YEMEN:

COUNTRY REPORT TO THE FAO INTERNATIONAL TECHNICAL CONFERENCE ON PLANT GENETIC RESOURCES

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CHAPTER 1
Introduction

Yemen is located in the South East of the Arabian Peninsula. It lies between 120° and 17°N Latitude and 43° and 56°E Longitude. The country has rugged surface features composed of mountains, hills, plateaus, plains, valleys and gorges. The varied topographic features and the variable climatic conditions of the country are among the major factors which resulted in diversified crop genetic resources in particular, and vegetation and flora types in general. Nearly two decades ago, many internationally known scientists and plant collectors has recognized Yemen as one of the important regions of Asia in particular and world-wise in general. They described the diversity of many cultivated crop plants in the main land and vegetation and flora types in Socotra Island. However, due to long period of human, habitation, high population density, particularly in the highlands and unwise utilization of natural resources, most of the natural vegetation of Yemen has been destroyed and some of the lands which has been under cultivation are at present highly eroded. Moreover, improved agricultural systems, urbanization and heavy constructions have accelerated the on-going genetic erosion in the last of thirty years.

Table 1 Land Resource Structure (1,000 ha)

Description	1987	1989	1990
Total area	55,000	55,000	55,000
Land area	55,000	55,000	55,000
Arable and permanent crops	1,479	1,481	1,481
Rainfed lands	1,171	1,167	1,133
Irrigated area	308	314	348
Permanent pastures	16,065	16,065	16,065
Forest	2,000	2,000	2,000
Marginal lands	7,000	7,000	7,000

Area of Yemen is about 550,000 sq. km, of which 1,47 million hectares are cultivated and 2 million hectares are as marginal areas, grown once each 3-4 years, 3 million hectares as forest and about 16 million hectares as natural range land and pasture. The population of the country in 1994 was about 14.8 million from which nearly 65% are in rural areas, and about 56% of the population are involved in agriculture.

1.1 CLIMATE

The climate of Yemen varies mainly with altitude from a hot and dry desert climate in the low lying South East and West regions to a temperate in Southern, Central and Northern highlands. Based on climate, Yemen has traditionally been divided into five climatic zones, and these are : Coastal areas, Southern Uplands, Central Uplands, Northern Highlands and Eastern plateau.

Mean annual temperature ranges from less than 12° in the highlands to above 30° in the coastal areas. In summer, temperature may rise up to 40° in low lands and above 40° in the desert of eastern region. In winter temperature may decrease below zero in the highlands, where it may cause some damages due to frost to crops. Mean relative humidity ranges from 30% in arid zones of the eastern region to above 80% in coastal areas, and generally it becomes less in winter during months of January to April.

1.2 RAINFALL

Rainfall has generally a bimodal pattern with two rainy seasons, the first is during February, March and May, and the second in July to September and October which is the heaviest rainy season. The average annual rainfall varies from less than 50 mm in coastal areas to up to 1,000 mm in the Southern uplands mainly around Ibb. In general, rainfall increases with distance from sea towards the foothills with 300-400 mm and then decreases gradually from the central highlands towards the capital Sana'a with an average of 250 mm and again increases towards Saada and Haja with an average ranges between 400-600 mm.

1.3 TOPOGRAPHICAL FEATURES

Yemen generally is characterized by extremely diverse physiography, climate and soil. That is due to great changes in elevation raising from sea level to nearly 3,700 m, which form the highest peak in the Arabian Peninsula. In terms of ecology the country may be divided into 4 major zones, varying significantly from each other in total climatic and edaphic factors.

1.3.1 Coastal plain

The coastal plain lies between the Red Sea and the Arabian sea with a length of 1,920 km and it includes :

a. Western plain

It lies between the Red Sea and the Western escapement. The altitude ranges between the sea level to about 300 m and 420 km long, and a width of 20-40 km. The plain covering a total area appr. 16,000 sq km. There are several wadis that cut Tihama plain and these are, Mor, Rima, Siham, Rusyan, Surdud and Zabid.

b. Southern plain

It lies between the Arabian sea and the southern escarpment with altitude range between sea level to about 200 m. The plain stretched to about 1500 km long and from 10-60 km wide. It includes the following wadis, Bana, Hassan, Ahwar, Hajer and Mayfa'a.

1.3.2 Mountainous regions

1.3.2.1 Low altitude mountains

a. Tihama foothills and low altitude Western mountains They include the mountains west of Hajja and Al-Mahweet governorate, Taiz mountains, around Madinet Al-Sharq, West Huth and West Al-Makhdeer (Ibb). The range of altitude of these mountains between 1,000 to 18,000 m above sea level.

b. Southern mountains They include mountains of Mukeyras, Al-Dhalaa, Yafea Al-Sufla, Jabel Eraf, Al-Awaleq Al-Sufla, Lodar, Modia and Hadramout hills. They range between 1,000 to 1,800 m above sea level.

1.3.2.2 High altitude mountains

They lie above 1,800 m and include mountains of Ibb, Dhamar, around Sana'a, Alturba, Saber, Reyma, Jabel Abran and Hajjah.

1.3.2.3 Eastern mountains

a. High eastern mountains They from the division between the wadis flowing West into the Red Sea and East into the desert. They include

mountains east plains of Dhamar and Amran, Huth east and north Rada, as well as mountains between Rada and Al-Bayda, and between Abyan and Al-Bayda. Their altitude is above 1,800 m above sea level.

b. Medium altitude eastern mountains They lie between 1,200-1,800 m and drop gradually into eastern desert. They include mountains east Saada, around and West Marib, North Al-Bayda, Bayhan and North Attaq.

1.3.3 High plains

They include plains above 1,800 m such as plains of Saada, Sana'a, Dhamar, Rada'a, Qa Bakil Qa Haql and Qa Shara and those that lie in less than 1,800 m, which include plains of Al-Qaeda.

1.3.4 Eastern desert (plateau)

They cover the northern boundary of Yemen and drop gradually from 1,000 m towards the north east to less than 500 m and include the area east and north Marib and Ramlet Al-Sabaateen.

1.4 SOIL

Soils in Yemen are generally recent soils of alluvial deposits produced by water and wind weathering. They country's soils are sandy to silty and loamy in coastal regions and silty to loamy and clay loamy in the highlands. The soils are generally low in nitrogen, phosphorus and organic material. In areas in the highlands soil are shallow with often calcareous layer which leads to poor moisture retention.

Table 2 Types of Rainfed and Irrigated Areas (1,000 ha)

Types	Total
Rainfed	
> 600 mm	190
450-600 mm	220
250-350 mm	62
< 450 mm	710
Irrigated	
permanent	
wells	146
springs	25
semi-irrigated	
spate (floods)	116
Total	**1,469**

1.5 WATER RESOURCES

The country's major resources for water are rainfall and underground water represented by wells and springs. Rains water is the basic source for agriculture where about 77% of the total cultivated area depends directly on it. Nearly half of the total rainfed area receives rainfall less than 350 mm which could be considered below the minimal amount needed for rainfed agriculture. Spate irrigation is experienced in the coastal region farming, covering about 41% of the total permanent and semi irrigated area. Wells and springs are very important sources for domestic water supply and irrigation. They are common in highlands, while floods (Spate) and wells are in the coastal plains.

Water resources now days are facing shortage problems, and that is due to: large increase in number of wells, uncontrolled use of pumped water, tendency to neglect the traditional spate irrigation, and low quality of water for irrigation and salinization of soils.

1.6 CROP PRODUCTION SYSTEM

Crop production system in Yemen is generally reflected by the availability of water supply as being the most important factor. The cultivated area may very from one year to another depending on the amount and distribution of rainfall. The total area under cultivation is about 1.4 million hectares, of which 93% devoted to annual crops and 7% to permanent crops.

Table 3 Area and Production of Main Agricultural Crops, 1987, 1989 and 1991

Crop	Area (1,000 ha)			Production (1,000 tons)		
	1987	**1989**	**1991**	**1987**	**1989**	**1991**
Total Cereals	**852**	**860**	**640**	**716**	**864**	**448**
Sorghum	589	521	381	470	516	247
Millet	98	140	91	38	59	25
Wheat	74	94	87	113	162	100
Maize	43	52	38	54	68	46
Barley	47	53	42	41	59	29
Total Dry Legumes	**24**	**45**	**39**	**39**	**72**	**43**
Cowpeas	16	26	21	27	37	25
Lentil	4	8	8	4	12	5
Beans	1	2	2	2	7	3
Faba beans	2	4	3	4	10	5
Fenugreek	1	2	2.5	1	3	3
Peas	0.5	2	1.5	1	3	2
Sesame	15	22	15	5	8	8
Cotton	9	16	9	6	13	7
Tobacco	3	3	4	5	4	7
Total Vegetables	**40**	**50**	**50**	**622**	**731**	**641**
Tomato	8	10	11	147	163	171
Potatoes	10	11	12	119	140	157
Watermelons	7	10	8	183	204	126
Cantaloupes	3	4	3	49	59	35
Cucumbers	0.5	0.5	0.5	13	14	11
Dry onions	3	5	4	45	78	
Okra	2	2	2	14	15	
Garlic	0.5	1	1	7	11	59
Carrots	0.4	0.6	0.7	4	7	14
Radish	0.8	0.6	0.9	11	8	12
Total Fruits	**48**	**54**	**59**	**295**	**313**	**316**

Crop	Area (1,000 ha)			Production (1,000 tons)		
Grapes	15	15	18	129	135	139
Dates	16	16	16	31	25	21
Bananas	6	8	7	42	48	52
Papayas	2	3	3	57	57	53
Pomegranate	0.4	0.6	0.8	3	5	5
Coffee	18	22	23	5	6	5
Total Forages	**56**	**73**	**58**	**501**	**651**	**499**
Grasses	8	11	11	54	58	50
Sorghum fodder	33	45	30	349	471	322
Alfalfa	15	17	18	98	121	127
Grand Total	**1067**	**1145**	**897**	**2195**	**2663**	**1975**

Crop production system can be divided into two as depending on water supply:

a. Rainfed farming system.This system can be classified into three categories:

1. The low rainfed system with rainfall average < 450 mm,

2. The moderate rainfed with rainfall average between 450–620 mm; and

3. The high rainfed system with rainfall average > 600 mm.

Major crops grown under rainfed farming are : sorghum, wheat, barley, millet and legumes. Barley is considered to be the base of dry land farming system in the highlands while millet is a marginal crop of low lands and sand dunes. Generally rainfed farming system is considered as the base of agriculture where more than 77% of the total cultivated area is under this system.

b. Irrigated farming system.There are two types of irrigation under this system. These are flood irrigation which is basically used in coastal region and the deltas. Crops predominantly grown under this system are sorghum, millet, cotton, cucurbitas, legumes, sesame and groundnuts. The second system is wells and springs irrigation farming system. It forms the base of intensive agriculture mainly for cash crops such as qat, vegetables, fruits and forage crops. Under such system intercropping and crop rotations can be easily utilized.

CHAPTER 2
Plant Genetic Resources

There are 3,418 plant species in the flora of the Arabian Peninsula (Milles, 1991). Of these 2,500 are represented in Yemen. The numbers of endemics in the country amounts to 137. Socotra Island is unique in this regard. It has over an area of 3,625 sq km 722 plant species, out of which 240 are endemic. There are 10 endemic genera in Socotra.

The important plant families are *Graminae, Amaranthaceae, Acanthaceae, Capparaceae, Brassicaceae* and *Caryophyllaceae.* One third of plant families is tropical. Most of the plants of Yemen are phanerophytes. The most prominent genera are Commiphora, Ficus & Acacia.

Most of the plant endemics 55% belong to *Asclepiadaceae* family with its succulent plants as *Huernia*. Other are *Caralluma Duvalia*, *Echinopsis, Rhitidocaulon.* The Euphorbiaceae includes 33% of the endemics like Euphorbia species. Aloe of *Liliaceae* has some endemics also. There is a wide diversity of crop species in Yemen, grown as indigenous material both as cultivated or wild forms. This may have been enhanced by the followings :

1. Geographical position as an important transport location used actively as a trade road to Asia, Africa and the near east which activated exchange of goods including plant material.
2. A long term agricultural heritage that would have assisted the crop establishment and continuous cultivation and selection.
3. The diverse agro-ecological zones, that have contributed towards the existence of a wide range of crops, natural selection, and geographical distribution of crops and plants as endemic and exotic form.

2.1 CULTIVATED CROPS

The main crop groups are cereals, legumes industrial and stimulant crops, vegetables, fruit trees. Cereals are grown on about 60% of the total cultivated land. Sorghum and millet cover 80% of the cereals area. Main industrial and stimulant crops are sesame, cotton, tobacco, Qat and coffee. Main vegetables, are tomatoes, potatoes, cucurbitas and onions. Fruit trees include grapes bananas, mangoes, papayas and dates.

Both cultivated, wild relatives and wild species, and few uncultivated taxa of crops found in Yemen count more than 80 species, and sub-*spp* excluding exotics. The asset of major crops grown for different use for the satisfaction of community includes crops that mostly have been evolved through a long term agricultural activity as the base of an old traditional system of which the most important are cereals including Triticum *spp*, Hordeum *spp*, Pennisetum, Sorghum. *spp* Legumes Vigna *spp*. Vicia faba, Dolichos lablab, Foenicum grecum, pisum ssp etc.) stone fruit (Amygdulus persica, Pyrous communis, Prunus armaniaca as well as pomegranate, figs, date palm and Vitis vignifera. Other crop such as Sesame indica, coffee arabica, Medicago sativa are also considered crop belong to this group.

Among crops which have been introduced at various time to form indigenous ecotypes are potatoes, tomatoes, cucurbitas, onion, tropical fruits maize etc., and they are becoming to play with other major crops an important roll in the agricultural production of the country.

Most of economical crops, especially those grown traditionally forming the base of agricultural activity, largely composed of land races. These land races, local farmers cultivars or ecotypes are varieties or genetically heterogeneous population resulted of a long term agricultural activities and natural selection. These varieties tended to show high adaptive, rate and consistency in performance to fluctuating environmental conditions. However, under favourable and optimum condition, with high agricultural input systems, land races even yield less than improved varieties.

The amount of land races in each crop, depends largely on its cultivation extent as well as its distribution over a geographical area. There is no accurate record how these varieties were classified, how they were developed, or from where the ecotypes were introduced. But the number of land races or farmers cultivars, in sorghum tend to be relatively high all of which belonging to Sorghum bicolor of 6 races and their crosses. In wheat there are 40 land races belonging to Triticum turgidum, dicoccum (the most widely spread species) T. dicoccon, T. durum and T. aestivum. In barely 8 land races belonging to both two row type, and six row types. In sesame 2 land races in alfalfa 3 land

Some times the same land race may exist in different names after the localities where it is introduced and adapted. Maize ecotypes generally identified by their growth period as early and late (Thulathi, Khumasi) or normally they called (Hindl, Romi, Shami, Misri) referring to name of countries, indicating their introduction. Most of maize ecotypes grown in the country are generally flint or semi-flint types.

2.2 VARIABILITY

Land races have shown both inter and intra variation in a wide range of characteristics, which still make them the most dependable source of variability to be exploited further in crop improvement for future sustainable agriculture and food production.

In wheat, land races were found to have variation in plant height, heading, head types and colour, susceptibility to rusts, susceptibly to lodging, lower number of seed/spike and low kernel weight. However, the most important features are the earliness and relatively drought tolerance. Straw quality of land races of wheat barley and lentils were found to be preferred by farmers as they are more palatable by livestock. They are also preferred to be used in mixture in mud blocks for building in case of wheat straw.

In sorghum due to its growing condition throughout a wide geographical area, it may have undergone a long term of intensive selection in which it has established well adapted races for different growing conditions. It was found some races of sorghum that are yellow endosperm type.

In sesame, it was found a great range of variation in maturity (90 day for early and 150 day for late). In lentils land races the variability was found in earliness and drought tolerance.

Great variation has also been observed in coffee arabica, stone fruits, pomegranate and fig, which have a wider adaptation rate. In figs, a wild form is found to exist naturally. Yet more emphasis has to be devoted to asses most important characteristics for ensuring their further exploitation in future development programme.

2.3 VARIETAL REPLACEMENT

The process of modernization and continuous development in agriculture during the last 3 decades, more or less has led to activate the dissemination of improved varieties. at production level. There is no yet accurate data for percentage of area grown by improved varieties. However, from rough estimate it can be indicated that more dynamic replacement to exist in vegetables with nearly more than 90%, in wheat 15-20% as well as in maize. Active introduction of improved varieties of fruits has also increasingly been expanded. Improved varieties are more likely introduced in conditions that are more favourable and where intensive agricultural system is experienced.

Varietal replacement may also account to one land race to replace the other as this may be enhanced with the expansion of road networks and better communication and transport means making the transfer of seed of plant material from location to location easier.

2.4 IMPROVED VARIETIES

Improved varieties in comparison to land races are characterized by high yielding, genetic uniformity, however, with narrow genetic base that make them liable to sudden change in biotic and abiotic stresses.

Improved varieties exist in wheat, vegetables, fruits, sorghum, barley, millet, and cotton. A number of varieties in faba bean, lentil, cowpea, and sesame have been identified as well. The extent of adoption of these varieties by farmers is largely dependant on overall economical return, marketable quality and consumer's demand. Accepting varieties is totally farmers choice because they know how to deal well with each variety on the basis of the growing conditions and farming systems. This necessitates that crop improvement program has to be oriented more towards farmers need. It is necessary to work closely with intensive contribution of farmers, during the various assessment stage of the varieties under farmers condition. More support should be devoted to enhance farmers oriented research approach in the assessment of both land races and improved varieties as well as land races, introductions, exotics and wild germplasm can be used as major source of parental material in breeding program.

2.5 WILD RACES

Among the most wild and wild relatives found were :

- *Olea crysophylla*, a wild taxon considered as a progenitor to olive.
- *Brassica nigra.*
- *Luffa spp.*
- *Gossypium incarnatum, G. arysianum.*
- *Citrullus spp.*
- *Ficus spp.*
- *Solanam unguiculatum.*

2.6 GENETIC EROSION

Among the most important factors for genetic erosion are:

- periodic drought.
- change in cropping pattern and drastic shift towards each crops.
- the cutting of trees and overgrazing.
- expansion of infrastructure and building in agricultural lands.
- terraces erosion.
- sand dune movement and desertification.

In wheat, it is has been found drastic decrease in the area of growing the land race. Alas, an old land race of unthreshable form (*Triticum diccocum*), due to its relatively low yield and difficulties in threshing.

Finger millet (*Eleusine crocana*), (*Eragrostis tef*) and oil rape (*Brassica napus, var., napus*), which were among the important traditional crops to be grown in the country, are no more grown or only grown in very specific areas.

Terrace deterioration and seasonal flood destruction can be among the major factors that cause partial loss of land races.

Qat (*Qata edulis*) expansion also is among the factors that lead to threaten plant genetic resources.

In fruits, expansion of improved varieties is likely to take place in new orchards, in which this has resulted in limitation of planting and rehabilitation of indigenous races and cultivars. Thus, this case will subject the land races in the long run to absolute threat by genetic erosion.

More accurate assessment on genetic erosion, for important crop species should be given a priority. In general, it appears that the degree of erosion would rather be slow in dry land crops including, cereals, legume, and oil crops. Future threats for erosion remains a question in stone fruits, where more emphasis should be devoted to their further conservation.

In vegetables, as the dynamic replacement is higher, more attention should be given for collection and conservation of the available land races.

2.7 TRENDS OF IMPROVED VARIETIES

During the last decade agricultural areas left unchanged while crop production changed drastically. Crop yield has been increased for sorghum from 712 kg/h to 914 kg/h; wheat from 1,050 kg/h to 1,700 kg/h; vegetables from 120,000 tons to 663,000 tons, and fruits from 102,000 tons to 330,000 tons for total areas. The increase in yield production can be related to some factors, such as: dissemination of high yielding varieties, practising of improved agricultural technology and the role of research and extension, and seed supply system.

Table 4 Trends in Production, Area and Yeld of Main Crops[1]

Crop	Production('000mt)		Area ('000 ha)		Yield (Kg/ha)	
	1969-71	**1988-90**	**1969-71**	**1988-90**	**1969-71**	**1988-90**
Cereals (Total)	891	839	1,093	876	815	958
Sorghum	637	530	895	580	712	914
Millet		57		114		500
Maize	16	54	8	46	2,000	1,174
Barley	126	50	111	45	1,135	1,111
Wheat	42	147	40	86	1,050	1,709
Seed cotton	20	21	0	22	1,000	954
Sesame	6	8	11	17	545	470

[1] **Means calculated from FAO AGROSTAT files, 1991.2.8 Seed Supplying System**

Crop	Production('000mt)		Area ('000 ha)		Yield (Kg/ha)	
	1969-71	1988-90	1969-71	1988-90	1969-71	1988-90
Vegetables (Total)	120	603	-	-	-	-
Potatoes	37	131	5	10	7,400	13,100
Tomatoes	0	164	0	10	-	16,400
Watermelon	27	236	1	8	27,000	29,500
Fruits (Total)	102	330	-	-	-	-
Grapes	21	135	5	15	4,200	9,000
Coffee	5	6	11	19	454	316
Papayas	0	56	-	-	-	-
Bananas	15	59	-	-	-	-
Dates	30	27	-	-	-	-

Seed supply in Yemen works through two main ways. The research side takes the responsibility of providing the breeder seed, while the national seed multiplication centre provides the certified seeds for distributions to the farmers. The other side on seed supplying is through the private sector (company) which imports seeds for economical crops mainly vegetables.

2.8 PEST AND DISEASES

It has been found that local races, in general, are susceptible to some important pests. Major agricultural pests in Yemen that have epidemic records are the white fly (*Bemisia tabaci*) , aphid (*Aphis gossypii*) both on tomato and melons, tuber moth (*Phthorimaea operculella*) on potato in field and storage and aryworm (*Spodoptora exempta*) on cereals. Termites, mainly Microtermis najdensis, is considered as one of the most serious insect attacking the root system and stems of many crops, mainly pepper and maize in Tihama region.

Thrips (*Scirtothrips auranthii*) on banana causing fruit spotting is fluctuating in its economical effect, but by regular spraying with insecticides the damage has been kept at low levels. However, yield losses in unsprayed banana ranges from 40-90%. Recently, the black park aphid (*Pterochloroides persieas*) on stone fruit trees, mainly plums and peaches, is very vital as it spreads widely and causes serious yield losses.

For diseases, late blight (*Phytophthora infestans*) , rusts on wheat, mainly yellow rust (*Puccinia striiformis*) and powdery mildews on vegetables (*Erysiphe sp, leviulla sp, odium sp.*) are considered the major fungal diseases that cause yield losses which range from 10-50%. Citrus canker caused by the bacteria (*Xanthomonas citri*) which was first recorded in Yemen in 1982 is still dominating in many citrus orchards. No effective control measures has been applied successfully and losses range between 10-50%. Major virus diseases recorded in Yemen are those transmitted by the white fly Bemisia tabaci and mainly on vegetables. These diseases are yellow leaf curl virus on tomato with a loss range of 20-60% and yellowing virus on water melon with a loss range of 10-90%.

CHAPTER 3
Collection, Conservation, and Utilization of Plant Genetic Resources

In the last 2 decades, in the Northern Provinces of the country, several collection campaigns through a collaborative activities with international and other relevant institutions have been carried out. Collected material included largely land races and farmer cultivars most of which field crops grown in the country. The collected materials make up more than 8,000 samples and accessions deposited at present in different Gene banks abroad.

Under the PGRU, during 1989-90. Collection was undertaken in new areas not covered before, where almost 617 samples for 70 species of cultivated crops were collected. Among the collected crops, were *Vigna unguiculata, V. radiata, V. aconitifolia, Lentils, Fenugreek*, Dolichos, Lablab, Phaseolus, Faba bean, Alfalfa, Peas, and Sesame. Duplicate copies of the various collection teams left at the National Research Centres, most of them were subjected to total loss due to poor conservation facilities. After PGRU establishment at AREA during 1988, all material collected which at present total up to 2,500 samples are conserved at a normal storage facilities AREA HQ.

In the Southern and Eastern Provinces, during the period 1969-87, three hundred and fifty-one (351) plant samples representing thirty (30) field and horticultural crops were collected. The majority of these collections were grown as field crop species. The samples were collected from fifteen (15) agricultural areas within the limits of five (5) agro-ecological zones in the south-eastern governorates of The Yemen. The number of varieties/or land races (local genetic germplasm) identified and collected was sixty eight (68), of which thirty four were sorghum and millet varieties and belong to the species Sorghum bicolor (L) Moerih, eighteen (18) were wheat varieties, all which belong to the species Triticum aestivum L., six (6) were grain legumes varieties that belong to six different plant species, four (4) varieties of barley crop that belong to the species Hordeum vulgare L., two (2) varieties of sesame crop which belong to the species Sesamum?? indicum L., and only one variety of alfalfa, crop that belongs to the species Medicago sativa. These collections have been performed during twenty-one (21) expeditions, and carried out by the Yemeni research workers posted at El-Kod Agricultural Research Centre, and during three missions carried out by a plant collector from the International Board for Plant Genetic Resources (IBPGR), and some of the Yemeni research workers from Agronomy, Forestry and Range management sections.

3.1 *EX SITU* CONSERVATION

Traditionally managed farms are still considered to be the most important *ex-situ* conservation system that provide a broad base of genetic variability for direct utilization. However, under such a system it would be difficult to achieve characterization and records of materials besides other factors that would limit effectiveness such as changing in cropping pattern. Therefore, for efficient *ex situ* conservation both methods should be considered. Research farms can be utilized effectively as *ex situ* conservation for fruits, Now most of research stations more or less manage for fruit and forest tree conservation including exotics and introductions, but this not done for the purpose of conservation of genetic resources.

In attempt to establish *ex situ* conservation in a manageable way under the collaborative regional program of WANANET, a collection of several clones of land races of figs and pomegranate were made and planted at the Northern Highland Regional Station. More support is still needed to enhance the establishment of *ex situ* conservation in each ecological zone to furnish a further conservation for important crops for each region.

3.2 IN *SITU* CONSERVATION

The local farm communities in Yemen have always been implementing conservation and preservation method known very recently to the formal sector as *in situ* and *ex situ* strategies, particularly for sorghum and millet crop varieties. Local communities are also experts in domesticating and conserving animal and plants as well as developing traditional pharmacopoeia. Indeed the knowledge they have developed over centuries are serving as a basis for the development of modern science in agriculture and medicine.

Wild races as well as land races normally are conserved *in situ*, wild races relatively may occur in rather scattered, isolated, limited area. However, no direct measures have been taken as yet for their conservation in their natural habitat. More a coordinated collaborative efforts through and relevant concerned international organization should be enhanced.

Some important areas have been proposed to be a protected areas for *in-situ* and *ex-situ* conservation. These areas are characterized by a wide range of vegetation. National Plant Genetic Resources unit (PGRU) is hoping that the government will consider these areas as a protected areas under a special national low.

A. *Proposed protected areas is situ conservation in Yemen Republic*

1. Socotra Island	(Three Locations)
2. Houf	(Mahra Gov.)
3. Bura'a Mountain	(Tihama Gov.)
4. Jabal Eraf	(Taiz Gov.)
5. Jabal Al-Araias	(Abyan Gover.)
6. Bir Ali - mangrove	(Shabwa Gov.)
7. Mifa Hajar	(Hadramout Gov.)

B. *Proposed Botanical Gardens (Ex situ Conservation)*

1. El-Kod	(Abyan Gov.)
2. Taiz	(Taiz Gov.)
3. Sana'a	(Sana'a Gov.)
4. Bajil	(Hodeidah Gov.)
5. Seyun	(Hadramout Gov.)

CHAPTER 4
In-Country Uses of Plant Genetic Resources

As mentioned earlier, plant genetic resources disciplines are under the umbrella of the Agricultural Research and Extension Authority as one of the important units in the plant research sector. The efforts and support that have been given to this unit is respectable but not enough to create a genebank responsible for conserving the Yemeni Plant Genetic Resources.

The most important activities that the plant genetic resources unit is conducting are collection, conservation, and utilization. Plant genetic resources unit has carried out some collection missions either locally organized or with outsider organizations (regional and International Research Centres). In all missions, collection activities were concentrated on cereal crops; sorghum, millet, wheat, barley, maize, and some legume crops: mainly lentils, cowpeas and faba beans.

Plant Genetic Resources Unit (PGRU) has contributed in crop improvement mainly in plant breeding aspect. There are two main functions of national plant breeding programs: improving of local varieties and to adopt introduced germplasm to local needs. Improving the local varieties can be through selection procedures or through incorporating them in a crossing programme.

The main objectives of the crossing programme is to increase productivity, disease resistance and tolerance to biotic and abiotic stresses that lead to sustainable agriculture development. Adoption of introduced germplasm is mainly as a result of selection germplasm that prove superiority. The selected germplasm either goes through normal evaluation steps till it reaches the releasing level, or goes in breeding program in order to utilize the genetical traits in crossing programmes. The (PGRU) has contributed some of its crop accessions to the breeding program, mainly in sorghum, wheat and lentils. The purpose was to improve the local varieties in productivity and utilize the useful traits of the local varieties such as earliness, drought tolerance, and wide adaptation. There has been no contribution of genetic resources of fruit trees or forage crops to the breeding programmes yet.

4.1 FOREST GENETIC RESOURCES

Some 8,000 years ago, the Arabian Peninsula boosted tropical vegetation. When the climate turned drier 5,000 years ago, agricultural technology created the dam of Marib, Since then the system of terraces was replacing natural forest. At present there are only few areas where forest is still present, only woodland, parkland and riverine forest is to be seen. The most important forest type are:

1. Coastal Plains of Tihama:

- Mangrove with *Avicennia marina*
- Thickets and woodland with *Hyphaene tabaica, Salvadora persica, Acacia ehrenbergiana, Balanites aegyptiaca, Dobera glabra, Zizphus spina-christi, Acacia tortilis, A. hamulosa, and Commiphora spp.*

2. Western mountains:

- of 400-2000 m. there is woodland with *Acacia millifera, A. tortilis, A. asak and Commiphera spp*. There is also riverine forest with *Combretum molle, Ficus spp., Tamarindus indica, Terminalia brownii, Mimusops lauifolia, Brwonada salicina, Cordia abyssinica,* and *Ficus spp*.

3. Central High Land and Wadis:

- There is woodland with *Acacia tortilis, A. nilotica and A. gerrardii.* Other woodlands include *Tamarix aphylla* and *Salvadora percica*. and orchards with *Ziziphus spina-christi*.

4. Mahra Woodland includes *Anogeissus dhofarica, Dodonea ungustifolia*, and *Croton confertus, Ficus vasta*,and *Commifora spp.*

5. There are some Juniper woodland on high mountains with the tertiary relic Juniperus excelsa.

Some forest trees are used by forestry services for afforestation. Of these few can be mentioned: Cordia abyssinia, Acacia nigrii, Ziziphus spina-christi.

Many local trees are maintained and used by the farmers on the edges of fields for fuel, forage, apiculture, medicine, shade and as wind breaks. The most important of these are Tamarix aphylla, Salvadora persica, Acacia *spp*. Ziziphus spina-christi, Commifora kataf and Cadaba rotundifolia.

Many forest plants are collected and used in folk medicine such as Cassia senna, Aloe *spp*., Ceratonia, Cadaba farinosa, Capparis cartilaginea, C. Spinosa, Salvadora persica, Peganum harmala and others. There are more than 100 plant species which are used in medicine.

Many plants are palatable and produce forage for livestock. Of these, there are more than 300 species of Graminae, most of them are perennials.

Some areas have been proposed as nature reserve or national parks. These have prominent features for genetic resources conservation.

1. Burra'a, a mountain area in the North of Tihama (over 2,000 m.) has a unique forest type for Arabia. There are more than 30 woody species which show some variability. Many plants are useful for pharmaceutical purposes.

2. Sokotra, a small island (3,625 sq. km) south east of Mukalla, which shelters 30% of endemics, the highest in Arabia. Among the threatened plants are *Dendrosicyos socotrana, Dracaena cinnabari* and a wild relative of pomegranate *Punica protopunica*. Other important species are myrrh trees: *Commiphora opobalsam, Balsamodendron mukul, B. socotrana*; Sokotran Incense trees: *Boswellia ammeero, B. elongata, B. socotrana; Sokotran Aloe: Aloe perryip* and the edible fruit tree *Cordia obovata*.

3. Al Jol region Mahra governorate has woodland and parkland wich *Angoeissus dhofarica, A. bentii, Commiphora abyssinica, C. gileadensis, Boscia arabica, Delonix elata, Ficus vasta, Maytheus dhofarica,* and *Tamarindus indica*. In Hadramout valley there is an endemic palm tree *Lowsonia canerience* which deserve protection because its importance as a wood tree.

4. Jabel Iraf: In the Hoggaria region has a tertiary relic of Juniperus excelsa which is worth protection. Of these rare tree species which deserve protection: Dracaena ambet and Cineraria prominent.

CHAPTER 5
National Goals, Policies Programmes and Legislations

The governmental policy is clear towards the genetic resources disciplines where it encourage the conservation and safeguard of the Yemen plant genetic resources and bio-diversity. Ratification of BDC is under the process of finalization. The Parliament has ratified in July 1995 the Environmental low. In the articles 11, 13, and 14 of this law it prohibit upgrading, cutting of trees, shrubs and wild plants. There are also a clear mention of the establishment of a net of nature reserves for the safeguard of forests and wild life. Obviously, this law is in full harmony with the Bio-diversity Convention.

So far, the plant genetic resources fall under the responsiblity of the Agricultural Research and Extension Authority (AREA). There is a special Plant Genetic Resources Unit (PGRU) which coordinating the PGR activities between the regional research stations and centres that belong to AREA which cover almost all the country.

Collection and characterization of plant genetic resources are carried out by the Headquarters staff and/or by the specialists of the concerned crop or both through a coordination program. A copy of the passport data is sent to the AREA Headquarters-PGRU. Conservation is still at the initial stages, where the materials are kept in envelopes and cans in a laboratory under room temperature. There is no conservation in the regional research stations or centres apart from the material that are used in the research program.

To upgrade this programme to a national level, PGRU has the following objectives:

1. Establishment of wide genetic base of the most important economic crops.
2. Collection and conservation of the plant genetic resources and availability for utilization in the breeding programs.
3. Strengthening of institutional set up and improving the national awareness of plant genetic resources.

4. Coordination the plant genetic resources activities with the relevant internal and external institutions.

5. Establishment of a data base system for plant genetic resources.

6. Creation of channels for information exchange with regional and international centres.

CHAPTER 6
International Collaboration

Yemen has participated actively in the IPGRI/WANANET regional network since its establishment in 1992 as it was represented in the steering committee, the horticultural working group and bio-diversity working group. Yemen is also a member of the commission of plant genetic resources as well as it signed the convention at the Earth summit conference held in RIO in 1992. Yemen is participating in regional and subregional research projects, through UNDP, FAO and AOAD as executive agencies for he sorghum and millet improvement, the oil crop improvement and supplementary irrigation project.

In the process of strengthening PGRU, AREA received an Italian grant through FAO, an international expatriate for one year during the establishment of the PGRU, IBGRI has provided the PGRU with some items for seed conservation and contributed in a number of collection missions throughout the country.

Since the deployment of research activities in the country during the last three decades, AREA has established very strong linkages with international and regional organizations and centres. The collaborative programmes resulted in the enhancement of germplasm exchange, information exchange and training opportunities. The output of this cooperative program has led to strengthening the national programmes with special emphasis in the establishment of a well defined commodity-wise research approach.

Due to new research approach that will tend to solve direct farmer's problems and develop sustainable agriculture, AREA is heading towards the farmers participatory research approach and farming system. Within this frame AREA is looking forward to enhance its future cooperation with relevant international and regional centres in relation to this approach, that more likely to serve dryland agriculture with more concentration on biotic and abiotic stresses.

CHAPTER 7
National Needs

7.1 INSTITUTIONAL SET UP

Completion of PGRU infrastructure and labs is requested drastically. That will help in achieving of the primary steps of plant genetic resources activities conservation, documentation and characterization. Utilization of plant genetic resources material is still very limited. That is because of the inadequate facilities in conservation and documentation. So, immediate strengthening of the PGRU will help in promoting the efforts for maintaining the national objectives of plant genetic resources.

Strengthening is demanded on the management side in order to make the PGRU undertakes the plant genetic resources activities at a national level efficiently.

7.2 FACILITIES

Concerning the facilities, PGRU need to establish a gene bank that enables the unit to conserve the material at least for a mid-term period.

As the plant genetic resources management will be expanded, the unit needs a computer set in order to improve the documentation by establishing a data base system which will ease the plant genetic resources services.

7.3 TRAINING

Training the national staff can be classified as follow:

- Long term training for higher degree to cover the most important fields in plant genetic resources management.
- Short term training for improving the skills, information exchange system. and genetic resource activities.
- In country training to upgrade the capacity of national staff.

7.4 TECHNICAL ASSISTANCE

Since the plant genetic resources activities are at an initial stage, the need for technical assistance is important . This includes special expertise help in urgent needed areas and the provision of necessary equipment for PGRU.

7.5 FUNDS

As mentioned earlier about the PGRU structure and activities we believe that the PGRU needs a special fund in order to meet the real mean of PGR activities at national level leading to make the activities enroled with international programme.

CHAPTER 8
Global Plan of Action

The Republic of Yemen is looking at the Global system on plant genetic resources as one of the very important international tasks. As the depletion and finally loss of most valuable plant genetic resources, this system will ensure the safe conservation and promote the availability and sustainable utilization of plant genetic resources for present and future generations.

The following points can be considered in the global plan of action:

- Establishing international rules for access to and benefit from the *ex situ* germplasm collections.
- Establishing effective mechanism to conserve bio-diversity *in-situ*, *ex-situ* and on farm.
- Intensify the role of IPGRI enrolment in strengthening national institutes and programs in genetic resources through efficient network and well defined mandates.
- Define the role of International Research Centres and their linkages with national research program in relation to utilization of plant genetic resources.
- Establishing of *in-situ* conservation areas with special emphasis on wild relatives of crops and "on farm" conservation and utilization of land races.
- Collecting and disseminating data and facilitating the exchange of information in plant genetic resources and related technologies.
- Establishing an early warning system with rapid attention to hazard threatening to the genebanks and the loss of the genetic diversity throughout the world.
- Strengthening the national genetic resources activities to be in harmony with regional and international frame work.
- Developing of national law restricting the availability of germplasm, and intellectual rights over new varieties.
- Recognizing of farmers rights over their genetic resources and indigenous knowledge, and establishing effective mechanism to implement this right.

FIG . 1 TERRITORY