Tezgha, Godairi	Shrub	Semi-arid & arid areas of Tunisia, Algeria and Morocco	Low, but high for goats	April-May	Low	-
Rhus tripartitum	Anacardiaceae	Somaq-Tholathi algzan, Godairi	Shrub	Semi-arid, arid & Sahran areas of Libya Tunisia and Algeria	Low, but high for goats	April-May	Low	Seeds to be washed before germination
Leptadenia pyrotechnica	Asclepediaceae	Selfeafo	Shrub	Abundant in Mauritania and southern desert of Morocco and Algeria	Low	-	-	Fruits are attached by insects
Periploca angustifolia	Asclepediaceae	Holab	Shrub	Founds west of Marsa Matrouh, Egypt	High of the	- spring	-	-
Periploca laevigata	Asclepdiaceae	Holab	Shrub areas in the region,	Semi-arid and arid except Mauritania	High June	May-	Medium	Shattering
Echiochilon fruticosum	Boraginaceae	Yadma, Hadma, Haddma, Zoraiqah	Sub Shrub	Semi-arid, arid & Saharan areas of the region except Mauritania	-	-	-	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Gymnocarpos decander		Khashrae, Qajroud, Bo-qroraidah Gafneh	Sub Shrub	Semi-arid, arid & Saharan areas of the region except Mauritania	Medium	June-July	Low	-
Anabasis Oropediorum		Chenopodiaceae Aajram	Tafayah,	Sub Shrub of Morocco, Algeria and Tunisia	Arid and Saharan areas for Camels		Medium	November
Arthrophytum schmittianumn	Chenopodiaceae	Baqel	Sub Shrub	Arid and Sahran areas of the region	Medium for Camels	November	Medium	Germination percentage is much reduced in storage
Atriplex glauca	Chenopodiaceae	Qataf mozraq	Shrub	Semi-arid & Sahran areas of the region except Mauritania	Medium	October	Medium	-
Atriplex halimus	Chenopodiaceae	Qataf mellic	Shrub	Semi-arid and Sahran areas of the region	Medium	November-December	Abundant	-
Atriplex mollis	Chenopodiaceae	Qataf na'aem	Shrub	Semi-arid, arid and Sahran areas of the region except Mauritania	Medium for Camels	November-December	Medium	-
Atriplex portulacoides	Chenopodiaceae	Qataf baqelaai	Shrub	Semi-arid, arid and Saharan areas of the region except Mauritania	Medium	October-November	-	-
Cornulaca monacantha	Chenopodiaceae	Hadh	Shrub	Arid and Sahran areas areas of the region	Medium for camels, low for other livestock groups	October-November	-	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Traganum nudatum	Chenopodiaceae	Damraan	Shrub	Arid and Saharan areas of the region	Good for Camels medium for sheep	October November	Medium	-
Salsola vermiculata var. *villosa*	Chenopodiaceae	Rotha, Joll	Shrub	Arid and Sahran areas of the region except Mauritania	High	October-November	Abundant	Short longivity
Salsola vermiculata var. *brevifolia*	Chenopodiaceae	Ghadham, Ghadhama	Shrub	Common in the arid and Sahran areas	Medium	October-November	Low	-
Helianthemum kahericum	Cistaceae	Karsheed, Ojrod qaheri	Sub shrub	Semi-arid, arid and Saharan areas in the region except Mauritania	Low	May	Low	Seed shattering
Helianthemum lippii var. *sessiliflorum*	Cistaceae belkaramis	Raqiqah- Tahsewat-aloud, Ojrod jales alazhar	Sub shrub Saharan areas in the	Semi-arid, arid and region except Mauritania	High	May	Medium require pre-	Seed shattering treatment to overcome dormancy
Helianthemum sp.	Cistaceae	Samhari	Sub shrub	Saharan areas of Tunisia, Algeria & Libya	Medium	May	Abundant	-
Artemisia herba-alba	Compositae	Shih	Sub shrub	Characterizes semi-arid and arid Artemisia steppe land in North Africa except Mauritania	Medium	Jan.	Abundant	Seed shattering and their smallness
Atractylis serratuloides	Compositae	Sor, Sori	Sub shrub	Semi-arid arid and Saharan areas in the region except Mauritania	Low for	June	Low	Seed shattering and spineness of the heads

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Launaea resedifolia	Compositae	Lobaineh, Aodaidah, Ya'adodah,	Herbaceous	Semi-arid arid and Saharan areas in the region except Mauritania	High	May-June	Medium to low	Seed shattering and their smallness
Nolletia chrysocomoides	Compositae	Wazwazah, Tebdokt	Herbaceous	Semi-arid arid and Saharan areas in the region except Mauritania	Medium	May-June	Low	Seed shattering and their smallness
Rhanterium chrysocomoides	Compositae	A'arfaj Tebdokt	Shrub	Egypt	Medium	May-June	Low	Seed shattering and their smallness
Rhanterium suaveolens	Compositae	A'arfaj	Shrub	Semi-arid and arid areas of the region except Mauritania	Medium	July	Abundant	Seeds are attacked by insects in the early stages. Seeds contain in water washed inhibitors

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Ephedra alata	Gentaceae	A'alanda, Shadedah (Morocco)	Shrub	Arid and Sahran areas of the region	Medium	June	Low	-
Globularia alypum	Globulariaceae	Zoreqaa	Shrub	Semi-arid areas of Morocco, Algeria, Tunisia and Libya	Low (medicinal)	-	-	-
Lavandula multifida	Labiatae	Klelet alhameer	Shrub	Semi-arid and arid areas of Morocco, Algeria, and Tunisia	Medium	-	-	-
Rosmarinus officinalis	Labiatae Hassaleban	Eklil,	Shrub areas of the region	Semi-arid and arid to except Mauritania	Medium low	-	-	-
Rosmarinus Tournefortii	Labiatae	Hassaleban bari	Shrub	Arid areas of Algeria	Medium	-	-	-
Thymus hirtus	Labiatae	Zaatar	Sub shrub	Semi-arid and arid areas of North Africa except Mauritania	Medium for goats	-	Low	-
Olea europaea	Oleaceae	Habouz, Zaitoun,	Tree	Semi-arid and arid areas of Morocco, Algeria, Tunisia and Libya.	Medium	-	-	-
Pituranthos chloranthus	Umbelliferae	A'aljan	Sub shrub	Arid areas of Algeria Tunisia and Morocco	Low	June	Low	-
Pituranthos tortuosus	Umbelliferae	Quzah	Sub shrub	Arid areas of the region except Mauritania	Low	June	Low	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Plantago albicans	Plantaginaceae	Yenam, Halma Rebl, Zobad	Herbaceous	Semi-arid, arid and Saharan areas of the region except Mauritania	High	May-June	Abundant	Germination percentage is low during few months after harvesting
Calligonum arich	Polygonaceae	A'arish	Shrub	Sahran areas, from South of Libya to the north western borders of the Sahara	High for Camels	May-June	-	-
Calligonum azel	Polygonaceae	Azel	Shrub	Sahran areas, from South of Libya to the north western borders of the Sahara	High for Camels	May-June	-	-
Calligonum comosum	Polygonaceae	Artta al-Artta al-jamil	Shrub	Sahran areas, from South of Libya to the north western borders of the Sahara	High for Camels	May-June	-	-
Polygonum equisetiforme	Polygonaceae	Qerdab	Sub shrub	Semi-arid and arid areas of the region except Mauritania	High	June	Low	-
Zizyphus lotus	Rhammaceae	Seder	Shrub	Semi-arid, arid and Saharan areas of Libya, Tunisia, Algeria and Morocco.	Medium	July	Medium	-
Zizyphus mauritanica	Rhammaceae	Seder mauritani	Tree	Mauritania	Medium for Camels & goats	-	Medium	-
Salvadora persica	Salvadoraceae	Arak, Ifershi (Mauritania)	Shrub tree	Central Sahara, mainly in Mauritania and Algeria	High for Camels medium for goats	-	-	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Argania spinosa	Sapotaceae	Argan, lowz albarber	Tree	Semi-arid, arid and Saharan areas of south western Morocco	Medium to high for goats	-	-	-
Linaria aegyptiaca	Scrophulariaceae	Shadeed, Yadmaa, Safraa slqa	Herbaceous	Arid and Saharan areas of the region, except Mauritania	Low	June	Low	-
Anarrhinum brevifolium	Scrophulariaceae	Jafjaf	Sub shrub	Endemic to Tunisia	Medium	July	Medium	-
Withania frutescens	Solanaceae	Folet alkalb	Shrub	Western of Algeria and Morocco	Medium to low	-	Low	-
Lycium arabicum	Solanaceae	Sakoum, Aawsag, Sareim	Shrub	Semi-arid, arid and Saharan areas of Morocco, Algeria, Tunisia and Libya	Medium to Camels and goats	-	Low	could be propagated by root sprouts
Thymelaea nitida	Thymelaceae	Methnan algazal	Sub shrub	In all countries except Egypt and Mauritania	Medium	-	-	-
Thymelaea microphylla	Thymelaceae	Methnan	Sub shrub	In all countries except Egypt and Mauritania	Low	-	-	-
Balanites aegyptiaca	Zygophyllaceae	Tamr albel, Hegleg, Abou-ragen, Aloub Tishet	Tree or shrub	Saharan areas of Mauritania, Egypt, Algeria and Morocco	Medium for Camels	-	-	-

Botanical name	Family name	Local name	Life form	Geographic distribution	Palatability	Collection season	Seed production	Seed collection problems
Nitraria retusa	Zygophyllaceae	Ghardaq, Gharqad, Qarziem	Shrub	Arid areas of Algeria, Tunisia and Libya, but rarely in the western Sahara and Mauritania	Low, but medium for Camels	-	-	-
Oudneya africana	Crucifereae	A'alqa, Hemmet albel	Shrub	Saharan areas of Libya Tunisia and Algeria	-	-	-	-
Cupressus dupreziana	Cupressaceae	Talout, sarow	Tree	Endemic to mountains of the Algerian Sahara	Low	-	-	-

Appendix 2: Natural bioreserves in the countries of North Africa.

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
Tunisia	al-Faijah (Initiated in 1990)	2632	1260-2000	*Quercus mirbecki* *Quercus suber* *Pistacia lentiscus* *Myrtus communis* *Calictome villosa* *Jasminum fruticans*	It supports about 700 plant species
	Ashkal (Initiated by a presidential act of 18 December 1980)	12600	625	*Ceratonia siliqua* *Olea europaea* *Pistacia lentiscus* *Asparagus acutifolius* *Calicotome villosa* *Capparis spinosa* *Euphorbia dendroides*	It supports about 500 plant species
	Mabarah Wa Zambartah (Initiated in 17/2/1987)	391	500	*Senecio cineraria* *Anthyllis barba-jovis* *Iberis semperflorens* *Erodium maritimum* *Olea sylvestris* *Olea europaea*	It supports about 230 species
	Bou Qarnain (Initiated in 17/2/1987	1939	770420	*Callitris articulata* *Cyclamen persicum* *Cistus* spp. *Calicotome villosa* *Rosmarinus officinalis* *Camaerops humilis* *Phillyrea angustifolia* *Pistacia lentiscus* *Myrtus communis*	It supports more than 600 species

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
	al-sha'anebi (Initiated in 1980)	6723	400-500 at highlands and 250 in the plains	*Quercus ilex* *Rosmarinus officinalis* *Pinus halepensis* *Juniperus phoenicia* *Globularia alypum* *Stipa tenacissima* *Retama raetam*	
	Bou-Haddmah (Initiated in 1980)	16488	200	*Acacia tortilis* subsp. *raddiana* *Calicotome villosa* *Retama ractam* *Cenchrus ciliaris* *Nerium oleander* *Digitaria nodosa* *Tuber album*	
	Sidi al-Towi Initiated in 1989)	6500	100	*Rhanterium Suaveolens* *Anthyllis sericea* *Stipagrostis pungens* *Retama raetam* *Periploca laevigata* *Arthrophytum schmittianum* *Zizyphus lotus*	

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
Libya	al-kouf National park	8500	300-600	*Cupersus sempervirens* *Olea europaea* *Quercus coccifera* *Juniperus phoenicia* *Pistacia lentiscus* *Arbutus lavari* *Rhus tripartita* *Rosmarinus officinalis* *Artemisia herba-alba* *Thymus hirtus*	
	Abou Ghailan park	4500	150	*Rhanterium suaveolens* *Calicotome villase* *Artemisia herba-alba* *Thymus hirtus* *Lygeum spartum*	
	Qarah-bolly park	8500	250	*Zizyphus lotus* *Retama raetam* *Calicotome villosa*	
	Sarman park	1450	150	*Zizyphus lotus* *Retama raetam* *Calicotome villosa*	

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
	Beer A'aiad protected Area	1150	150	*Acacia tortilis* subsp. *raddiana* *Zizyphus lotus* *Retama raetam* *Atriplex halimus* *Rhanterium suaveolens* *Artemisia herba-alba* *Anabasis articulata*	
	al-Haisha al-Gadidah (Sankary,1991 reported about 300 species from this project)	100000	100-125	*Acacia tortilis* subsp. *raddiana* *Rhus tripartita* *Retama raetam* *Periploca laevigata* *Lycium arabicum* *Nitraria retusa* *Limoniastrum* spp. *Tamarix* spp. *Atriplex halimus* *Artemisia herba alba* *Cenchrus ciliaris* *Stipagroslis ciliata* *Cymbopogon schoenanthos* *Salsola tetragona* *Salsola vermiculata brevifolia* *Salsola tetrandra*	

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
Algeria	Gargarah (Initiated in 1925 and considered a national park in 1983. It is located in a mountaneous area with highest elevation reaches 2308 m.	18850	1000-1200	*Cedrus atlantica* *Juniperus monogyna* *Quercus ilex* *Ilex aquifolium* *Pinus nigra* *Cytrus triflorus* *Prunus avium* *Lonocera kabilika* *Dactylis glomerata*	
	Sharia'a (Initiated in 1925 and considered a considered a national park in 1983)	26550	1000-1300	*Taxus baccatus* *Ilex aquifolium* *Fraxinus angustifolia* *Alnus glutinosa* *Sorbus terminalis*	
	Qauraia (Initiated in 1924 and considered a national park in 1984. It is located at the eastern coast in Bajaiah)	2080	1000	*Pinus halepensis* *Quercus coccifera* *Euphorbia dendroides* *Lithospermum rosmarinifolium*	
	al-Qalah (Initiated in 1983 near A'anabah city at the AlgerianTunisian borders. It is a UNESCO declared reserve area within the International heritage system.	76438	1200	*Quercus coccifera* *Pinus halepensis* *Quercus* spp.	

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
	al-Hoqqar	450000	Saharan climate combined with sporadic monsoon showers during May-September	*Acacia* spp. *Piatacia atlantica* *Artemisia herba-alba* *Rhus tripartita* *Artemisia campestris* *Zilla spinosa* *Panicum turgidum* *Tamarix* spp. *Atriplex halimus*	
	Taisely-Nager (It was declared a within the International heritage system in 1986 and it is considered one of the most important desert reserve areas in the world.	80000	Differentiated desert climate	*Cupressus dupreziana* *Olea lapperini* *Acacia* spp.	UNESCO reserve area
	Taza (Initiated in 1983, and it extends on 9 km along gulf of Bajajah, on the Mediterranean Sea).	3807	1000-1400	*Quercus faginea* *Cupressus sempervirens* *Olea europaea* *Pistacia lentiscus* *Quercus coccifera* *Myrtus communis* *Viola odorata* *Nerium oleander* *Scilla maritima* *Plantago lanceolata* *Ajuga iva*	

Country	Name of the Protected area	Area (Hectare)	Rainfall (mm)	Dominant plant species	Notes
	Blazma (It was initiated by a presidential order in 1984. It is a mountaneous reserve, up to 2138 m and supports about 400 plant species	26250	500	*Ilex aquifolion* *Cedrus atlantica* *Pinus halepensis* *Rosa canina* *Epipactis helleboune* *Quercus* spp.	
	Thaneat-alhad (It is the oldest reserve area in Algeria in a mountaneous area having in average 500 m. height. If was protected in 1923.	3424	800-900	*Quercus ilex* *Cedrus atlantica* *Crataegus monogyna* *Rubus ulmifolius* *Juniperus oxycedrus* *Daphne gingidium* *Viola monogyna*	

Protected and reserve areas in Morocco are divided into two types:

(a) The aquatic and humid area reserves, that include swamps and lakes, mainly on the Atlantic coast, or around artificial dams on the valleys of the interiors. The aim of this type is to provide safe migration stations for the migratory birds along their onward and backward routes between Africa and Europe.

(b) The wild life reserve to protect both plants and animals. Sidi-Shaiker, Takherkhort, Maissour and Massah Park are just examples.

Protected wild areas are divided into two groups as well, permanent and temporary. The first and second groups cover about 3 and 9 million ha, respectively.

The following table summarizes locations and major climates of the protected wild areas in Morocco.

Name of the protected areas	Location	climate	Notes
Sidi Shaiker	Aasevi region		
Takherkhort	Marakesh region	arid	
Maissour	Eastern region	continental arid and semi-Saharan	
Massah	-	-	It supports *Euphorbia* plants

Several protected areas are found in Mauritania, as well. The most important of which are; Shot om Aragen, sectors of Mal and Arakeez lakes.

Appendix 3: Genetic resources collection and evaluation recording sheet

1. General information

Researcher(s) name(s)
Foundation or research centre
Country Region
Location Number of the location
Collection date Latitude
Longitude Altitude (m)
Precipitation (mm) Minimum temperature of the coldest month (m) in centigrade The absolute minimum
The bioclimatic stage; upper semi-arid _____ lower semi-arid
upper arid _____ lower arid _____ upper saharan
lower saharan _____

2. Botanical information

Plant name; Genus species
Subspecies variety
Ecotype
Synonyms
Arabic and (or) local names

The most important companion species
1. _____ 2. _____
3. _____ 4. _____
5. _____ 6. _____
7. _____ 8. _____
Life form, Annual _____ Geophyte _____ Hemicryptophyte
Chamaephyte _____ Nanophanerophyte
Phanerophyte _____ Epiphyte
Life cycle; Annual _____ Biennial _____ short lived
perennial _____ Long lived perennial
plant shape; creeping _____ Erect _____ climber
The particular phenotype; woody _____ spiny
Lush _____ Hirsute _____
Eco-situation; common _____, Endemic _____ Rare ,
Endangered _____, Introduced
The Dynamic situation; Invader _____, Increaser
Decreaser _____, Balanced
Longevity of leaves; Evergreen _____, Deciduous ,

a) in the dry season _____ b) in the cold season

Physiological characteristics; N_2 Synbiotic fixation

a) bacterial _____

b) Mycorhizal _____

CO_2 fixation pathways

a) C_3

b) C_4

Plant health status; Fungal diseases _____, Entomological

Bacterial _____, others

Growing season; Fall _____, Winter

spring _____, Summer

Biseasonal _____, continuous

Palatability; very high _____, continuous

Low _____, very low

Palatable parts; leaves, _____ leaves and twigs

Fruits _____ Roots

Grazing animals; Sheep _____ Goats _____ Camels

Cattle _____ Horses _____ Donkeys

Wildlife (specify)

Grazing season; Fall _____ Winter _____ Spring

Summer _____ All year round _____

suitable stage for grazing; vegetative _____ Flowering

Fruiting _____ Dormancy or the dry stage

Feeding value; very highly nutritive _____highly nutritive

Nutritive _____ Low

very low

Non-grazing uses; Human food _____ bi-culturing

ornamental _____ sand dune fixation

windbreak _____ Medicinal

Industrial _____ oil producing

poisonous

3. Collection's site data

Physiography; Swamp _____River sides

Wadi sides _____ Flood plains

Open plain _____ Wadi bottoms

Hammada plateau _____ Sands

Sand dune _____ Hill

Plateau _____ Mountain _____

Sabkha _____

Slope direction; East _____ West _____ North

South _____ North east _____ North West

South east _____ South west

Slope (%) less than 5 _____ 6-10

11-20 _____ 21-30

31-50 _____

Drainage properties; very good _____ Good

Seasonally logged _____ yearly logged

occasionally logged

Soil texture; sandy _____ sandyloam _____ loam

sandy clayloam _____ clayloam _____ clayey

Soil depth (cm); less than 10 _____ 11-25 _____ 26-50

50-100 _____ more than 100 cm

Salinity; non-saline _____ Moderately saline

Highly saline _____ Gypsiforous

calcareous

Salisic sands

PH; Acidic _____ Neutral _____ Alkaline

Moderately alkaline_____ Highly alkaline

Water table depth

* This information sheet was derived from several sheets and field booklets, mainly, the International Centre for Agricultural Research in the Dry Areas (ICARDA), The International livestock Centre (ILCA), and the Arab Centre for Studies Arid Zones and Dry Lands (ACSAD).

** Collection of forage and range legumes should go together with collection of their *Rhizobium* bacteria.

Appendix 4: Genetic resources adaptability evaluation sheet.

The name of the evaluating foundation or research centre:

The researcher(s)

The evaluation's site _____ Precipitation (mm)

Soil physiography and type

The botanical name; Genus _____ species

Subspecies _____ variety

Ecotype _____

Genetic homogencity; Homogeneous _____Hetrogeneous

The collection site _____ Precipitation (mm)

Soil physiography and type

Date of seeding or transplantation

Seeding method and depth

Seeding rate; High _____ Medium;_____ Low

Germination (October - December)

Evaluation date _____ the estimated date of germination

plant density (m^2) _____ Dried seedlings; yes ____ No

Seedling vigor; vigorous _____ Moderate _____ weak

Notes

Evaluation of field cold resistance (December - January)

Evaluation date _____ Establishment (%)

Cold resistance; High _____. Moderate

Low _____. The absolute minimum

temperature (c) _____.

Notes: record variation in color and shape of the evaluated plant or its parts

Evaluation of growth and growth characteristics

Evaluation date _____Moderate _____ Low

Leaf percentage; High _____Moderate _____ Low

Survival percentage

Notes

Evaluation of drought resistance (July - August)

Evaluation date

Resistance value; High _____ Moderate _____Low

Survival percentage _____ Notes

The final evaluation resolution

Season of the seed maturity

Seed production; Abundant _____ Moderate

Low _____

Future use chances; Many _____ Restricted _____ Low

Pest resistance

Notes

1. This information and evaluation sheet has been adopted from other sheets that were developed by Madnine Institute for Arid Zone Research, Tunisia and Range Seeds Centre in Jadaidah, Morocco.

2. Annual plants are evaluated in spring

3. Perennial plants are evaluated in spring and fall and for several years.

4. Cool season grasses, such as *Dactylis glonerata*, *Phalaris tuberosa*, *Festuca* spp., etc. undergo summer dormancy period during the hot and dry season. Such species should be evaluated for their summer somancy regulating mechanisms, as well (Sankary & al. 1969).

Appendix 5: Tools, materials and conditions needed for successful genetic resources collection missions

The following tools and materials are needed to carry out the collection missions:

- Land cruiser field car, with supplementary water and fuel tanks.
- Detailed topographical maps that show roads, dirt roads, towns, villages, water wells and the important land marks.
- Bags of various sizes and types.
- Compass and altimeter.
- PH and E.C. meters.
- Notebooks and large number of data collecting sheets.
- Plant presser and drying papers.
- Stapler, staples, clips and pins.
- Carton boxes, glues and adhesive papers
- Knives, scissors, shovel, and small digging tools.
- Hard papers, plastic and metallic tags and threads and strings.
- Pesticides for treating the collected seeds and prepagules.
- First aid kits and medical supplies.
- Camping and cooking facilities.
- Field camera with close ups.

It is suggested that the genetic resources collection teams should have specialists in plant taxonomy, plant genetics, soil science, soil classification, ecology as well as a local guide who is well aware of wild routes and localities.

Missions should be timed to coincide with the maturity of a large number of species. Vegetative propagules and cuttings could be collected as well for vegetative propagation.

Appendix 6: List of scientists and administrators met and with whom discussions were held during the visits paid to Libya and Algeria.

1. Libya:

- Mohamed Ramadan A'ajaj, Director, General Directorate of Forestry, Range and Soil.
- Moustafa Blak, Director General, Agricultural Research Centre, Tripoli.
- Qabi Dheib, Deputy, UNDP.
- Basheiah Fawzi, Director of Research, Agricultural Research Centre (A.R.C.) Tripoli.
- Abdul-Qader Abou-Faed, Director, The Technical Centre for the Protection of the Environment.
- Ahmed al-Shamakhi, researcher, Range & Forestry, A.R.C.
- Mohamed al-Idrissi, researcher, Range & Forestry, A.R.C.
- Adnan Gebriel, research, Range & Forestry, A.R.C.
- Adnan Sbeitah, research, Range & Forestry, A.R.C.

- Soleiman Abou al- Khair, research, Range & Forestry, A.R.C.- Al-Sadeq al-Rouisi, Agricultural Engineer at the General Directorate of Forestry.
- Mohamed Goma'ah al-Gadoua'i, co researcher, A.R.C.

2. Algeria:

- Abdulah Ghabalou, Director, Forestry Directorate.
- Ali Ghazi, National Agency for the Environmental Protection.
- Hashmi Bahloul, UNDP, Algeria.

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