International Center for Agricultural Research in the Dry Areas (ICARDA)
Arabian Peninsula Regional Program (APRP)

Agricultural Research Strengthening and Human Resource Development in the Arabian Peninsula (1995- 2000)

FINAL REPORT

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FOREWARD

The Arabian Peninsula (AP), comprising the countries of Bahrain, Kuwait, Oman, Qatar, the Kingdom of Saudi Arabia, the United Arab Emirates and the Republic of Yemen, is characterized by extreme aridity and limited renewable water resources. In these countries, rangeland biodiversity and livestock production co-exist in a delicate balance. An increase in the small ruminant population has meant that the palatable indigenous plant species have been severely overgrazed resulting not only in a loss of biomass, but also a loss of the genetic variation that provided adaptation to the harsh environment. Exotic species, in the form of alfalfa (Medicago sativa) and Rhodes grass (Chloris gayana) are not well adapted to the environment of the Peninsula, yet are being grown to accommodate the shortfall of forage from rangelands. These species, however, require large volumes of irrigation water, mainly from groundwater sources. This has compounded the problems of desertification by lowering the groundwater levels and raising salinity levels, resulting in reduced potential productivity of agricultural land and, in severe cases, to the abandoning of the cultivated land.

Since its establishment in 1977, ICARDA has actively collaborated with the countries of the Arabian Peninsula in technical assistance, exchange of germplasm and human resource development. ICARDA's Arabian Peninsula Regional Program (APRP) was established to serve the needs of the region through specific projects. In 1988, ICARDA initiated a regional project for strengthening research and training in the Arabian Peninsula with financial support from the Arab Fund for Economic and Social Development (AFESD). Although this project was aimed primarily at the improvement of cereal production in the region, it served an important function in identifying priority needs and gaps in agricultural research. Based on an analysis of the major constraints to agricultural development in the region, a new program on Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula was established in 1995, with support from AFESD and the International Fund for Agricultural Development (IFAD). This report covers the activities in that program from 1995 to 2000. The overall goal of the program was to contribute to increased food security in the Arabian Peninsula by increasing the productivity of field crops and livestock through the optimization of water use efficiency, conservation of natural vegetation, prevention of soil degradation and desertification, and strengthened cooperation among the participating countries and with concerned regional and international organizations.

The collaborative research program, conducted jointly by ICARDA and the national agricultural research systems (NARS) of the region, addressed some of the major problems facing the region: scarcity of renewable water sources combined with the inefficient use of water; degradation of the large areas of rangeland and resulting desertification; and the need to develop a resource-efficient protected agriculture industry that generates high quality high-value produce and ensures there is no environmental and product contamination by agricultural chemicals. During this second phase, in response to the collective priorities determined by the seven countries of the Arabian Peninsula, APRP expanded its scope to encompass the three principal themes of (i) rangelands, (ii) water, and (iii) protected agriculture. These were supported by activities in agro-ecological characterization and research on abiotic stresses, which contributed to the major research themes.

The main strategy of the rangeland component of the program was seed multiplication and rehabilitation of degraded rangelands utilizing the adapted genetic variation of indigenous forage species. Germplasm collection missions were conducted in various countries of the region, along with the development of herbaria, regional databases and protective enclosures. Seeds of priority species were multiplied and their water use efficiency and nutritive values were evaluated. Initial data show that not only do the indigenous desert species use less water than the introduced forages, but their nutritive value is also as good.

Agricultural production in the Arabian Peninsula is constrained by adverse climatic conditions, scarcity of water and limited arable land resources. Under protected agriculture (glass and plastic houses), the environment and production timing can be controlled, improving efficiency and increasing yields per unit of land and water. As such it plays an important role in increasing the income of ordinary farmers and provides the local markets with fresh products all year round.

The APRP has developed and implemented an Integrated Production and Protection Management program that has resulted in strong healthy plants producing high quality products with less or no pesticides. New simple techniques for soil-less culture were also developed and adopted by farmers. Capacity building of NARS was a second major objective of APRP and an integral part of the research program. Technical meetings and workshops enabled scientists from the region to share results and exchange information and contributed to the development of an integrated regional research program. Human resource development encompassed training in various forms, including short-term group training courses on specific topics and longer-term individual training. For example, a total of 282 individuals from the region participated in training activities held at ICARDA's headquarters and in the region.

Finally, the APRP would not have achieved what it has without the full support of its donors, AFESD and IFAD. Their financial and technical support is highly appreciated. The support of the Ministry of Agriculture and Fisheries of the United Arab Emirates, which hosts the APRP Regional Office is also acknowledged and appreciated.

Prof. Dr Adel El-Beltagy
Director General
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1. INTRODUCTION

The Arabian Peninsular, comprising the countries of Bahrain, Kuwait, Oman, Qatar, the Kingdom of Saudi Arabia, the United Arab Emirates and the Republic of Yemen, is characterized by extreme aridity and limited renewable water resources. Rapid economic development in the latter half of this century has resulted in significant changes to the traditional agricultural systems of the Arabian Peninsula. Increased production has contributed to economic growth, but has often resulted in the degradation of natural resources.

The issue of water resources and their use is fundamental to the sustainable development of the Arabian Peninsula. Water demand greatly exceeds available renewable water supplies, and is supported mainly by the consumption of non-renewable groundwater resources and desalinated water. While the renewable supply of water per capita is amongst the lowest in the world, water consumption per capita is among the highest in the world in some countries of the region, yet there are few incentives to conserve water. Irrigation uses by far the largest share of water resources in the Arabian Peninsula.

Continued use of groundwater for irrigation to meet agricultural production targets has led to declining water levels and saline intrusion in many coastal areas. At the same time, water is still wasted in the region because of inefficiencies in water application and management. Improving water use efficiency in irrigated agriculture would therefore have a major impact on water conservation.
Large areas of rangelands have been lost to urban expansion or irrigated cultivation, or have been degraded to unproductive levels due to overgrazing by the greatly expanded population of livestock, resulting in the loss of indigenous plant species, accompanied by low rangeland productivity and soil erosion. The indigenous rangeland plants that are adapted to the harsh arid environment represent a valuable genetic and economic resource that may be of great economic value in the future to the Peninsula, and other regions of the world, if temperatures and the incidence of drought increase as a result of global warming and associated changes in agroecological systems.

The Arabian Peninsula is faced with the challenges of developing more sustainable land and water use, preserving its environment and heritage, and sustaining the development of its population. Innovative research and technology development is needed in the improvement of on-farm water management and water use efficiency, development and use of alternative water sources, restoring the productivity and arresting the degradation of rangelands and developing protected agriculture.

A Regional Program for *Strengthening Agricultural Research and Human Resource*

Development in the Arabian Peninsula was initiated in September 1996, with financial support for three years (1997-1999) from the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD). The program was coordinated by ICARDA and implemented in partnership with the national programs of the Arabian Peninsula. During this phase of the Program (Phase I), emphasis was placed on initiating a regional program of research and human resource development. The priority areas of research were established, as follows:

On farm water use and irrigation management;
Rangeland, shrubs, irrigated forages and livestock; Abiotic stresses and
Protected agriculture.

These research components were supported by activities in:

Agroecological characterization, and
Human resources development
Two aspects of this work program should be noted:
Although presented under different components, many of the activities are closely inter-related;
All countries conduct not all activities. Some countries take the lead in specific activities and transfer their findings to other countries, thereby avoiding duplication of effort and enhancing the efficient use of limited resources.

This report is a record of the activities and achievements of Phase I.

The organisation of this Final Phase I Report follows closely that of the **Summary of Priority Research Areas, Activities and Training** document (Appendix I), prepared at the first RTCM of Phase I held in Aleppo from 1-4 March 1997. This can be used as a guide when reading this Phase I Report. It should also be noted that each main heading from the **Summary of Priority Research Areas, Activities and Training** document has been covered, even if an activity was not completed or for other reasons was not implemented during Phase I.

2. PRIORITY RESEARCH THEMES

2.1 RANGELANDS, SHRUBS, IRRIGATED FORAGES AND LIVESTOCK

The research, outputs and activities, in this theme on Rangelands, Shrubs, Irrigated forages and Livestock is primarily aimed at arresting desertification caused essentially by overgrazing and at the same time to conserve the valuable natural resources of the Arabian Peninsula.

The Arabian Peninsula, which comprises the seven countries, viz. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates (UAE), and Yemen, experiences some of the most extreme climatic conditions found on Earth and has in recent years also experienced large changes in human activities. These have contributed to desertification together with a considerable loss of the plant biodiversity of the Arabian Peninsula. Within these countries, there are very diverse ecosystems, which encourage species diversity and are likely to reflect genetic variation within those species found across these ecosystems. This native plant biodiversity is probably, in the context of sustainable agricultural production and arresting desertification, the most important on Earth.

The Arabian Peninsula is characterized by low, erratic rainfall, high evaporation rates and amongst the highest temperatures on Earth (Bõer, 1997; Ghazanfar & Fisher, 1998; Zahran, 1997). Added to this are high levels of soil and water salinity, which can increase rapidly under irrigation. Over the centuries, these extreme conditions have applied stringent evolutionary selection pressures resulting in a uniquely adapted biodiversity, an expression of genetic variation. With increases in global levels of soil and water salinity and changes brought about through global warming, adaptation to extreme environmental conditions will become even more critical in an agricultural context.

The native plant biodiversity of the Arabian Peninsula, which comprises over 3500 species (Ghazanfar & Fisher, 1998), is being rapidly depleted. Over 90% of the total land area now suffers from some form of desertification, and 44% is severely or very severely degraded (UNEP, 1992). The primary cause is overgrazing.

Figure 2.1.1:Indigenous forages such as Coelachyrum piercei (left) and Lasiurus scindicus (right) may be used to enhance the productivity of degraded rangelands in countries of the Arabian Peninsula.

Since the late 1960’s the region has experienced a sharp increase in numbers of animals, mainly because of improved veterinary services and the subsidy that allows the purchase of processed feed and baled hay. Producers have also become very reluctant to sell surplus unproductive animals. In 1998, it was estimated that there were 24 million head of livestock, comprised mainly of sheep, goats and camels.

Overgrazing not only lowers the productivity of these ecosystems, but also results in a change in plant species richness and the relative abundance. Herbivores, because of their dietary selection, select palatable species, which are quickly taken out, thus leaving an ecosystem dominated by un palatable and sometimes poisonous species.

Overgrazing is seriously threatening the genetic resources and biodiversity of these important palatable forage species; species, which in the past were, and could again be, the basis for a sustainable system of animal production.

Figure 2-1-2:Over grazing by livestock lowers productivity of the ecosystem and results in dominance of unpalatable plant species

A viable, sustainable livestock industry requires not only a sustainable grazing regime, but also a sustainable system for the production of cheap fodder. Currently, in the Arabian Peninsula, the main fodder crops are alfalfa (*Medicago sativa*) and Rhodes-grass (*Chloris gayana*). These species require vast quantities of water (up to 48, 000m3/ha/yr) usually derived from a ground-water source, which, apart from being unsustainable, has resulted in many areas having to be abandoned due to problems of salinity.

This theme, which is comprised of a number of different research objectives forms part of a long-term research project. The research forms a systematic and a holistic approach to address the issue of arresting desertification through the conservation and utilization of the important forages of the Arabian Peninsula.

Figure 2-1-3: Rhodes – grass, one of the main fodder crops in the Arabian Peninsula, requires vast quality of water (48000 m^3/ha/yr)

The main approach to addressing the problem lies in the utilization of adapted indigenous forage species. By replacing Rhodes-grass with indigenous adapted species, it may be possible to produce fodder in a sustainable manner, while taking the grazing pressure off the rangelands, hence protecting the delicate environment, and its valuable biodiversity.

Indeed Cenchrus ciliaris, indigenous to the Arabian Peninsula, is currently being successfully used as a fodder in parts of Australia and India.

It has been shown to be highly drought resistant and can respond dramatically to very small amounts of irrigation.

In addition, if indigenous forages are to be utilized, the genetic variation existing within species must also be explored and utilized for optimum production. This necessarily requires its initial collection and conservation.

Figure 2.1.4:* Cenchrus ciliaris*, indigenous to the Arabian Peninsula is an important fodder crop in many parts of the world

In addition to fodder production, indigenous forages may be used to enhance the productivity of rangelands through either restoration (planting or reseeding with indigenous grasses, shrubs and trees) or rehabilitation (planting or reseeding with both exotic and indigenous grasses, shrubs and trees). Seed or cuttings of different palatable species must also be collected, conserved, and then evaluated in a range of different ecosystems, for establishment, productivity and ability to ultimately survive with no supplementary irrigation.

The National Agricultural Research Systems (NARS) of the Arabian Peninsula (AP), in collaboration with the Arabian Peninsula Regional Program (APRP) of the International Center for Agricultural Research in the Dry Areas (ICARDA), followed these approaches, during Phase I of this project. Each component is dealt with in detail below and by country. e.g. in the UAE, based on an initiative of H.E. Saeed Al Ragabani, the Minister of Agriculture and Fisheries, a team comprising of scientists from 5 organizations in the UAE have developed and carried out a program of research. The importance of working as a team, involving many organizations, both national and international, was emphasised throughout PhaseI

2.1.1: Research on indigenous forages

2.1.1.1: Comparison of the Water Use Efficiency (WUE) of important forages grown in the region (Arabian Peninsula Regional Forage Crop and WUE Trial (APRT)).

Objective: To evaluate the WUE of currently used forages and their mixtures.
(This section of the research is reported in detail under R.4. ON FARM WATER USE AND IRRIGATION MANAGEMENT)

2.1.1.2: Assessment of the current Status of Germplasm Collections of indigenous forage species in the Arabian Peninsula

Objective: To review the status of germplasm collections in Arabian Peninsula and to identify priority areas for collection.

Location: All countries
Dr Jan Valkoun (ICARDA, GRU) prepared a questionnaire, which was circulated and completed. He also visited the Republic of Yemen, the UAE and the Sultanate of Oman.
Based on this information it was agreed that priority should be given to collection missions in the UAE, the Sultanate of Oman and the Republic of Yemen

2.1.1.3:Collection, classification and storage of indigenous pasture and rangeland plants and shrubs

Objective: To collect, classify and store the important indigenous desert and mountain forages and shrubs. Firstly, a very successful training course involving 12 trainees was held at the Natural History Museum and Desert Park, Sharjah, UAE from 28th February to 4th March 1998.

Following the training course, separate Germplasm collection missions were carried out in the United Arab Emirates, the Sultanate of Oman and the Republic of Yemen for the major indigenous forage grasses, legumes, shrubs and trees of the region, with the ultimate objective of utilising the most promising germplasm for degraded rangeland rehabilitation and for irrigated fodder production under systems requiring substantially less water than those currently used (alfalfa and Rhodes grass).
A major objective of the first two collection missions in the UAE and the Sultanate of Oman was the training of counterparts from the Ministry of Agriculture and Fisheries, UAE, and the Directorate of Agricultural Research, Oman, in germplasm collection techniques.The mission in UAE, 12th – 19th March 1998, targeted the higher rainfall zones, which occur North of the Abu Dhabi to Al-Ain main road (Fig.2.1.5). Prior to the mission, target taxa had been prioritised according to discussions with farmers, local botanists and international consultants on rangeland development.
In total 114 accessions were collected, representing 22 taxa from 27 sites (Table2.1.1). The locations of collection sites are shown in Figure 2.1.5.

In the Sultanate of Oman, 20th March to 6th April 1998, the mission targeted the northern regions including the northern and eastern coastal plains, Wahiba Sands, the northern and eastern interior plains and the Hajar mountains (Fig.2.1.6). In total 68 accessions were collected, representing 27 taxa, from 18 sites (Table 2.1.2). In addition, time was spent talking to farmers, collecting indigenous knowledge and prioritising species for potential use for rangeland rehabilitation and for use as fodder crops. During both expeditions, herbarium specimens were taken in order to identify unknown species, which may be of interest as browse species, and to define the
distributional range of target species for which seed was unavailable. At each site soil samples were taken to help define the ecological preferences of each species. All samples were analysed by the appropriate authority in each country.

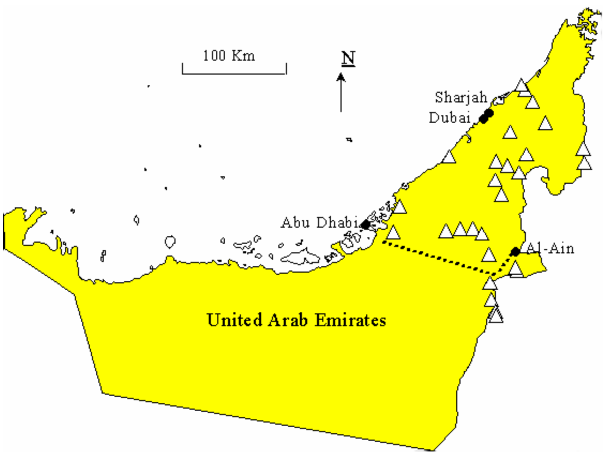


Figure 2.1.5: Location of collection sites in the United Arab Emirates (1998)

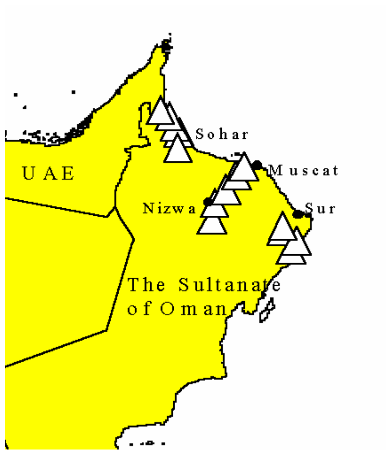


Figure 2.1.6: Location of collection sites in the Sultanate of Oman (1998)

All the seed was sent to the Genetic Resources Unit, ICARDA, for 'black box' storage, until suitable storage facilities were available within the Arabian Peninsula. A working collection is now stored in the Genetic Resources Unit of the International Center for Biosaline Research (ICBA) in Dubai. Thus providing easy access to scientists in both countries for further evaluation and seed multiplication. In total 2 scientists

From the UAE and 6 scientists from the Sultanate of Oman were trained in ' hands-on' germplasm collection techniques

Table 2.1.1:Nunber of accessions of rangeland species collected in the United Arab Emirates (March 1998)

Genus	Species	Number of Accessions
Calligonum	***crinitum subsp. arabicum***	**1**
Cassia	***italica***	**1**
Cenchrus	***ciliaris***	**11**
Coelachyrum	***piercei***	**5**
Dichanthium	***foveolatum***	**5**
Dipterigium	***glaucum***	**8**
Farsetia	***aegyptiaca***	**1**
Heliotropium	***kotschyi***	**2**
Indigofera	***articulate***	**1**
Indigofera	***sp.***	**2**
Lasiurus	***scindicus***	**9**
Leptadenia	***pyrotechnica***	**1**
Panicum	***turgidum***	**18**
Pennisetum	***divisum***	**19**
Rhanterium	***eppaposum***	**1**
Savignya	***parviflora***	**1**
Sphaerocoma	***aucheri***	**2**
Sporobolus	***loclades***	**2**
Sporobolus	***spicatus***	**5**
Stipagrostis	***plumose***	**15**
Stipagrostis	***Sp.***	**2**
Unidentified		**2**
TOTAL		**114**

A database was compiled of all collection passport data and a photographic Flora produced to assist in rangeland species identification. In addition a database of 152 rangeland plants, which were brought to our attention by farmers, herders and scientists, has been developed

This includes information concerning biological characteristics and potential use in forage production, rangeland enhancement and /or rangeland rehabilitation. This database has been used to produce a 'target species' list. The database includes 27 species of high priority, 39 of medium priority, 60 of low priority and 26 of unknown potential (but likely to be low). Table 2.1.3.

Bulk seed samples were then collected of *Panicum turgidum, Pennisetum divisum, Lasiurus scindicus, Cenchrus ciliaris, Dipterigium glaucum, Dichanthium foveolatum, Rhanterium eppaposum, Stipagrostis plumosa* and *Coelachyrum piercei* from locations identified during the collection mission. This seed was used in experiments for evaluation and seed multiplication in both UAE and the Sultanate of Oman.

Table 2.1.2: Number of accessions of rangeland species collected in the Sultanate of Oman. (April 1998)

Genus	Species	Number of Accessions
Asphodelus	*tenuifolius*	2
Calligonum	*comosum*	1
Calligonum	*crinitum subsp. arabicum*	1
Cenchrus	*ciliaris*	7
Cenchrus	*setigerus*	1
Crotalaria	*aegyptiaca*	5
Cyperus	*conglomeratus*	2
Dichanthium	*foveolatum*	5
Dipterigium	*glaucum*	5
Farsetia	*linearis*	1
Heliotropium	*kotschyi*	1
Indigofera	*intricate*	2
Jaubertia	*aucheri*	2
Kohautia	*retrorsa*	1
Lasiurus	*scindicus*	8
Lotus	*garcinii*	1
Ochradenus	*arabicus*	1
Ochradenus	*aucheri*	4
Ochtochloa	*compressa*	1
Panicum	*turgidum*	3
Pennisetum	*divisum*	6
Polygala	*erioptera*	1
Sporobolus	*ioclades*	2
Sporobolus	*spicatus*	1
Stipagrostis	*plumose*	1
Tephrosia	*apollinea*	1
Ziziphus	*spina-christi*	2
TOTAL		68

Table 2.1.3: List of high priority species compiled according to observations and discussions with farmers, herders and scientists both in the UAE and in the northern part of the Sultanate of Oman.

Grasses (10species)		**Shrubs & trees (15 species)**	
Cenchrus	*ciliaris*	*Acacia*	*chrenbergiana*
Cenchrus	*setigerus*	*Acacia*	*gerardii*
Coelachyrum	*piercei*	*Acacia*	*nilotica*
Dichanthium	*foveolatum*	*Acacia*	*tortilis*
Ochtochloa	*compressa*	*Calligonum*	*comosum*
Sporobolus	*ioclades*	*Calligonum*	*crinitum sub p.arabicum*
Sporobolus	*nervosus*	*Ceratonia*	*oreothauma sub sp.oreothauma*
Sporobolus	*virginicus*	*Convovulus*	*virgatus*
Stipagrostis	*plumosa*	*Cressa*	*cretica*
Stipagrostis	*sokotrana*	*Crotalaria*	*aegyptiaca*
		Dipterigium	*glaucum*
		Heliotropium	*digynum*
Grass shrubs (2 species)		*Maerua*	*crassifolia*
Lasiurus	*scindicus*	*Prosopis*	*cinerea*
Panicum	*turgidum*	*Rhanterium*	*epapposum*

2.1.1.4:Seed multiplication of collected germplasm including seed multiplication for further testing

Objective: Multiplication of important species collected under 2.1.2.2

Materials and Methods: Material to be grown out at appropriate locations in each country.

Location: All countries

Seed production in the Arabian Peninsula is underdeveloped or non-existent. Where it exists, seed production is mainly 'informal' and limited to few species e.g. alfalfa. In general, no quality control or certification scheme is applied. Most of the seed used in the region is imported.

The region is also concerned that the rangelands are being degraded, salinity is rising and water is becoming scarce. Overgrazing of the natural vegetation is becoming serious and ground water resources are being depleted to support crop production and result so often in the increase of the level of salinity at the soil surface. This leads to the abandonment of more farming land every year.

There is an increasing interest in the replacement of introduced forage species by indigenous pasture and shrub species. These are adapted to the local conditions and may be much more efficient in their use of water while providing sustainable livestock feed and restoring degraded lands. The challenge is to identify the appropriate indigenous species, collect and conserve this material, and start to produce their seeds to meet the demand. This activity (2.1.2.3) marks the beginning of this new approach, which now forms a regional project " seed production of native forage species in the Arabian Peninsula region".

Seed of the material earlier collected by Dr. Morag Ferguson and the Emirati contact scientists was sent to ICARDA headquarters for evaluation on germination and dormancy characteristics. Dr. Michael Turner (ICARDA, SPU) organised a student to look at this. Dr Lahcen Grass visited UAE and Yemen in mid December 1997 and a full report of these visits is available.

The ICARDA Seed Unit prepared a full project proposal on *Seed Production for the Arabian Peninsula* .To assist with this Dr Michael Turner, who was involved in the two training courses in Oman and Sharjah, UAE visited the sites where the important forage species are growing. Drs Turner and Lahcen Grass (ICARDA), with their colleagues from the ICARDA seed unit conducted a ten-day training program on *Seed Technology and Production* from 16-26 February 1998 in the Sultanate of Oman.

With the priority species identified, a necessary next step in the approach was to obtain large quantities of seed and subsequent mechanized seed multiplication. Bulk seed samples were collected of *Panicum turgidum, Pennisetum divisum, Lasiurus scindicus, Cenchrus ciliaris, Dipterigium glaucum, Dichanthium foveolatum, Rhanterium eppaposum, Stipagrostis plumosa, Coelachyrum piercei* and *Calligonum comosum* from locations identified during the earlier collection mission. In view of the fact, that since this collection in April 1998, there has been no appreciable rain in the UAE, there was no other seed available, either in the desert or elsewhere and therefore what was collected can only be described as "gold dust". With help from ICARDA's Seed Production Unit, who provided a scarifier and aspirator, scientists from the UAE Ministry of Agriculture and Fisheries were able to thresh this precious seed. This also provided important information on which species were easiest to thresh. Based on these data and the germination and establishment data and information from the Central Arid zone Research Institute, (CAZRI) Jodhpur, India, three species were selected *viz. Cenchrus ciliaris, Lasiurus scindicus.* and *Coelachyrum piercei* for seed increase. It should be noted that the first two of the species *Cenchrus ciliaris* and *Lasiurus scindicus* have already been successfully used in major reseeding programs in similar ecosystems in northern India.

Seed increase is now the priority research area in Phase II and it is hoped to start producing large quantities of seed of these three species in the UAE, the Sultanate of

Oman and the Kingdom of Saudi Arabia early in Phase II of the project.

Earlier (before Phase I started) the Range & Animal Research Center in Al-Jouf, Kingdom of Saudi Arabia, initiated a seed multiplication unit for native species in the northern region (Buseita). Currently, more than 40 important species were selected for propagation (Table 2.1. 4.). Seed propagation is carried out in native range under both drip and central pivot systems. Production reached about 4 tons per annum by 1999. These seeds are used for rangeland rehabilitation, basic seed research, and seedling production. In addition, the unit supplies seeds to the Department of Forestry and Range, local farmers, and research institutes locally and within the Arabian Peninsula.

This center will continue to play a major role with seed production in Phase II.

Table 2.1.4: List of Important species selected for seed production at the Range and Animal Development Center. Al-Jouf, Saudi Arabia.

1. *Traganum nudatum*
2. *Atriplex leucoclada*
3. *Salsola villosa*
4. *Piturathos triradiatus*
5. *Heliotopium sp.*
6. *Pulicaria crispa*
7. *Rhanterium epapposum*
8. *Achillea fragrantissima*
9. *Salsola rosmarinus*
10. *Anabasis articulata*
11. *Artemisia herba alba*
12. *Salsola cyclophylla*
13. *Haloxylon persicum*
14. *Mammada elgans*
15. *Agathophora iraqensis*
16. *Sueda vera*
17. *Anabasis setifera*
18. *Reumuria sp.*
19. *Acacia garradii sp.*
20. *Astragalus spinosus*
21. *Farsetia aegyptica*
22. *Calligonum comosum*
23. *Salsola hypericifolia*
24. *Artemisia judaica*
25. *Fagonia glutinosa*
26. *Onobrychis sp.*
27. *Astragalus bombycinus*
28. *Salsola tetrandra*
29. *Atriplex halimus*
30. *Nitraria retusa*
31. *Teucrium polium L.*
32. *Thumas sp.*
33. *Artemisia monosperma*
34. *Halothamnum iragensis*
35. *Retama retama*
36. *Lycium shawii*
37. *Ephedra alata*
38. *Cornulaca monacantha*
39. *Teucrium oliverianum*
40. *Pennisetum divisum*
41. *Koelpinia linearis*
42. *Echinops sp.*
43. *Limonium sp.*
44. *Rhanterium suaeveolens*
45. *Chenapadinm opulifalium schrad*

2.1.1.5:Assessment of feed quality of important forages grown in the region

Objective: Assessment of digestible dry matter and feed quality of species used in 2.1.1.1

Apart from evaluating the indigenous forages for their water use efficiency, it is also important to assess their nutritive value in comparisons with the exotic forages i.e Rhodes grass. This is being done through a collaborative project with the Faculty of Agricultural Sciences of the UAE University in Al-Ain. Chemical composition, in *vitro* dry matter degradation and *in-situ* dry matter degradation were determined to estimate the nutritive value of six desert grass species in relation to Rhodes grass.

During 1997, samples of five desert grasses (*Cenchrus ciliaris, Stipagrostis plumosa, Panicum turgidum, Pennisetum divisum and Coelachyrum piercei)* were collected once from two sites in the UAE during the spring of 1997. The first four grasses were collected from the Al-Ain area and the fifth one from near Jebel Ali. Samples of Rhodes grass were collected from the University Farm in Al-Ain during the same period. In 1998, during the month of February, March, April and May, samples of five desert grass species (*Cenchrus ciliaris, Coelachyrum piercei, Lasiurus scindicus, Stipagrostis plumosa, and Panicum turgidum)* were collected from two sites in the UAE. Samples of Rhodes grass were again collected from the University Farm in Al Ain during the same period.

Chemical analysis data (Table 2.1.5) showed that most of these desert grass species are similar in their chemical composition to that of irrigated Rhodes grass. In fact, the 1998 data of *Cenchrus ciliaris* and *Panicum turgidum* are almost the same as that of irrigated Rhodes grass in crude protein, neutral detergent fiber (which provide an indication of dry matter intake),

Table 2.1.5: Chemical composition and gas production valuse shown for three desert grass species and Rhodes grass.

	Cenchrus ciliaris	Coelachyrum piercei	Lasiurus scindicus	Rhodes grass
Chemical composition % DM basis				
Crude protein	9.6	7.8	6.9	9.4
Neutral detergent fiber	70.1	71.9	79.1	72.9
Acid detergent fiber	38.6	40.1	49.3	38.8
Acid detergent insoluble N	0.1	0.1	0.1	0.1
Ash	10.0	8.8	7.2	9.6
Gas production (ml)				
06 h	8.9	6.7	7.2	7.9
12 h	17.8	12.8	12.4	15.5
24 h	28.0	20.6	18.5	26.8
48 h	38.8	30.7	24.5	37.4

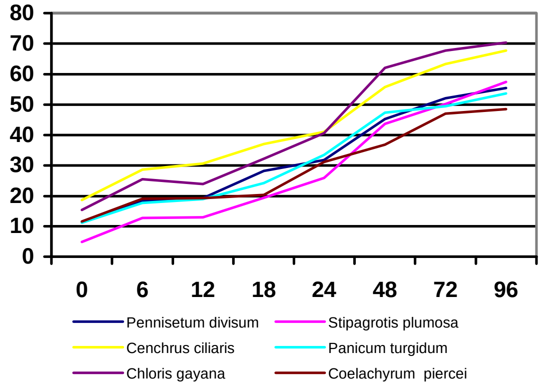


Figure2.1.7: Dry matter disappearance curves of five desert grass species compared to irrigatedRhodes grass, at different incubation times in 1997, incubated in-sitru in camels

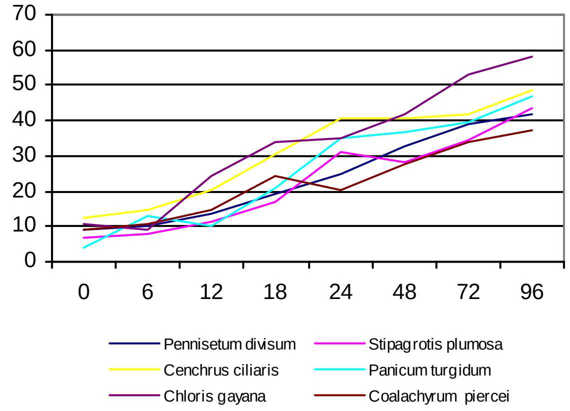


Figure 2.1.8: Dry matter disappearance curves of five desert grass species compared to irrigated Rhodes grass, at different incubation times for 1997, incubated in-sitru in goats

acid detergent fibber, acid detergent insoluble nitrogen and ash. For *Cenchrus ciliaris* the CP value of 9.6 is similar to that of 9.4% shown for Rhodes grass

The *in-vitro* dry matter disappearance in camels and goats of the five desert grasses species (samples collected in the spring of 1997) is shown by Figures 2.1.7 and 2.1.8 In both camels and goats, *Cenchrus ciliaris* had a similar nutritive value to Rhodes grass, while *Coelachyrum pierce*i and *Stipagrostis plumosa* had the lowest nutritive value. The plant materials used in this study for *Coelachyrum piercei* were very dry and had lots of stems, which indicate that the grass was very mature. This may have contributed to the lower quality value obtained in this study. However, 1998 data showed that *Cenchrus ciliaris* had a similar nutritive value to Rhodes grass followed by *Coelachyrum piercei* as measured by the gas production technique (Table 2.1.6). In addition, it was found that camels were more efficient at digesting the desert grasses than goats, which is a good example of the advantages of natural adaptation.

Table 2.1.6: Gas production (ml/200 mg sample) of five desert grass species compared toIrrigated Rhodes grass at different incubation time, 1998.

Incubation time	**Rhodes grass**	***Cenchurs ciliaris***	***Coelachyrum piercei***	***Lasiurus scindicus***	***Stipagrostis plumosa***	***Panicum turgidum***
6h	7.9	8.9	6.7	7.2	5.3	6.6
12h	15.5	17.7	12.8	12.4	9.9	11.0
24h	26.8	28.0	20.6	18.5	16.4	15.5
48h	37.4	38.8	30.7	24.5	28.2	23.4

2.1.2: On-farm trials

2.1.2.1: Rehabilitation of Rangeland

Objective: To rehabilitate degraded rangelands

Location: Saudi Arabia & Kuwait

Duration: Continuous

This activity was restricted to two countries, Kuwait and Saudi Arabia. In the Kingdom of Saudi Arabia (KSA) one of the main goals of the Range & Animal Development Research Centre in Al-Jouf is to find a solution for rangeland degradation through rangeland research. Three areas with 7000 ha are used as rangeland experimental stations, two of which represent high potential wadi sites and a third representing a gravel plain

Figure 2.1.9: Protected rangeland site demonstrates potential for recovery of degraded rangeland in the northern KSA

In addition, there are 12 range-monitoring enclosures selected within the Al-Jouf region, representing different range sites and vegetation types. The protected rangeland sites showed an increase in both density and total dry matter biomass of perennial species such as *Atriplex leucoclada* and *Salsola vermiculata*. The observed improvement could be attributed to good seed production of protected species. Initial data from rehabilitation of rangeland by cultural treatments, such as contour furrowing, pitting and reseeding or/and transplanting of native rangeland species, showed good seedling emergence in *Atriplex halimus* and *Artimisia herba* alba and good seedling survival following high rainfall (Plate showing water harvest by pitting).

Figure 2.1.10: Water harvesting by pitting the ground improves survival of perennial shrubs during range rehabilitation

Transplanting of native species in pits with initial supplementary irrigation resulted in a 90% survival rate. However, the success of rangeland rehabilitation in Saudi Arabia is very dependent on rainfall amount and distribution. It is argued that rehabilitation in arid systems cannot be predicted because that climatic variation is too large. Data showed that re-seeding using contour furrowing or pitting, although increased water infiltration, the survival rates were very variable over years depending on rainfall. This work will be continued in PhaseII.

The other location selected was KISR's Sulaibiya Experimental Station in Kuwait. Work at Sulaibiya was restricted to the measurement of Water Use Efficiency of Important forage species

2.2.ABIOTIC STRESSES

2.2.1:Researcher-managed trials

2.2.1.1:Field assessment of different crops for tolerance to drought, heat and salinity

Objective: Assessment of different crops (see below) to different levels of soil moisture

Location: Yemen

Duration: Continuous
This work conducted in the Republic of Yemen is reported under the Water section.

2.2.1.2:Field assessment of different crops for tolerance to salinity

Objective: Assessment of different crops (see below) for ability to different levels of salinity
Location: Sultanate of Oman and UAE
Duration: Continuous
These activities were conducted in both the UAE and the Sultanate of Oman.

In the UAE, at Al-Ain, barley is being screened at the UAE University Farm at three levels of salinity. At the Zayed International Experimental Farm at Narshallah in Abu Dhabi an experiment to look at the performance of *Sporobulus virginicatus* was initiated by Drs Ghaleb Al-Hadrami and Abdullah Dakheel from UAE University Al-Ain.
In the Sultanate of Oman, three locations, with different levels of salinity (200 to 13000 ppm) have been selected and will be used to screen a number of forages and feed crops in Phase II.

A collaborative research program was initiated, in 1997, with the Faculty of Agricultural Sciences, UAE University, with the objective of identifying plant species and varieties, which have high potential for salt tolerance and high forage value. Traditional crop plants, natural halophyte and local range grass species were evaluated. Two types of salt-affected environments/areas were targeted for the development of salt tolerant forage production systems in the Arabian Peninsula.
Marginal environments that are out of the range of conventional cropping systems and are subjected to high salinity stress (EC=12-25 dSm^{-1}).
Enviroments that are subject to moderate to high salinity stresses and less suitable for conventional crop production systems (salt concentrations in soil or irrigation water up to an EC of 10-12 dSm^{-1}).

For the first saline environmental type, several natural range grasses and shrubs were collected from salt-affected areas (Table 2.2.1). Detailed evaluation of these will form the basis of future research and collaborative research with the UAE University in Al-Ain and the new International Center for Biosaline Agriculture (ICBA), in Dubai.

Currently, two species have been evaluated, a halophyte grass (*Sporobolus virginicus*) and five *Atriplex spp.* These two species complement each other in their nutritional values and are being used successfully in camel-feeding trials at the UAE University Farm (Al-Hadrami, personal communication).

Five Atriplex species (*A. halimus; A. nummularia; A. leucoclada; A. lentiformis; A. canescens*) were evaluated for their productivity and nutritional values in the field under different levels of salinity; ranging from EC= 10 to 40 $dS\ m^{-1}$; and three levels of NPK fertilizer. Productivity and chemical composition of *Sporobolus virginicus* was also evaluated in the field with irrigation water of high salt levels that exceeded 20 $dS\ m^{-1}$.

Table 2.2.1: Variation in site characteristics from which three indigenous grass species were collected in the UAE, 1998.

Genus	Species	Site Habitat	Land Form	Soil Texture	pH	EC (DS/m)
Cenchrus	*ciliaris*	Protected	Sand dune	Sand	8.2	0.27
Cenchrus	*ciliaris*	Disturbed	Gravel plain	Sandy loam	8.2	0.36
Cenchrus	*ciliaris*	Communal grazing	Sand dune	Sand	8.1	0.25
Cenchrus	*ciliaris*	Communal grazing	Sand dune	Sand	8.2	0.22
Cenchrus	*ciliaris*	Communal grazing	Sand dune	Sand	8.3	0.23
Cenchrus	*ciliaris*	Coastal	Salt pan	Sand	7.8	11.92
Cenchrus	*ciliaris*	Communal grazing	Sand dune	Sand	8.2	0.32
Cenchrus	*ciliaris*	Communal grazing	Sand dune	Sand	8.3	0.26
Cenchrus	*ciliaris*	Roadside	Sand dune	Sand	8.2	0.44
Cenchrus	*ciliaris*	Roadside	Sand dune	Sand	8.0	8.12
Cenchrus	*ciliaris*	Communal grazing	Salt pan	Sand	7.9	3.71
Lasiurus	*scindicus*	Protected/enclosed	Sand dune	Sand	8.2	0.27
Lasiurus	*scindicus*	Communal grazing	Sand dune	Sand	8.1	0.25
Lasiurus	*scindicus*	Communal grazing	Sand dune	Sand	8.2	0.32
Lasiurus	*scindicus*	Communal grazing	Sand dune	Sand	8.3	0.26
Lasiurus	*scindicus*	Protected/enclosed	Sand dune	Sand	8.0	19.00
Lasiurus	*scindicus*	Protected/enclosed	Gravel plain	Sand	7.5	3.03
Lasiurus	*scindicus*	Roadside	Gravel plain	Sand	7.8	2.72
Lasiurus	*scindicus*	Roadside	Gravel plain	Sand	7.9	0.97
Lasiurus	*scindicus*	Roadside	Sand dune	Sand	8.0	5.8
Coelachyrum	*piercei*	Protected/enclosed	Sand dune	Sand	8.2	0.26
Coelachyrum	*piercei*	Communal grazing	Sand dune	Sand	8.2	0.22
Coelachyrum	*piercei*	Communal grazing	Sand dune	Sand	8.3	0.23
Coelachyrum	*piercei*	Coastal	Salt pan	Sand	7.8	11.92
Coelachyrum	*piercei*	Coastal	Salt pan	Sand	7.8	8.33

Figure 2.2.1 & 2.2.2 show that *A. lentiformis* and *A. nummularia* have a higher stem fresh weight than the other three species (*A. halimus*, *A canescens & A. leucoclada*) under all salinity levels. The leaf dry weight was higher in *A. halimus* and *A. lentiformis* in comparison with the other three species (Figure 2.2.2). Fertilizer (NPK) increased leaf area and dry weight and this was more evident at the higher salinity levels. At the low fertilizer level (F1), the crude protein (CP) decreased with salinity. However, this negative effect was corrected as the level of fertilizer was increased (Figure 2.2.3).

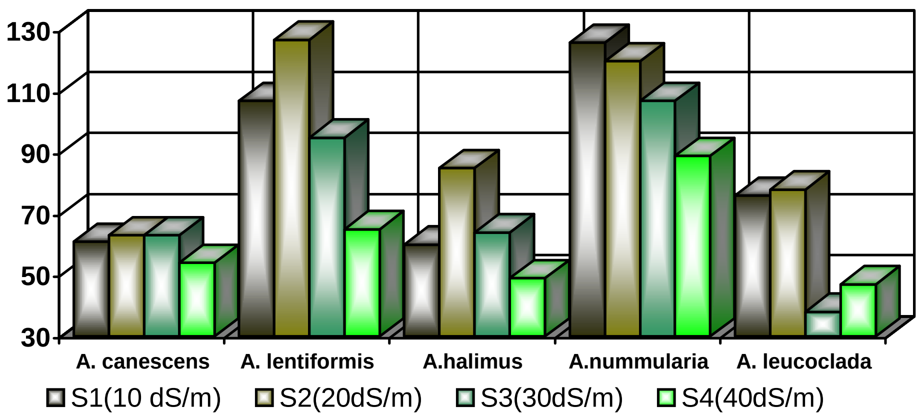


Figure 2.2.1. Mean stem fresh weight (over all fertilizers levels) of five Atriplex spp. under four salinity levels - wt/plant (g)

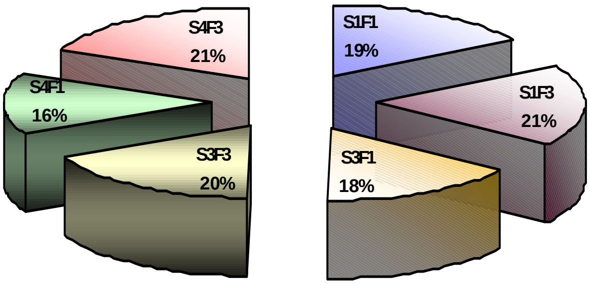


Figure 2.2.3: Mean crude protein content of five Atriplex spp. at different combinations of salinity and fertilizer levels. (% values are increase in CP at higher fertilizer level)

The yield of Sporobolus virginicus, grown with irrigation water with a high salt content (20 dSm^{-1}) exceeded 17 tons ha^{-1} $year^{-1}$, which was only 35% lower than that of Rhodes grass grown under normal irrigation water (2.5 dSm^{-1}) and high management intensity. With the exception of crude protein (CP) the, the chemical composition of *Sporobolus virginicus*, was found to be very similar to that of Rhodes grass (Table 2.2.2).

Table 2.2.2: Chemical composition of Rhodes grass and Sporobulus hay

	Rhodes grass hay1	Sporobulus grass hay2
Crude Protein	11.1	6.3
Ether Extract	1.6	1.7
Acid Detergent Fiber	38.4	38.9
Neutral Detergent Fiber	72.8	75.9
Ash	10.0	12.5

1 irrigated with low salinity water (2.5 dSm1)
2 irrigated with high salinity water (20 dSm1)

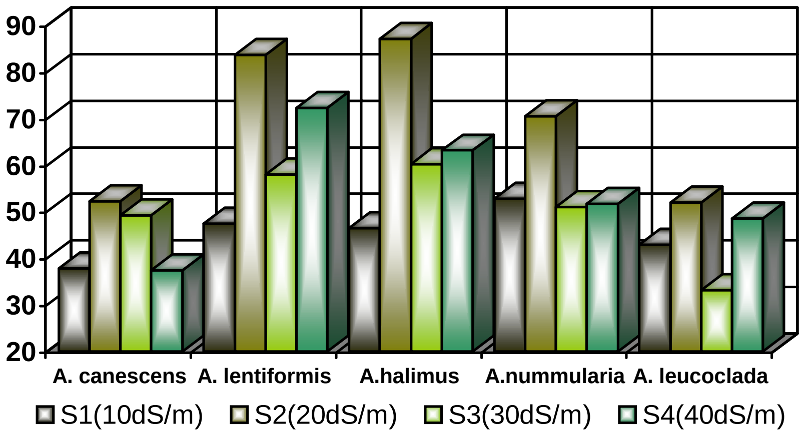


Figure 2.2.2: Mean leaf dry weight (over all fertilizers levels) of five Atriplex spp. under four salinity levels

For the second salinity type, two forage crop species, barley (*Hordeum vulgare*) and pearl millet *(Pennisetum glaucum),* were evaluated. In the 1995/96 cropping season a set of 320 barley lines were evaluated for yield potential and general adaptation at the UAE University farm. The barley genotypes were developed at The International Center for Agricultural Research in Dry Areas (ICARDA) with potential for tolerance of high temperature and salinity. Thirty-six top performing and 12 low-performing genotypes were selected. In 1996/97 season, 12 genotypes were selected for their high performance under these conditions, including the Omani local line. During 1997/1998 and 1998/1999 seasons, the 12 genotypes were evaluated further for dry matter and seed production under three different levels of salinity in field plots (4,9and14 dSm^{-1}). Similar procedures were followed with pearl millet. A set of 20 genotypes (provided through the ICRISAT breeding program) was evaluated for biomass production potential during a winter and a summer planting in 1998/99.Results for barley over the 4 years of evaluation showed that at the medium to high salinity levels the local Omani line, and four ICARDA's genotypes were capable of maintaining high productivity (Figure 2.2.4). Seed production was, however, low in the Omani line compared with the best ICARDA lines at all levels of salinity (data not shown). Nutritional value in terms of crude protein percentage showed that both the Omani line and the top ICARDA's lines were similar (Figure 2.2.5).

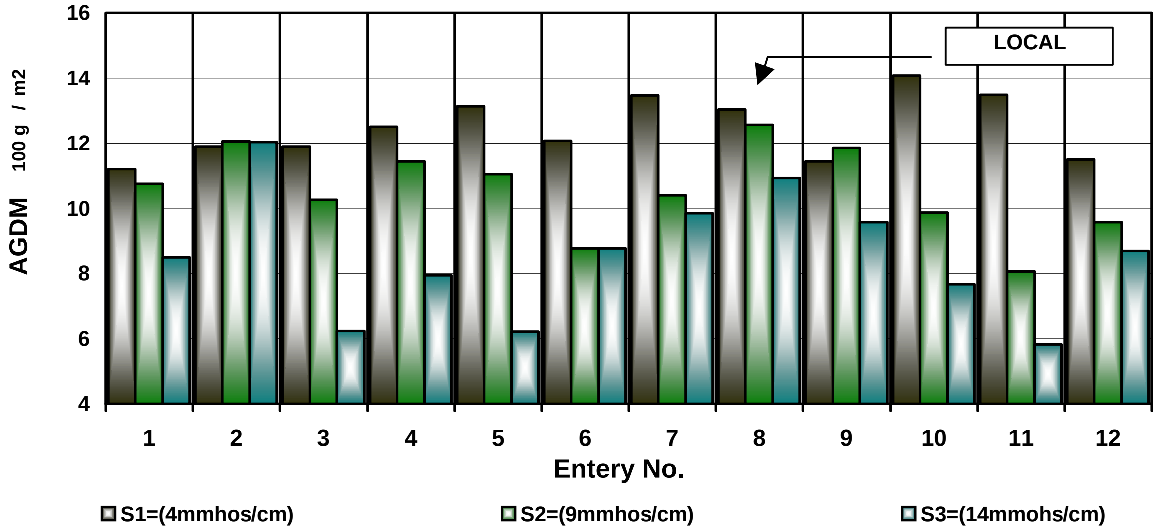


Figure 2.2.4: Total above-ground dry matter production of 12 barley lines at three salinity levels. Al-Ain UAE 1998/99

Initial data from the pearl millet, which was well adapted to the harsh environment, showed very high crude protein contents compared to barley (5-8 %). Crude protein % ranged between 12 -21 %, ash % from 12-13 %, while NDF was from 60-70% (data not shown). As a consequence, during the current 1999/2000 season, the salinity tolerance among the best performing lines of pearl millet is being evaluated under different levels of salinity ranging between 5-14 dSm^{-1}. Initial results indicate that there are pearl millet genotypes with high potential for production under high salinity.

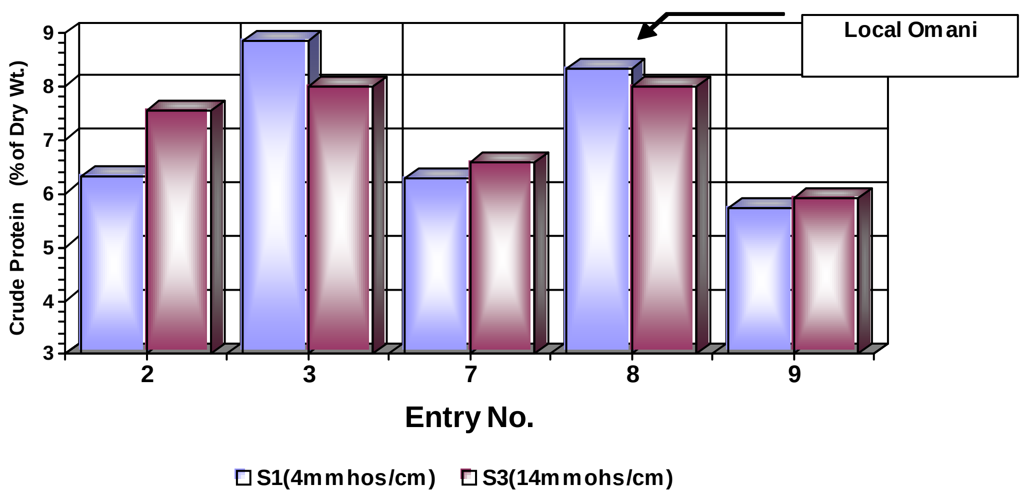


Figure 2.2.5: Percentage crude protein of five selected barley lines at two salinity levels. Al-Ain 1998/99

2.3. PROTECTED AGRICULTURE

INTRODUCTION

Protected agriculture represents the most intensive and dynamic form of agricultural production. In the Arabian Peninsula, the adverse climatic conditions of harsh weather, scarcity of water and limited land resources necessitate the use of protected agriculture in which environment and production timing can be controlled and yield improved (Moustafa et al.1998). It plays an important role in supplying the region's market with fresh products that cannot be grown otherwise.

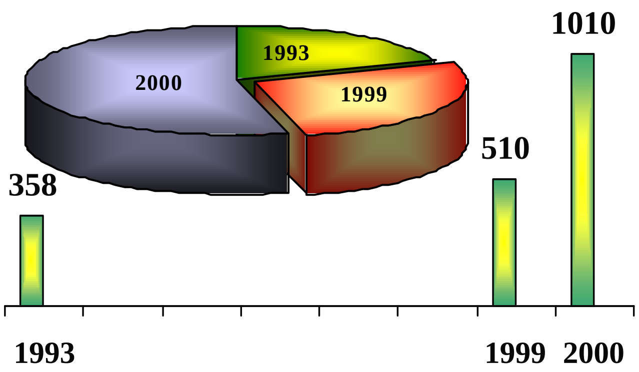


Figure 2.3.1 - Developments of the Number of Greenhouses in Oman

Protected agriculture—with its associated growing systems—can significantly reduce the amount of water and fertilizers utilized in growing high value fresh products compared with open field production. The total yield of protected agriculture per year is tripled as compared to open field yield.

In the Arabian Peninsula (AP) countries where arable land is limited and water is scarce, protected agriculture appears to 1provide an opportunity for vertical expansion. In most of the AP countries, the protected agriculture areas have been doubled in the last decade.

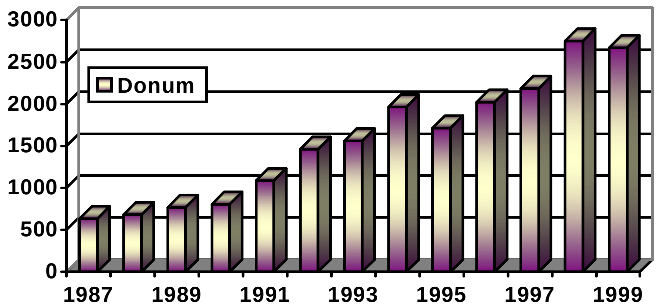
Protected Agricultural (PA) in the AP countries is constrained by lack of improved cultivars and cultural practices, as well as lack of trained manpower.

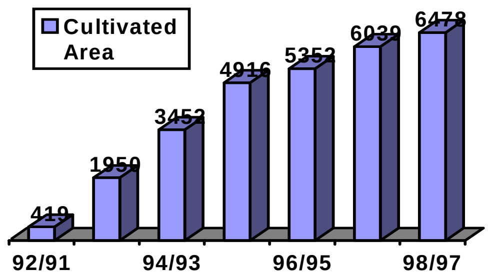
Water, both in quality and quantity, is one of the major limiting factors for the development of agriculture in general and PA in particular in the region. Successful production of high-value crops from greenhouses requires good-quality water that in many cases is produced from desalination units at a high cost. Current growing systems and irrigation techniques are detrimental to the water-use efficiency.

Surface irrigation in protected agriculture is still being practiced in some countries in the region. The general recommendation for greenhouse is to use drip irrigation in association with plastic mulch to cover the growing rows, beds or lines. When using plastic mulches, drip irrigation provides a uniform water and fertilizer application to the plants. It assures optimum production with minimal use of water.

Also, the use of plastic mulches will prevent water evaporation and reduce the humidity in the greenhouse and prevent the build up of salts on the soil surface. Drip irrigation should replace surface irrigation where water is scarce or expensive.
Water saving with drip irrigation is also associated with fertilizer saving. Applying water along the plant row through the drip line, directs the salt away from plants, as opposed to surface irrigation, where salts are pushed into the root zone. Drip irrigation systems can be designed with automatic control using a simple timer or irrigation control unit. Through such devices, irrigation and fertilization could be scheduled. This ensures more economical use of water while inducing less stress on plants and maximizing yield.
Growers often choose to use pesticides excessively to control diseases and insect pests, which attack the plant. Public awareness about health hazards which accompany the extensive use of pesticides in many countries around the world is pushing growers to use less and less of these chemicals in vegetable production in

general, and in protected agriculture in particular. Growers are everywhere profit driven. In the Arabian Peninsula, at least at present, consumers are not prepared to pay higher prices for 'organic' or 'bio-products.'





2.3.2 - Development of Greenhouse Area in UAE

However, this could change in the near future, and consumers might shift to buying products with labels indicating that ecologically friendly approaches were used in their production. Growers need to be prepared for this market evolution.

It is obvious that there is a public demand to reduce the use of pesticides as much as possible. In the short term, it is unlikely that we can produce crops economically in protected agriculture without using pesticides. A better approach is minimal use of pesticides, with emphasis on those that are selective. Other control strategies need to be used, such as resistant varieties, biological control, and appropriate cultural practices—components of IPM. Is essential to develop an integrated production and protection management (IPPM) program for vegetable production in protected agriculture suitable for the Arabian Peninsula.

The essential components of IPP are similar to those of integrated pest management (IPM) with more emphasis on the production techniques and activities and the management of the greenhouse. These essential components are: (i) coordinated climate control in the greenhouse, (ii) adequate cultivation practices, (iii) the use of improved adapted cultivars, which together will reduce dependency on use of pesticides and provide adequate control of insect pests and diseases which seriously limit crop production in protected environments. However, to succeed in adapting IPP approaches, research under local environments is essential to permit the development of IPM packages which will be acceptable to the growers. In the long term, however, and with heavy investment in research on biological control, biotechnology, soil solarization, etc., we might be able to achieve zero or close to zero pesticide use.

High light intensity and temperature, combined with high relative humidity, characterizes the climate in the Arabian Peninsula region. The PA structures that are widely used in the region are those that have been developed to suit cool-weather countries with low light intensity. There is a great need to develop a simple greenhouse structure suitable for the region's climate. Greater attention should be given to ventilation and cooling systems.

The development should include the covering materials. Currently, polyethylene sheets are widely used as covering materials. With the existing technology, the industry should be able to develop a new film with selective wavelength transmission and longer life.

2.3.1 - Assessment of the current Status of Protected Agriculture Research and Development in the Arabian Peninsula

Objective: To review the current state of the art of Protected Agriculture in the Arabian Peninsula

The first important step before developing the workplan for the PA research activities for the region was to review the existing situation and to identify the main problems. Also to make an inventory of the existing research facilities and human resources actively evolved in PA in the region. A questionnaire was developed by Dr. Ahmed Moustafa (formerly Head of the Horticultural Section in the Ministry of Municipal Affairs and Agriculture, Qatar) and circulated to all the AP countries. Dr Ayman Abou Hadid, Ain Shams University, Cairo, Egypt was hired by ICARDA as a consultant to review the outcome of the questionnaire. He visited all the AP countries except the Kingdom of Saudi Arabia which was covered by Dr J.M. Peacock, APRP Regional Coordinator. Dr Hasid's review formed the basis of his paper " the State of the Art of PA in AP" presented at the International Workshop on Protected Agriculture held in Doha 15-18th February 1998. Recommendations for Protected Agriculture research in the 21st century were developed out of this review and the workshop discussion.

The review covers the countries of the Gulf Cooperation Council (Bahrain, Kuwait, Qatar, Saudi Arabia, Oman and the United Arab Emirates) and Yemen—a total area of 246 million hectares.

The introduction of greenhouse activities to the Arabian Peninsula (AP) started as early as the 1960s in the Gulf area. The protected-agriculture area has increased substantially since then. The types of protected agriculture (PA) range from low tunnels to sophisticated glasshouses with heating and cooling capabilities. The most common house type is the single-span tunnel plastic-house covered with polyethylene sheets of 200 µm thickness. The cost of plastic houses varies from one country to another, but the average is about US$13 per square meter. Climate modification of greenhouses varies according to the needs of each country. In general, the special requirements in the Arabian Peninsula countries are related to high temperature and, in many places, high relative humidity, which reduce the potential of using evaporative cooling systems. Irrigation systems in greenhouses are mainly localized and are predominantly pressurized systems such as drip or trickle irrigation, low-pressure sprinklers and mist irrigation.

Most of the countries use soil-based cultivation techniques, although some soilless culture and hydroponics systems have been introduced on a commercial basis. The main crops grown under PA are vegetables—such

as tomato, pepper, cucumber, cantaloupe, green bean, squash and eggplant—and fruit—such as watermelon and strawberry. Some ornamentals are cultivated in many countries but on a limited scale. The productivity of the crops varies widely from one country to another, depending on the cultivation technique and the infrastructure used for production. Some crops are produced at levels comparable with PA elsewhere in the world, while others are below the international average yield.

The inputs of PA are largely dependant on imported materials such as seeds, fertilizers, pesticides and soil-disinfect ion chemicals, which pose constraints on the economics of production.

The production of high-quality fruits that can compete on the international markets could be improved. The most important constraints, needs and problems related to PA in the Arabian Peninsula can be summarized as follows.

- The design and construction of structures that can protect plants under the long hot season and relatively short, mild winter.

- The availability of scientific and technical personnel, and laborers for production practices.
- Solving the problems of natural-resource management such as water desalination and the utilization of wind and solar energy in the production systems.
- Problems related to the application of pest- and disease-control measures, and the rational utilization of water and fertilizers.
- The use of soil-based versus soilless culture and the limits of technology utilization in the light of cost and returns of the products and their compatibility in local and international markets.
- The quality of products to suit the increased quality demands of local markets and the availability of good-quality products from international markets.
- The availability of inputs such as seeds and chemicals and the cost involved.
- Improving the research and teaching capability in subjects related to protected agriculture.
- Provision of extension and agricultural advice and administration.
- Training facilities.
- Support services such as cooling, grading, sorting, packing, insurance and transportation.
- Laboratories for soil, plant and residue analysis.
- Scientific and extension publishing and the accessibility of information to growers and investors.

2.3.1.1 Protected Agriculture Research Themes and Strategy

The development of such an important industry requires a strategy to follow, in order to achieve specific goals. The decision of holding the International Workshop on Protected Agriculture for the Arabian Peninsula was part of ICARDA's strategy to identify the problems, constraints and research-and-development priorities. The outcome of this Workshop can be listed under three major issues:

1. Research Activities
2. Regional Networking
3. Human Resources and Training Programs

Research Activities

The major research themes for PA have been identified and agreed upon by all the county representatives of the AP. These are:

1. Greenhouse structure and covering materials
2. Water-use efficiency
3. Integrated production and protection.

Research programs for PA should be initiated immediately at the national research-station level with backstopping from regional and international experts in the following activities.

Greenhouse Structure and Covering Materials

High light intensity and temperature, combined with high relative humidity, characterizes the climate in the Arabian Peninsula region. The PA structures that are widely used in the region are those that have been developed to suit cool-weather countries with low light intensity. There is a great need to develop a simple greenhouse structure suitable for the region's climate. Greater attention should be given to ventilation and cooling systems.

The development should include the covering materials. Currently, polyethylene sheets are widely used as covering materials. With the existing technology, the industry should be able to develop a new film with selective wavelength transmission and longer life.
Research points:

- Greenhouse structure
- Covering materials
- Ventilation and cooling systems.

Water Use Efficiency

Water, both in quality and quantity, is one of the major limiting factors for the development of agriculture in general and PA in particular in the region. Successful production of high-value crops from greenhouses requires good-quality water that in many cases is produced from desalination units at a high cost. Current growing systems and irrigation techniques are detrimental to the water-use efficiency.

Research points:

- Adaptation of soilless culture techniques
- Improve the efficiency of the drip irrigation system
- Identification of the crop water-requirements
- Automation of irrigation systems.

Integrated Production and Protection Management

The greenhouse environment can be characterized as warm and humid with low air velocities. This ideal condition for plants also provides a thriving condition for pests and diseases. Pests and diseases are in competition with the growers since most greenhouse crops are of a high commercial value—any slight damage can result in a significant reduction in the market value. The extensive use of chemicals to control diseases and pests results in complicated problems of resistance build-up, and health and environment hazards. Also, natural enemies have been killed along with the pests (by non-target-specific chemicals). A healthy plant is usually able to withstand pest attack better than a stressed one. This can be achieved by applying other control measures that reduces the use of hazardous chemicals.

Regional Networking

There is great similarity in the climate conditions, available natural resources and social structure among the Arabian Peninsula countries. As a result, PA problems—including the type of structure and covering materials, irrigation and fertigation, production forecasting, pests and diseases, and marketing—are similar across the region. Networking is an efficient and economical way of sharing and exchanging the available information and experiences to tackle problems of common interest.

Networking can be developed in many forms:

1. Sharing of information among the AP countries, including:
    - An APRP Newsletter
    - Exchange of existing documents
    - Establishment of a database on crop and cultivar performance
    - Training information
    - Calendar of PA events in APRP and world-wide
    - A PA section on an APRP HomePage on the Internet, including most of the above.
2. Establishing a Protected Agriculture Working Group for the Arabian Peninsula.
3. Establishing a Regional Technical PA Advisory Committee.

Human Resources and Training Programs

Development of human resources is one of the most important activities of the APRP. It has been made clear by all country representatives in the Workshop that the lack of trained personnel is a major constraint to the development of the PA industry in the region.

The following are the some of the training courses to be designed for the PA research and extension personnel in the region:

- Greenhouse management
- Integrated production and protection
- Soilless culture
- Growing techniques and methods
- Fertigation and nutrient solution formulation
- Growing room—principles, design and management.

The implementation of this workplan should be carried-out under the coordination of the APRP by the PA Specialist. Research activities should be executed within the AP countries subject to their requirements, existing problems and constraints, and availability of research facilities and equipment. Research with cooling systems is most valuable for Kuwait and Qatar, while growing systems, irrigation and fertigation are important for Yemen.

Recommendations from this workplan qualifying for immediate implementation have been put forward to the Regional Steering Committee of the APRP in the form of a one-year workplan for the 1998/99 season. The major part of this strategy and the related workplans will be implemented in the new phase of the APRP, which is due to start by June 1999.

2.3.2 Assessment of the current Status of Protected Agriculture Research and Development in the Arabian Peninsula

Objective: To review the current state of the art of Protected Agriculture in the Arabian Peninsula

The first important step before developing the workplan for the PA research activities for the region was to review the existing situation and to identify the main problems. Also to make an inventory of the existing research facilities and human resources actively evolved in PA in the region. A questionnaire was developed by Dr. Ahmed Moustafa (formerly Head of the Horticultural Section in the Ministry of Municipal Affairs and Agriculture, Qatar) and circulated to all the AP countries. Dr Ayman Abou Hadid, Ain Shams University, Cairo, Egypt was hired by ICARDA as a consultant to review the outcome of the questionnaire. He visited all the AP countries except the Kingdom of Saudi Arabia which was covered by Dr J.M. Peacock, APRP Regional Coordinator. Dr Hadid's review formed the basis of his paper " the State of the Art of PA in AP" presented at the International Workshop on Protected Agriculture held in Doha 15-18th February 1998.

Recommendations for Protected Agriculture research in the 21st century were developed out of this review and the workshop discussion.

The review covers the countries of the Gulf Cooperation Council (Bahrain, Kuwait, Qatar, Saudi Arabia, Oman and the United Arab Emirates) and Yemen—a total area of 246 million hectares.

The introduction of greenhouse activities to the Arabian Peninsula (AP) started as early as the 1960s in the Gulf area. The protected-agriculture area has increased substantially since then. The types of protected agriculture (PA) range from low tunnels to sophisticated glasshouses with heating and cooling capabilities. The most common house type is the single-span tunnel plastic-house covered with polyethylene sheets of 200 µm thickness.The cost of plastic houses varies from one country to another, but the average is about US$13 per square meter. Climate modification of greenhouses varies according to the needs of each country. In general, the special requirements in the Arabian Peninsula countries are related to high temperature and, in many places, high relative humidity, which reduce the potential of using evaporative cooling systems. Irrigation systems in greenhouses are mainly localized and are predominantly pressurized systems such as drip or trickle irrigation, low-pressure sprinklers and mist irrigation.

Most of the countries use soil-based cultivation techniques, although some soilless culture and hydroponics systems have been introduced on a commercial basis. The main crops grown under PA are vegetables—such as tomato, pepper, cucumber, cantaloupe, green bean, squash and eggplant—and fruit—such as watermelon and strawberry. Some ornamentals are cultivated in many countries but on a limited scale. The productivity of the crops varies widely from one country to another, depending on the cultivation technique and the infrastructure used for production. Some crops are produced at levels comparable with PA elsewhere in the world, while others are below the international average yield.

The inputs of PA are largely dependant on imported materials such as seeds, fertilizers, pesticides and soil-disinfect ion chemicals, which pose constraints on the economics of production. The production of high-quality fruits that can compete on the international markets could be improved. The most important constraints, needs and problems related to PA in the Arabian Peninsula can be summarized as follows.

- The design and construction of structures that can protect plants under the long hot season and relatively short, mild winter.
- The availability of scientific and technical personnel, and laborers for production practices.
- Solving the problems of natural-resource management such as water desalination and the utilization of wind and solar energy in the production systems.
- Problems related to the application of pest- and disease-control measures, and the rational utilization of water and fertilizers.
- The use of soil-based versus soilless culture and the limits of technology utilization in the light of cost and returns of the products and their compatibility in local and international markets.
- The quality of products to suit the increased quality demands of local markets and the availability of good-quality products from international markets.
- The availability of inputs such as seeds and chemicals and the cost involved.
- Improving the research and teaching capability in subjects related to protected agriculture.
- Provision of extension and agricultural advice and administration.
- Training facilities.
- Support services such as cooling, grading, sorting, packing, insurance and transportation.
- Laboratories for soil, plant and residue analysis.
- Scientific and extension publishing and the accessibility of information to growers and investors.

2.3.3 Development of an Integrated Production & Protection Management Program for the Arabian Peninsula

Objective: To develop based on the current methodology and prevailing conditions in the Arabian Peninsula an Integrated Production and Protection Management Program to produce high quality crops free of hazardous chemicals.

Dr Khalid Makkouk (ICARDA Plant Protection Specialist) and Dr Ahmed Moustafa (formerly Head of the Horticultural Section in the Ministry of Municipal Affairs and Agriculture, Qatar) prepared a plan for this activity. The ambitious strategy for integrated production and protection management (IPPM) consists of two workplans.

A. Short-term plan (Immediate)

- Identification of the common pests and diseases in the region. This should result in the publication of a color identification

handbook in Arabic that will be useful for growers, extension workers and scientists.
- Initiation of a series of on-farm experiments and demonstrations of different control techniques and measures, with the aim of preventing or minimizing the use of chemicals.

1. Cultural control
- Planting schedule and crop rotation
- Irrigation and fertilization
- Use of pest- and disease-free seeds and planting materials
- Crop environment factors (temperature, humidity, ventilation).

2. Physical and mechanical control
- Growing media and techniques
- Sterilization (solar, chemical)
- Screens and nets on openings
- Insect traps.

3. Biological control
- Use of natural enemies (parasites, predators, pathogens)
- Use of resistant cultivars.

4. Chemical control
- Use of selective chemicals with low hazard
- Use of detergents
- Use of insect pheromones.

B. Long-term plan
- Establish a central regional biological laboratory to identify the native natural enemies
- Establish a strategic plan to be adopted in the region
- Develop a training program and advisory materials
- Carry out/initiate routine screening for resistant cultivars for the commonly grown crops
- Carry out/initiate routine screening for the most effective and least hazardous chemicals.
-

2.3.4 Agro-economic assessment of production in cooled and none cooled greenhouse

Growers are often ask important questions about which type of green houses should they use? Cooled or none cooled GH? Is it more economical to grow cucumber during the autumn, winter and spring only, or to produce year round in cooled GHs?
To provide the answers, an economical study was performed by PAAAFR in Kuwait based on actual data gathered from two growers specialized in production of cucumber in cooled and none cooled GHs. The second assessment was an experiment done in DAWR in Qatar where the production of cucumber from 3 different types of greenhouse were assessed.
The objective of the study was to evaluate the production of cucumber in the cooling and non-cooling plastic houses in Kuwait.

2.3.4.1 Economical evaluation of cucumber production in cooled and none cooled greenhouses in Kuwait

Objective: To evaluate the production of cucumber in cooled and non-cooled plastic houses based on the actual production and cost under growers condition in Kuwait.

Location: The Public Authority for Agriculture Affairs and Fish Resources (PAAAFR), Kuwait

Materials and Methods: Two growers were selected in Wafra agricultural Area in Kuwait. Both farms were producing cucumber in soil. The first grower was using single span plastic GH with fan & pad cooling system, while the other grower was producing from non-cooled single span plastic GH (natural ventilation).

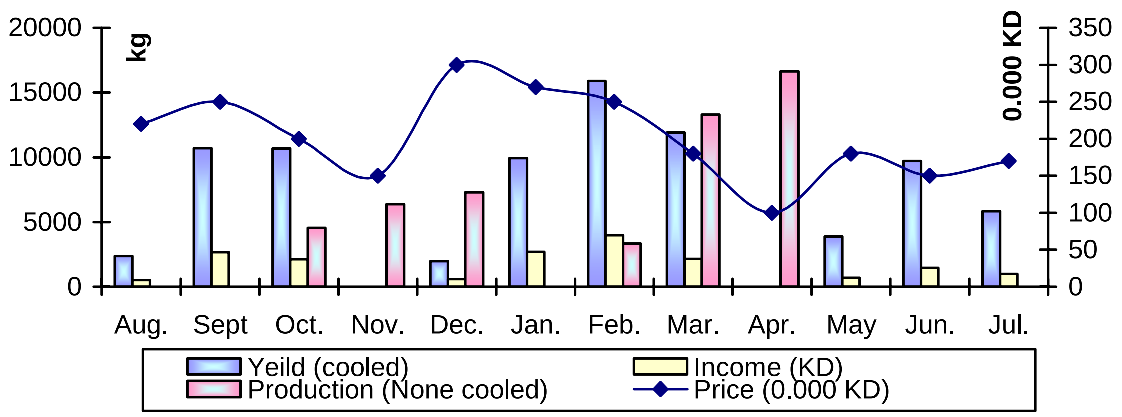
Table 2.3.1 : Particulars of the farms and crops selected for the study in Kuwait

	Farm 2 None Cooled GHs	**Farm 1 Cooled GHs**
Number of GHs	15	18
GH Area (m2)	264	240
First Crop		
Seed Planting Date	15/08/1998	19/07/1998
Transplanting Date	25/08/1998	24/07/1998
Production Starting date	25/09/1998	15/08/1998
End of Production Date	15/12/1998	05/11/1998
Days in Production	81	112
Total Yield (kg)	18216	23760
Average Yield /GH (kg)	1214.4	1320
Yield /m2 (kg)	4.6	5.5
Second Crop		
Seed Planting Date	02/01/1999	07/11/1998
Transplanting Date	11/01/1999	12/11/1998
Production Starting date	15/02/1999	19/12/1998
End of Production Date	17/04/1999	26/03/1999
Days in Production	61	105
Total Yield (kg)	33264	39744
Average Yield /GH (kg)	2217.6	2649.6
Yield /m2 (kg)	8.4	9.2
Third Crop		
Seed Planting Date		01/04/1998
Transplanting Date		08/04/1998
Production Starting date		15/05/1998
End of Production Date		06/07/1998
Days in Production		52
Total Yield (kg)		19440
Average Yield /GH (kg)		1080
Yield /me (kg)		4.5
Seed Planting Date	142	269
Total Yield (kg)	51480	82944
Average Yield /GH (kg)	3432	4608
Yield /m2 (kg)	13	19.2

Results:

Data and information were collected from the growers and it represents the actual production from the two farms. Although, the total production of the two farms are low and could be improved by improving the management but this is the case in the majority of farms in Kuwait.

The following curve shows the production in both farms during the different season.



Conclusion

Production from the cooled GH was greater by 61% that of none cooled GH. This was greatly reflected on the total income.

The return on the investment was higher for the cooled GH.

Even without the government subsidy, the retune on the investment was more than 50% comparing to none cooled GH.

Table 2.3.2.Yield, income and market price of cucumber produced in different seasons

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Average Market Price (0.000 KD)	220	250	200	150	300	270	250	180	100	180	150	170
	First Crop				**Second Crop**					**Third Crop**		
Yield (kg)	2367	10701	10692		1987	9936	15898	11923		3888	9720	5832
Income (KD)	523	2675	2138		596	2683	3975	2146		700	1458	991
Income + Subsidy (KD)	591	2996	2459		656	2981	4451	2504		816	1750	1166
Crop			**First Crop**				**Second Crop**					
Yield (kg)			4554	6375	7287		3326	13306	16632			
Income (KD)			911	956	2186		832	2395	1663			
Income + Subsidy (KD)			1047	1148	2405		931	2794	2162			

Table 2.3.3. Economic analysis of production from cooled and none cooled greenhouses

	Cooled GHs	**None Cooled GHs**
Number of GHs	18	15
Total Area (m2)		3960
Cost of greenhouses	13014	5550
Other Fixed costs	14928	4250
Operational costs	14958	7380
Total Yield	82944	51480
Average production kg/m2	19.2	13
Income (without subsidy) KD	17885	8579
Income with subsidy (KD)	20370	10122
total annual costs	16830	8360
net profit without subsidy	1055	219
Net profit with subsidy	3540	1762
Return on investment (without subsidy)	5.63%	2.23%
Return on investment (with subsidy)	18.91%	17.98%.

2.3.5 Application of Integrated Production and Protection Management (IPPM)

Objective: Observations on the application of IPPM program in cooled and none cooled green houses (GH) for the production of an economical yield, free of hazard chemicals.

Location : All countries

Materials and Methods:

In most countries, plants were grown in soil in single spine green houses (plastic Tunnels 8.5 m– 9m width). In all countries, one GH was treated and compared with another GH with no application of the IPPM (Control). The preparations of soil in the control GH was carried out in the same manner as the growers. The drip irrigation system is cleaned, carefully balanced and checked. Seedlings were planted in double lines according to the standard plant density . The following table indicates the different treatments for the control and treated GHs.

Plastic House I (IPPM)	Plastic House II (control)
Double doors	Single door
Insect proof netting on cooling pads	without
Yellow sticky traps	without
Soil mulch	No soil mulch

Figure 2.3.3.Inset proof nets covering the cooling pads

Figure 2.3.4.Double door installed in the treated GH in Oman

The followings are some of the early results been confirmed from some countries.
In Oman, the cucumber yield and number of fruits from the IPPM treated GH were higher with the four different cultivars that have been used in the experiment (table 2.3.2.1).

Table 2.3.4 : Yield of four Cucumber varieties tested under treated (IPPM) and control greenhouse in Oman

Varieties	Treated Greenhouse		Control Greenhouse	
	No. Fruits/GH	Yield (kg/GH)	No. Fruits/GH	Yield (kg/GH)
Printo F1	49035	5617.5	36435	3867
Hana F1	51720	6036.0	36900	3543
Nun 7922 F1	46755	6150.0	30510	3488
Nun 7656 F1	49440	6019.5	35820	3357
Mean	49237.5	5955.8	34916	3563.8

GH*= Greenhouse (9 x 40m).

The total yield of the IPPM treated GH was higher by 67% than that of the control GH. This was mainly due to the spread of disease and pests in the control GH. Although, chemical treatments were applied in the control GH but due to insufficient protection and high humidity the damage was high.
Cucumber fruits from the four GHs were tested for the residue of Deltamethrin sprayed early on the experiment. The analysis results are showing in table 2.3.3

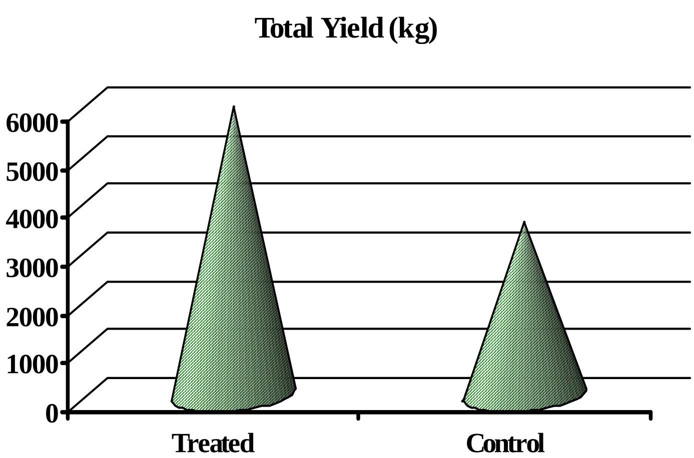


Figure 2.3.5: Total Yield of Cucumber (kg) in the IPPM and Control GH

Conclusion:

The production of cucumber crops with no chemicals (pesticides) is possible by adopting the IPPM program which consists of simple techniques for the growers to adopt.

Table 2.3.5: Results of pesticide residues in Cucumber fruits from four greenhouse at Agriculture Research Center of Rummies, Oman

Sample	Pesticide sprayed	Residues found(mg/kg)	MRL
GH 1	Deltamethrin(decis)	N.D	0.2
GH 2	Deltamethrin(decis)	N.D	0.2
GH 3	Deltamethrin(decis)	N.D	0.2
GH 4	Deltamethrin(decis)	N.D	0.2

*ND= Non detectable residues.

*MRL-= Maximum residue limit.

Figure 2.3.6.Using soil mulch and yellow stickers in the treated (IPPM) GH

2.3.6 Greenhouse design and modelling

In the proceedings of the International Workshop for Protected Agriculture in the Arabian peninsula, held in Doha, Qatar between 15th to 18t" February 1998, the need for research work covering, Greenhouse construction, covering material and cooling was pointed out by a number of participants in their presented technical papers. The recommendations of that meeting urged further work in that field.

The objective was to introduce some useful modifications to the commonly used green houses (single span plastic house) within the context of overall IPP approach. Special focus will be on GH ventilation and cooling systems. The following are some of the major criteria and points of consideration:

- Greenhouse size, location, orientation
- Opening vents, size & allocation
- Screens and nets on openings
- Humidity control
- Structure materials
- Fertigation systems and techniques
- Sterilisation (solar, chemical)
- Insect traps

2.3.6.1. New Greenhouse Design with Improved Cooling System in Bahrain

Objective: To develop and test an alternative evaporative cooling system for the greenhouses that could offer adequate cooling, less water consumption, and less cost than the existing system.

A new design for simple greenhouse model was developed and constructed in Bahrain. The enclosed GH featuring an oval-shape structure covering an area of 713 m2 with ca. 30m2 service area in the middle. In addition to the extra crop protection and the ability to inject additional CO_2 economically, the new structure provides an improvement of the cooling system and facilitates the production of fresh water recovered from the enclosed GH aerospace.

In the Arabian Peninsula Region, it was always found necessary to cool the greenhouse to extend the growing season during summer. Greenhouse cooling is always done by evaporative cooling method because of its simplicity and low running cost. This system works best in dry desert weather conditions because the system deepened mainly on wet bulb depression, i.e., relative humidity of the air. The efficiency drops with the increase in relative humidity. Unfortunately, the relative humidity in Arabian Peninsula is very high at times when cooling is desperately needed. If the cooling efficiency to be increased, the RH of air

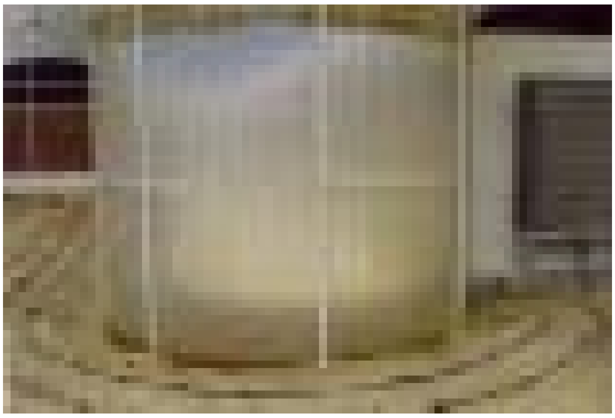


Figure2.3.7. Internal view of the Round Greenhouse

should be reduced before it passes over the cooling pads. We are approaching the problem in two dimensions.

1. Circulate the air inside the GH. This will result in dramatic increase in RH.
2. High RH will be condensed on cooler surface to reduce the RH top the suitable level for plants and generate fresh water from the condensate to be used for irrigation.

Figure 2.3.8 Round green house constructed in Bahrain

The round GH was constructed from two single span greenhouses connected together by a circular structure on both ends to provide a closed system. Cooled air from each house is directed to the wet pads of the other house and so on. Condensation of excess water vapor will do over copper pipes with relatively cold water circulating in it. The project is already implemented and equipped and the first trials will start in summer 1999.

Relative humidity, air temperature and soil temperature at different locations inside the greenhouse as well as outside will be monitored by special instruments. Carbon dioxide is also monitored since we do not ventilate. Carbon dioxide enrichment may also be needed.

2.3.6.2 Evaluation and Comparison of Different Cooling Systems in Greenhouses

Objective: to evaluate different types of evaporative cooling systems in terms of climate control within specific temperatures and relative humidity; economy with respect to capital, water, and power savings; and yield.

Figure2.3.9. : Middle section of the Round GH

Figure 2.3.10. : Measuring temperature and RH in different locations inside Round GH

Location : Pubic Authority for Agriculture and Fish Affaires (PAAAFR)

Materials & methods: 4 identical round arched, single span greenhouses, covered with single layer, corrugated acrylic sheets are existing in the research station of PAAAFR. The greenhouses have forced ventilation by fans and each of them is equipped with a cooling system.

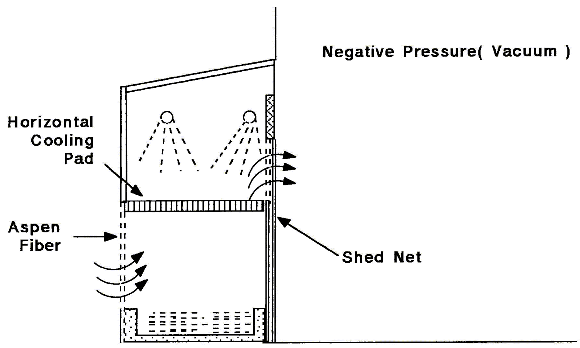
The installed 4 cooling systems are (Figure 2.3.11):

Design 1. Horizontal pad with a dry aspen filter, operated by negative pressure system.

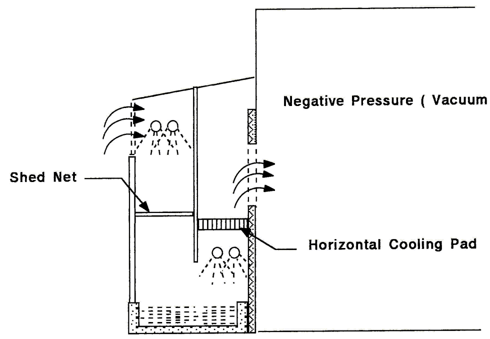
Design 2. Spray cooling system operated by negative pressure system

Design 3. Spray cooling system operated by positive pressure system

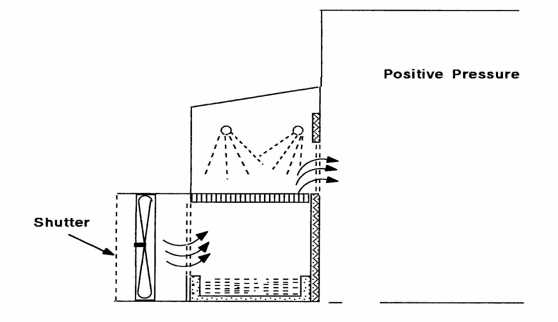
Design 4. Vertical pad with positive pressure system



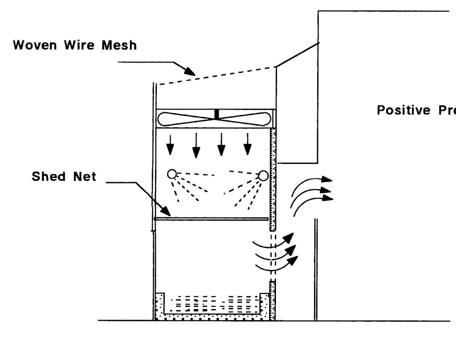
Design 1



Design 2



Design 3



Design 4

Figure2.3.11. New Design for different cooling systems under evaluation in Kuwait

All houses are planted with the same crop (cucumber) at the same time. Plant density and spacing are the same. All plants received an equal treatment in relation to irrigation, fertilization and crop management.

Measurements:

- Water consumption for each cooling system
- Temperature at 3 points within the house (beginning-middle-end)
- R.H. at 3 points within the house (beginning-middle-end)
- Yield & quality
- Visual assessment of crop performance

Figure 2.3.12.Spray cooling system operated by positive pressure system

The experiment was started in 1998/1999 season. Due to some maintenance problems the experiment was interrupted. The decision was taken to carry out the necessary maintenances and to call for meeting with GH Cooling Experts to examine the systems. In April 1999, ICARDA-APRP hired two consultants, Prof. Dr. Christian von Zabeltitz, Institute for Horticultural Engineering, University of Hannover and Prof. Dr. Ayman Abou Hadid, Ain Shams University, Egypt, to visited Kuwait to examine the new GH cooling designs and ventilation systems and the existing hydroponics systems. The outcome of this scientific mission was laid out in two reports presented by the consultants. The following steps were proposed by Prof. Dr. Christian von Zabeltitz for a research and development project:

1. Maintenance and sealing of the 4 greenhouses and cooling systems at PAAAFR.
2. Installation of measurement equipment for continuous data recording.

The following climate factors should be measured inside and outside the greenhouse to investigate the efficiency of the cooling systems and the climate conditions in the greenhouses:

- Outside temperature, humidity and global radiation in a weather station close to the greenhouses.

- For the calculation of the cooling efficiency, the following should be measured:
  - Temperatures and humidity directly at the inlet and outlet of the cooling system.
  - Water flow rate through the cooling system.
- For measurements of climate conditions in the greenhouses:
  -Temperatures and humidity at different points between cooling system and outlet on the opposite side of the greenhouse.
  -Radiation inside the greenhouse.

From the measurements of this initial experiment, the cooling efficiency of each system could be identified and used to design and build a new cooling systems in a new greenhouse at the same location as

Figure 2.3.13.Typical view of the growing system inside the GHs with the 4 new cooling design

3. the existing ones for further investigation. The cooling systems have to be operated according to the main design criteria and guidelines for evaporative cooling. Examples

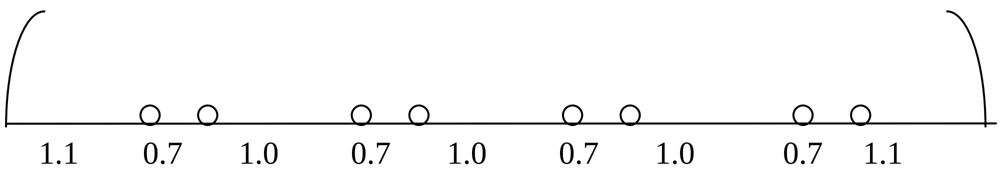
for cooling systems to be compared are:
-Vertical conventional fan and pad system from Celdec.
-Horizontal fan and pad system.
-Spray cooler with counter current airflow and nozzles, which are insensitive to clogging by salt.
-Spray cooler with positive pressure system.
The cooling systems have to be operated with salt or brackish water to investigate the sensitivity to salt deposition.
The fan and pad cooler should be operated in accordance to the standards for water flow rates, circulation of water and bleed off.
If necessary the nozzles in the spray cooler and the drop separation from the air stream have to be changed and adapted depending on the measurement results and observations of clogging.
An economical comparison of investment and running costs has to be made.
Maintenances were carried out according to the recommendation and the experiment will continue for the following seasons.

2.3.6.3 Greenhouse Ventilation

Objective: To compare different ventilation systems for single span plastic house.
Location : Al-Dhaid Research Station, UAE
Materials & Method: Three single span green houses were used in the experiment. Each house was fit with a different ventilation type according to the following table and figure.

	Ventilation Type (Treatment)	# of plants	# of lines	# Plant/line	in-line spacing	Between- line spacing
1.	Static Arc ventilation	520	8	65	0.5m	1.0m
2.	Mobile Side ventilation	520	8	65	0.5m	1.0m
3.	Mechanical ventilation	520	8	65	0.5m	1.0m

In all greenhouses, preparation of the soil is carried out in the same manner as the growers. The drip irrigation system in each GH are carefully cleaned, balanced and checked. The drip Irrigation lines are placed along the growing bed and covered with black plastic mulch. Cucumber seedlings planted in double lines according to the number and spaces specified in the above table and the following layout.



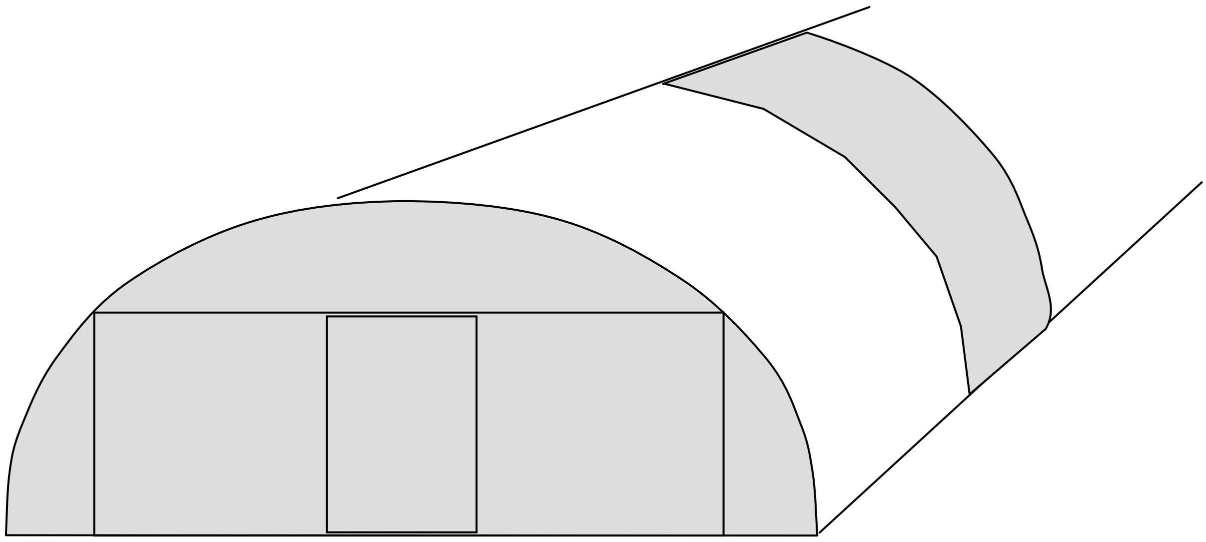
Lay out of plants in soil beds

During the experiment the following measurements were considered :

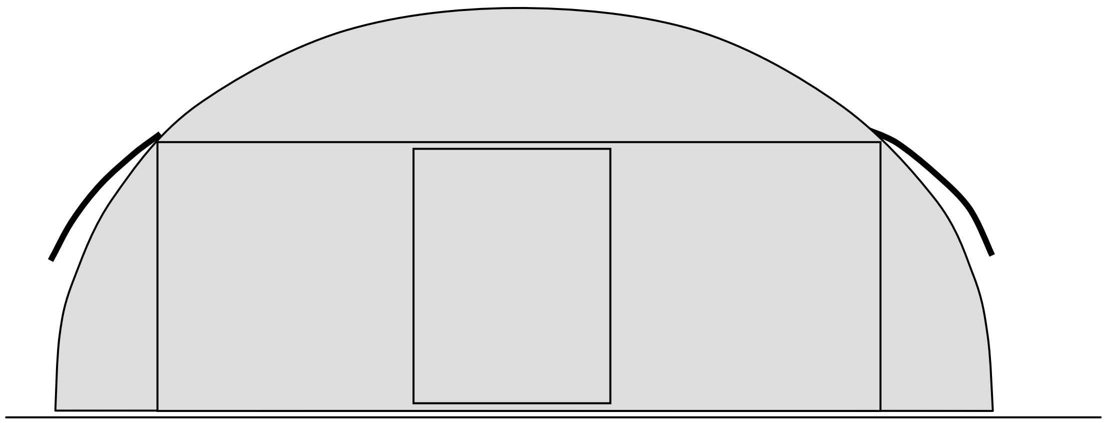
1. Continuous monitoring of Temperature & RH
2. Daily records of: -
   - Water consumption for each GH
   - Used chemicals and fertilizers
3. Yield & quality
4. Visual assessment of crop performance

Results and conclusion

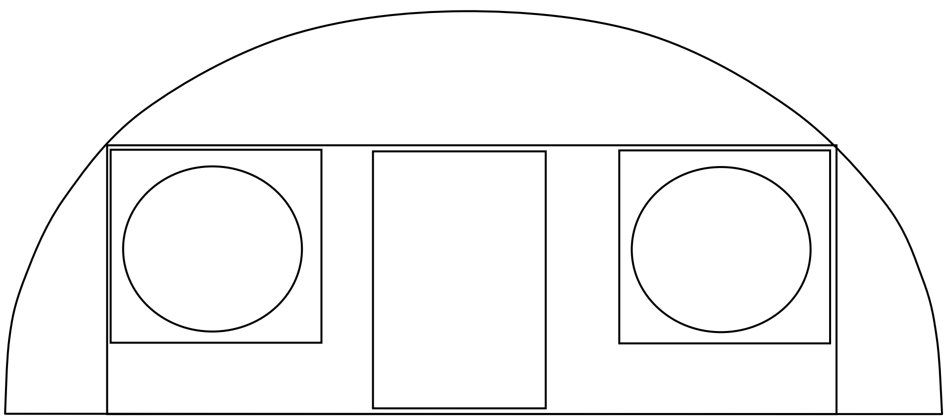
The results indicated that the mechanical ventilation will be more costly for growers although it provides more control specially during the very sunny days.
Side ventilation would provide more adequate aeration of the GH providing that it is constructed in the top of the GH.
The third type of ventilation which consists of insect proof nets covering one meter every 4 meter of the GH and nets fitted on the front and back of the GH would provide a good ventilation with good protection and less cost.



Static Arc Ventilation



Mobile Side ventilation



Mechanical ventilation

Figure2.3.14. : Drawings of the three types of ventilations in AL-Dhaid RS, UAE

2.3.7 Water Use Efficiency, Plant Nutrition & Fertigation

The production of high value crops requires a certain quantity and quality of water that is practically impossible to obtain in such a dry region as the Arabian Peninsula. The underground water level has been rapidly declining and become more brackish with higher salt content. Good quality fresh water can only be obtained by using expensive desalination equipment and techniques. Traditional techniques in protected agriculture may be highly productive but their relative use of water may be high due to run off and infiltration; thus, the water-use efficiency may be relatively low. In arid countries, rapid evaporation from the soil surface may also lead to salinity problems. Soilless techniques offer a way of improving water-use efficiency and obtaining better water management in crop production.

A good grower may achieve the same yield in soil as in soilless cultivation, but is likely to use 50–100% more water as a result of water losses from over-watering the soil and evaporation from the soil surface. If we consider yield per unit of water applied, soilless systems may increase yield substantially over soil-based systems.

There are two main types of soilless cultivation. (a) Open systems, where the water and nutrients are supplied as in conventional soil culture and the surplus (about 25%) nutrient and water is allowed to run to waste. The attraction of this technique is its similarity to soil as a growing medium and many similar techniques have been developed using a variety of inert media such as rockwool, sand, vermiculite, perlite and gravel. The two most important features relating to the substrate are that it is inert and that it has a great water-holding/release capacity. The maintenance of an appropriate water and nutrient level within the substrate is essential to prevent stress of the plants. A major disadvantage of open systems is that a proportion of the water and nutrients must be allowed to run to waste. This lowers water-use efficiency and contaminates groundwater supplies with salts.

(b) Closed systems, where a film of nutrient solution flows through plastic lined channels, which contain the plant roots. The growing channels could be made of flexible polyethylene sheets or PVC pipes or even constructed with concrete blocks and lined with polyethylene sheeting. The main feature of the growing channels is to protect the roots, exclude light and prevent evaporation. Because the solution is continually moving, there is very little short-term variation in salinity, unlike in the soil where salinity rises and falls with the water content. It is possible, therefore, to grow plants in much higher salinity in nutrient solution culture than would normally be used in soil-based production.

2.3.7.1 Introduction of new irrigation and fertigation tools and equipments

Objective: To improve existing fertigation techniques and irrigation systems. This will involve the introduction and demonstration of newly developed irrigation and fertigation tools and equipment *techniques* as well as hydroponics systems.

Location: All countries

Duration: Continuous

In order to maximize the water and fertilizers use efficiency, APRP have installed and demonstrated an automatic fertigation system in Al Dahid Research Station, UAE and Rumise Research Station in Oman. The system consists of a solenoid valve installed on the main irrigation line for each GH and linked to irrigation controller that operates automatically according to preset programs. According to the program, the solenoids can open for any number of minutes exactly at the set time to provide irrigation/ fertigation to the GH. Advantages of the system

1. Precise control over the irrigation time and duration
2. Elimination of Labor mistakes
3. Easy to irrigation in different times during the day to maintain a constant soil water content.
4. Major saving in water, fertilizers and labor.

2.3.7.2 Responses of Cucumber to Different Levels of Nitrogen Fertigation Under the Conditions of Single and Double Layer Plastic Houses

This experiment was carried out on the Rummies Research Station in Oman.

Objectives

- To determine the optimum level of nitrogen fertilizer that can give the best growth and yield of cucumber grown in soil in plastic houses.
- To study the effect of single and double layers GH cover on growth and yield.
- To study the effect of nitrogen source (Urea vs. Compound fertilizer) on growth and yield of cucumber.

Materials and Methods

Two GHs were used in this experiment. This first GH was covered with single layer of clear polyethylene while the second one was covered with double layer of the same polyethylene. Cucumber plants cv. Printo F1 were grown in the two GHs with five different levels of N (table 2.3.4.)

Table 2.3.6. : Levels and source of N for the five treatments

Treatment	Nitrogen levels g / m2	N source
T_1	0.0g	
T_2	18.0	Urea
T_3	36.8	Urea
T_4	55.2	Urea
T_5	36.8	N.P.K, 17:6:18

Experiment was designed as RCBD with four replicates. The plot size was 11.2m2 (8x1.4m) with plant population of 40 plants/plot.
The results are showing in the following tables:

Table 2.3.7. Effects of different nitrogen fertigation on dry Wt. (g/plant) of cucumber plants sampled at stage 1

Treatments	Single Layer Site 1	Double layer Site 11	Mean
T1	12.3	22.5	17.4
T2	17.0	17.6	17.3
T3	34.0	24.6	29.3
T4	37.1	22.3	29.7
T5	25.9	24.8	25.3
Mean	25.2	22.4	

LSD for site =NS
LSD for treatments at 0.05 =6.0
LSD for site x treatments =NS

Table 2.3.8. Effects of different levels of nitrogen fertigation on leaf area (cm2) Of cucumber plants raised in single and double layer plastic houses

Treatments	Single Layer Site 1	Double layer Site 11	Mean
T1	352.5	242.0	297.3
T2	452.5	338.5	395.5
T3	403.3	375.8	389.6
T4	360.8	322.5	341.7
T5	344.0	357.0	350.5
Mean	382.6	327.4	

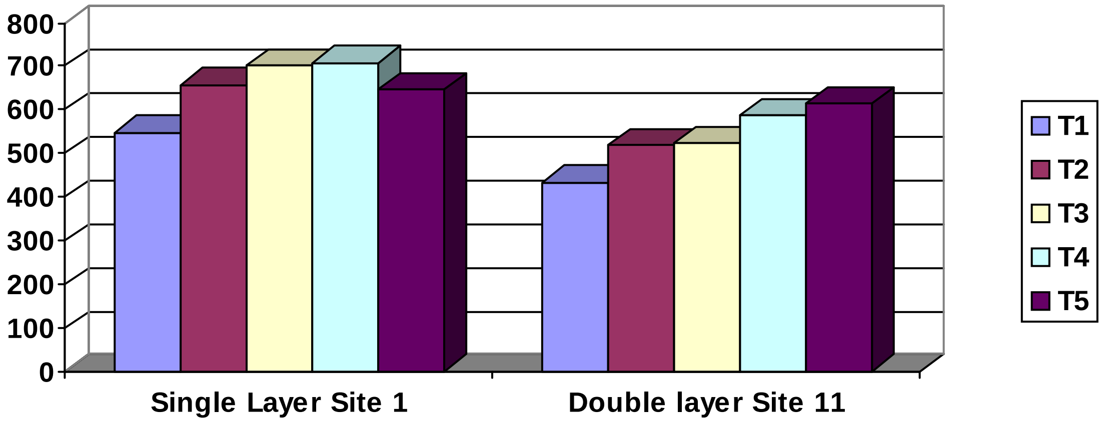
LSD for site at 0.05 =15.6
LSD for treatments at 0.05 =24.6
LSD for site x treatments at 0.05 =34.8

Table 2.3.9. Effects of different levels of nitrogen fertigation on percentage abortive fruits of cucumber plants raised in both single and double layer plastic houses.

Treatments	Single Layer Site 1	Double layer Site 11	Mean
T1	24.8	22.7	23.8
T2	21.4	24.0	22.7
T3	23.4	22.8	23.1
T4	21.1	23.4	22.2
T5	23.3	20.7	22.0
Mean	22.8	22.7	

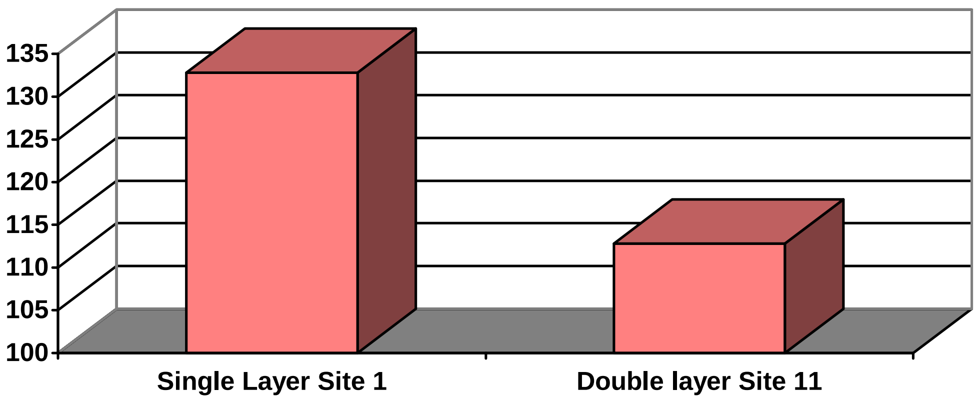
LSD for site at 0.05 = NS
LSD for treatments at 0.05 = NS
LSD for site x treatments at 0.05 = 1.8

Figure 2.3.15. Effects of different levels of nitrogen fertigation on number of cucumber fruits from both single and double layer plastic houses.



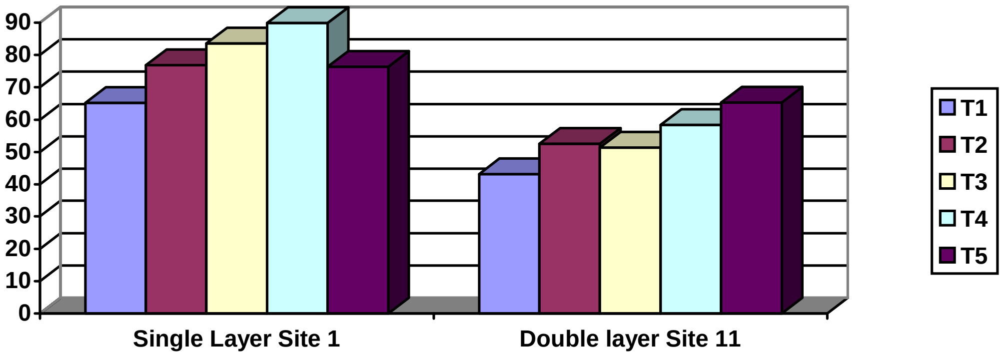
LSD for site at 0.05 = 29.7
LSD for treatments at 0.05 = 46.9
LSD for site x treatments 0.05 = NS

Figure 2.3.16. Effects of different levels of nitrogen fertigation on average fruit weight (g) of cucumber raised in single and double layer plastic houses.



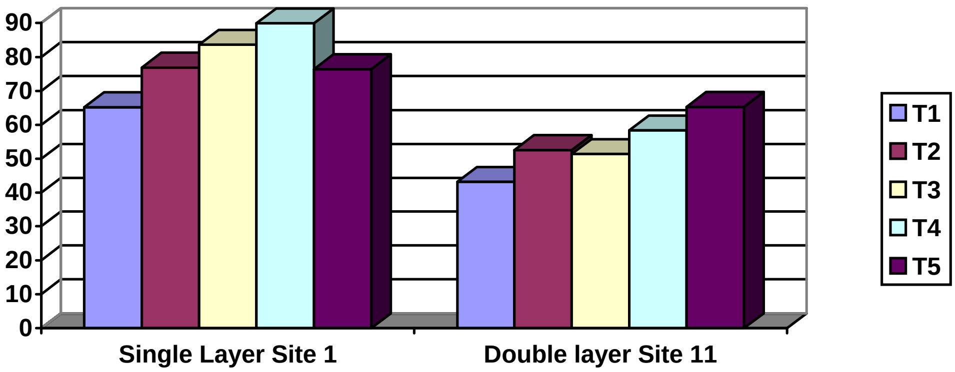
LSD for site at 0.05 = 2.6
LSD for treatments at 0.05 = NS
LSD for site x treatments at 0.05 = NS

Figure2.3.17. Effects of different levels of nitrogen fertigation on yield (ton\ha) of cucumber raised under the conditions of both single and double layer plastic houses.



LSD for site at 0.05 = 4.4
LSD for treatments at 0.05 = 6.9
LSD for site x treatment at 0.05 = NS

Figure 2.3.18. Effects of different levels of nitrogen fertigation on fruit length (cm) of cucumber plants raised under single and double layer plastic house conditions



LSD for site at 0.05 = 0.4
LSD for treatments = 0.6
LSD for site x treatments = NS

Table 2.3.10. Effects of different nitrogen levels on fruit width (cm) of cucumber raised under single and double layer plastic houses

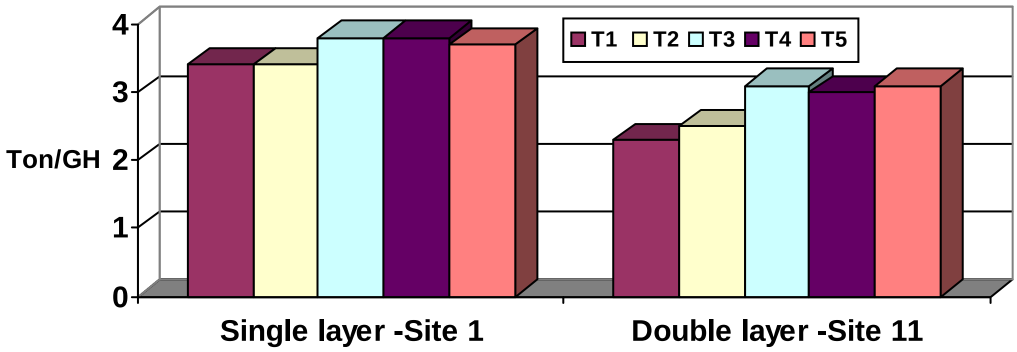
Treatments	Single Layer Site 1	Double layer Site 11	Mean
T1	2.9	3.2	3.0
T2	3.2	3.4	3.3
T3	3.6	3.3	3.4
T4	3.5	3.0	3.2
T5	3.4	3.1	3.2
Mean	3.3	3.2	

LSD for site at 0.05 = NS
LSD for treatments at 0.05 = 0.2
LSD for site x treatments = 0.2

Season 11

The material and methods were similar to those of the first season except that an additional urea treatment (T5 = 64.4 gN/m^2) was included.

Figure 2.3.19 Effects of different levels of nitrogen fertigation on yield of cucumber raised in single and double layer plastic houses



*GH = Greenhouse (area = 9 x 40m)
Data not statistically analysed

Conclusion

1. The performance of cucumber plants under the single layer GH was greater that that of the double layers. Yield and quality were superb and the overall cost was less. Growers will be advised to use one layer of polyethylene to cover GHs in Oman.

2. The recommended level of Nitrogen (N) should be in the range of 35-55 g/m2. Although, Urea is the less costly than other forms of N but it is advisable to use the compound ready made fertilizers (NPK) to insure the balance of the other required elements.

2.4. WATER RESOURCES AND IRRIGATION

2.4.1:Introduction

The Arabian Peninsula (AP) is endowed with great economic resources, mainly in the form of oil. It is also characterized by aridity and very limited renewable water resources. Annual precipitation is usually much less than potential crop water use so that, with few exceptions, all arable crop production requires irrigation.

The renewable supply of water per capita is amongst the lowest in the world. According to figures published by the World Bank, the average worldwide renewable water supply per capita per year is 7500 m^3. In the Middle East and North Africa, the average is 1250 m^3. In the Republic of Yemen, which is the only country in the AP that can support significant rainfed agriculture, the average is only 150 m^3, with an uneven distribution such that 90% of the Yemen's population has less than 90 m^3 per person per year. These figures for Yemen are some of the lowest values in the world, even though the country receives significant rainfall in its mountainous areas. This situation of renewable water scarcity prevails in the entire peninsula, and is mitigated mainly by the consumption of non-renewable ground water resources

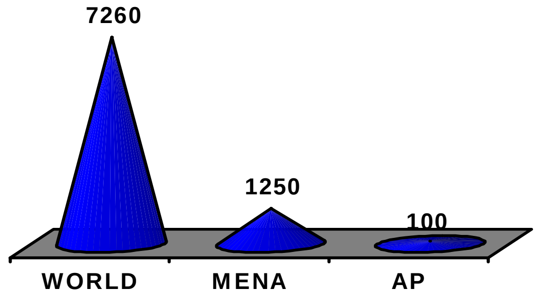


Figure 2.4.1:Renewable water(m^3per person per year) resources per capita for the world, Middle East and North Africa (MENA), and the Arabian Peninsula (AP) Source: World Bank

In arid regions, by definition, the difference between potential evapotranspiration and precipitation is large. This difference must be supplied by irrigation if yields are not to be limited by water. In contrast, natural rangeland depends only on rainfall. However, rainfall is usually limited and highly variable in amount, intensity and timing. Historically, most of the agricultural land in the Arabian Peninsular was rangeland that was managed so as to provide grazing for a sustainable population of animals. Along with rangeland, there were limited areas of irrigated production that depended on water from sources such as springs, shallow wells, runoff and aflaj (qanat) systems.

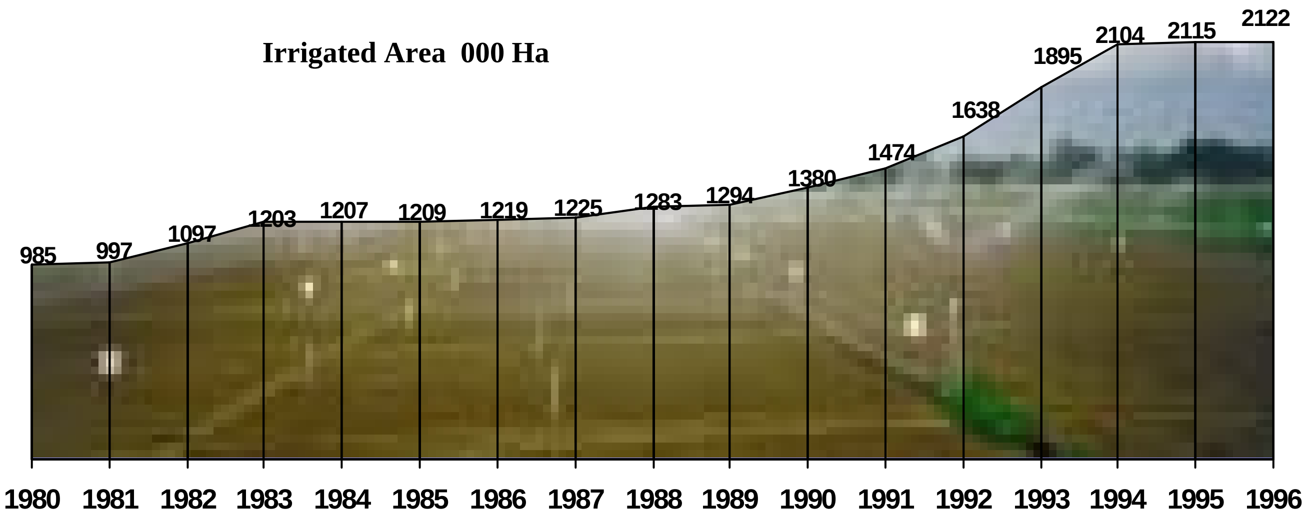


Figure 2.4.2: Irrigation Area in Arabian Peninsula

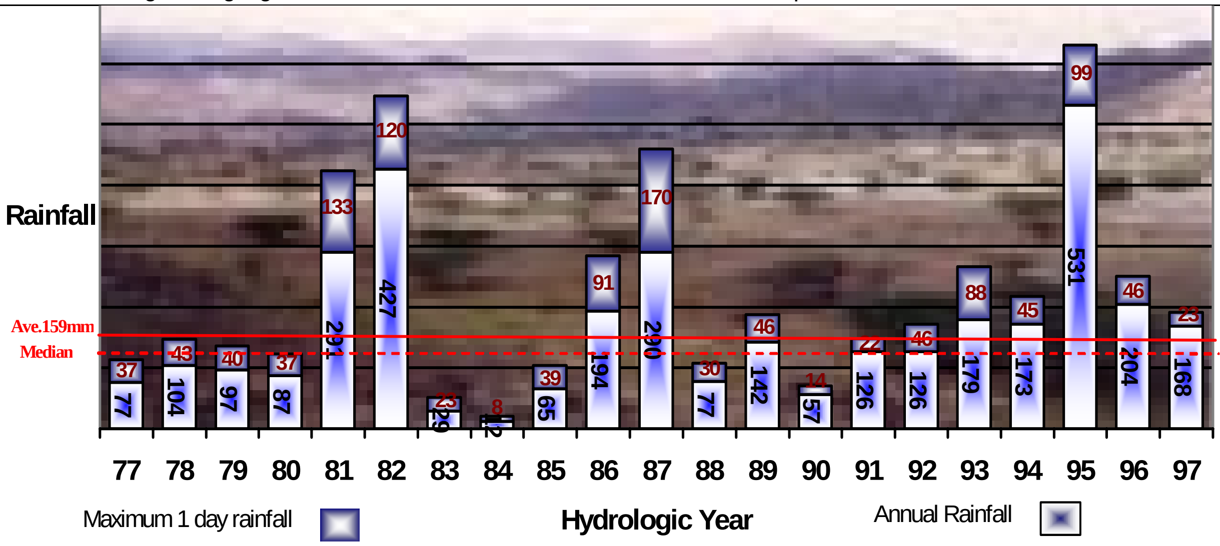


Figure 2.4.3: Annual Rainfall at Fujairah, UAE

Rapid economic development in the latter half of this century has resulted in significant changes to the traditional agricultural systems, which by necessity had to be sustainable. Increased production, both of crops and animals, has been dramatic. However, increased production has often been at the expense of sustainability and has caused damage to natural and environmental resources. The irrigated area has increased enormously, aided by the use of modern irrigation technology such as center-pivot and drip.

For example, during the 1980's there was a very large increase in irrigated land in Saudi Arabia as center-pivots became the dominant irrigation system. However, this large increase was matched by an approximately equal increase in population, so that the irrigated area per person has not substantially increased during this time.

A significant part of the increase in irrigated area is devoted to forage production to support a livestock population that has also increased dramatically. Much of the increased water requirement is provided by groundwater from aquifers with little or no recharge.

Maintaining full irrigation requires large volumes of water, especially for perennial crops such as alfalfa and Rhodes grass, because crop water requirements have to be met during the long hot summer period. Continued use of groundwater for irrigation to meet agricultural production targets has led to declining water levels and saline intrusion in many areas.

An example is Al-Batinah region in northern Oman. This is an important agricultural area between the Hajar mountains and the sea that historically depended either on aflaj systems that exploited runoff or groundwater originating in the adjoining mountains, or on wells that used animal power to raise water from shallow water tables. Date palm and other fruit trees such as lime, mango and banana were grown along with vegetables and fodder crops.

In recent times, groundwater in Al-Batinah has 1`a large number of new wells with mechanical pumps. Over 80% of the irrigated land in the South Batinah currently produces perennial crops, primarily fruit trees and fodder. Alfalfa and Rhodes grass account for about 90% of the irrigated forage area.

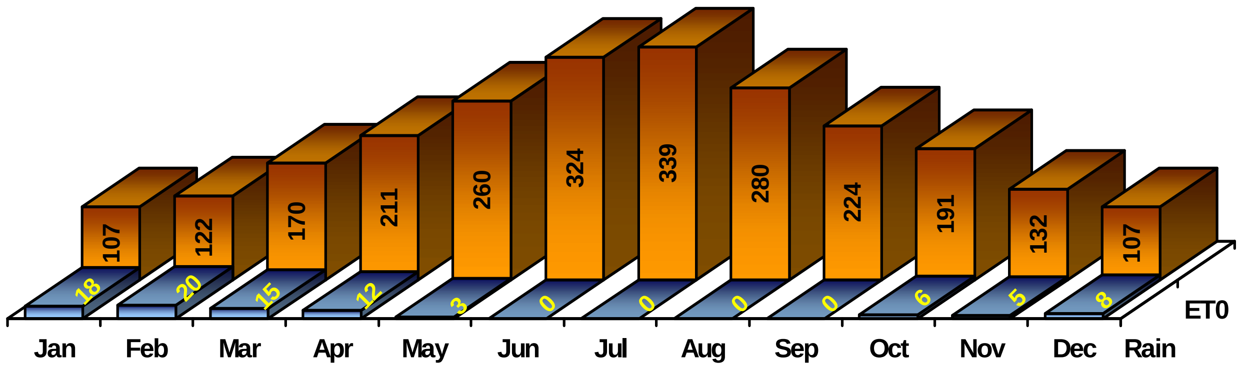


Figure 2.4.4:-Reference Evapotranspiration ET_0 and Rainfall (mm/month)

Maintaining perennial crops such as these under full irrigation requires very large amounts of water, particularly during the summer months when crop water use is very high.

The increase in the irrigated area and over-exploitation of the groundwater has led to saline intrusion in many areas, resulting in salinity and abandonment of farms, particularly near the coast. Even date palm, which is indigenous to the peninsula because of its heat and salinity tolerance, has not been able to survive in the worst affected areas. Studies conducted by the Ministry of Agriculture for the South Batinah region estimate the annual groundwater deficit to be at least 60 million m3 (S. Batinah Integrated Study). This has contributed to the abandonment of farms comprising about 10% of the total farmland.

In inland areas, the difference between precipitation and potential evapotranspiration is even larger. Annual potential evapotranspiration in many areas of Saudi Arabia is over 2,400 mm, which requires over 24,000 m3 of water per hectare. For example, alfalfa grown in Northern Saudi Arabia requires an average total of 24,600 m3 of water per hectare to meet crop water use. Over 68% of this total is required during the six months from April to September. For date palm, the total annual requirement is 17,200 m3 of water per hectare, of which 72% is used during the same six-month period. During the three peak water use months of June, July and August, alfalfa requires 38% of the annual total, while date palm requires 41%. Irrigation in this region depends almost entirely on fossil groundwater with negligible recharge. In addition, the actual water applied is significantly more than crop water requirements because of inefficiencies in water application and management.

The opportunities to augment the fresh water supply for agriculture remain limited at present. One alternative source of water for the Arabian Peninsula, which may or may not be considered renewable, is desalination of seawater. Solar based desalination would generate essentially renewable water supplies, but at present the technology is too costly to meet demand. Desalination is currently based on energy from oil, and is used to meet a significant amount of municipal water requirements in most of the GCC countries. For example, in the UAE, the cities of Dubai and Abu Dhabi depend almost entirely on desalination. Dubai in 1998 consumed 175 million cubic meters of

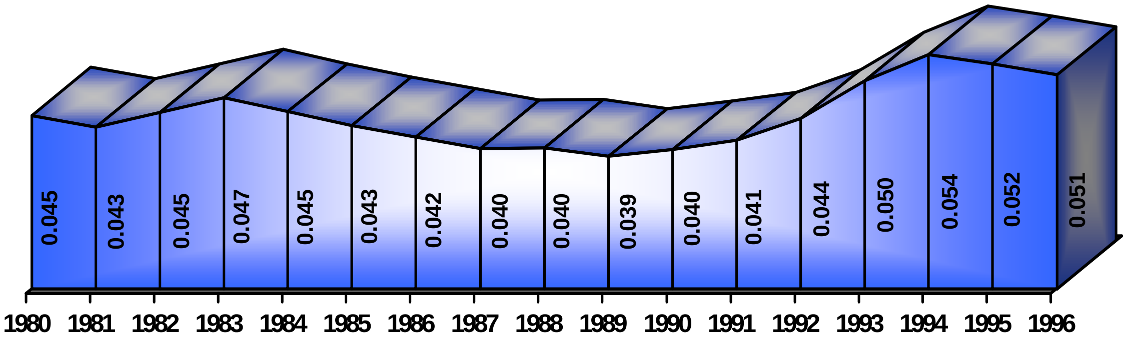


Figure 2.4. 5: Irrigation Area Per Person in Arabian Peninsula

desalinated water. The installed capacity in the entire country is about 550 million cubic meters per year, and this is expected to increase dramatically during the next decade. However, depending on the costing methods employed, desalinated water is very expensive, at around $1-2 per m3, which makes it prohibitive for agriculture using conventional economics. There are also environmental concerns about the disposal of the resulting brine, particularly in inland areas.
There are some opportunities for ground-water recharge using dams constructed across wadis to impound runoff after rainfall events so that it can infiltrate. However, the low and variable rainfall and the cost of such structures complicates the long-term economics. There are also some surface storage dams and reservoirs, but a significant amount of the stored water can be lost due to the high evaporation rates.
Apart from quantity, the quality of surface and groundwater needs consideration. Shallow water tables are prone to contamination by agricultural and industrial chemicals, such as fertilizers, pesticides, solvents and petroleum products such as oil and gasoline which have leaked or been disposed of incorrectly. There may be a direct danger to human health if such groundwater is also a source of potable water.
Another potential source of water is recycled water (treated waste water) from municipalities. Recycled water (RW) can represent a significant amount of water, but its use in agriculture presents problems. Of primary concern is contamination of agricultural produce by bacteria and chemicals in RW. This has led to it being used primarily for fodder crops and fruit trees where the water does not come into direct contact with the fruit. Environmental concerns are also important, such as contamination of soil by heavy metals from prolonged use of RW. It is currently most commonly used for landscaping purposes in municipalities. The cost of RW is also high, as much as 30 to 50% of the cost of desalination.
In some cities, a significant amount of the municipal water supply is recycled, while in others the reclamation rate is much lower. Some of the treated water is used for irrigation, but the supply, which is relatively constant throughout the year, may not often match demand because of large seasonal differences in potential crop water requirements. Storage is one solution to better match supply with demand so as to make the most effective use of the water. However, the volumes of water involved preclude the use of tank storage, and favor alternatives such as injection into suitable aquifers for later recovery. Delivering the treated water to farms for use in conventional irrigated agriculture in the quantities required, and at the times required, is a challenge.
Another source of water is saline or brackish groundwater. One source of such water can sometimes be found in municipalities as a result of landscape irrigation, inefficient distribution, and poor drainage. For example, some buildings in Kuwait City are currently threatened by a water table near the surface that has built up over many years.
The cost of water to the user can have a significant effect on how efficiently the water is used, and this is true for irrigated agriculture. There is evidence from studies in Oman that less irrigation water per unit area is used when water costs are high and supplies limited. This is true

even with traditional agriculture which may employ non-commercial costing procedures. An example from the interior of Oman showed that water in one of the few remaining animal powered shallow well systems (Al-Zaggarah) was used very efficiently because, although the water in the well was "free", it cost a substantial amount in non-monetary terms to the owner because of the time, labor and animal requirements. Another study on a traditional Falaj system in the Hajar mountains showed that the flow in the system was used quite efficiently because, although the water was again "free", the maintenance of the system and the limited flow rate actually made the water quite expensive in non-commercial terms. In contrast, farms which depend on pumped groundwater can be very inefficient because the water is cheap. Apart from the amortised cost of the equipment and its maintenace, the only ongoing cost to the owner is for the energy to operate the pump. The cost of the water, although it is may be non renewable, is relatively cheap, particularly if the cost of energy or equipment is subsidized. As a result, large areas are devoted to producing crops with a very high water requirement, such as alfalfa and other forages for use in such industries as dairy.

The various measures of irrigation water use efficiency are based on the amount of agricultural production or revenue per unit volume of water consumed or applied. An example would be annual alfalfa dry matter production per m^3 of irrigation water. Yields generally increase with increasing irrigation up to the point that the crop is fully irrigated with no water stress. Irrigation much beyond this point can cause decreasing yields due to factors such as leaching of nutrients, diseases, and waterlogging.

At the point of maximum production, the marginal increase in yield as a function of water is zero. The point of maximum economic return is usually slightly less than the point of maximum production, and depends on the costs of inputs such as water, chemicals and labor. Much research has been conducted to identify the point of maximum production and the water use efficiency of commonly grown crops in the world, including forage crops. Ideally, all the water applied should be used by the crop, although this is not usually attainable under full irrigation. Of the total irrigation water applied, some is used beneficially by the crop, such as for transpiration and leaching of salts, and some is not used beneficially because of inherent inefficiencies, and scheduling, management and equipment problems. In the AP, water is the most limiting resource, and so productivity would be better measured in terms of production per unit volume of water rather than per unit land area. Water use efficiency (WUE) should therefore be of primary importance.

Because irrigation uses by far the largest share of water resources in the AP (80-90%), improving water use efficiency in irrigated agriculture can have a major impact on water conservation.

The Arabian Peninsula is faced with the challenges of developing more sustainable land and water use, preserving its environment and heritage, and sustaining the development and self sufficiency of its population in times of depleting energy reserves and unstable prices. Ways to address these challenges require innovative and appropriate research on a number of topics. The APRP has attempted to find solutions to the pressing problems of water scarcity, and continues to do so.

2.4.2:Researcher Managed Trials

2.4.2.1:Comparison of the WUE of important forages grown in the region.

Much of the effort in Phase I has gone into this component. Experiments were conducted at different locations within the region to obtain baseline information on water use by currently grown crops, and preliminary information on water use and production of potential alternative crops that may be more efficient in terms of water use. In addition to pure stands of currently used forage crops, research was conducted on mixtures of these species,such as alfalfa grown with Rhodes grass. In Oman, a study was conducted at the experiment station in Rumais to compare production of 3 varieties of Rhodes grass, 2 varieties of alfalfa and 3different alfalfa/ Rhodes grass mixtures,all under full irrigation. Solid-set sprinkler irrigation was used, and was scheduled using data from a weather station.Results are shown in table2.4.1

Table 2.4.1:* Means *of WUE vs dry matter yield (kg/m3) of eight treatments of forage and forage mixtures

- *Treatments*	Cut-1 April 98	Cut-2 May 98	Cut-3 June 98	Cut-4 July 98	Cut-5 Aug 98	Cut-6 Sep 98	Cut-7 Sep 98	Cut-8 Nov 98	Cut-9 Nov 98	Cut-10 Dec 98	Cut-11 Jan 99	Cut-12 Feb 99	Mean
1. Alfalfa -Batinah	0.85	0.41	1.23	1.01	1.13	0.96	1.09	0.57	2.97	3.50	2.67	3.36	1.645 d
2. Alfalfa -Interior	0.81	0.45	1.78	1.09	1.43	1.18	0.99	0.53	3.38	3.39	2.80	3.23	1.755 d
3. RG Katambora	-	0.67	5.33	2.07	1.57	1.80	-	1.00	-	2.54	-	3.73	2.34^{+} a
4. RG Callide	-	0.39	6.88	1.81	1.67	1.78	-	0.94	-	2.18	-	3.97	2.45^{+} a
5. RG Top cut	-	0.30	5.89	2.18	1.17	1.48	-	0.60	-	1.86	-	3.51	2.12^{+} b
6. Alfalfa-RG 1:1)	0.66	0.33	3.07	2.08	1.35	0.97	1.10	0.60	3.70	3.28	3.16	3.46	1.981 c
7. Alfalfa-RG 1:2	0.74	0.45	3.23	2.13	1.21	1.06	1.00	0.59	4.11	3.15	3.13	3.38	2.013 bc
8. Alfalfa-RG 2:1	0.84	0.44	2.65	2.07	1.18	1.04	0.98	0.59	3.56	3.32	3.06	3.93	1.97 c
Mean	**0.78**	**0.43**	**3.76**	**1.80**	**1.34**	**1.28**	**1.03**	**0.58**	**3.54**	**3.33**	**2.96**	**3.47**	

Statistical Analysis F-TEST

Treatments	**	(LSD at p=0.05 = 0.137 kg/m^3)
Cuts	**	(LSD at p=0.05 = 0.168 kg/m^3)
Interaction	**	(LSD at p=0.05 = 0.474 kg/m^3)
CV %		19.61

+ *For Rhodes grass varieties means are computed for 8 cuts*

* *Values with similar letter(s) are not significantly different at p=0.05*

In Yemen, studies were conducted in the south of the country, at Lahej, to determine yield and water use efficiency of Sorghum and cowpea, two important forages in the region. The experiment was conducted under surface irrigation, which is the predominant method in the country. The studies were conducted over two years, with three cuts per year. In the first year, full irrigation was applied, while in the second year, full and deficit irrigation were applied. The deficit irrigation treatments corresponded to 75%, 50% and 25% of the full irrigation (100%) treatment. Results show that yields of sorghum declined with reduced irrigation, as would be expected. However, the decrease in yield was less than the decrease in irrigation, implying greater water use efficiency. The yield of cowpea was lower than sorghum, as expected. However, reduced irrigation did not appear to reduce yield. Results for the mixture were between those of the two crops. During the second year however, yields of both crops were lower than in the previous year. One danger of deficit irrigation, that of salinity build up due to lack of leaching, needs further investigation if Opportunities to increase water use efficiency and/or reduce non-renewable water use will be investigated.

irrigation, may be well suited for a deficit irrigation strategy in Yemen.

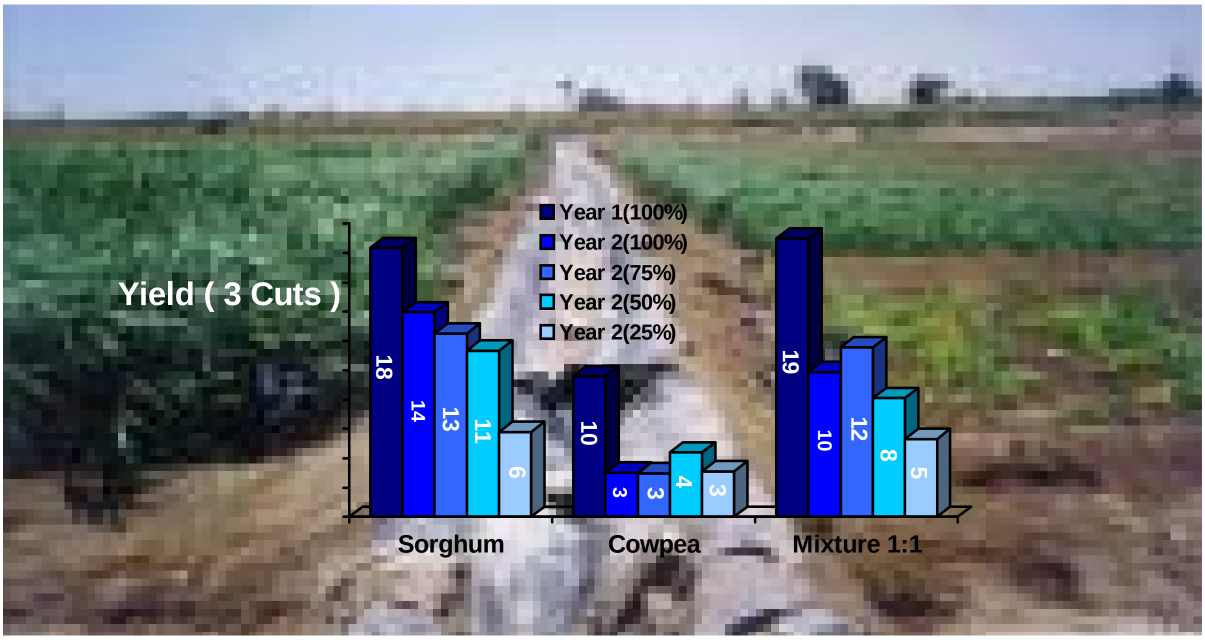


Figure2.4.6: A comparison of yield of Sorghum, Cowpea, and their equal mixture, in Yemen

For example, a single spate irrigation of half the full amount on twice the area may well result in higher total production than the existing system, in which upstream producers tend to receive more than the crop can use, while downstream users receive much less.

Figure 2.4.7 shows the water use efficiency (Yield/water applied) of sorghum for the different treatments.

As the water applied decreases, the productivity of the water increases, as suggested above. In regions where water is the most limiting resource, information such as this is very important in developing appropriate strategies.

In Kuwait, an experiment was conducted by Kuwait Institute for Scientific Research (KISR) at their research station in Sulaibiya to determine WUE of five forage species (Medicago sativa, Lolium perene, Panicum maximum, Cenchrus ciliaris, and Chloris gayana), as well as four mixtures of grasses with the legume alfalfa (Medicago sativa). Poor germination and weed competition adversely affected the results. However, Rye grass (Lolium perene) and the Rye grass/alfalfa mixture produced the best results, although yields and WUE were considerably lower than in other locations.

Research was initiated in UAE to assess the performance of indigenous forage grasses under irrigation. A line-source sprinkler system was established at the research station in Al-Dhaid, in Sharjah emirate. The system applies a gradient of irrigation, with maximum rates close to the line, and a rate that reduces with distance from the line. The results are preliminary, but do show that the indigenous species (Cenchrus ciliaris, Coelachyrum piercii, and Lasirius scindicus) are very drought tolerant, and capable of producing under very limited irrigation. Under full irrigation, Cenchrus ciliaris is at least as productive as the widely grown Rhodes grass (Chloris gayana). There are also data on the nutritional value of these forages from research conducted under the rangeland component that show that the indigenous species are generally superior.

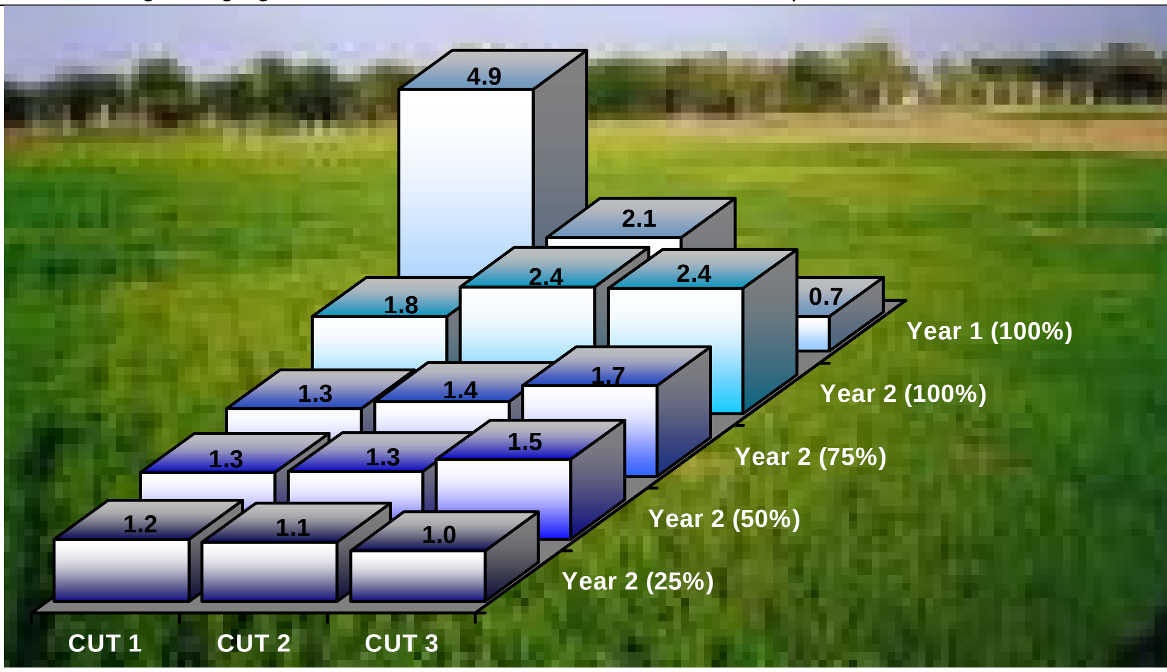


Figure 2.4.7: Water use efficiency (Kg/m^3) of sorghum in Yemen.

2.4.2.2:Assessment of the actual water requirement of two vegetable crops under plastic house conditions

An experiment was begun in the UAE to monitor the soil water balance in greenhouses at the UAE Al-Dhaid research station. Soil water measurement TDR access tubes were installed in three greenhouses growing cucumbers. Each house had a different water application rate. By monitoring soil water content with depth over time, it is possible to determine whether excess or insufficient water is being applied. However, disease and water distribution problems prevented good data from being taken, and the experiment was subsequently abandoned.

2.4.2.3:Comparison of the efficiency of existing system of water application

No activities were conducted. However, simple catch can devices were made for measuring sprinkler irrigation on farm, but they were used only to measure irrigation on indigenous forages experiment at Al-Dhaid, UAE. Figure 9 shows the cans, which are constructed out of simple and readily available materials. They can be seen in figure …..

Figure2.4.8: An automated weather station in the UAE collecting the data required to estimate potential

2.4.2.4:Calibration, improvement and validation of existing regional models on water use and crop growth

A simple approach to using irrigation water more efficiently is to develop irrigation scheduling and management strategies so that wastage of water is minimized. Wastage can occur as a result of many factors, including poor irrigation scheduling (timing and amount of irrigations), and poor maintenance and operation of irrigation equipment. Models that make all the calculations necessary for irrigation equipment. Models that make all the calculations necessary for irrigation scheduling are available, but they may need calibration and validation..

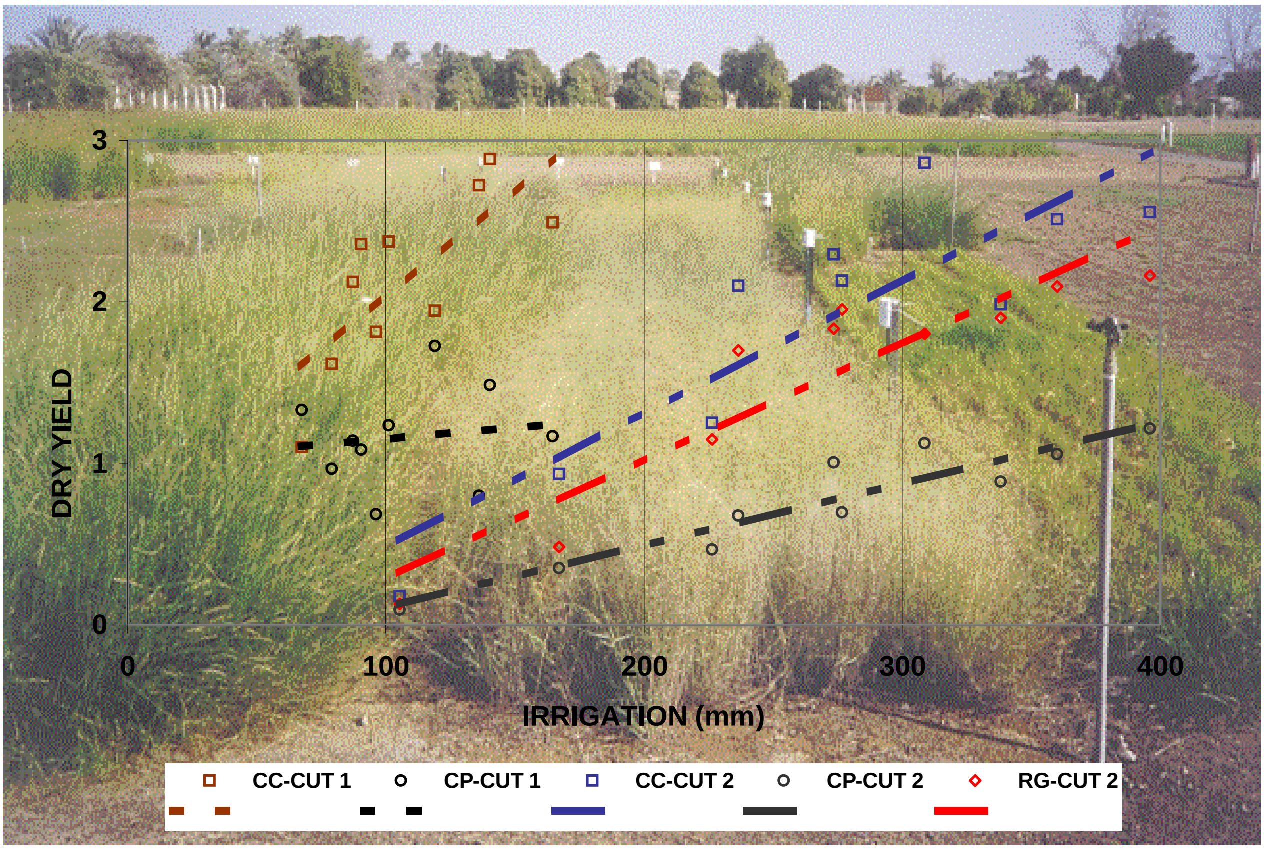


Fig2.4. 9: Yield of two indigenous species, Cenchrus ciliaris (CC) and Coelachyrum piercii (CP) for two cuts, as a function of irrigation amount applied with a sprinkler line source in UAE. Yield of Chloris gayana (Rhodes grass, RG) is also shown for cut 2.

It was not possible to do this due to resource limitations, but a program was initiated that will form the basis of an agrometeorological network in Phase II. Correct irrigation scheduling can have a big impact on agricultural water use. Farmers will tend to apply more water than necessary as a form of insurance against applying too little. This is particularly true if they do not have good information on how much water is necessary The information needs to be available rapidly enough to be used for irrigation decisions if it is to be beneficial. The correct amount of water to apply is largely determined by the weather. In the UAE, an automated weather station has been installed at the Desert Park in Sharjah. The data from this weather station is used to estimate potential evapotranspiration, and thus crop water use, using standard and widely accepted methods. These methods are often incorporated into computer programs, and have been programmed into a spreadsheet that is being used to schedule irrigation at the indigenous forage experiment at Al-Dhaid, UAE. The data from the weather station are transferred into the spreadsheet, which uses them to estimate daily ET0, using the Penman Monteith method that has become the de facto standard method for such estimates. Also important in irrigation scheduling are measurements of the amount of water applied, and of soil water content. These measurements are especially important for research. As part of APRP Phase I, Saudi Arabia purchased an 'Enviroscan' unit for measuring soil water content at fixed locations and depths within a field, and a TDR system with both handheld and access tube probes was purchased in UAE. Oman and Saudi Arabia also use neutron probes.

3.CAPACITY BUILDING AND INSTITUTIONAL STRENGHTENING

3.1:Training Program on Protected Agriculture (Integrated Management of Greenhouses)

Objective: The course aims at introducing some of the principles associated with the following topics:
(i) Integrated pest and disease management
(ii) Fertigation
(iii) Improved water use efficiency for greenhouse and open field crops
Location: Doha, Qatar
Duration:19 – 24 Apr. 1999
ICARDA Scientist: Dr. Ahmed T. Moustafa

The Course:
The course covered the principal's of the integrated management of the green houses and protected agriculture practices in the Arabian Peninsula. These were including:

- Protected agriculture and its importance for AP, Types of protected agriculture and their cover
- Environment control inside the green houses, Weather stations and their importance for protected agriculture.
- Integrated pest management in protected agriculture
- Cooling and Ventilation
- Management of vegetable crops under protected agriculture, Production of vegetable seedlings for protected Agriculture.
- Soilless cropping
- Water sources for protected Agriculture
- Technical and Economical assessment of protected agriculture
- Basis for calculating water requirement
- Basics of Fertigation
- Harvesting, Hurdling and Storage of fruits

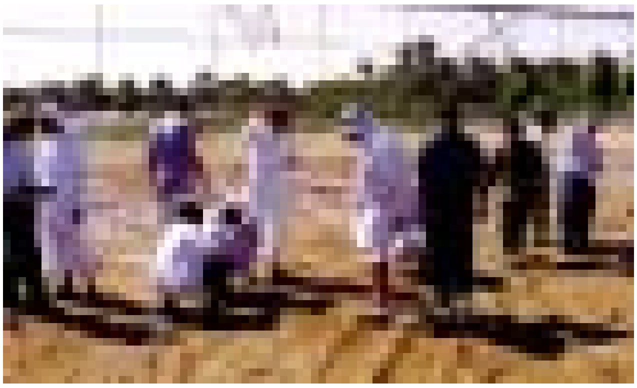
Practical sections mostly had followed the lectures to make chances for the trainees to try their new information in practice. Further more, Participants visited the Qatar-Arabian Company farms at the end of the course, to get an idea about commercial protected agriculture activates in AP countries.
Nine scientists lectured in this course:

- Prof. Dr. Aiman Farid Abo Hadid, CLAC, Egypt
- Prof. Dr. Badwi Abdul Al-Rahim, NRC, Cairo, Egypt
- Dr. Abd Al-Monem Abo Gasise, Qatar
- Dr. Abdollah Abodi, MAF, UAE
- Dr. Ahmed T. Moustafa, ICARDA-APRP
- Dr. Essam Moustafa Abd Al-Razagh, Ministry of Housing & Agriculture, Bahrain
- Eng. Hassan Abo Sokker, DAWR, Qatar
- Dr. Ian McCann, ICARDA-APRP

- Dr. Mohamed Hashem, DAWR, Qatar

3.2:Water Use and Fertigation (Irrigation and Fertigation)

Objectives: Providing the technical information on Water use and Fertigation and usage of computer on current studies
Location: Riyadh, Saudi Arabia
Duration:15-25 Nov 1998 plus 2 days of filed trip



A specialized 10-day course in Irrigation and Fertigation was held in Nov. 1998 in Riyadh, Saudi Arabia. It was attended by trainees from all seven AP countries, and was considered by all to be a success. The list of participants is attached.

The Course
The course incorporated theoretical, practical and computer oriented approaches to topics such as irrigation scheduling and irrigation system assessment.
It was held at the National Agriculture and Water Research Center in Riyadh, and at King Saud University. Faculty and staff from King Saud University and King Fahd University in Dharan also contributed towards the program. Field trips were made to large commercial farms to look at irrigation and production practices.

<u>Content</u>
The main topics of the course were:

- Introduction to Soil & Water
- Soil water measurements and movement
- Introduction to hydraulics
- Intro Crop water requirements
- Irrigation scheduling techniques
- Fertigation
- Irrigation systems
- Computer models and current research

<u>Lecturers and Contributors</u>
Three scientists lectured in this course:

- Dr. Ahmed Al-Amood, King Saud University - Riyadh
- Dr. Ian McCann, ICARDA-APRP
- Dr. Walid Abderahman, King Fahad University of Petroleum and Minerals – Dhahran

Course Evaluation
An assessment of the trainees knowledge was made at the beginning and at the end. In addition, a course evaluation was completed by all trainees.
The test scores improved considerably (by 27%), showing that their skills and knowledge benefited substantially from the course.

3.3: Training Program on Field Plot techniques, data analysis and presentation and scientific writing

Objective: The course aims at introducing some of the important tools and techniques used in these four disciplines and demonstrates how they can be used and applied .

Location: Doha, Qatar

Duration: 25 Apr.-6th May 1998

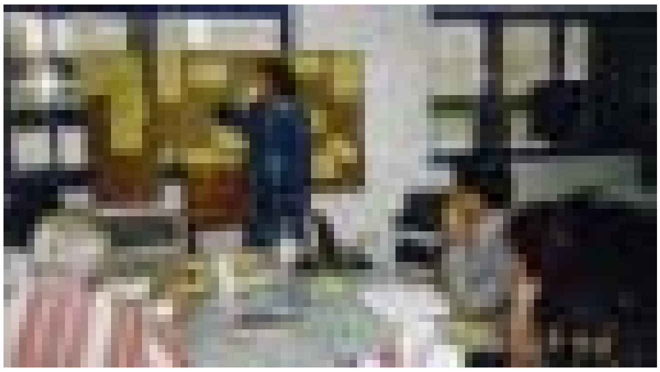
ICARDA Scientist(s): Zaid Abdul-Hadi, Murari Singh, S. Bittar and Guy Manners.

This was the tenth regional, sub-regional, in-country course (component) on science writing sponsored by ICARDA. The course-component was conducted from 3 to 6 February 1998 (3½ working days), at the MIS, Ministry of Municipal Affairs and Agriculture, Doha, Qatar. The 21 trainees were agricultural researchers and support staff from the national programs of the Arabian Peninsula. Three of the trainees were female. The course-component was conducted by a single trainer.

The course

As in the past, the course emphasized writing research reports for primary journals, and seminar and poster presentations.

Training took the form of informal lectures, with discussion integrated into each session. However, because of the English-language level of many of the participants, it was considered necessary (by the ICARDA,APRP Coordinator and the course coordinator in Qatar) that some sort of simultaneous interpretation be provided: this was done by Sawra Bitar of CBSU,ICARDA, who stayed on in Doha beyond her own course-component for this purpose. In addition, Sawra translated the post-course evaluations (Post-course, Instructor, and Course) onto overhead transparencies.
Training material distributed to the participants comprised the handbook and various other hand-outs used at similar courses over the last few years.



Trainees' performance

The same questionnaire used in previous courses was used for both pre- and post-course evaluation to aid the assessment of trainees' progress. The questionnaire comprised a multiple-choice section (10 questions), a true-or-false section (10 questions), and 3 questions requiring descriptive answers.
Combined results were as follows. In the pre-course assessment, the average score was 12.0 (out of 26; range = 8–17½; n = 19). In the post-course assessment, the average score was 15.9 (range 10½–20½; n = 15). The average improvement of participants was 4 points (range –1½ to 8; n = 12—one post-course assessment was returned anonymously); average relative improvement was 36.3% (range –8.6 to 100%).

Trainer and course evaluation

Trainer evaluation

Instructor evaluation was performed on the last afternoon—15 participants completed the forms. Questions were rated on a point-scale of 1–5, with 5 or 3 comprising the best score, depending on question (indicated in parentheses).

	Average	Range
Mastery of subject matter (5)	4.7	3–5
Ability to create & sustain interest (5)	4.5	3–5
Openness to ideas of trainees (5)	4.4	2–5
Time management (5)	4.2	2–5
Speed in talking (3)	3.3	3–5
Clarity of speech (5)	4.3	2–5
Overall evaluation (5)	4.5	3–5

Trainer's comments

The tendency among ICARDA regional course organizers to reduce the course duration between planning stage and the start of courses also affected this course. Reduction in training time has a detrimental effect on trainee benefit, as the part to suffer is the practical application (it is well known that adult retention from lecture, seminar-based training is far less than from courses with active participation and practical work). I strongly recommend that ICARDA Regional Coordinators be encouraged to discuss course content and timing with trainers well in advance (during the planning stages) and schedule courses accordingly. The time-factor problem was clearly highlighted by the participants.

This was the first time in several years when language ability was a serious hindrance to trainee learning (in the past this has usually affected only 2–3 participants). The language-barrier was clearly highlighted in the Course Evaluation when several participants indicated that the time for discussion was on the long side—this was clearly *not* the case! Again, it is the responsibility of ICARDA Regional Coordinators and other course organizers to ensure that participants have sufficient ability to follow the proposed training schedule.

3.4: Insect Taxonomy and IPM of Insect Pests

Objective: Providing the Technical Information on principles of taxonomy and IPM of insect pests of protected vegetable crops, date palm and citrus trees.

Location: Rumais, Oman.

Duration: 21 Mar.-1 Apr. 1998

Participants :

From the 5 Arabian Peninsula countries 21, trainees had participated in this course. The complete list of participants is attached.

The Course

Content

This course covered principles of taxonomy and IPM of insect pests of protected vegetable crops, date palm and citrus trees. The main topics were:

- Introduction to insects, Introduction to IPM
- Principals of insect Taxonomy, Techniques of insect collection, Preservation and identification
- Principals of Insect Control, Major pests of protected Vegetable crops
- Role of insecticides in IPM
- IPM of citrus leaf miner and scale insects, IPM of Fruit flies
- Red palm weevil in the sultanate of Oman, Techniques of mass rearing predators and parasitism.
- Insects and mites of Date palm tress in Oman, Role of pesticides in IPM
- Biology control of Citrus

- Lecturers and Contributors

Seven scientists lectured in this course:

- Dr. Haidar Al-Haidari, Oman
- Dr.Yussef Shriqui, Oman
- Dr.Fathi Fahim, Oman
- Dr.Mounir Al-Louati, Oman
- Dr.Naif Al-Salti, University of Aleppo
- Dr.Adnan Babi, University of Aleppo
- Dr.M. El Bouhssini.ICARDA

About Half of the course was devoted to practical aspects in lab and in the field. During these Practical aspects, the participants learned techniques of insect collection, Mounting, Preservation and identification. They had also visited the pesticide residue lab and the museum of natural history.

Course Evaluation

At the end, participants evaluated the course, they mentioned that the course went very well. The average grades of the performance test went from 23% (initial test) to 63% (final test)

Closing

The course were closed by the presence of H.E. the Minister of Agriculture, Dr. Ahmed ben Khaled ben Mohamed Rouahi. In this speech Mr. the Minister tanked ICARDA for Conducting this course on IPM in Oman. He also stressed the importance of IPM approach for the control of insect pests, as this is friendly to the environment, natural enemies and animals. H.E. Mr. the Minister was very appreciative and supportive of ICARDA efforts in Oman.

3.5:Training on Germplasm Collection and Maintenance

Objective: Training course on how to collect, classify and store germplasm
Location: Genetic Resources Unit, ICARDA, Syria and Oman
Duration: 28 Feb. – 4 Mar. 1998
ICARDA Scientist: Jan Valkoun , Morag Ferguson (ICARDA)

A successful training course involving 14 trainees and 15 trainers was held at the Natural History Museum and Desert Park, Sharjah, UAE from 28th February to 4th Mar. 1998. Following this the trainees from both UAE and Oman successfully completed collection missions in their own countries.

ICARDA's Genetic Resources Unit (GRU) and the Arabian Peninsula Regional Program (APRP) organized jointly with IPGRI a training course on 'Germplasm Collection and Maintenance'. The course was opened by H.E. Hamad Abdulla Al-Mutawa'a, Deputy Minister of Agriculture and Fisheries. A welcoming address was also given by His Highness Sheikh Sultan bin Saeed bin Majid Al-Qasimi, Managing Director of Museum Affairs and Dr John Peacock, the APRP Regional Coordinator. The opening ceremony was filmed for Sharjah television.

A total of 23 lectures were given covering a wide range of topics from planning a collection mission to complementary conservation strategies and seed multiplication. Part of the course was held at the Natural History Museum and Desert Park in Sharjah and the participants had also the opportunity to visit sites in Dubai and Sharjah for practical experience in germplasm collecting. The IPGRI contributions were mainly in the field of underutilized and neglected species (Stefano Padulosi), general genetic resource conservation (George Ayad) and germplasm health (Marlene Diekmann). The course was appreciated by the participants who came from Bahrain, Egypt, Kuwait, Oman, Palestine, Qatar, Saudi Arabia, Tunisia, UAE, and Yemen.

On the final day certificates were presented to the 14 participants by H.E. Saeed Al-Raqabani, the Minister of Agriculture and Fisheries in the Avari Dubai Hotel. In his speech H.E. expressed his thanks to all the trainees and trainers in completing one of the most important courses to be held in the Arabian Peninsula.

3.6:Training Course on Seed Production and Technology

Objective: The objectives of this course were (i) to provide the technical information on seed production and technology and (ii) to create awareness and stimulate interest in the importance of producing and using improved seed in the region.

Location: Rumais, Sultanate of Oman

Duration: 16 – 26 February 1998,

Participants and Funding

The course was originally planned as a national course for the Sultanate of Oman, but was broadened into a regional course for the Arabian Peninsula and then later extended its scope to include participants from other WANA countries. Sixteen trainees participated in this course from 10 countries: Sultanate of Oman, United Arab Emirates, Qatar, Bahrain, Saudi Arabia, Kuwait, Yemen, Egypt, Jordan, and Tunisia. The list of participants is attached.

Participants from the Gulf region and Yemen were supported by the APRP project, whereas participants from Egypt, Jordan and Tunisia were supported by Dr Christiansen's project.

Logistics and Local Arrangements

The course was organized by ICARDA in collaboration with the Ministry of Agriculture and Fisheries of the Sultanate of Oman. The course was held at the Ministry of Agriculture Training Center adjacent to the Directorate of Research in Rumais. The participants as well as the lecturers were accommodated in the guesthouse attached to the Training Center. The teaching facilities –

conference rooms, audio-visual equipment, photocopying and accommodation were excellent and created a favorable environment for the success of the course.
The local organization of the course was assured in an excellent and professional way by Mr. Ahmed Al-Bakri on behalf of Mr. Ali Al-Jabri, DG of the Research.
Mr. Youssef Al-Mazroui, deputy director opened the course. He welcomed the participants, stressed the importance of the subject in the region and thanked ICARDA for organizing this course in the Sultanate. The opening was covered by the newspaper
A field visit was organized to Nizwa area to see some research activities in the Jimah Research Station, to visit seed production fields and to discuss with local farmers. Site seeing trips were also organized.

The closing ceremony was chaired by Sheikh Omar Bin Said Bin Salem Al-Marhoun, General Director of Administration and Finance in the Ministry of Agriculture and Fisheries. The Sheikh addressed the audience, expressing thanks to ICARDA for its precious activities and involvement in the region and hoping that this course will mark the beginning of more collaboration between the Sultanate and ICARDA. Dr Turner then spoke on a behalf of ICARDA emphasizing the importance attached to natural resource management. The Sheikh then presented the certificates to the participants. The ceremony was again covered by the media. The Ministry of Agriculture hosted lunch after the closing remarks and dinner after the final and general discussions.

The Course

Content
The course was designed to provide the trainees with technical and management knowledge on the production and technology of improved seed and to alert them to special issues relating to seed production of forage crops. The course was divided into two parts. A variety of topics were covered during the first week and this include: organization of seed industry, plant breeding, cultivar assessment and release, multiplication, processing, storage and quality control – legislation, certification and testing. Also, laboratory sessions were conducted on seed testing – sampling, purity, moisture content and germination. The second week was more specialized and focused on forage and pasture seed production in the region. The last day was a brainstorming session on native pasture and shrub seed production. Country reports were presented by participants in- between lectures.
The course was delivered mostly in Arabic with some lectures in English. The brainstorming session was instantly translated into Arabic to ensure maximum participation.

Contributors
Several experts and specialists contributed in one way or another in the success of this course.

Dr M. Turner, Dr L. Grass and Mr. A. Niane from Seed Unit, ICARDA

Dr M. Bounejmate from NRMP, ICARDA

Dr S. Nadaf and Dr M. Akhtar from the Directorate of Research, Sultanate of Oman

Dr S. Christiansen from ICARDA – Egypt

Dr H. LeHouerou (consultant) from Montpelier, France

The last day discussion (brain-storming) was attended by Dr J. Peacock and Mr. A. Al-Jabri, Director General of Research in Oman and many other local staff.

Training materials

A set of books and manuals (seed technology book,) were distributed at the beginning of the course and handouts were prepared for each lecture. Subject oriented books were also available for consultation in the conference room during the whole period of the course. These books were borrowed by the interested participants to complete their knowledge in specific areas.

Evaluation of the Course

Gain of knowledge

Before the course started, the participants were requested to take an initial test to assess their knowledge of the seed industry and to orient the course towards their needs. At the end of the course the participants were given the same test, to assess their progress.
The average mark of the initial and final tests was 47% and 65% indicating an average gain of 19%.

Evaluation of the course by the participants

At the final session, the participants were requested to evaluate the course. In general, the course was well appreciated by the participants: very useful (68%), useful (30%) and not useful (2%). Some participants commented that the duration of the course was too short to assimilate all the materials presented.

General evaluation of the course

In general, the course achieved the planned objectives by:

1. Providing basic information on the techniques required to producing high quality seed.
2. Raising awareness of the different possibilities for using forage species to feed livestock in a more sustainable way and without causing permanent damage to the environment.
3. Stimulating interest, in local seed production, both personally and in the agricultural research institutions of the region – “local production versus seed import”.
4. Providing a forum to exchange ideas between participants of the region and ICARDA staff on different matters of seed production in the Arabian Peninsula region, specifically
    - Consciousness about some constraints in the region – degradation of rangelands as a result of overgrazing, increase of salinated lands and shortage of water in the region.
    - Sustainable use of natural resources – importance of native species as a feed to livestock and a mean to restore vegetation and rehabilitate degraded land.
    - Collection of germplasm – what species to collect, how to collect, exchange of germplasm and seeds.
5. Providing other invisible benefits – personal contact, platform of future networking.

Conclusion and Recommendation

This is the first time the Seed Unit had organized such course in the Gulf region. The course was a success and achieved its planned objectives. It is an important and acute subject to the region due to the lack of organized local seed production and to the specific harsh environmental conditions in the region. The course laid the ground for future collaboration and practical efforts to collect, conserve and produce seed of indigenous species.
The participants and organizers agreed that other training activities on specific topics in seed production should be planned for the benefit of the region. A full list of all the participants is attached.

3.7: Training for External student

A six month training program for Mr. Antoine Leveau from the Universite Paris XII, Faculte des Sciences et Technologie (DESS) was successfully completed. Whilst working with APRP and the NARS in UAE, Mr. Leveau collected and analysed important data on factors affecting the restoration and rehabilitation of degraded rangelands. Mr. Leveau received his M.Sc.

4.WORKSHOPS AND MEETINGS

4.1:Protected Agriculture Workshop

Objective: To address the priority research areas listed for this theme, in particular, greenhouse management, integrated pest management, Fertigation and improved water use efficiency.

Location: Qatar

Duration:4 days

Starting Date:15-18 February 1998

Protected agriculture (PA) plays an important role in supplying the region's market with fresh products that cannot be grown otherwise due to the harsh weather and insufficient land and water resources. The demand is for high-quality products. Growers aim for high yields to maximize their profits. The combination of high quality and yield depends on many factors such as management, production techniques, and greenhouse structure and climate control. Some of the major constraints facing the PA industry in the Arabian Peninsula (AP) are human resources and marketing. To address the limitation, constrains, potentials and to review the state-of-the-art of protected agriculture in the region, this workshop, the first of its kind, was organized by the Arabian Peninsula Regional Program (APRP) and financially supported by the Arab Fund for Economic and Social Development (AFESD) and the International Fund for Agricultural Development (IFAD). International experts in different aspects of protected agriculture, together with the regional experts, researchers and specialists from the Arabian Peninsula countries attended this meeting to exchange information and discuss the present and future for protected agriculture in the Arabian Peninsula.

16 national scientists and 15 international and regional experts attended this first International Workshop on Protected Agriculture in the Arabian Peninsula. The complete list of Participants was attached as Annex III. The two groups gave 21 presentations, which were presented under four themes:

- Greenhouse design, structure and covering materials
- Growing systems in relation to water-use efficiency, Fertigation and post harvest technology
- Integrated plant production and protection
- Regional networking for the exchange of experience and information.

Summary of Discussions and outcomes

The recommendations from this meeting formed the basis for immediate and long-term strategies for protected-agriculture development in the Arabian Peninsula.

One the issue that has been highlighted in the workshop was communication and exchange of information. All participants were agreed that, what is really required from the APRP is coordination, and the fostering of collaboration, integration and information exchange among the AP countries, i.e. networking. In fact, the establishment of a PA network is a primary goal of the APRP PA project, and it has already highlighted the need for information sharing among the various PA players within countries as well as among the countries. However, there is still concern that a network should start small and grow, rather than start big and die from lack of resources.

During the workshop, also the major research themes for PA also have been discussed and identified and agreed upon by all the county representatives of the AP. These are:

1. Greenhouse structure and covering materials
2. Water-use efficiency
3. Integrated production and protection.

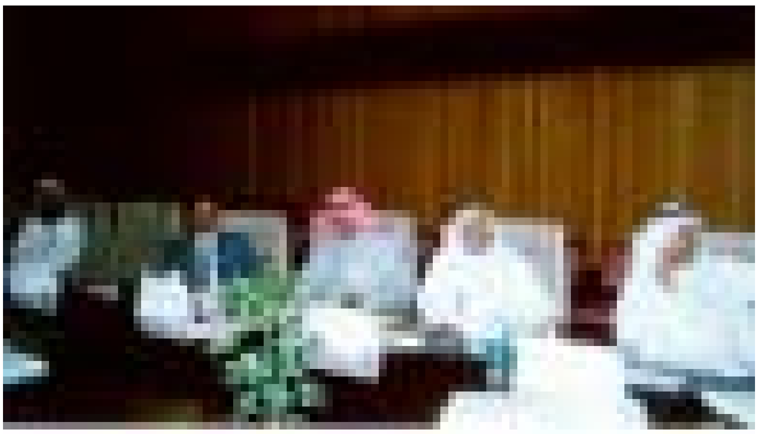
Generally the outcome of this Workshop can be listed under three major issues:

1. Research Activities
   The participated countries were agreed that Research programs for PA should be initiated immediately at the national research-station level with backstopping from regional and international experts in the following activities.
   - Greenhouse Structure and Covering Materials
   - Water Use Efficiency
   - Integrated Production and Protection Management

2. Regional Networking
   All attendance were emphasis on the necessity of Regional Network for exchanging the information regarding great similarity in the climate conditions, available natural resources and social structure among the Arabian Peninsula countries, and as a result, PA problems—including the type of structure and covering materials, irrigation and fertigation, production forecasting, pests and diseases, and marketing—are similar across the region. Networking is an efficient and economical way of sharing and exchanging the available information and experiences to tackle problems of common interest.
3. Human Resources and Training Programs
   It has been made clear by all country representatives in the Workshop that the lack of trained personnel is a major constraint to the development of the PA industry in the region.
   The following are the some of the training courses, which suggested by attendance to be designed for the PA research and extension personnel in the region:

1- Greenhouse management	4- Growing techniques and methods
2- Integrated production and protection	5- Fertigation and nutrient solution formulation
3- Soilless culture	6- Growing room—principles, design, and management

The countries representatives also mentioned that none of the countries has centralized seedling nurseries for PA. The situation had been explained as "The private sector in Yemen has recently started to produce seedlings for PA. Both Oman and the UAE have centralized nurseries for fruit trees, but not for PA vegetables; Kuwait is close to setting up a centralized nursery for ornamental plants for landscape-greenery planting". There are advantages and disadvantages to centralized seedling production—buying seedlings can be cheaper for the growers because of the losses involved when growing from seed; however, UAE growers had



experienced no difficulty in rearing PA crops from seed, and maximized the season by having their own nurseries.

At the end synthesis groups for the three themes developed work plans and a strategy for the next decade. The Workshop was including seven Session.

Field visit

One day was set aside to enable all the participants to visit four protected-agriculture complexes. The diversity of structures, growing systems and crops provided an excellent forum for further discussion of the major themes of the Workshop.

Brief descriptions of the four complexes follow:

Horticulture & Greenhouse Experimental Station, Ottoria

The Horticulture & Greenhouse Experimental Station is one of three research stations belonging to the Department of Agricultural and Water Research, Ministry of Municipal Affairs and Agriculture. It is located in the middle of Qatar in Ottoria village some 35 km east of Doha.

The station was established in 1979. The total area of the farm is 7 ha and consists of 12 plastic houses (2160 m²). In 1984, a modern fiberglass house with computer control was erected. The total area of this well-equipped unit was 1102 m² and it consists of six compartments. The unit was furnished with control room, central computer, small laboratory, stand-by generators and nutrient film technique (NFT) controlling equipment. Major research activates of the station were as follow:

- Development and/or adaptation of new growing systems and techniques with more emphasis on soilless culture.
- Greenhouse management, including greenhouse cooling systems, shading systems and materials, and the utilization of solar power for irrigation and water desalination.
- Crop management in relation to plant density, irrigation, nutrition, and pest and disease control programs.
- Crop and cultivar responses and performance under local conditions for cucumber, tomato, pepper, eggplant, lettuce, melon, squash, strawberry, banana and cut flowers such as roses, carnations, and bird of paradise.

Arab Qatari Agricultural Production Company

The Arab Qatari Agricultural Production Company was established by the 58th decree issued by His Highness the Amir of the State of Qatar in November 1989. It is a joint-venture company between the Government of the State of Qatar and the Arab Authority for Agricultural & Investment Development (AAAID), and has capital assets of 47,000,000 QR. The main objectives and activites of this company can be listes as:

- Contribution to the agricultural development and food security in Qatar.
- Apical intensification of vegetable production by maximizing the utilization of greenhouses throughout the year.
- Involvement in production of cut flowers and ornamental plants, and vegetable and flower seedlings.
- Vegetable and fodder production in open fields.

Other activities include introduction of some European vegetables, sale of some agricultural inputs and supply of quality products for the fresh food market.

The main production of this company can be separated in two groups:

Green house production: Cucumber, Tomato, Sweet pepper, Snap beans, Okra, Cut flowers, Indoor plants,

Open field production: Alfalfa, Sweet corn, Squash, Celery, Lettuce and Chinese cabbage

Al Sameria Farm, Rawdat Rashid, Al Shahania

The Al Sameria Farm, which is owned by Sheikh Ahmed Bin Hamed Al Thani, has an area of 85.15 ha, of which 20 ha are cultivated. Eight plastic houses (9 × 40 m) are used in the protected-agriculture industry, with the following crops and growing systems.
Cucumber: cv Shabieb; planted 10 October 1997; first production 2 December 1997; production period 60 days; 1000 plants/greenhouse; in-line spacing 35 cm; production rate 200 boxes per greenhouse (13 kg/box); total production 2600 kg in 60 days.
Green beans: cv Daimona and Amira; planted 15 October 1997; first production 10 December 1997; production period 60 days;2 plastic houses; in-line spacing 35 cm; total production 500 kg.
Sweet pepper: 1 plastic house; 800 plants/greenhouse; planted 1 November 1997; first production 5 December 1997.

Al-Sulaiteen Agricultural Complex

The Al-Sulaiteen Agricultural Complex is located at Aum-Salal Ali city, some 20 km north of Doha. The total area of the project is approximately 40 ha with scope for expansion according to the requirements of different stages of the project.
In March 1995, activities started at the farm with preparatory survey and geological maps. A complete soil and water survey was carried out accompanied with the necessary physical and chemical analyses. This was done with the assistance of the Department of Agricultural and Water Research, the Department of Agricultural Development and specialized private companies and consultants. The feasibility study and design of the project were completed in December 1996. The project is designed according to the latest scientific standards and techniques to achieve the following:

1. To establish an agricultural complex using suitable scientific methods and techniques to preserve natural resources and to provide the local market with top-quality fresh products.
2. To establish centrally (and fully) controlled growing rooms for the production of high-quality seedlings and young plants.
3. To act as a technical and training center to provide consultancy, and technical and management expert systems to growers.
4. To conduct research and experiments with national, regional and international research organizations.

The main Production of this complex was as follow

Open field sector: This comprises fodder production using sprinkler irrigation, vegetable production with drip irrigation, and date palm and fruit trees under bubbler irrigatation.

Protected agriculture sector: This sector consists of many production zones.

- Multi- and single-span greenhouses with evaporative cooling systems for the production of cut flowers, vegetables and fresh fruits on a total area of 4900 m².
- Shaded nursery with a total area of 1500 m² for the production of outdoor decorative plants, fruit trees and shrubs.
- A fully controlled growing room for the production of vegetable seedlings and young plants, with a capacity of 40,000 plants/month.

Animal production sector: This section is divided into many production units that include poultry, dairy and beef cattle, and small ruminants for dairy and meat.

Special production sector: Honey bees and ostrich farming.

4.2: Regional Technical Co-ordination Meeting

Over 60 scientists and managers attended the Regional Technical Co-ordination Meeting, which was held in the Sultanate of Oman, in mid-June, from the Arabian Peninsula. The NARs and ICARDA scientists made over 40 presentations, which were of a high standard. The achievements of Phase II were listed during the Regional Steering Committee Meeting which was also attended by a representative of one of the major donors, AFESD.

PARTICIPANTS FROM ARABIAN PENINSULA AT ICARDA's TRAINING COURSES 1996-2000

1996

Long-term Group Training Course

Cereal Improvement,GP

1. Abdullah Al Turaif,S. Arabia

Headquarters Training Short-term Courses:

(a). Biometrical methods in agricultural research,GP, FRMP, CBSU (3-14 Mar. 1996)

2. Juma Mohamed Saeed,UAE

(b). Morphological variety description,SU (14-25 Apr. 1996)

3. Saeed Mukbil Dahan,R. Yemen
4. Safaa Mohammed Nasser Al-Farsi,S. Oman

(c). Economics of seed production,SU (29 Sept.-10 Oct., 1996)

5. Abdul Baset Abdull Samad Alaghbary,Yemen
6. Nageeb Abdu Al-Areeky,Yemen

(d). Experimental station operation management,St.Op (6-17 Oct. 1996)

7. Adnan Abdel Mohsen Al-Fares,S. Arabia

(e). Follow-up training seminar on seed technology,SU (1-12 December 1996)

8. Kamal Mohammed Hussein,Yemen
9. Mohamed Othman Al-Amodi,Yemen

Regional Short-term Training Courses

WANA referee seed testing workshop,SU (21-25 Jan. 1996) held in Jordan

10. Wadee Abdul Habib,R. Yemen
11. Yusuf El Mazroui,S. Oman

Individual Non-degree

(a). Cereal virology (12-27Apr. 1996)

12. Abdulla Salim Ahmed,UAE

(b). Diagnosis of plant viruses (14 Jul. to 01 August 1996)

13. Izzeldin M. Elsamani Abdalla,S. Arabia

(c). Training on purification and Detection viruses (9 –22 Jul. 1996)

14. Khalid Al Hudaib,S. Arabia

1997

Headquarter Short-term Training Courses

(a). Integrated Management of Cereal and Food Legume Insect Pests,GP (27 Apr.-8 May)

1. Mohamed Nagi Saleh Al-Saadi,R. Yemen

(b). *Improving on-farm Water Use Efficiency,FRMP (27 Apr.-8 May 1997)*

2. Gaid Abdulla Mohamed Al Kathiry,R.Yemen
3. Nagib Mohammed Al Ghulaibi,R.Yemen
4. Yousuf Abdulla Salih,Qatar

(c). *Train the Trainers on Seed Processing and Storage,SU (13-24 Jul. 1997)*

5. Ibrahim Yahia Al-Ahigny,Yemen
6. Khalid Mohammed Hizam,Yemen

(d). *Automated Library Management and Modern Information Technology,CODIS (28 Sept.-09 Oct.)*

7. Abdul Aziz Kaid Hassn Al Kadasy,Yemen
8. Mariam Mubarak Al-Ateeq Al-Dossary,Qatar

(e). *Experimental Station Operation Management,S.O (5-16 Oct. 1997)*

9. Abdulla Hussein Abboudi,UAE
10. Abdul-Salam Mohamed Al-Maktari,Yemen
11. Hani Abdulhadi Hajiyeh,Kuwait

Non-headquarters Short-term Training Courses

(a). *Soil Fertility Laboratory Methods, FRMP (6-13 Apr.) in Dhamar, R. Yemen*

12. Abdalla Kamees Yislam,R.Yemen
13. Abdul Ghani Ahmed Shamsan,R.Yemen
14. Abdul Raheem Radman Naji,R.Yemen
15. Abdul Rahman Abdul Aziz,R.Yemen
16. Ahmed Kassim Al-Goufi,R.Yemen
17. Alawi Saeed Mansoor,R.Yemen
18. Ameen Mohamed Gohan,R.Yemen
19. Fadhle Haider Mutlak,R.Yemen
20. Ibrahim Ahmed Hakmi,R.Yemen
21. Iskandar Thabit Al-Hammdi,R. Yemen
22. Mohamad Yousef El Hajji,R.Yemen
23. Mohamed Abdul Malik Haider,R.Yemen
24. Mohamed Ali Haider,R.Yemen
25. Mohamed Bin Mohamed Marzooki,R.Yemen
26. Mohamed Saad Bahunan,R.Yemen
27. Mohamed Saeed Ahmed,R.Yemen
28. Ramadan Awad Saleh,R.Yemen
29. Sadik Abdalla Naji,R.Yemen
30. Shams Al-Deen Faraa,R.Yemen
31. Thabiet Abdul Bari Al Sageer,R.Yemen

(b). *Utilization of Expert Systems in Agricultural Research and Production,HRD Oct. 5-9, 1997 held at Cairo, Egypt*

32. Abdul Rahman Saleh Al Muhammadi,Qatar

(c). *Principles of Agro ecological Characterization,NRMP (12-23 Oct. 1997) held at Amman, Jordan*

33. Bafadel AbdulQader Omar,Yemen

Individual Non-degree

(a). National Resources Management, 29 Apr.- 9 May 1997

34. Gaid Abdalla Alkathir,Yemen,

(b). Introduction to library and information management, 11 May-1 Jun. 1997

35. Amin Abdulla Al Hemiari,R. Yemen
36. Nasr Mansoor Abdullah,R. Yemen

Individual Degree 1997

37. Abdulrahman El-Massoudi, Yemen. Ph.D. Degree, Wales University -1996- 1998
38. Ahmed Mansour Abdullah, Yemen. Ph.D. Degree, Cairo University 1996-1998
39. Hamoud Al Mokbel, Yemen. Ph.D. Degree, Jordan University1996-1998
40. Mansour Nasser Al-Aquil, Yemen. Ph.D. Degree, Wales University 1996-1998
41. Hamad A. Salman, UAE. Ph.D. Degree, Glasgow University. 1997-2000
42. A.Al Nokhaif, Yemen. MSc. Degree, Sana'a University, 1994-1997
43. A.Al Surori,Yemen. MSc. Degree, Sana'a University, 1994-1997
44. Abdalla H.M. Haidarah, Yemen. MSc. Degree, Sana'a University , 1994- 1997
45. A.A. Dobai, Yemen. MSc. Degree, Jordan University ,1996-1998
46. Abdulnur A.M. Shaher, Yemen. MSc. Degree, Jordan University ,1996-1998
47. Abdulrahman A. Hassan, Yemen. MSc. Degree, Alexandria University ,1996-1998
48. Ahmed A. Al Barr, Yemen. MSc. Degree, Cairo University ,1996-1998
49. Mohamed Fouad Maki, Yemen. MSc. Degree, Cairo University ,1996-1998
50. Mubarek A. Bamuftah, Yemen. MSc. Degree, Jordan University,1996-1998
51. Nagi Mohamed A. Zeid, Yemen. MSc. Degree Jordan University ,1996-1998
52. Naguib Al Areif Mahiub, Yemen. MSc. Degree, Jordan University,1996-1998
53. Nasser Saeed Al Mohaiya, Yemen. MSc. Degree, Jordan University,1996-1998
54. Salah Ahmed Sha'alan, Yemen. MSc. Degree, Jordan University ,1996-1998

1998

Headquarters Training Courses

(a). Variety Descriptions, Maintenance and Breeder Seed Production,SU (20-30 Apr. 1998)

1. Shafeeq Ismail Hussein Alkhawlani,Yemen

(b). Improving Water-use Efficiency in Agriculture,NRMP (3-14 May 1998)

2. Adnan Abdul Habib Al-Kirshi,Yemen
3. Hamdan Ogereef Al-Hassan,S. Arabia
4. Mariam Sulieman Darwish Al-Azri,S. Oman

(c). Use of GIS,RS in Agriculture Resource Management,CBSU, NRMP (31 May-11 Jun. 1998)

5. Abdullah A.K Al-Borani Alamery,Yemen
6. Ishaq Omar Al-Jabri,S. Oman

(d). DNA Molecular Marker Techniques for Crop Improvement (13-24 Sep. 1998)

7. Hamad Abdullah Salman,UAE

(e). Automated Library Management & Modern Information Technologies,CODIS (18-29 Oct. 1998)

8. Abdul Aziz Kaid Al-Kadassy,Yemen
9. Hassan Saleh Al-Balushi,S. Oman

(f). Plant Genetic Resources Documentation & Information Management,GRU, IPGRI (22 Nov. -3 Dec.)

10. Saleh Ali Said Al-Hinai,S.Oman

In-Country Short-term Training Course

(a). Seed Production and Technology,SU (16-26 Feb. 1998) held at ARC, Rumais, Sultanate of Oman

11. Abdul Karim Ahmed Ashoor,Bahrain
12. Akil Hamdan Al-Hamidi,S. Arabia
13. Ali Ahmed Saleh Al-Mahrizi,UAE
14. Khalifa Hamad Al-Jaffari,S. Oman
15. Majda Khalil Suleiman,Kuwait
16. Masood Harith Al-Adawey,S. Oman
17. Rashed Ahmed Ali Saeed Al-Hantoby,UAE
18. Saeed Mokpel Dahan,Yemen
19. Safa Mohammed Al-Farsi,S. Oman
20. Saif Ali Al Khamisi,S. Oman
21. Saif Khalfan Salem Al-Qutaiti,S. Oman
22. Salih Yousef Abdulla,Qatar
23. Sayed Muhsin Mohamed Nasser Mohamed,Bahrain

(b). Germplasm Collection and Maintenance,GRU, IPGRI (28 Feb.-4 Mar. 1998) held at UAE

24. Abdulaziz A. Al-Jowayed,S. Arabia
25. Abdullah J. Mohamed Al-Buainain,Qatar
26. Ali Ahmed Saleh Al-Mehrizi,UAE
27. Hasan S. Ali,Bahrain
28. Hassan Jassim Al-Shamlan,Qatar
29. Masood Harith Al-Adawey,S. Oman
30. Rashed Ahmed Ali Saeed Al-Hantoby,UAE
31. Saeed Mokpel Dahan,Yemen
32. Saeed Saif,Yemen
33. Safaa Mohammed Al-Farsi,S. Oman
34. Sayed N. Nasser,Bahrain
35. Tareque A. Madouh,Kuwait

(c). Experimental Design, Analysis and Presentation of Data,CBSU (1-12 Mar. 1998) held at AREA, Dhamar, R Yemen

36. Abdulla Hassan Mufarreh,Yemen
37. Abdulrahman Haider,Yemen
38. Abdulwahed Abdulla Saif,Yemen
39. Ahmed Abdulhabib Malik,Yemen
40. Ahmed Awad Mugahed,Yemen
41. Ahmed Mohammed Juhaish,Yemen
42. Ali Abdulmogni Shamsan,Yemen
43. Awad Salman Basaleh,Yemen
44. Faisal Abdulla Basunbol,Yemen
45. Hajj Salem Bahamish,Yemen
46. Mohammed Mohammed Mufarreh,Yemen
47. Talal Hussain Al-Sofi,Yemen
48. Watheq Abdulla Aulaqi,Yemen

(d). Scientific Writing,CODIS (14-18 Mar. 1998) held at AREA, Dhamar, R.Yemen

49. Abdulla Abdelgaffar Sailan,Yemen
50. Abelal Aziz Saeed Radman,Yemen
51. Ahmed Lutf Saeed,Yemen
52. Ahmed Omer Bukair,Yemen
53. Ali Abdulla Al-Shurai,Yemen
54. Amin Abdo Hassan Al-Kirshi,Yemen
55. Hadi Mohammed Ashoubihi,Yemen
56. Haj Salem Bahamish,Yemen
57. Hassan Ali Bin Yahya,Yemen
58. Hassan Salem Ahmed Abdulla,Yemen
59. Mohammed Kaid Mohammed,Yemen
60. Mohammed Mohammed Mofarreh,Yemen
61. Najeeb Abdul Galeel Mahyoub,Yemen
62. Sakkaf Hassan Al-Sakkaf,Yemen
63. Sallam Ahmed Sallam Al-Ghoury,Yemen

(e). Insect Taxonomy and IPM of Insect Pests,GP (21 Mar.-1 Apr. 1998) held at Oman

64. Aamir Mohammed Aamir,S. Oman
65. Abdullah Sadeq Al-Haddad,Kuwait
66. Abulrahman Mohammed Obaid,S. Oman
67. Ali Rashid Saeed,S. Oman
68. Amin Ma'yoof Harib,S. Oman
69. Fadel Abass Ebrahim,Bahrain
70. Fatima Shamreed Mohammed,S. Oman
71. Ismail Hussain M. Hussain,UAE
72. Khalid Hamdan Hammoud,S. Oman
73. Khamees Ali Al-Sareeri,S. Oman
74. Majed Saud Al-Fahaid,S. Arabia
75. Mohammed Humaid Zahir,S. Oman
76. Mohammed Musallam Ali,S. Oman
77. Muthir Salih Saeed,S. Oman
78. Najma Mahmoud Somar,S. Oman
79. Rashid Hamdan Rashid,S. Oman
80. Saeed Hamad Humaid,S. Oman
81. Saif Ali Al-Sareeri,S. Oman
82. Saif Humaid Saif,S. Oman
83. Salim Ali Salim,S. Oman
84. Yunis Khamees Faraj,S. Oman

(f). Data Analysis, Presentation and Scientific Writing,CBSU,CODIS (25 Apr.-6 May) held in Doha, Qatar

85. Abdallah Jassem Al-Thane,Qatar
86. Abdel Salam Musaad Al-Harbi,Qatar
87. Abdella Jassim M. Al Buainain ,Qatar
88. Abdul Muhsin Redha Al Kharraz,Qatar
89. Abdul Rashid Yasin Ibrahim,Yemen
90. Ahmed Mubrouk Al-Saad,Bahrain
91. Hassam Jasim Al-Shamlan,Qatar
92. Hassan Kamel Abu Sukar,Qatar
93. Khalid Mohammed Abo Moza,Qatar

94. Khalida Hassan Al Awadi,Kuwait
95. Mansour Ibrahim Mansour,UAE
96. Mariam Mubarak Al Dossari,Qatar
97. Mohamad Ali Al Hindi,Bahrain
98. Mohammed Ebrahim Al-Qayed,Qatar
99. Nasir Zahir Al-Abri,S. Oman
100. Qassim Mohammed Al-Bukhari,Qatar
101. Radia Awad Al-Faqick,Qatar
102. Rashid Khames Borshaid,UAE
103. Said Khamis Al-Sabahi,S. Oman
104. Saif Khalfan Salem Al Qutaitil,S. Oman
105. Saud Al-Rowaily,S. Arabia

(g). Horticulture, Plant Protection and Livestock,HRDU (May 5-18, 1998) EICA, Cairo, Egypt

106. Abdo Saied Al-Kateb,Yemen
107. Ibrahim AL-Mukaba,Yemen
108. Khalid Al-Kirshi,Yemen
109. Mohammed Mufarreh,Yemen
110. Sharaf Al-Azazi,Yemen
111. Suad Ali Mohammed,Yemen

(h). Research Management,HRDU (Jun. 2-15, 1998) EICA, Cairo, Egypt

112. Abdulla Alwan,Yemen
113. Abdulla Sailan,Yemen
114. Ahmed Lutf,Yemen
115. Mohammed Musali,Yemen
116. Mohiuddin El-Ghoury,Yemen
117. Omar Khambari,Yemen

(i). Utilization of Expert Systems in Agricultural Research and Production,HRDU (10-22 Oct. 1998) held at Cairo, Egypt

118. Ali Salem Al-MuMutawa,UAE
119. Faisal Abdulla Basubbol,Yemen
120. Yassin Bin Abdullah Al-Sheikh,S. Arabia

(j). Irrigation and Fertigation (15-25 Nov. 1998),AP, held in Riyadh, Kingdom of Saudi Arabia

121. Abdulla Jassim Mohamed Al-Boainain,Qatar
122. Abdulla Yousuf A.M. Al-Mansoori,Qatar
123. Adel Khader Buzaid,Saudi Arabia
124. Adnan Al-Fares,Saudi Arabia
125. Ali Ahmed Hassan Ali,U.A.E.
126. Ali Ahmed Nasser,Bahrain
127. Fahad Al-Qurainy,Saudi Arabia
128. Hamdan Salem Said Al-Wahaibi,S. Oman
129. Jamal Mahmoud Hassan,U.A.E.
130. Khalifa Abdullah Al-Kuwaity,Saudi Arabia
131. Maher Hisham Al-Hinady,Kuwait
132. Nageeb Abdul-Jaleel Al-Ariqi,Yemen
133. Saeed Salman Ahmed,Bahrain
134. Saif Bin Ali Al-Khameisi,S. Oman
135. Talal Hussein Al-Soufi,Yemen

Individual Non-degree

(a). Grain qualities,(11-25 Oct 1998)

136. Mohamed Salem Al-Mussali,Yemen

(b). Estimated of genetic and non-genetic parameters for some growth traits of Dhamari sheep (8 Feb.-9 May 1998)

137. Abdullah Ali Al-Nokhaif,Yemen

(c). Statistical analysis of data on lentil genotypes for MSc study project (25 Jul.-6 Aug. 1998)

138. Naji Mohammed Zaid,Yemen

Non-Headquarters

(a). Pearl millet improvements. 01-30 Sep., ICRISAT, INDIA

139. Dirhim Abdul Mehdi Noaman,Yemen

(b). Sorghum improvement. 14 Sept.-13 Oct.,

140. Ahmed Abdalrahman Al-Moallem,Yemen

(c). Dryland farming research and Watershed management 1-21 Jul., ICRISAT, INDIA

141. Abdul Rahman Abdulla Haider,Yemen
142. Mohamed Saif Ghaleb,Yemen

Individual degree

143. Abdulrahman El-Massoudi, Yemen.Ph.D. Degree ,Wales University 1996-2000
144. Ahmed Mansour Abdullah, Yemen,Ph.D. Degree ,Cairo University,1996-1999
145. Mansour Nasser Al-Aquil, Yemen,Ph.D. Degree ,Wales University,1996-1999
146. Hamad A. Salman,UAE,Ph.D. Degree ,Glasgow University,1997-2000
147. Abdulnasser M. Al-Bakri, Yemen ,Ph.D. Degree ,Gezira University,1998-2001
148. Hamoud Al Mokbel, Yemen,Ph.D. Degree ,Alexandria University ,1998-2001
149. A.Al Nukhaif, Yemen,MSc. Degree ,Sana'a University,1994-1999
150. A.Al Sururi, Yemen,MSc. Degree ,Sana'a University,1994-1998
151. Abdalla H.M. Haidarah,Yemen,MSc. Degree ,Sana'a University, 1994- 1998
152. Mohamed Fouad Maki, Yemen,MSc. Degree ,Cairo University,1996-1999
153. N.H. Hariri, Yemen,MSc. Degree,Aden Universi,1996- 1999
154. Naji Mohamed A. Zeid, Yemen.MSc. Degree ,Jordan University,1996-1999
155. Nasser Saeed Al-Mohayaa, Yemen.MSc. Degree ,Jordan University,1996-1999
156. Abdulrahman A. Hassan, Yemen.MSc. Degree ,Alexandria University,1997-1999
157. Moubarak A. Bamoftah, Yemen.MSc. Degree ,Alexandria University,1997-2000
158. Maha Makawi, Yemen.MSc. Degree,Aden University,1999

1999

Headquarters Short-term Training Courses

(a). Human Resources Development on Biodiversity Conservation, GRU, IPGRI (Mar. 7-11)ICARDA

1. Ali Awadh Banoubi,UAE
2. Farah Abdul Kader Ibrahim,Kuwait
3. Nasser Issa Al-Maskari,S. Oman
4. Tariq Abdul wahab Ismail,S. Arabia

(b). DNA Molecular Marker Techniques for Crop Improvement (Sep. 12-23, 1999)

5. Rashid Khames Burasheed,UAE

(c). Seed Bank Management, GRU, IPGRI (Sep. 12-27, 1999)

6. Abdullah Hosein Ali Mohamed All Naggar,Yemen
7. Ali Hussein Al-Lawat,S. Oman

(d). Automated Library Management and Modern Information Technologies, CODIS (Oct. 3-14, 1999)

8. Hussein Ahmed Ali Akbar,Qatar
9. Muflehi Fadl A. Hameed,Yemen
10. Waleed Khamis Al-Farsi,S. Oman

(e). Efficient Water use in Agricultural Production, NRMP (Oct. 10-21, 1999)

11. Al-Emad Saleh Saleh,Yemen

(f). Marginal Water Management for Sustainable Agriculture in the Dry Areas, NRMP (Oct. 24-Nov. 4, 99)

12. Suliman Awagi,Yemen
13. Zain M. Hadi Haige,Yemen

(g). Scientific Writing and Data Presentation, CODIS (Nov. 7-11, 1999)

14. Mahmoud Ahmed Hashim,Qatar

Non-headquarters Training Courses

(a). Integrated Management of Greenhouses, AP (25 Apr.-5 May 1999) held in Doha, Qatar

15. Abd Al-Salam Al-harbi,Qatar
16. Ahmed Habib Khadim,Bahrain
17. Fadhel Abbas Ebrahim,Bahrain
18. Galal Hassan Ahmed Alnqawi,Kuwait
19. Habibah S. Al-Menaie,Kuwait
20. Haj Salim Bahamish,Yemen
21. Jumah Mohamed Ali,UAE
22. Khaled Amer,Qatar
23. Khaled Amer,Qatar
24. Khaled Hellal Al-Anzi,Qatar
25. Khaled Mohamed Abou Moza,Qatar
26. Majid Al-Zizaleh,Kuwait
27. Monira Ali Al Msiferi,Qatar
28. Muthir Saleh Al-Rawany,S. Oman
29. Naser Yaqoub Ramadan Gader,Kuwait
30. Rashid Ahmed,UAE
31. Saleh Abdulla Mohamed,Yemen
32. Suleiman Aballa Al-Amri,S. Oman
33. Yousof Abdualla Saleh,Qatar
34. Yousof Khaled Al-Kelafi,Qatar

(b). Alternative Feed Resources and Small Ruminants Management in Low Rainfall Areas of the WANA (15-20 May 1999), held at Tunis, Tunisia

35. Faisal Salem Al-Barakch,S. Arabia

(c). Economics of Seed Production Follow-up Training Course, SU (12-21 Jun. 1999) held at GSMC, Dhamar, The Republic of Yemen

36. Abdul Wali Mohammed Salih,Yemen
37. Abdulla Ali Mohammed,Yemen
38. Abdulla Mohammed Ghalib,Yemen
39. Amin Abdo Al-Kirshi,Yemen
40. Mohammed H.aza'a Al-Mamary,Yemen
41. Mohammed S. Al-Moontassir,Yemen
42. Mohammed Salih Bashouaib,Yemen
43. Shafeiq Ismaeel Al-Kholany,Yemen

(d). Seed Processing and Storage Follow-up Training Course, SU (12-21 Jun. 1999) held at GSMC, Dhamar, The Republic of Yemen

44. Abdel-kader Mohamed Said,Yemen
45. Abdul-Hamid Ghalib Abdul-wahab,Yemen
46. Ali Mohammed Al-Fadl,Yemen
47. Fadel Mohammed Al-Gomai,Yemen
48. Mansour Hadi Abu-Arigal
49. Shawgi Yassin Abdoul-khaleq,Yemen

(e). Utilization of Expert systems in Agricultural Research and Production, HRDU (Oct. 10-21, 1999) held at Egypt

50. Jumaa Al-Obaidani,Oman
51. Khalid Helal Al-Enazi,Qatar

Individual Non-degree

(a). Germplasm characterization & conservation (8-20 May 1999)

52. Nagib Abdullah Mohamed,Yemen

(b). Computer application in agriculture Research (10-27 May)

53. Hamad Ben Abdullah Salman,UAE

Individual degree

54. Mansour Nasser Al Aquil, Yemen. Ph.D. Degree,Wales University,1996-1999
55. Ahmed Mansour Abdullah,Yemen.Ph.D. Degree,Cairo University,1996-1999
56. Abdulrahman El-Massoudi,Yemen.Ph.D. Degree,Wales University,1996-2000
57. Hamad A. Salman,UAE,Ph.D. Degree,Glasgow University,1997-2000
58. Hamoud Al-Mokbel,Yemen.,Ph.D. Degree,Alexandria University,1998-2001
59. Abdulnasser M. Al- Bakri,Yemen,,Ph.D. Degree,Gezira University,1998-2001
60. Abdalla H.M. Haidarah,Yemen.MSc. Degree,Sana'a University,1994-1998
61. A.Al Sururi,Yemen.MSc. Degree,Sana'a University,1994-1998
62. AAl Nukhaif,Yemen. Sana'a University,MSc. Degree,Sana'a University,1994-1999
63. Nasser Saeed Al Mohayaa,Yemen.MSc. Degree ,Jordan University,1996-1999
64. Naji Mohamed A. Zeid,Yemen.MSc. Degree,Jordan University,1996-1999
65. N.H. Hariri,Yemen. MSc. Degree,Aden University,1996-1999
66. Mohamed Fouad Maki,Yemen.MSc. Degree,Cairo University,1996-1999
67. Moubarak A.Bamoftah,Yemen,MSc. Degree,Alexandria University,1997-2000
68. Abdulrahman A.Hassan,Yemen.MSc. Degree,Alexandria University,1997-1999
69. Maha Makawi,Yemen.MSc. Degree,Aden University,1999

2000

Headquarters Short-term Training Courses

(c). Forage and Pasture Seed Production, SU (04-15 Jun. 2000)

1. Abdullah Marzoug Al-Hajoj,S. Arabia
2. Ali Ahmed Hassan,UAE
3. Hadeed Salim Hadeed Bait Shajanah,S. Oman
4. Hamad Eid Al-Enazy,Qatar
5. Hana Amin Mohd Al-Zarooni,UAE

(d). Statistical Analysis of Data,CBSU (3-14 Sep.)

6. Ahmed Abdul Wahab Malek, R. Yemen

Non-headquarters Short-term Training Courses

(e). Integrated Approaches to Breeding Cereals for Drought Resistance, GP, NRMP (27 Mar.-7 Apr. 2000) held at Rabat, Morocco

7. Raad M. Salman,Yemen

(f). Watershed Management,NRMP (17-28 Sep. 2000) in Mersa Matrouh, Egypt

8. Lotfi Kasim Al-Asbahi,Yemen

(g). Utilization of Expert Systems in Agricultural Research and Production, HRDU (8-19 Oct.) held at CLASE, Cairo, Egypt

9. Ali Salem Al-Mutawa,UAE
10. Khalil M. Alsharjabi,Yemen

Individual Non-degree

Organization and management of seed quality control (16 Jan.-10 Feb 2000)

11. Abo Backer Saleh Al-Hakem,Yemen.
12. Abdulrahman Saleh Saeed Al-Ansi,Yemen

Individual degree

13. Abdulrahman El Massoudi,Yemen.Ph.D. Degree,Wales University,1996-2000*
14. Mansour Nasser Al Aquil,Yemen.PhD. Degree,Wales University,1996-1999
15. Hamad A. Salman,UAE.Ph.D. Degree,Glasgow University,1997-2000
16. Abdulnasser M. Al Bakri,Yemen.Ph.D. Degree,Gezira University,1998-2001
17. Hamoud Al Mokbel,Yemen.Ph.D. Degree,Alexandria University,1998-2001
18. Abdalla H.M. Haidarah,Yemen. MSc. Degree,Sana'a University,1994-1998
19. A.Al Sururi,Yemen.MSc. Degree,Sana'a University,1994-1998
20. A.Al Nukhaif,Yemen.MSc. Degree,Sana'a University,1994-1999
21. N.H. Hariri,Yemen.MSc. Degree, Aden University,1996
22. Abdulrahman A. Hassan,Yemen.MSc. Degree,Alexandria University,1997-1999
23. Moubarak A. Bamoftah,Yemen. MSc. Degree,Alexandria University,1997-2000
24. Maha Makawi,Yemen.MSc. Degree,Aden University,1999

* Theses completed

ANNEX I

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2 Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula Phase II***: Summary of Priority research Areas, Activities and training.*** ICARDA, Aleppo, 1-4 March 1997.

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ANNEX II

Proceeding of the first Steering Committee

Introduction

- The First Regional Steering Committee Meeting of APRP was held 25-26 September 1996 at ICARDA near Aleppo, Syria, to discus management and policy issues to be followed in implementing Phase II of the collaborative Project on “ Strengthening Agricultural Research and Human Resource Development in the Arabian Peninsula”. The Project is Financially supported by the Arab Found for Economic and social Development (AFSED) and the international Fund for Agricultural Development (IFAD).
- The meeting was attended the Director Generals/Deputies of National Agricultural Research Institutes or their representative from the UAE, Bahrain, Qatar, Kuwait Oman and Yemen; a representative from AFSED; ICARDA’s Acting Director General; the Acting Director of International Cooperation; APRP Regional Coordinators (Current and newly appointed); and Program Leaders. Some ICARDA’s technical staff attended the Meeting as observers.
- The program of the Meeting, Agenda and list of Participants are presented in Appendix I, while the project Document for Phase II is presented in Appendix II.
- The meeting was chaired by Dr. Mahmoud B. Solh Action Director of International Cooperation (A/D-IC).

Agenda Item 1.Opening Session

- Introductory remarks were made by the Chairman, who welcomes all the members of the Regional Steering Committee (RSC) and observers on behalf of ICARDA’s International Cooperation. He indicated that the main Objective of the first meeting of RSC was to discuss the management and policy issue in the implementation of the Arabian Peninsula Regional Program (APRP) and establish priorities from the various research themes of Phase II of the APRP. He introduced the program and Agenda of Meeting. Dr. Solh indicated that the RSC is the highest authoritative body of APRP and the decisions taken by the Committee are binging to all partners in implementing the program. Appreciation was expressed to AFESD and IFAD for supporting the APRP.
- Dr. M.C.Saxena, Research Coordinator, on behalf of ICARDA’s Director General, Dr. Adel El-Beltagy. Presented ICARDA’s opening statement. Dr. Sexena welcomed the Participants to ICARDA and emphasized ICARDA’s commitments to APRP and the importance of RSC Meeting. He pointed out that Phase II would have strong natural resource management and technical transfer components in contrast to Phase I project which and greater emphasis on germplasm enhancement. He expressed ICARDA’s great appreciation to AFESD for their continuous support APRP and IFAD for supporting Phase II. He referred to the salient features of IFAD President’s Report and Recommendations to IFAD’s Board on the Project, underpinning the need to transfer superior technology already identified and for strengthening the research capabilities of NARSs. He thanked Dr. Samir El-Sebea Ahmed for hid dedicated efforts as the Regional Coordinator to keep Phase I of the APRP going despite the difficulties. He informed the committee members of the new appointment of Dr. John Peacock the Regional Coordinator for Phase II. Dr. Peacock will assume his responsibilities immediately after the first RSC Meeting. Dr. Saxena conclude the opening statement by wishing the meeting fruitful discussions and deliberations.

- AFESD opening statement was presented by Mr. Samir Jarrad who expressed his appreciation for the involvement of the various Arabian Peninsula national programs in the RSC Meeting. He thanked ICARDA for its continued efforts to consolidate the Arabian Peninsula and international agricultural Research cooperation. Mr. Jarrad stressed the desire of AFESD to support project which will address the basic needs of developing countries, namely food production and security. He highlighted salinity and drought as the key issue in agricultural development in the Arabian Peninsula. He encouraged both ICARDA and the concerned NARSs to cooperate fully and expand the exciting programs, while not ignoring the possibilities for starting new programs and attracting new funding. He pointed out the recent emphasis of the Arabian Peninsula on agricultural research, highlighting the lack of trained national staff and the urgent need for a framework on which to base the new project. He also emphasized the importance of working on problems of regional importance. Mr. Jarrad hoped the program will come up with practical solution to the region's agricultural problems which can be utilized by farmers of the region.

Agenda Item 2. ICARDA's Role in Enhancing Agricultural Research and Human Resource Development

- Dr.Mohan Saxena gave a concise overview of ICARDA's mandate and work, stressing the role of the Regional Programs in ensuring the research continuum between the base research programs at ICARDA and those of National Programs. He clearly indicated the various areas where ICARDA can provide technical backstopping for the APRP.

Agenda Item3. Achievements of the Regional Program of the Arabian Peninsula (Phase I) and Proposed Program for Phase II

- Dr.Samir El-Sebae Ahmed, Regional Coordinator for the APRP during Phase I, gave an overview of the achievements (See Appendix III, and page 2 of the Project Document in Appendix II) and then went on to describe the possible modus operandi of Phase II(See pages 10-19, Project document). It was pointed out that at the request of the donors and the NARSs, Phase II will use the consortium, or multi-institutional approach, drawing upon expertise in national programs and ICARDA as well as expertise both within and outside the region, in particular, other CG centers (ISNAR, IIMI, and IPGRI) will be partners in area of their particular specialties. He thanked both AFESD and IFAD for their support and wished the new Coordinator for the APRP, Dr. John Peacock, success in his new venture.
- In the discussions that followed, attention was drawn to the need for a problem-oriented approach, which is adaptive and capable of making impact. It was stressed that this should be kept in mind when developing country and regional workplan.
- The need to involve other CG centers was discussed and it was agreed that a number of international and regional centers would be participating in this project. The important role to be played by ISNAR, IIMI and IPGRI was noted.
- The representative of AFESD was keen on establishing the extent to which phase I had succeeded in setting up a mechanism for integrated the research programs among the participating countries. In addition, Mr. Jarrad was keen to establish whether the training programs carried out in Phase I were organized within the framework of the project or just part of ICARDA's general training program. It was indicated that given the constraints of resources and manpower, Phase I had achieved its objectives reasonably well. Many of the activities of Phase I were specifically organized for the project, although the NARS scientists also benefited from the general training coerces organized at the Center. The Chairman suggested that in Phase II, integration could be improved by adopting the approach of Nile Valley and Red Sea Regional

Program (NVRSRP) as a model. Countries would also be encouraged to take the leadership for a particular themes, am approach, which has been very successful in NVRSRP.

- The agenda item was concluded by Mr.Rashed Khalfan Al-Shariqi (UAE Representative) who gave a prepared statement on what he hoped would be achieved both during this meeting and in the future. Mr. Rashed's points will be considered in the program planning and implementation.

Agenda Item 4. Prioritization of Program Activities

- Dr. Samir Ahmed introduced this item by drawing the meeting's attention to table 3, on page 12 of the Project Document. The relative importance associated with each activates was confirmed or modified by the Representatives of the countries present. (Information for Oman and Kuwait was obtained when the Representatives participated in the next day Meeting). There were few changes and the revised table 3 (referred to here as table 1) is shown below. Table one will be finalized after having the inputs of Saudi Arabia during the coming visit of the Regional Coordinator to Saudi Arabia.
- The question of whether to include a line for seed production was raised and considered, but it was argued that this was included in the section on Technology Transfer (3.7, page 17 of the project Document), which is discussed at length under section 3.1 (Page 13) on Research Management: Development of a Regional Strategy. Considerable discussion took place on the apparent discrepancy between what is listed in Table 3 and section 3.1 of the Project Document. It was indicated that all the Items listed after 3.1 (viz 3.2 ti 3.9) would also be covered under one or the other of the research themes listed in table 3 of the Project Documents.
- The chairman stressed that this was a Regional Steering Meeting which deals with policy issues; and if there were technical issues, they could be resolved later at the Regional Technical Coordination Meeting (RTCM). Issue of implementation would also be discussed at RTCM. He added that the purpose of this meeting, themes which are a priority at the regional level should be selected from table 1 and can be used to develop the workplan. This was done with each country listing its top seven priority (see table 2). (Sultanate of Oman and Kuwait completed this later; only Saudi Arabia input is missing). These were then averaged giving the ranking of the research themes as shown in table 2. The Regional Coordinator will obtain information for Saudi Arabia later and table will be updated.
- It was appreciated that the job of the group present was difficult, because the group had no guidelines from a Regional Technical Coordination Meeting (RTCM), which under normal circumstances would have preceded this meeting. It was agreed that the priority themes (Table 2) would be discussed at the RTCM (see item 8
- integration at the regional level(which was unanimously agreed upon by the group) but accepting that the activities would be organised at a country level. He endorsed the need for the RTCM to prioritise activities and to ensure that important milestones were within the time frame of the project.
- It was agreed that in the future, the RSC would follow immediately after the RTCM. It was also pointed out that in reference to transfer of technology issue, there was a need to be clear on the distinction between national and regional research development
- It should also be noted that Technology Transfer, Human Resource Development, Information Dissemination and Research Management were very important across all countries, there for, not included in table 2. In conclusion, it was mentioned that to facilitate the transfer of technology across and between countries and to strengthen the rationality of the program, an agro-ecological survey needs to be done early in the project implementation. Information for Saudi Arabia will be obtained later by the Research Coordinator and the table will be updated.

Table 1: Suggested Research and Training Priorities for the Arabian Peninsula Countries

Activities	Countries						
	Bahrain	Kuwait	Oman	Qatar	S.Arabia	UAE	Yemen
Germplasm Enhancement							
Barley	--	+	+	+	+	+	+
Bread Wheat	--	+	+	--	+	+	++
Durum Wheat	--	--	+	--	+	--	+
Chickpea	--	+	+	--	+	--	+
Lentil	--	+	+	--	+	--	+
Forage Legumes	+	+	+	+	+	--	+
Alfalfa	++	++	++	++	++	++	++
Forage Grasses	++	++	++	++	++	++	++
Germplasm Collection and Exchange	--	--	+	--	+	--	+
Salinity/Salt Tolerance	++	++	++	++	++	++	++
Heat Tolerance	+	++	++	++	++	++	++
Disease and Pest Control	++	+	++	+	++	++	++
Weed Control	++	+	++	+	++	++	++
Agronomy Research	+	+	++	++	++	+	++
Livestock Research	+	--	++	++	++	+	++
Protected Agriculture	++	++	++	++	++	++	++
Water Harvest / Conservation	+	+	++	++	++	++	++
Irrigation Techniques	++	++	++	++	++	++	++
Water-Use Efficiency	++	++	++	++	++	++	++
Technology Transfer	++	++	++	+	++	++	++
Research Management	++	++	++	++	++	++	++
Training/Institution Building	++	++	++	++	++	++	++
Information Dissemination	++	++	++	++	++	++	++

-- **Not important**

+ **Important**

++ **Very Important**

Table 2: Prioritisation of Research Themes

Activities	Countries						
	Bahrain	Kuwait	Oman	Qatar	S.Arabia	UAE	Yemen
Abiotic stress	2	7	2	2	2	2	2
Diseases / pests	5	4	5	6	5	5	5
Water Issues	1	1	1	1	1	1	1
Irrigated Forages	4	2	4	3	3	3	3
Agronomy	7	5	7	7	7	7	7
Livestock	6	6	6	6	6	6	6
Protected Agriculture	3	3	3	5	4	4	4

Agenda Item 5:Formulation of Regional Steering Committee (RSC)

- The A/D-IC presented to the group for consideration an outline (i) of the responsibilities of the RSC and (ii) its makeup. These were both clear and comprehensive. Following some discussion and clarification from the member countries, the following definition was agreed upon:

The regional Steering Committee of the Arabian Peninsula will comprise the following: the Director General of the Agricultural Research Institute/Authority from each country; the national Coordinator responsible for implementing the program of work of the project in each country; a representative from each donor organization; the Director for International Cooperation (ICARDA) and when necessary, a representative from each cooperating international organization (upon invitation). ICARDA program Leaders/Unit Head concerned may also be participating in the RSC when feasible

The role of the Regional Steering Committee will be to:

(i) *Evaluate the progress and achievement on an annual basic, covering research, transfer of technology, human resource development and capacity building*

(ii) *Approved the research workplan, including the training to be implemented in the next season;*

(iii) *Approved the budget allocation per activity and per country;*

(iv) *Provide guidance on future emphasis, priorities and the strategy of the program; and*

(v) *Ensure the continuity and effectiveness of the program through seeking support from interested donors.*

- It was drawn to the attention of the group that on 29 February 1996, the countries had made their official nomination for the Regional Steering Committee of the APRP which were, at the time, as follow:

United Arab Emirates (UAE)

Mr.Rashed Khalfan Al-Shariqi
Director
Director of Agricultural Research and Production
Ministry of Agriculture and Fisheris

Mr.Mohamed Saker Al-Assam
Director
Directorate of Water and Soil
Ministry of Agriculture and Fisheries

Bahrain

H.E. Seddik S. Al-Alawi
Deputy Under Secretary
Ministry of Works and Agriculture

Shiek Mohamed Abdul Wahab Al-Khalifa
Directore, Agricultural Research Department
Ministry of Works and Agriculture

Qatar

Mr. Abdalrahman Mohamed Youssef Al-Mahmoud
Director
Directorate of Agricultural Research And Water
Ministry of Municipal Affairs and Water

Mr.Abdalraham Saleh Al-Muhammadi
Head, Agricultural Research Department
Directorate of Agricultural Research and Water
Ministry of Municipal Affairs and Water

Kuwait

Mr.Amir Al-Zalzalah
Director
Directorate of Plant Research
Public Authotity for Agricultural Affairs and Fish Resources (PAAAFR)

Saudi Arabia Mr.Abdulkarim Bin Mohamed Al-Ghamdi Director General Agricultural Research Department Ministry of Agricultural and Water **Sultanat of Oman** Mr.Saoud Bin Salim Al-Harthy Director General Directorate of Agricultural Research Ministry ofAgriculture and Fisheries	**Republic of Yemen** Dr.Abdulraham M.Bamatraf Director General Agricultural Research and Extension Authority Ministry of Agriculture and Water Resources Dr.Ali Mkred APRP National Coordinator Agricultural Reserch and Extention Authority Ministry of Agriculture and Water Resources

- It was agreed, however, that the makeup of the RSC would be based on the designated positions rather than names. It was confirmed that apart from Kuwait, the focal point in each country is the body responsible for agricultural affairs. The Kuwait representative will ask the Kuwait authority to indicated which body in Kuwait is the focal point for this project. Two representatives from each country are preferable in the RSC as indicated earlier. All countries were asked to confirm the above nomination.

Agenda Item 6: Discussion of the Administration and Management Arrangement for APRP

- This Item was partly covered in the above session
- It is now certain that a Regional Office for ICARDA will be established in the UAE. The Regional Coordination posted in the UAE will carry out the administration and management of APRP. The Regional Coordination will work together with the National Coordination of the Project in each member country to implement workplan (research, transfer of technology and training) approved by the RSC. For technical Regional office (as specified in Phase II project Document).
- Work has to be organized at the national level by the respective National Coordinator with backstopping, cooperation and follow-up the regional Coordinator. The respective directors of research institute or authorities will be kept informed of all activities to be conducted in their country. There may be a need for conducting annual national coordinator meetings to develop workplan to be basis for discussion at the Regional Technical Coordination Meeting (RTCM) to be discussed later
- The RTCM will be held annually on a Rotational basis in one of the members’ countries and ICARDA. The recommendations of the RTCM (recommended workplan including training) will be presented to the Regional Steering Committee (RSC) Meeting to be approved for implementation.
- The chairman indicated that this system has proven its effectiveness in ICARDA outreach programs, e.g., the NVRSRP, North Africa Regional Program (NARP) and West Asian Regional Program (WARP).

Agenda Item 7:Date and Place for the next Meeting of the Regional Steering Committee See Agenda Item 8

Agenda Item 8:Regional Technical Coordination Meeting (RTCM)

- A major objective of RTCM will be to discuss the status of ongoing research by theme and country, develop workplan for the coming seasons and itemize the budget on an activity and country basis. The country Representatives were asked by the Chairman to prepare a research Review to be presented at RTCM. Proposals need to be made on which countries will take leadership for the different themes based on the available expertise and facilities in each country. The regional Coordinator will, amongst other things, discuss these in detail with the concerned authorities in each country when he visits the Arabian Peninsula in November. It is vital that the APRP builds on to the ongoing activities in the region rather than a start new ones.

- After a very useful discussion, it was unanimously agreed that the 1997 regional coordination Meeting would be held at ICARDA's headquarter from 1^{st} to 4^{th} March 1997 (4 days). This would include both the RTCM and RSC. It was also agreed that the future Coordination and Steering Committee will be held in the Arabian Peninsula and starting from 1998 would be rotated in alphabetical (Arabic) according to the GCC system, i.e., the first country will be UAE, followed by Bahrain, Qatar, Kuwait, Saudi Arabia, Oman and finally Yemen to complete the rotation cycle.

Agenda Item9: Other Business.

- The visit of Dr.John Peacock, the new Regional Coordinator (RC), to the Arabian Peninsula was discussed and it was agreed that it was essential that he should spend up to 2-3 days in each country to get an idea about the ongoing activities and terrain. He was asked to draw up a draft schedule for consideration by the countries and A/D-IC. An important item will be the training needs of the region, existing databases and facilities. He would circulate in advance a list of what was required from this introductory visit. Qatar would like the RC visit to be toward the beginning of November as they commitments later. A later visit by the RC would to follow-up on the preparation of materials for the RTCM.

- The A/D-IC circulated a project proposal entitled " A Regional Research Strategy and Program Plan for the Agricultural Sector in the Arabian Peninsula Countries". It was proposed that this document should be discussed with countries and RC on his visit to the Arabian Peninsula in November and would be a key item on the agenda of the RTCM in March.

Agenda Item10:Closing Session

- The RSC meeting was concluded with positive and concise statements from all the country representatives. They all thanked ICARDA and the donors for making this meeting possible. They all look forward to the impact of APRP on agricultural research and development in their respective countries.

- In response, AFESD representative expressed his appreciation of the commitment and seriousness of the national program Representative and stressed the need for better integration of cooperation at a regional level and relevant training activities according to real needs. He emphasized the importance of development a sustainable cooperative system among the partners involved. He expressed the commitment of AFESD for agricultural Research and Development in the Arabian Peninsula.

- ICARDA endorsed the need for improved integration and cooperation at the regional level in addition to improved information dissemination and linkages. The catalytic and backstopping role of the Regional Coordinator was emphasized. Referring to the report and Recommendation of IFAD President to the IFAD Board on the Project, the need for development and transfer of technology and training, which will benefit both the scientists, and the farmers of the region was also emphasized. The strengthening of linkages with other regional and international institutes was considered essential. ICARDA expressed appreciation for the UAE for hosting and supporting ICARDA's Regional Office for the APRP. Appreciation and gratitude were also expressed for the continued support of AFESD and IFAD to ICARDA in general and to the APRP in particular. Dr.Samir El-Sebae Ahmed, who will continue to be an important resource to APRP, was thanked for his valuable contributions to Phase I of the APRP.

- Dr. Peacock who will shoulder the Regional Coordination position immediately after this RSC Meeting, was welcomed to his new position.

- In conclusion Dr.Samir Ahmed expressed great appreciation and tribute to all the country representatives and the donors and expressed full commitment to the APRP and wished the new incumbent, Dr. John Peacock, all the best.

- The Chairman closed the meeting at 13:00 on Thursday, 26 September.

ANNEX III

List of Protected Agriculture Workshop Participants

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