Proposal for Expanding the Crop Mandate of ICARDA to Include Horticultural Crops

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International Center for Agricultural Research in the Dry Areas (ICARDA)

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About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based in Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland, and small-ruminant production; and the Central and West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered, from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from many country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South–North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to the strengthening of agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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1. Executive Summary

The International Center for Agricultural Research in the Dry Areas (ICARDA) serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland, and small-ruminant production; and the Central and West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. Since its establishment in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) has served to improve barley, faba bean, and lentils in developing countries, and to improve bread and durum wheats, chickpea and farming systems in the Central and West Asia and North Africa (CWANA). ICARDA's activities have included research, training, and dissemination of information in partnership with the national agricultural research and development systems throughout the developing countries, especially in the CWANA region. This proposal to expand the crop mandate for ICARDA to include horticultural crops and other high-value crops and their products was developed in response to a recommendation of the Program Committee of the Board of Trustees of ICARDA, made at its 33rd meeting held on 30 April-1 May 2002. These crops and products can provide higher incomes and more employment opportunities, which are key components for poverty reduction and overall rural development in developing countries. Horticultural crops contribute to diversifying production systems of small-scale farmers and achieving healthier diets since fruits and vegetables are very important sources of vitamins, minerals, dietary fiber, and antioxidant phytochemicals.

Among the hundreds of horticultural crops there are some that are and can be produced under arid conditions including those originating in the CWANA region. The specific range of horticultural crops that will be selected for inclusion in the rotation and interplanting of crops within sustainable farming operations will vary among areas within countries and among countries within the CWANA region. Selection will be guided by cost/benefit analysis; average farm size; availability of inputs and facilities needed for production, processing, and marketing; and potential marketability of the products. Fruit and nut crops that can be grown with relatively small amounts of water include almond, pistachio, walnut, grape, fig, jujube (Chinese and Indian), olive, pomegranate, date, and cactus pear. Vegetable crops that should be considered include green beans, sweet peas, edible-pod peas, cowpeas, garlic, onion,

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tomato, eggplant, pepper, cucumber, and melons. Herbs and spices such as basil, cumin, mint, oregano, and thyme should also be included. Medicinal plants, such as anise, cardamom, chamomile, coriander, marjoram, and sage may be appropriate in some locations. Organic production systems should be encouraged whenever possible because there is an increasing demand for organically-produced crops and a higher price is often gained when selling such crops and their products. Protected cultivation of some horticultural crops can result in improved water-use efficiency and may be economical in some locations.

Another approach to increased diversification of plant species produced by small-scale farmers in the CWANA region is by domesticating wild desert plants, including medicinal plants, forage plants, woody plants, and fiber plants. These plants are naturally adapted to the inhospitable conditions in the desert and have economic value as cash crops. Well-managed and protected desert plant cultivation with or without limited supplementary irrigation may be a viable alternative to costly irrigation programs in large areas with low levels of production per hectare. Benefits of cultivation of wild desert plants include conservation of water, sustainable development, and protection of the environment. Medicinal plants (such as Alexandrian senna, henna, Egyptian henbane, caper, and holy thistle) fill in a gap in the domestic needs of folk medicine and the pharmaceutical industry. Forage plants (such as panicum) provide fodder for farm animals while improving soil conservation. Woody plants (such as acacia, casuarina, eucalyptus, and tamarix) can serve as wind breaks, provide fuel wood, and in some cases provide feed for animals and/or food for humans. Fiber plants (such as agave) can be used in manufacturing useful fiber-based products.

In all cases, assuring orderly marketing is very critical to success in helping small-scale farmers. This includes availability of accumulation centers where products can be received, prepared for market (cleaning, sorting by quality, drying if needed, packaging, etc.), and stored under optimal conditions until shipped to markets or processing plants. Other steps in orderly marketing include transportation from production sites to the accumulation centers and from there to markets or processing plants. All these steps can create many employment opportunities in the rural areas of developing countries. Adding value to products and maintaining their quality and safety throughout the postharvest handling system can be done using available information. Thus, most of the efforts needed will be in training and disseminating information to all those who need it. ICARDA has a lot of experience in working with national research and extension organizations and can provide the leadership and coordination to extend this expertise to production and marketing of horticultural crops and other high-value products in the CWANA region.

Postharvest losses in foods of plant origin between the production and consumption sites are estimated to average about 33% and range from 5% to 50%, depending on the product's perishability and handling conditions during domestic and export marketing. Reduction of these losses can increase food availability to the growing population, decrease the area needed for food production, and conserve natural resources. Strategies for loss reduction include use of cultivars with longer postharvest life, use of an integrated crop management system that maximizes yield and quality, and use of prop-

er postharvest handling procedures to maintain quality and safety of the products. Although reducing postharvest losses of already produced food is more sustainable than increasing production to compensate for these losses, less than 5% of the funding of agricultural research internationally and in the CWANA region is allocated to the postharvest research areas. Furthermore, the research and development efforts, in most cases, do not address the important problems in food quality and safety in each country within the region. Very little true collaboration among disciplines (such as economics, engineering, food science, and postharvest biology) or coordination among researchers within each discipline exist. Although much of the information needed to properly handle foods of plant origin is known, there is a need to refine the requirements and recommendations for the particular cultivars of each commodity produced in the region. Also, there are a few crops that are grown in the CWANA region about which we do not have enough information on optimal postharvest handling conditions. In all countries, there is a need to improve the outreach (extension) efforts aimed at informing producers, handlers, marketers, and consumers about how to maintain the quality and safety of food products. ICARDA can facilitate cooperation among countries in the CWANA region in designing and implementing a postharvest loss reduction program.

2. Producing Horticultural Crops

Horticulture is part of our daily life in relation to food, medicine, recreation, enjoyment, and enhancement of the environment. Fruits and vegetables contribute about 90% of vitamin C and 48% of vitamin A in the human diet. Other important nutrients supplied by fruits and vegetables include vitamin B, minerals, dietary fiber, and antioxidant phytochemicals (such as carotenoids and flavonoids). Health authorities recommend regular consumption of a variety of fruits and vegetables to enhance human nutrition and health.

Production of horticultural crops (which are more labor intensive than agronomic crops) and value-addition through postharvest processing, handling and storage have great potential for agricultural development and economic growth, and hence increasing incomes and generating off-farm employment in rural areas of developing countries. Associated economic benefits can be maximized with increased productivity at the farmer level. Improving linkages between production and processing through contract farming and formation of farmers' associations and cooperatives can improve productivity and competitiveness in value addition.

The challenge to producers of horticultural crops is maintaining high productivity of good-quality crops while protecting the environment and preserving natural resources. Increasingly producers are reducing their use of water (by employing more efficient irrigation methods), chemical fertilizers (by improving application methods and timing), and pesticides (by using integrated pest management procedures). These trends toward more sustainable production systems are relevant for small and large farms as well as for the home garden.

2.1 Targeted horticultural crops

Among the hundreds of horticultural crops there are some that are and can be produced under arid conditions including those originating in the CWANA region. The specific range of horticultural crops that will be selected for inclusion in the rotation and interplanting of crops within sustainable farming operations will vary among areas within countries and among countries within the CWANA. Selection will be guided by cost/benefit analysis; average farm size; availability of inputs and facilities needed for production, processing and marketing; and potential marketability of the product. Fruit and nut crops that can be grown with relatively small amounts of water include almond, pistachio, walnut, grape, fig, jujube (Chinese and Indian), olive, pomegranate, date, and cactus pear. Vegetable crops that should be considered include green beans, sweet peas, edible-pod peas, cowpeas, garlic, onion, tomato, eggplant, pepper, cucumber, and melons. Herbs and spices such as basil, cumin, mint, oregano, and thyme should also be included. Medicinal plants (such as anise, cardamom, chamomile, coriander, marjoram, and sage) may be appropriate in some locations.

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2.2 Organic production

Organic farming is one of several approaches to sustainable agriculture. Indeed, many of the techniques used in organic farming, such as inter-cropping, mulching, and integration of crops and livestock are practiced under various agricultural systems. The demand for organic products has created new export opportunities for the developing world. Since demand for a variety of foods year-round makes it impossible for any country to satisfy all its organic food needs domestically, many developing countries have started to tap lucrative export markets for organically grown products. Typically, organic exports are sold at prices 20-50% higher than identical products produced on non-organic farms. The ultimate profitability of organic farming varies; however, few studies have assessed its long-term prospects. Nevertheless, under the right circumstances, market returns from organic agriculture can contribute to local food security by increasing family income. Entering this lucrative market is not easy. Farmers and agribusinesses seeking to sell their products in developed countries must usually hire an organic certification agency to annually inspect and confirm that they adhere to the standards established by various trading partners. Typically, farmers experience some loss in yields after discarding synthetic inputs and converting their operations to organic production. Before restoration of full biological activity (e.g. growth in beneficial insect populations, nitrogen fixation from legumes), pest suppression and fertility problems are common. Sometimes it may take years to restore the ecosystem to the point where organic production is possible.

Domestic production of organic products in developed countries is expected to rise within the next few years (there is usually a time-lag of three years between conversion and production of certified organic produce), but it is unlikely to meet the demand for most products. Consumer preference for locally or regionally produced organic fruits and vegetables indicate that the best opportunities are in counter-seasonal fresh organic produce. For products that cannot be produced in the colder climates in northern developed countries (e.g. orange, kiwifruit, etc.), most organic supply comes from countries close to these markets, such as Mediterranean countries for the EC.

There are some important requirements of the major markets to be fulfilled by the developing countries to export their organic products to the developed countries. To export to the European Community, Regulation EEC 2092/91 determines the minimum requirements

for organic farming in all the member states and is a directly applicable law. It contains standards for production, processing, imports, inspection and certification, marketing and labeling of organic products. Organic food products originating from non-EC countries may be imported and marketed in the EC with an organic label if it is accepted that the products are produced and certified according to procedures equivalent to those of the EC.

2.3 Protected cultivation

Vegetable production in the CWANA region is carried out predominantly by small-scale producers in greenhouses (mostly plastic covered), low tunnels, as well as in the open. The major reason for increasing the area of protected cultivation is the improved water-use efficiency. One cubic meter of water in the field grown tomato produces about four kg of fruits, while it produces 17 kg of tomatoes under greenhouse conditions. The efficiency is much higher if the technique of soilless culture is used where one cubic meter of water produces 45 kg of tomato. Similar conclusions were reported by various researchers for several other crops. If such an increase is associated with the price of vegetables, especially the off-season price, it indicates how the utilization of land and water resources may be managed to generate much better income for the small-scale producers, especially with the limited water resources in the region.

Within the region itself there is considerable awareness of aspects of crop production including the value of improved cultivars, seedling production, greenhouse structures, the significance of adequate ventilation, heating, irrigation, fertigation, pest control, etc. But these measures are generally not applied in an integrated manner, especially by the small-scale producers. As a result, inputs made by the small-scale producers for the purchase of greenhouses, improved seeds, or seedlings, for irrigation, fertigation, pest control, etc. are not optimally used. Furthermore, the misuse of pesticides, through over-application at regular calendar intervals, irrespective of need, often at higher than recommended doses, has already resulted in the building up of resistance of certain insect pests and fungi to specific pesticides. Furthermore, these developments have also resulted in environmental pollution. In addition, the misuse of pesticides is becoming a serious health hazard for both producers and consumers, and the presence of pesticide residues on exported produce leads to its rejection by importing countries. Obviously the present situation and practices are not conducive to sustainable production.

Countries of North Africa and the Near East Region adjacent to the Mediterranean Sea have recently developed a sizeable greenhouse industry, made up of both walk-in greenhouses and low tunnels. It is estimated that this sector, mostly farmed by small farmers, covers an area of over 80,000 hectares and produces a large range of crops, including fruits, flowers and predominantly vegetables. Most of the production is consumed locally, but nearly all countries also export, particularly to Europe. Substantial and indiscriminate use of inputs including water, fertilizers, and particularly pesticides is not conducive to the sector's long-term development and sustainability. Integrated Production and Protection (IPP) Management practices were introduced to the region, resulting in healthy crops and high yields of good quality, with a minimum use of pesticide. The

wide adoption of IPP in the region did not only result in improved yields, but also led to considerably less environmental pollution. The technology is now available for a successful transfer operation to the region. Further support by international research organizations is required to upgrade the human and physical infrastructure in the region and to allow the easy and successful technology transfer.

3. Domesticating Wild Desert Plants

Use of wild desert plants and their cultivation is not a new practice. It has been common in many countries all over the world. In USA, Mexico, India and many other countries, such plants have been cultivated over varied areas and produce considerable economic returns.

The economic wild desert plants comprise different groups, e.g. medicinal, forage, woody species, etc. Some are able to grow in habitats with considerable constraints that inhibit the growth of other species, i.e. the saline habitats.

Propagation of the wild plants, especially fodder plants, will also provide an opportunity for the natives to continue their important style of land use, i.e. grazing and animal breeding and their culture.

Well-managed and protected desert plant cultivation with or without limited supplementary irrigation may be a viable alternative to costly irrigation programs in large areas. This study focuses mainly on plants that are unique to the CWANA region.

The potential value of the forage and fuel group is particularly impressive in light of the large store of traditional knowledge and experience in use of such plants. The costs of propagation and management of these plants are very low compared to other traditional crops. At the low end the only inputs are labor for planting, protection and harvesting. At the high end some manure or fertilizer and small applications of water would be added. These low input requirements make these plants suitable for dry lands, which have austere water supplies.

Benefits of cultivation of wild desert plants include:

1. Conservation of water
- Have low water consumption
- Make use of seepage water along the margins of the farms and irrigation canals
- Able to tolerate the unavailability of continuous exogenous water supply

2. Sustainable development
- They do not introduce new weeds or pests
- Many plants do not require pesticides
- Minimal ecological consequence for the agro-ecosystem
- Minimal degradation, salinization, soil erosion, waterlogging, etc.

3. Medicinal plants
- Fill in a gap in domestic needs such as folk medicine and pharmaceutical industries
- Potential for exports, especially pharmacoepial drugs
- Potential for creation of small industries in cutting, drying, grinding, extraction, packing, etc.
- Provides cash (crop) income for settlers

4. Forage plants
- Fodder supply for farm animals
- Sand and soil binders (soil conservation)
- Conservation of indigenous genetic resources, especially of grasses and legumes

5. Agro-forestry industry
- Wind breaks
- Supply of fuel wood
- Amenity
- Feed for animals
- Food for humans

6. Environmental protection
- Dune stabilization
- Wildlife habitat
- Biodiversity conservation

The list of wild desert plants and those already cultivated under desert conditions, which can be proposed for the pres-

ent report, is inexhaustible. A few examples of the proposed plants will be given here.

These examples include:

A. Medicinal Plants:
Alexandrian Senna, Henna, Plantains, Egyptian Henbane, Squill, Caper, Holy thistle, Aloe

B. Forage Plants:
Panicum

C. Multipurpose trees:
1- Forage and sand fixation: Toothbrush tree, *Prosopis*
2- Windbreak, forage, fuelwood, soil fertility: *Acacia*
3- Food, medicine, forage, fuelwood, windbreak: *Argania*, *Balanites*, *Ziziphus*
4- Sand fixation: *Retama*, *Tamarix*
5- Windbreaks and fuelwood: *Eucalyptus*, *Casuarina*, *Tamarix* (especially in saline soil), *Acacia*

D. Fiber Plants: Agave

More details about these plants are included in Appendix 6.1.

4. Marketing Potential of Identified Crops and Economic Impact

The rain fed agriculture in many countries in the CWANA region is facing several challenges including variable and low rainfall, very small holding sizes, continuous decrease in the holding size, and low level of mechanization. The dry lands are mainly cultivated with winter cereals and legumes; the returns and value added from these crops are small.

Many countries in the region are going through a serious economic structural adjustment and trade liberalization. Some countries (such as Tunisia, Jordan, and Oman) became members of the World Trade Organization (WTO), and signed the Free Trade Agreement and the EU-Jordan Partnership. As a result, these countries need to reconsider their agricultural strategy and look for more profitable agricultural investments. In light of this global competition, agricultural production should be competitive in the domestic and world markets. This means that current cropping has to be changed, new crops should be introduced, and new technologies should be adopted that will improve the crop productivity per unit of land, decrease losses, improve the quality, and increase the return per unit of land, labor and water.

In this section three case studies are presented in which a detailed marketing and economic analysis is conducted. These case studies justify expanding ICARDA's mandate to include horticultural crops that have relatively low water requirements and can grow at an economic level in arid areas served by ICARDA.

4.1 Case study #1: Medicinal and herbal plants

The CWANA region is active in trade and marketing of medicinal and herbal plant materials as a result of: 1) the high diversity and richness of medicinal plants; 2) spatial distribution of medicinal plant species as a result of the varied land use, topography and climate in the region; 3) concentrations of consumer demand in major urban centers; 4) people in the rural areas are still collecting a wide variety of medicinal plants without trading use in healing and cooking; and 5) mixture of socio-economic factors (including culture and accessible health care) that sustain and motivate demand for indigenous plants. These plants are of vital importance in the region's folk medicine and have good opportunity for industrialization by local and international pharmaceutical companies.

Wild medicinal and herbal plant species are under serious risk of extinction due to excess collection by the inhabitants for medicinal and culinary needs and over-grazing by small ruminants such as sheep and goats. Urgent action is needed to conserve this valuable resource. A major mitigation measure is the cultivation of medicinal and herbal plants. Cultivation will sustain the supply to the desirable levels, relieve the pressure on the wild plant species, and improve the quality of the product.

The World Bank and the General Environmental Fund (GEF) will soon initiate a project in Jordan to promote the production, processing and export of medicinal and herbal plants especially in the rainfed areas and under limited

irrigation. The project's document that was prepared recently has identified 76 major medicinal and herbal plants that could be cultivated in Jordan (or in the other countries of the region with similar climatic conditions). Thyme, oregano and mint are the major identified crops that could be produced under irrigation, while anise seeds and cumin seeds are the major crops that could be produced under rain fed conditions.

Production under rainfed conditions:

Table 1 shows the crop budgets per hectare of the three field crops (wheat, barely and lentils) currently adopted by ICARDA and widely produced in the rainfed areas of CWANA region. The table also contains two medicinal field crops that compete for the same land and resources in the rainfed areas in the region, namely, anise and cumin. These medicinal crops are widely produced in certain countries such as Syria and Turkey. In many countries in the CWANA region, anise is mostly used in bread, cakes and in spice mixtures for sausages and stews. As a medicinal plant, it is used as a bronchodilator and as a flavoring agent in cold and cough medicines and throat lozenges to mask the unpleasant taste of other drugs. Cumin is used as a stimulant, carminative, and to cure stomachache.

The results reported in Table 1 indicate that anise and cumin show a significant advantage over wheat, barley and lentil. Nevertheless, this advantage is dynamic and affected by world markets through import prices which need to be updated at regular intervals.

Cost/Benefit Analysis of rainfed production:

The data in Table 1 was used to estimate the net income per hectare, the value added and the benefit-cost ratio for the five field crops. The net income per one hectare is calculated by deducting the total gross output from the total production cost. Figure 1 shows that the net income obtained from the two medicinal

Table 1. Crop budgets of selected field crops in the rain fed areas of Jordan

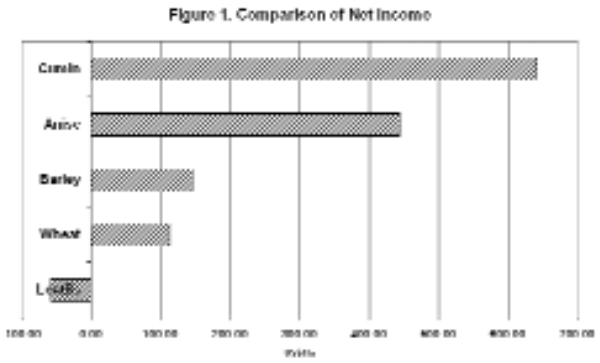
Item	Unit	Wheat	Barley	Lentils	Cumin	Anise
Crop main produce (Yield)	Kg/ha	1000.00	1200.00	800.00	500.00	500.00
Import Price of Output	US$/kg	0.21	0.18	0.49	2.11	1.51
Return of By-Products	US$/kg	0.18	0.18	0.07	0.14	0.07
TOTAL GROSS OUTPUT	**US$/Ha**	**388.73**	**427.20**	**450.70**	**1126.76**	**788.73**
Summer plowing	US$/kg	9.15	9.15	9.15	9.15	9.15
Seed bed preparation	US$/kg	9.15	9.15	9.15	9.15	9.15
Seeds	US$/kg	32.39	32.39	56.34	70.42	49.30
Seed drill	US$/kg	14.08	14.08	14.08	14.08	14.08
Fertilizers	US$/kg	28.17	28.17	28.17	28.17	28.17
Weed Control: Chemically	US$/kg	14.08	14.08	70.42	36.62	36.62
Weed Control: Manually	US$/kg	0.00	0.00	0.00	140.85	0.00
Harvest: Combine	US$/kg	21.13	25.00	0.00	0.00	21.13
Harvest: Manually	US$/kg	0.00	0.00	140.85	0.00	0.00
Bags	US$/kg	7.04	9.05	11.97	9.15	8.45
Seed Cleaning	US$/kg	0.00	0.00	28.17	28.17	28.17
Land Rent	US$/kg	140.85	140.85	140.85	140.85	140.85
TOTAL PRODUCTION COST	**US$/Ha**	**276.06**	**281.94**	**509.15**	**486.62**	**345.07**

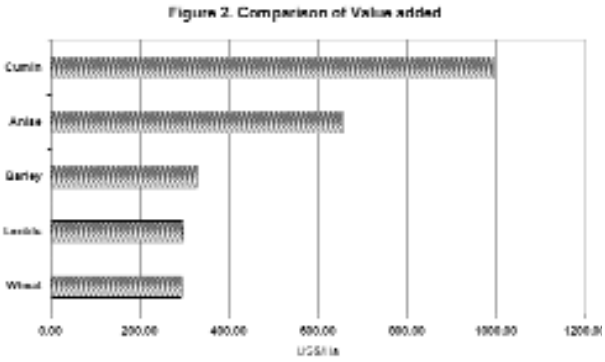
Adapted from: Haddad N., and M. Turk, Medicinal and Herbal Plants Cultivation, Conservation of Medicinal and Herbal Project Preparation, Grant/GEF TF 023719, World Bank-GEF project, 2002, Amman, Jordan.

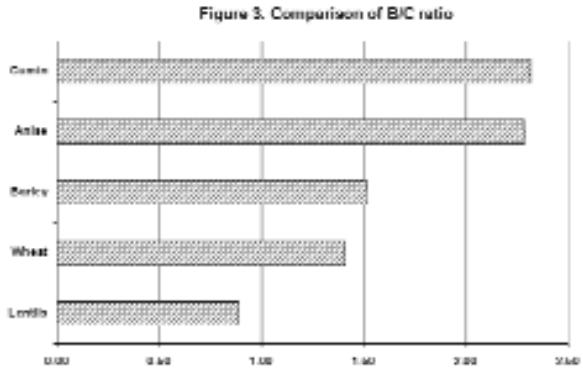
field crops is much higher than the net income obtained from the other three traditional field crops. For instance, the net income per hectare of cumin is more than six-fold the net income of wheat and four-fold of barley.

Another important economic measure for comparing feasibility of these crops is the value added to the national economy from cultivation of one hectare of each crop. The value added is estimated here by deducting the cost of tradable inputs used in the production process from the total gross output. Figure 2 shows the estimated value added of the five crops. It is clear that the two medicinal field crops add a lot more to the national economy than other three traditional crops. The figure shows that cumin seeds add in value about five times of what wheat adds to the national economy.

The benefit-cost ratio (B/C) is an important financial indicator to select between different alternatives of investments. The ratio is calculated by dividing the benefits (returns) of one hectare by the total costs. The ratio should exceed (1.0) in order for the investment to be made (i.e. the benefits should exceed costs). The B/C ratio is used here for comparing the feasibility of the five crops. Figure 3 confirms the results illustrated in the previous two charts. It is apparent that the two medicinal field crops add much higher benefits than invested costs compared to the other three traditional crops.







Production with supplementary irrigation:

Several medicinal and herbal crops are produced under rainfed conditions with supplemental irrigation in the region. For example, farmers in Jordan are growing oregano, chamomile, sage and mint under supplemental irrigation. Some farmers use plastic houses for growing oregano, which resulted in about 70% increase in yield, compared to its yield under open field conditions. In the following section we conduct a comparison between the three traditional field crops and two medicinal plants that can be grown with supplemental irrigation, mint and oregano.

Mint is a perennial crop produced under supplemental irrigation in open field or under full irrigation if produced in plastic houses. As a medicinal plant, the menthol in peppermint appeases the coating of the digestive tract and stimulates the production of bile, which is an essential digestive fluid. Peppermint is used for flavoring toothpaste and as an excellent breath freshener. The menthol vapor extracted from mint is used for easing upper respiratory system and chest congestion.

Oregano is an aromatic perennial herb that is very common in the Mediterranean region. The plant is rich in essential oil, tannin and origanene. It is used as a condiment and in preparation of many traditional dishes. As a medicinal plant, it is used to relieve stomachaches and acts as a diuretic. Oregano is cultivated under supplemental irrigation in open field and under full irrigation in plastic houses.

Cost/Benefit analysis of production under supplemental irrigation:

Table 2 contains the crop budget for cultivating one hectare of oregano and mint under rainfed conditions with supplemental irrigation. Irrigation water in the rainfed areas can be obtained from different sources including underground water or harvested water. Water harvesting is becoming a crucial practice in the rainfed areas. ICARDA has done a lot of research related to water harvesting in several countries in the region. Since water resources are very limited in this region, and rainfall is in general low and irregular, water-harvesting techniques should be considered as an important approach in supplementing water for medicinal plant production.

The data in Table 2 was used to estimate the net income per hectare, the value added and the benefit-cost ratio for the two irrigated crops, oregano and mint. The three economic and financial measures used above to analyze the five rainfed crops were used here with two irrigated crops. Figure 4 shows that the net income obtained from the two medicinal plants produced under supplemental irrigation is also much higher than the net income obtained from the other three traditional field crops currently adopted by

Table 2. Crop budgets of selected medicinal plants in the rainfed areas of Jordan under supplemental irrigation

Item	Unit	Oregano	Mint
Crop main produce (Yield) Dried leaves	Kg/Ha	7000	8000
Import Price of Output	US$/kg	1.4	1.1
TOTAL GROSS OUTPUT	**US$/Ha**	**10000.0**	**9142.9**
Plowing	US$/Ha	64.3	64.3
Bed preparation	US$/Ha	64.3	64.3
Seedlings (utilized for 4-5 years)	US$/Ha	857.1	514.3
Organic Fertilizers (Manure)	US$/Ha	971.4	971.4
Chemical Fertilizers (Super Phosphate)	US$/Ha	117.9	117.9
Chemical Fertilizers (Ammonium Sulphate)	US$/Ha	102.9	102.9
Chemical Fertilizers (Potassium Sulfate)	US$/Ha	64.3	64.3
Weed Control: Manually	US$/Ha	142.9	142.9
Water	US$/Ha	2000.0	2000.0
Harvest: Manually	US$/Ha	1714.3	1714.3
Land Rent	US$/Ha	142.9	142.9
TOTAL PRODUCTION COST	**US$/Ha**	**6242.1**	**5899.3**

Adapted from: Haddad N., and M. Turk, Medicinal and Herbal Plants Cultivation, Conservation of Medicinal and Herbal Project Preparation, Grant/GEF TF 023719, World Bank-GEF project, 2002, Amman, Jordan.

ICARDA (wheat, barley and lentils). The net income per hectare of oregano is more than thirty-fold the net income of wheat.

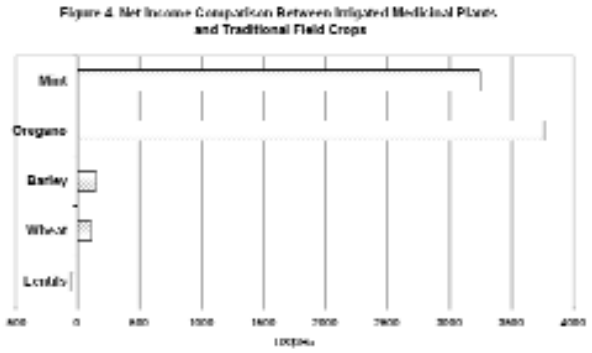


Figure 5 shows the estimated value added by the two irrigated medicinal crops and the three traditional field crops. As in the previous comparisons, it is clear from Figure 5 that the two irrigated medicinal plants add a lot more to the national economy than other three traditional crops. The figure shows that oregano adds in value about twenty four times what wheat adds to the national economy.

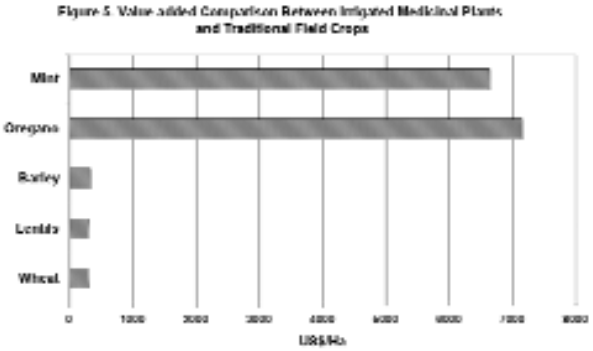
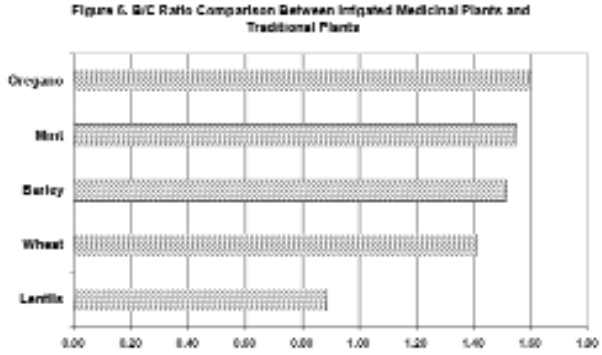


Figure 6 also confirms the results illustrated in the previous charts. The two irrigated medicinal plants provide higher benefits than invested costs compared to the other three traditional crops.



The import trends in world markets (mainly the EU):

There are several countries that provide a significant amount of horticultural products to the EU market during the off-season. This creates a more competitive atmosphere for producers in the region. Medicinal plants are promising crops for profitable exports to the EU market. Although, additional research is needed to determine whether these products enjoy a comparative advantage, it is apparent from the available data that many countries in the CWANA region are already competing in the EU markets. Prices in potential markets are quite high, and with appropriate technology, growers could supply these markets during the highest price periods. Medicinal plant markets are large and growing in most Western and Eastern European countries.

Anise and cumin are some of the major medicinal and aromatic plants imported to the EU market. Available information shows that it is imported in the form of seeds that could be used as such or for oil extraction. Figure 7 shows the import trends of anise seeds during 1993, 1997, 1999 and 2000. On average, the EU market annually imports about 2000 metric tons worth about ECU 4.2 million. The major suppliers of anise seeds to the EU markets are China, Spain, Syria and Turkey.

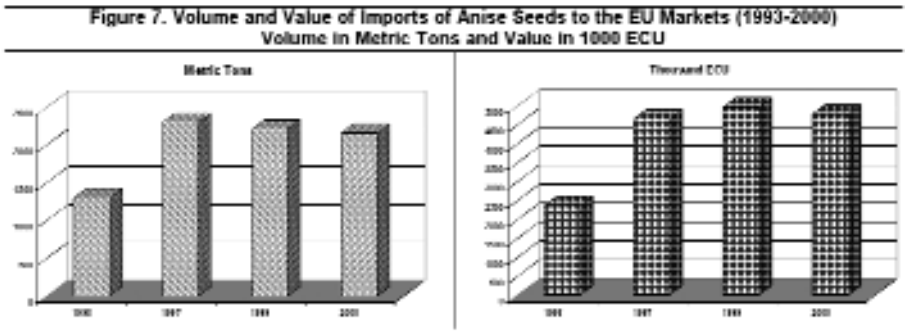
Figure 8 demonstrates the import trends of cumin seeds during the years 1993, 1997, 1999 and 2000. On average, the EU market annually imports about 6500 metric tons worth about ECU 11.2 million. Figure 8 indicates that there is an increasing trend in imports to the EU markets especially in the year 2000. Imports of cumin seeds were doubled in 2000. The major suppliers of cumin to the EU markets are the Netherlands, Syria, Turkey, and Iran.

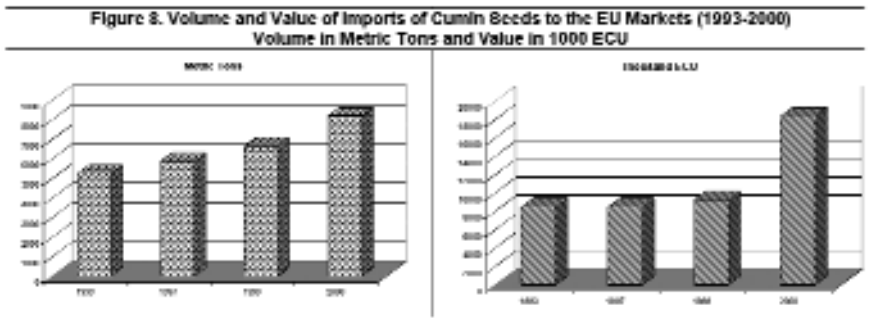
Figure 9 shows the price trends during 1993-2000 in the EU market. The figure indicates that oregano prices during the nineties increased at a slow pace. Prices in the year 2000 were 22% higher than prices of 1993.

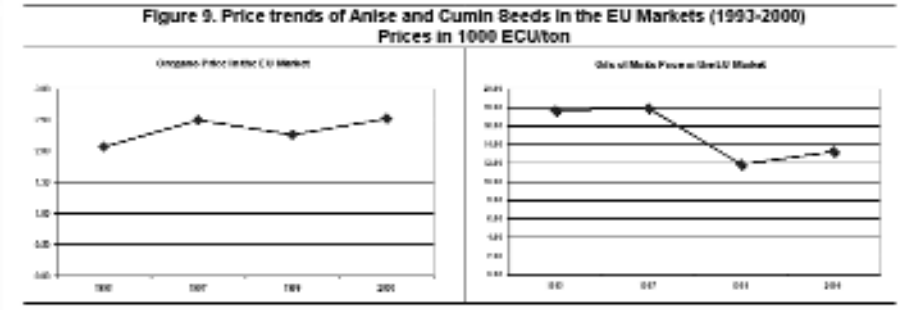
Figure 9 also demonstrates that the prices of oils of mints have sharply declined at the end of the nineties and in 2000. Prices declined by about one fourth in year 2000 compared to 1993 while volume of import increased by 84% for the same years. This could be explained by competition among the suppliers to the EU market.

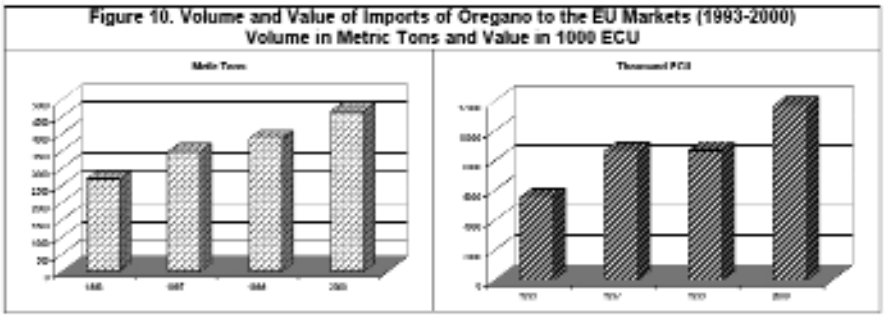
Oregano is another major medicinal and aromatic plant imported to the EU market. EU statistics show that Oregano is imported in the form of leaves that could be used either fresh for oil extraction or dried in food recipes. The major suppliers of Oregano in the EU market are Turkey, Spain, Poland, France and Germany. During the nineties, Turkey was the dominant supplier by supplying about one third of the EU imports, followed by Spain. Figure 10 shows that import volumes to the EU market during the nineties exhibited a continuous increase. The quantity of imports increased by 74% in 2000 compared to 1993. In monetary terms, import values have increased by 211% in 2000 compared to 1993, which indicates that prices were also on a continuous increase during the last decade.

Aromatic oils are another major medicinal and aromatic product imported to the EU market and used in pharmaceutical, cosmetic and food industries. Mint oils are an important aromatic oil imported to this market. Peppermint is used for

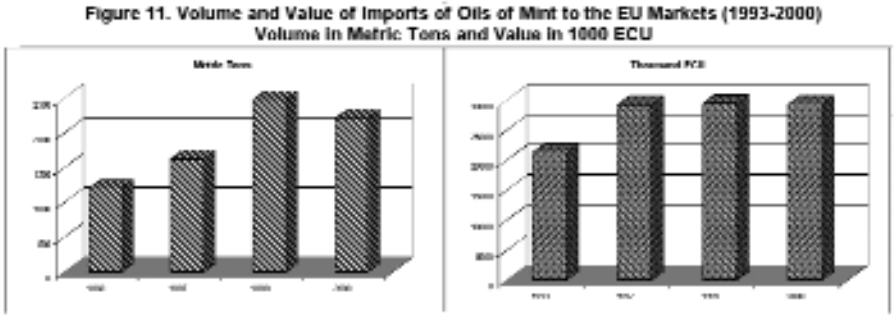








flavoring toothpaste and as an excellent breath freshener. Menthol vapors are used for relieving nasal, sinus and chest congestion. Figure 11 shows that the import trends of mint oils to the EU market during the nineties were similar to other selected medicinal and herbal plants. The figure shows that import volumes during the nineties increased steadily. The imported quantities to this market increased in year 2000 by 84% compared to 1993 (from 1203 tons in 1993 to 2213 tons in 2000). Consequently, import value also increased from ECU 21.3 million in 1993 to 29.3 million in 2000. The major competitors in the EU market are India, USA, UK and China.



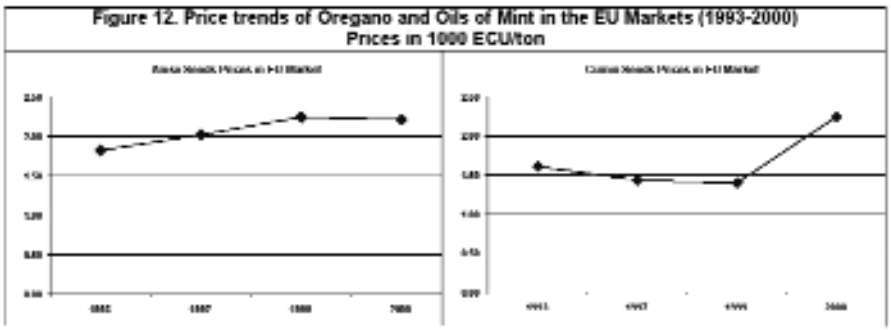


Figure 12 demonstrates the price trends for oregano and oils of mints during 1993-2000 in the EU market. The figure indicates that cumin prices during the nineties were almost stable at about 1500 ECU per ton but in the year 2000 prices increased by about 70% to reach to 2240 ECU per ton. The figure also shows that anise seeds prices were on a continuous increase during the nineties.

4.2 Case study #2: Vegetables and strawberries

ICARDA through its program in the Nile Valley and the Red Sea region played a vital role in providing growers in Egypt, Sudan, Ethiopia, Eritrea and Yemen with improved high-yielding varieties of wheat, barley, faba bean, lentil and chickpea. These new cultivars were released to farmers through NARS and improved production technology packages demonstrated to farmers.

As indicated by ICARDA's publications, the issue of natural resource management is being addressed in Egypt through alternative crop rotations; irrigation regimes and crop management options are being tested in long-term trials in cooperation with farmers. In the rainfed areas, efforts were focused on crop rotations, soil moisture conservation, watershed management, water harvesting, soil conservation, rangeland rehabilitation, and crop-livestock integration.

A major challenge facing ICARDA as well as other research institutions in the CWANA region was and still is to find, develop, adapt, and deliver technologies and management approaches that can increase the farmers' profitability and to convince growers & businessmen to adopt those improved technologies and management practices.

A recent study that was conducted by the Agricultural Technology Utilization and Transfer Project (ATUT) analyzed a group of horticultural crops to determine whether these crops efficiently utilize the scarce resources and achieve good profits to growers. The list of the studied crops included artichokes, dates, garlic, grapes, green beans, mange tout (sugar peas), mangoes, mixed melons, nectarine, green onions, peaches, peppers (capsicum), potatoes, strawberries, sweet potatoes, cherry tomatoes, salad tomatoes, and sweet corn. A detailed economic analysis was conducted using the crop enterprise budgets. The cost data used in constructing the budgets was originally prepared by Central Department of Horticulture at the Ministry of Agriculture and Land Reclamation (MALR). The data was updated through personal interviews with specialized growers, exporters and scientists at ATUT and MALR. The study concluded that the majority of the studied crops enjoy a comparative advantage including the three crops reported in Table 3.

Table 3 contains three budgets for strawberries, dried onions and Galia melons. The data is presented in US dollars per hectare to standardize the analysis and the comparisons with other products in other countries. The table clearly indicates that profits for the three horticultural crops are positive. The most profitable enterprise is strawberry, which offers up to US$ 6362 per hectare followed by dried onions and Galia melons.

It is worth noting that the three crops are labor intensive. The total labor requirement per hectare for the listed crops is reported in person-days/hectare. An important criterion that links the economic profits and the total labor requirement is the returns of labor. This criterion reflects the efficiency of labor allocation

or the amount of economic profit generated by each unit of labor allocated to the listed crops. The results of the analysis indicate that dried onion is the most efficient crop in labor utilization followed by strawberries and then by Galia melon.

Employment and gender issues became a hot topic in recent years especially for decision-makers in less developed countries. The governments of the CWANA region as well as many international donors working in the region are giving special attention to these issues. In this regard, the results of the analysis indicate that strawberry is the most intensive crop in employing women. Women do high-quality work especially in postharvest handling of delicate crops. Women's share in the activities of production, harvesting, and preparation for market sorting, grading and packaging) amounts to about 40%, 50% and 70% respectively.

Cost/Benefit analysis of the selected horticultural crops under irrigation:

The three crops are considered high value crops and they have high water requirements that can't be met by rainfall. Consequently, for their successful cultivation, a source of irrigation is needed and should be given high priority and attention. The returns to water (i.e. the water productivity) were calculated by dividing the returns of one hectare by water requirement for each crop. Strawberry was found to be the most efficient crop in water utilization followed by Galia melons and then dry onions.

As in the previous case study, the data in Table 3 was used to estimate the net income per hectare, the value added and the benefit/cost ratio for the three crops. The three economic and financial measures were used to analyze the three irrigated crops. Figure 13 shows that the net income obtained from the three horticultural corps produced under irrigation is much higher than the net income obtained from the two field crops currently adopted by ICARDA (wheat and barley). The net income per hectare of strawberry is more than sixty-fold the net income of wheat.

Figure 14 demonstrates the estimated value added of the three horticultural crops and two traditional field crops. As in the previous comparisons, it is clear from Figure 14 that the three irrigated crops add a lot more to the national economy than the three traditional crops. The figure shows that strawberry adds in value about thirty times of what wheat adds to the national economy.

It is clear from Figure 15 that dried onion is the most feasible crop in relative terms of comparing invested costs with obtained benefits. The B/C ratios are above one indicating that the obtained benefits are higher than the invested costs.

The import trends in world markets (the Gulf Market):

In this case study we selected another major export market that consumes large amounts of fresh horticultural products. The Gulf Cooperation Council (GCC) includes five Gulf States characterized by the highest per capita income in the WANA region. Several countries provide huge amount of horticultural products to the GCC market year round, which creates a competitive atmosphere for producers in the region. Many of the WANA countries enjoy a comparative advantage in producing these products and the available data concludes that many countries in the WANA region are already competing in the GCC market. Prices in this market are relatively high, and with proper production and postharvest

Table 3. Crop budgets of selected horticultural crops produced under irrigation in Egypt

ITEM	Unit Definition	Strawberry	Dry Onion	Galia Melons
Crop produce (output)	US$/Ha	19841.3	5511.5	5511.5
By-Products(if any)	US$/Ha	0.0	0.0	0.0
TOTAL GROSS OUTPUT	US$/Ha	19841.3	5511.5	5511.5
Water requirements	US$/Ha	352.7	529.1	132.3
Seed/seedling	US$/Ha	2469.1	220.5	220.5
Seed transplanting	US$/Ha	0.0	0.0	0.0
Manure-Fertilizer	US$/Ha	0.0	132.3	264.6
Total chemical fertilizer	**US$/Ha**	**1252.8**	**581.5**	**1174.2**
- N	US$/Ha	147.0	49.0	293.9
- P2O5	US$/Ha	177.5	443.8	443.8
- K2O	US$/Ha	710.1	88.8	133.1
Micro elements	US$/Ha	218.3	0.0	303.4
Pesticides & Methyl bromide	US$/Ha	2204.6	220.5	374.8
Mulch	US$/Ha	1278.7	0.0	383.6
Costs of machinery	US$/Ha	165.3	103.6	580.5
- land preparation	US$/Ha	33.1	33.1	529.1
- sowing / planting	US$/Ha	88.1	44.0	29.4
- husbandry	US$/Ha	44.1	26.5	22.0
Labor requirements:	US$/Ha	2204.6	206.7	730.2
- for land preparation	US$/Ha	141.1	0.0	70.5
- sowing / planting	US$/Ha	141.1	18.7	70.5
- husbandry	US$/Ha	158.7	75.1	306.9
- harvesting	US$/Ha	1763.7	112.9	282.2
TOTAL VARIABLE COSTS	**US$/Ha**	**9927.7**	**1994.1**	**3860.5**
GROSS MARGIN (GROSS OUTPUT-V.COSTS)	**US$/Ha**	**9913.5**	**3517.4**	**1650.9**
Fixed Costs:		2645.5	220.5	485.0
- Land rent	US$/Ha	440.9	220.5	220.5
- Depreciation(plastic, frame & drip)	US$/Ha	2204.6	0.0	264.6
- Interest on working capital	US$/Ha	1005.9	177.2	347.6
TOTAL FIXED COSTS	**US$/Ha**	**3651.4**	**397.6**	**832.7**
TOTAL COST	**US$/Ha**	**13579.1**	**2391.7**	**4693.2**
NET RETURNS	**US$/Ha**	**6262.2**	**3119.7**	**818.3**
GROSS MARGIN / cbm irreg. water	US$/CM	2.5	0.6	1.1
GROSS MARGIN /man day	US$/Person.hr	1.6	6.0	0.8

Source: Updated from: ATUT, Crop Candidate Study, 1999, based on Data from Ministry of Agriculture and Land Reclamation, Central Department of Horticulture, Egypt, Cairo, 1999.

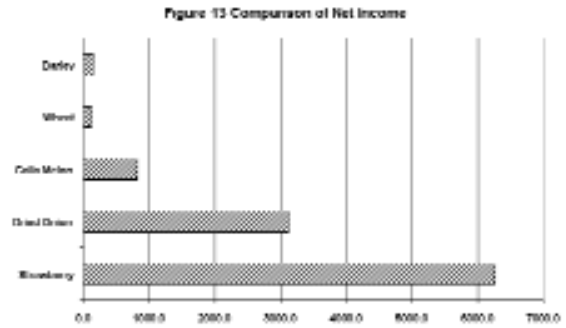


Figure 14. Comparison of Value Added

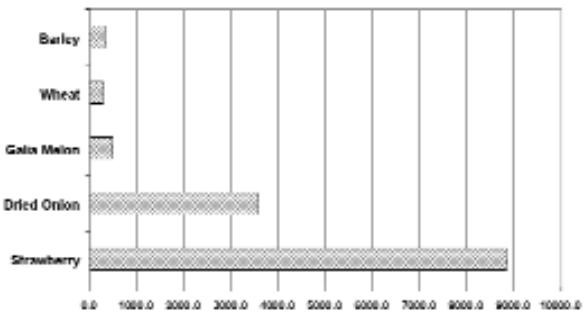
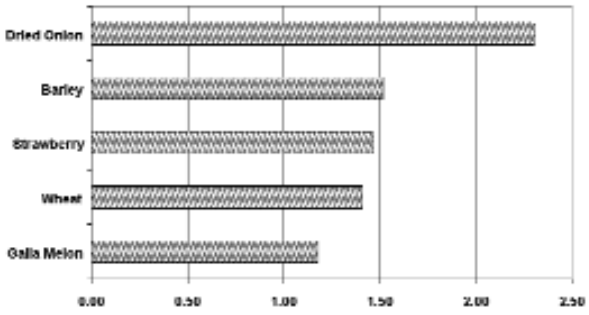


Figure 15 Comparison of B/C Ratio



technologies, growers and exporters could increase their annual supply to these markets and obtain higher prices.

Figure 16 shows the import trends of strawberry, onion and melon during the years 1987 to 1998. On average, the GCC market annually absorbs about 55,715, 106,325 and 46,486 tons of strawberry, onion and melon, respectively. Figure 16 demonstrates that melon imports were continuously increasing during the last decade, while strawberry imports were increasing at a slower pace. Onion import was decreasing which may be explained by the increase in domestic production. The main suppliers of strawberry are Egypt, Syria, Turkey and Jordan. The major suppliers of melons are also Egypt, Syria, Turkey and Jordan, while the dominant suppliers of onion are Egypt, Turkey and UAE.

Figure 16 Import Trends in GCC Market

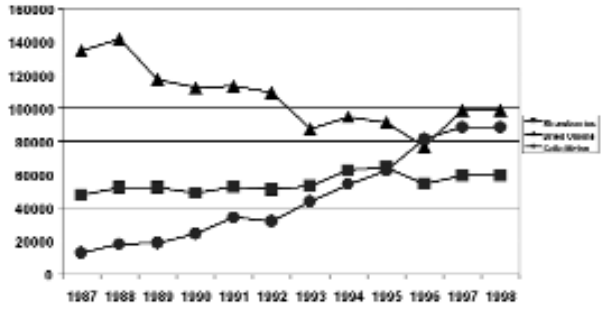


Figure 17 shows the price trends during 1987-1998 in the GCC market for the three selected products. The figure indicates that except for onion, the import price trend was on a continuous decline during the last decade.

Figure 17. Import Price Trends in GCC Market

4.3 Case study #3: Fruits and nuts

ICARDA's major task in the dry areas is to respond to the serious threats of overgrazing, urbanization, industrialization and unplanned expansion of arable agriculture. One of the major projects that is currently managed by ICARDA and funded by GEF is the Conservation and Sustainable Use of Dryland Agro-Biodiversity in Jordan, Lebanon, Syria and Palestine. This project is designed to

respond to these threats and concerns. The project is intended to support the conservation of the important wild relatives and landraces of the major food and feed crops including fruit trees in the four counties through the introduction of in-situ and on-farm conservation techniques in full participation of farmers and users. Pistachio, almonds and olive trees were among the fruit trees that are targeted by the project.

The three selected fruit trees are cultivated mainly under rainfed conditions with supplemental irrigation during the first year and the establishment period. In certain areas, where water is abundant, some of these fruit trees are produced under irrigated conditions. The data used in this case study was obtained from the Ministry of Agriculture and Agrarian Reforms in Syria. In addition to Syria, the three fruit trees are widely cultivated in Turkey, Lebanon, Palestine and Jordan.

Table 4 contains three budgets for almonds, olives and pistachios. As in the other two cases, the data is presented in US dollars per hectare to standardize the analysis and the comparisons with other products in other countries. The tables clearly indicate that profits for the three fruit trees are positive. The most profitable enterprise is the pistachio that offers a gross margin up to US$ 1402 per hectare followed by almond and olive.

As in the case of the other suggested crops in the other two cases above, the three selected perennial crops are also labor intensive. However, in the rainfed areas, farmers rely on family labor especially during harvest. The cost of total labor needed to produce the three crops represents about 44%, 38% and 48% of the total costs incurred by growers.

Benefit/Cost analysis of the selected perennial crops under rainfed conditions:

The data in Table 4 was used to estimate the net income per hectare, the value added and the benefit-cost ratio for the three crops. In certain countries of the CWANA region, fruit and nut trees are cultivated under rainfed conditions in sloped-rocky lands as well as in areas where field crops are grown. In this case study we draw a comparison between almond, olive and pistachio on one side and wheat and barley on the other. Figure 18 shows that the net income obtained from the three proposed fruit and nut trees produced under rainfed conditions are much higher than the net income obtained from the two field crops currently adopted by ICARDA (wheat and barley). The net income per hectare of pistachio is more than nine-fold the net income of barley and twelve times more than the net income obtained from wheat.

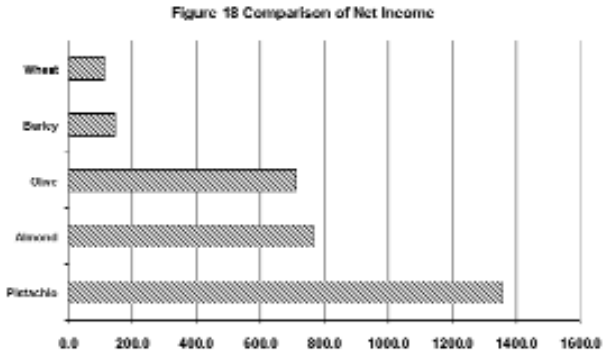
Figure 19 contains a comparison between the estimated value added of the three fruit and nut trees and the two traditional field crops. As in the previous comparisons, it is clear from Figure 19 that the three proposed fruit crops add a lot more to the national economy than the three traditional crops. The figure shows that pistachio adds in value to the national economy about seven times of what wheat or barley adds.

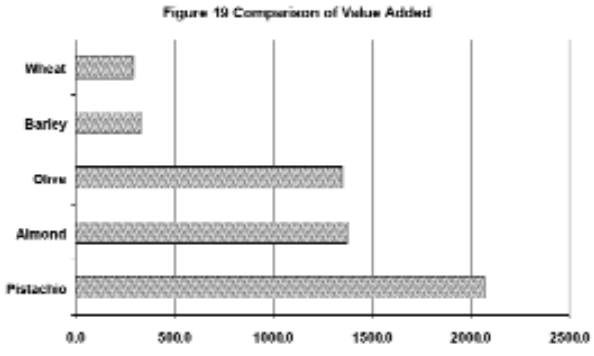
Comparing the financial feasibility indicators shows that pistachio is the most feasible crop in relative terms followed by almond and olive. Figure 20 shows that in terms of B/C ratios, the five crops are financially feasible, however, wheat is the least feasible crop in the rainfed areas of Syria.

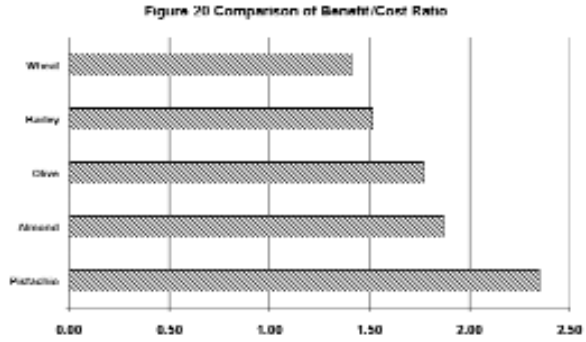
Table 4. Crop budgets of selected fruit trees and nuts produced under rainfed conditions in Syria

Item	Unit Def.	Almonds	Olive	Pistachio
TOTAL GROSS OUTPUT	US$/Ha	1744.2	1744.2	2441.9
Irrigation: Water requirements:	US$/Ha	0.0	0.0	10.5
Seedlings: bought/owned	US$/Ha	5.8	41.9	10.5
Manure - Fertilizer	US$/Ha	69.8	69.8	0.0
Total mineral fertilizer	US$/Ha	91.7	75.1	93.4
N	US$/Ha	41.6	25.0	33.3
P	US$/Ha	21.4	21.4	25.7
K	US$/Ha	28.7	28.7	34.5
Chemicals:	US$/Ha	46.5	46.5	116.3
- Weeds control	US$/Ha	46.5	46.5	116.3
- Insecticides	US$/Ha	0.0	0.0	0.0
Containers	US$/Ha	29.1	55.8	37.2
Costs of hired machinery	US$/Ha	279.1	319.8	281.4
- Tillage and flatting	US$/Ha	93.0	186.0	93.0
- Controlling	US$/Ha	116.3	116.3	174.4
- Harvesting	US$/Ha	0.0	0.0	0.0
- Others	US$/Ha	0.0	0.0	0.0
- Transportation (crop specific!)	US$/Ha	69.8	17.4	14.0
Variable costs of owned machinery	US$/Ha	0.0	0.0	0.0
Labor requirements for:	US$/Ha	411.6	376.7	501.2
- Fertilization	US$/Ha	0.0	0.0	0.0
-Chemical	US$/Ha	34.9	11.6	11.6
-Organic	US$/Ha	11.6	11.6	0.0
- Controlling	US$/Ha	16.3	16.3	24.4
- Harvesting	US$/Ha	174.4	162.8	174.4
- Irrigation	US$/Ha	0.0	0.0	0.0
- Pruning	US$/Ha	174.4	174.4	290.7
Land rent	US$/Ha	46.5	46.5	46.5
TOTAL VARIABLE COSTS	**US$/Ha**	**932.4**	**985.6**	**1040.0**
GROSS MARGIN	**US$/Ha**	**811.7**	**758.6**	**1401.9**
NET RETURNS	**US$/Ha**	**765.2**	**712.1**	**1355.4**

Source: Syrian Arab Republic, Ministry of Agriculture and Land Reclamation, Farm Data Handbook, 1995







Marketing issues regarding the selected crops:

This part of the study contained an unsophisticated competitiveness analysis for the selected irrigated and rainfed products due to the following reasons:

- The selected irrigated plants are characterized by high returns per cubic meter of water compared to other traditional crops
- The selected medicinal and herbal plants in particular employ a significant number of farmers, traders and processors, and could employ more in the case of penetrating new markets. Medicinal and herbal plants have many potential links to other economic sectors such as pharmaceutical and food industries
- In general, the introduction of the selected crops will increase crop diversification and will improve farmers' incomes
- In many countries of the CWANA region, the basic infrastructure required in terms of greenhouses, etc. is available
- Promoting the production of the selected fruits and nuts trees and medicinal and herbal plants is vital to conserve the biodiversity of the region
- Export potentials are high. In particular, the European market annually absorbs a sum of US$ 3.6 billion in terms of herbal supplements and herbal remedies. Germany is by far the largest market. The market is growing rapidly at over 4% per annum for herbal remedies and considerably faster for herbal supplements. Another important market is the US market that absorbs a sum of US$ 6-8 billion. Their dietary herbal supplement market has been growing at a rate of 6-8% annually
- While quality is the major issue in international and even domestic markets, many countries of the CWANA regions could benefit from several comparative benefits that they enjoy, such as seasonal position, transport cost and low wage rates

Marketing constraints:

The marketing system of agricultural products in many of the CWANA countries suffers from a number of problems and constraints that hinder the agricultural development. These constraints are summarized to form the basis for making recommendations for further action

- Absence of a sound marketing strategy
- Lack of enthusiasm of private investors to invest in marketing development related projects. This is mainly due to the risk involved in this kind of business and the lack of vertical integration among producers, processors and exports combined with high risk in marketing and distribution system
- The low income of producers is a result of the unclear identification of the opportunities offered by many high value products to promote development
- Absence of regulations relating to grading, standards, and packaging

materials for local and export markets
- Inadequate extension and training services at both production and marketing levels
- Lack of effective market research and market information system
- Lack of experience in pre and postharvest technologies
- Irregularity of supply of plant products, in quantity and quality
- Absence of any sort of market organization for such associations or cooperatives resulting in a very limited lobbying ability to develop the industry
- Absence of product development opportunities as a result of limited access to sufficient plant stocks
- Limited skills in the sustainable use of medicinal plant resources
- Limited production initiatives in the region
- Inadequate extension and training services at the production level
- Little knowledge of the financial opportunities in cultivating and managing high-value crops for export markets
- Lack of detailed technical and economic information on products demanded, timing, quality, forms, both in local and export markets
- Lack of coordination among the market players
- Insufficient information available to producers and exporters on issues related to international agreements such as EU-MED partnership agreements, WTO, the intellectual property rights and other bilateral trade agreements
- Poorly developed business skills in international trade creating limitations for developing the export industry
- Strong competition in terms of price and quality with other suppliers in the importing markets

5. Reducing Postharvest Losses

5.1 Introduction

The primary goals of research on postharvest biology and technology of fresh produce are to reduce losses in quantity and quality and to maintain safety between harvest and consumption sites. The strategies for attaining these goals include: 1) growing cultivars that have good flavor and nutritional quality when harvested at optimum maturity plus long postharvest-life potential, 2) using an integrated crop management system that maximizes yield without sacrificing quality, and 3) using optimal postharvest handling procedures to maintain quality and safety of the food products. The most useful technological changes in production, harvesting, and postharvest handling systems for horticultural perishables have resulted from interdisciplinary team approaches in research and extension programs. Quality, especially flavor and nutritional quality, and safety (avoiding chemical and microbial contamination) must be the focus of future research and extension activities in all countries of the CWANA region.

5.2 Causes and Estimation of Postharvest Losses

Biological (internal) causes of deterioration include respiration and associated metabolic rate, ethylene production and action, rates of compositional changes (associated with color, texture, flavor, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological breakdown. The rate of biological deterioration depends on several environmental (external) factors, including temperature, relative humidity, air velocity, atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene), and sanitation procedures. Although the biological and environmental factors that contribute to postharvest losses are well understood and many technologies have been developed to reduce these losses, they have not been implemented in many cases due to one or more of the following socioeconomic factors: 1) inadequate marketing systems; 2) inadequate transportation modes; 3) lack of needed materials, tools, and/or equipment; 4) lack of information; and 5) governmental regulations and legislations.

Postharvest losses vary greatly among commodities and production areas and seasons. Very few studies have been conducted to estimate the magnitude and to identify the causes of postharvest food losses. In a comprehensive survey conducted in Egypt in the early 1980s, postharvest losses were estimated at 18% for potatoes, 28% for grapes, and 43% for red-ripe tomatoes. The overall losses in fresh fruits and vegetables between production and consumption sites were 20% and 30% respectively. While it may not be economical or practical to aim for 0% losses, an acceptable loss level for each commodity and production area combination can be identified on the basis of cost-benefit analysis (return on investment determination). A systematic analysis of the production and handling system for each commodity is the logical first step in identifying an appropriate strategy for reducing postharvest losses. Also, it is essential to determine the return on investment in each of the selected postharvest technologies. Such

information can greatly facilitate convincing handlers and marketers of the value of adopting the recommended technologies.

5.3 Current Research and Extension Programs

Although there are a few researchers in each country in the CWANA region who carry out some postharvest research, there is very little coordination among them or among countries within the region. Interdisciplinary collaboration among production horticulturists, plant pathologists, entomologists, marketing economists, engineers, food technologist, consumer scientists, and others who may be involved in various aspects of the production and marketing systems is also lacking. Such cooperation and collaboration is essential to establishing effective research and extension programs.

In most cases, solutions to existing problems in the postharvest handling system require using available information and implementating appropriate technologies. Thus, it is highly desirable to strengthen the connection between researchers and extensionists (both public and private consultants) to assure the smooth transfer of relevant information to those who need it. The most successful model is where researchers and extensionists belong to the same organization and are co-located for maximum interaction and collaboration.

Establishing a Postharvest Working Group in each country can be very useful in providing a forum for communication among all those concerned with postharvest biology and technology research and extension. The next step is to establish a link among the various Postharvest Working Groups in the CWANA region to facilitate exchange of information and regional collaboration on training and other areas of mutual interest. ICARDA can play a very important role in facilitating the proposed regional interactions and collaborations.

5.4 Future Research and Extension Needs

Studies of the causes and magnitudes of postharvest losses can be very helpful in identifying priority areas of research and extension in each country. Such studies should include the socioeconomic constraints to the implementation of recommended technologies in each situation and methods to overcome these constraints. Much more research is needed to determine the return on investment (ROI) of various postharvest technologies (such as packaging, cooling, refrigerated transport, ethylene exclusion and/or scrubbing, treatment with 1-methylcyclopropene to inhibit ethylene action, modified atmosphere packaging, and decay control treatments). Such information can greatly enhance adoption of technologies with high ROI potential by produce handlers.

Food safety is a major concern of the produce industry and regulatory agencies, such as the U.S. Food and Drug Administration. Use of "Good Agricultural Practices" throughout the production system and use of "Good Manufacturing Practices" during all processing steps are highly recommended. Future research areas include developing reliable indices of microbial quality and procedures for minimizing microbial contamination, and investigating how various postharvest handling treatments and conditions influence survival of human pathogens on produce.

More attention should be given to developing value-added products with

superior flavor and nutritional quality that satisfy consumer preferences.

There is a need in all countries of the CWANA region to improve the postharvest extension program and to strengthen the connections between researchers, extension workers, and clientele groups of producers and handlers. All appropriate methods of communicating relevant information in a concise manner should be used. There are many opportunities for collaborative efforts in extending postharvest information among many of the countries in the CWANA region. ICARDA can provide the leadership and facilitate cooperation among these countries.

Producers and handlers of foods of plant origin in each country should be encouraged to form a trade organization that can serve their collective interests in promoting their products in domestic and international markets, supporting high-priority research and extension efforts, and representing their interests in dealing with governmental agencies, such as those responsible for food quality and safety regulations.

6. Appendixes

Appendix 6.1 Examples of wild desert plants that can be domesticated

A- MEDICINAL PLANTS

Alexandrian Senna, Henna, Plantains, Egyptian Henbane
Squill, Caper, Holy thistle, Aloe

SANNA MAKKI سنامكي

1. TRUE SENNA, ALEXANDRIAN SENNA

Senna alexandrina Mill.
[SYN: *Cassia senna* L., *C. lanceolata* Forssk., *C. acutifolia* Delile]
Family: Leguminosae

The official drug is produced from *Senna alexandrina* Mill. However, the leaves of *C. italica* Mill. have the same uses.

Senna was introduced into Western Europe by the Arab physicians of the 10th and 11th century, who preferred the pods to the leaves, though they employed both. It was formally exported from Alexandria, hence the name of the drug, but now reaches the European market from Port Sudan.

The plant is an under-shrub, with a height ranging from 30 to 100 cm. Leaves compound, with 3-12 pairs of leaflets. Leaflets lanceolate, 1.5-5.2 cm long, 7-12 mm wide. When dry, leaves are pale grayish-green, thin, and brittle. The margin is entire, and the apex is acute. The leaflets are unequal at the base. Pods flattened, shortly oblong, 4-7 cm long and 1.6-2.6 cm wide with oblong seed.

Distribution:

The species is found in central Sahara, eastwards to Arabia and India. Its distribution extends in Africa to the Sudan, Eritrea, and Somaliland to the coasts of Kenya.

Active constituents:

The leaves contain 2.5 percent glycosides of dianthorones of rhein, e.g. sennoside A and B, and of rhein and aloe emodin, e.g. sennoside C and D, and other anthraquinones. The constituents vary according to the plant organ and growth stage (Table 2) and the soil type (Table 3). The data in these tables show that the best time for harvest is during the vegetative and early flowering stages.

Cultivation of Senna :

Planting data

The proper time is spring time when the air temperature starts rising. It is not recommended to be later than April.

Soil

Light sandy soils with good infiltration are the best for Senna. Heavy soils are not preferred. Addition of manure or other fertilizers is usually recommended.

Sowing

Manual planting in leveled land, with 14 rows every 7 meters, at a distance of 30 cm. Mechanical planting, a planter or grain drill is used in rows 45 cm apart at a distance of 20 cm between the successive plants.

Sowing rate, per Feddan

Mechanical (planter):	5-6 kg seeds
Manual:	8-9 kg seeds

Seeds may be soaked in water for 12 hours before sowing to increase germination.

Herbicides

Soil is sprayed with the herbicide triflan at a rate of 1 kg/Feddan before sowing. The land is plowed after spraying and before sowing. This is not important in newly reclaimed land and where manure from cultivated land is not used.

Irrigation

It is to be noted that Senna is sensitive to water; it needs very little water. Sprinkler irrigation could be used every 5 days after the establishment of the plant. Irrigation should be reduced after flowering. Excessive water causes chlorosis of the leaves and decreases the glycoside content.

Fertilizers

It has been recommended to add per Feddan:

500 kg ca Super Phosphate
200 kg Ammonium Sulphate
100 kg Potassium Sulphate

Foliar fertilizers could be used at a rate of 4 gm/liter; 200 liters/Feddan

Harvest:

It is possible to get three cuttings, the first about three months from sowing, the next one month later; harvest timing depends on the tillage and irrigation processes and fertilizers, etc. If inputs are reduced for saving, the harvest may be reduced to two cuttings instead of three during the growing season.

The time of harvest depends on the drug to be used, the leaves or the fruits, or both. In case of leaves, cutting would be 2 or 3 times, while in the case of fruits harvest generally is in July; daily picking of the fruits is required.

Yield:

One feddan would produce from 1 to 1.5 tons of dry fruits. In case of cutting for leaves, one feddan produces from 1 to 1.5 tons of leaves mixed with fruits. The total glycosides in mature fruits range from 4.3 to 5.6 percent and in dry leaves from 1.5 to 2.8 percent. Experiments showed that one feddan produces from 750 to 100 kg of air dry leaves, 2.5-3 tons of twigs and 350-400 kg of dry fruits.

2. HENNA-EGYPTIAN PRIVET

HENNA الحناء

Lawsonia alba Lam.
[*Lawsonia inermis* L.]
Family: Lythraceae

Henna has a long history of cultivation in the region. There is a demand for henna in all the countries in the region.

The henna tree may grow up to 5 m high. It is an evergreen tree with spinescent branches, elliptic lanceolate, and opposite leaves. Inflorescence corymb forming terminal panicle. Fruit capsule dehiscent. The tolerance of this plant to drought justifies its inclusion for cultivation in dry land.

The growth and the amount of active constituents of the henna plant vary according to the environment; the latter is affected by the geographical location of the county. Previous studies showed that the percentage of lawsone glycoside is higher in warmer sites than in the cool ones.

It is to be noted that the growth of the plant is better in light soils; it is not successful in saline or waterlogged soils.

Cultivation:

The plant is cultivated by cuttings during the period March to May.

One feddan needs 15,000 cuttings, from at least one-year old branches, 15-20 cm long, and 1-1.5 cm thick with 2 buds at least.

Sprinkler or drip irrigation could be used. Generally, the plant needs moderate amounts of water. Fertilizers may be applied.

Harvesting:

In the first year, the plants are cut to a level of 25 cm above the ground level during autumn (September to October). In successive years, cuttings are harvested two times per year (June and October). The plants remain productive for five years.

Preparation:

Cut branches are arranged in bundles to be air dried in shade. Leaves are separated from the branches and left to dry in shade. Leaves are ground into fine powder after complete drying.

Yield:

One feddan yields 750-800 kg of dry leaves. This yield increases at the rate of about 25% per year over the productive life.

Constituents:

Henna leaves contain different glycosides, the most important is lawsone. This is the active principle, with pharmacological effects; the active derivative it constitutes about 0.88 percent of the leaves. Flowers contain resin. Seeds contain fixed oil.

Uses:

Dye for hair, hands and feet and generally for cosmetics. Leaf decoction is astringent antiseptic, vulnerary; used for wounds and burns.

Recommendations:

In view of the great need of the local and regional markets, the cultivation of henna is quite profitable. It would be fruitful to use the plant as an income hedge in newly reclaimed land. In addition to its importance to the environment and economic yield using infiltrated irrigated water, it may be cultivated along irrigation canals. The production of henna could provide the basis for small industries such as drying, grinding and packing.

3. PLANTAINS

Plantago spp.

In the region, there are numerous different species growing in the deserts, coastal zones or in the cultivated land and wet habitats. The important species are: *Plantago ovata* Forssk. *P. psylluim* L., *P. coronopus* L., and *P. albicans* L. The latter is a perennial palatable herb which could be used as a fodder, in addition to its useful seeds.

The seeds of *Plantago afra* and *P. ovata* are official drugs in many pharmacopoeias. The leaves of *P. lanceolata* are pharmacopoeial in the German Pharmacopoeia.

3.1 FLEA WORT

حشيشة البراغيث–بذر قطونة

Plantago afra L.
[SYN: *Plantago psylluim* L.]

A richly branched annual herb. The plant is glabrous or glandular hairy with distinct stem. Leaves opposite, linear. Flowers in long-peduncled heads.

The seeds contain mucilage in the epidermis of the testa. It is pharmacopoeial in the Egyptian (1984), British (1993), US (1995) and Indian (1985) Pharmacopoeias. The cleaned, dried, ripe plantain seeds of *P. psylluim* are known in commerce as Spanish or French psylluim seeds. According to the British pharmacopoeia codex (1963), psylluim (seeds of *P. psyllium*) has the property of absorbing and retaining water and has therefore been used as a bulk-providing medium in the treatment of chronic constipation. On account of its content of mucilage, psylluim has been used as a demulcent.

The seed coat of psylluim is composed of about 98% of a mucilage, which can be extracted with cold water, either from the whole seed or the separated seed coat. The mucilage is contained entirely in the seed coat and is composed of L-arabinose, D- xylose and D- galacturonic acid.

The plant grows in Europe and North Africa and is cultivated in France

3.2 SPOGEL PLANTAIN- ISPAGHULA BIZR QATOUNAH

Plantago ovata Forssk.

Herbs with flowers are arranged into long or ovata spikes. The plants are palatable and the seeds are used for medicinal and other industrial purposes. They are valued for their content of mucilage and other active principles. The seeds of Plantago are among the oldest medicinal drugs.

The seeds of *P. ovata*, known in commerce as blond psylluim or Indian Plantago, have been used in Europe as a domestic remedy, since the 16th century. Since 1930 they have been extensively used in the USA as a popular remedy for constipation. Commercially the most important plant product is the husk of the seed which is produced in North-Western India and purified and processed in the USA It has been reported that the herbs have the characteristics useful as an ice-cream stabilizer and that they can be developed as a suitable economical substitute for sodium alginate.

The seeds *P. ovata* (Ispaghula) are mentioned in the "Extra Pharmacopoeia Martindale" (1958) to be useful in the treatment of chronic constipation. Ispaghula seeds, due to their large content of mucilage, are said to be of value in bacillary dysentery and chronic diarrhea, especially in the particular form of intestinal irritation, known as hill diarrhea.

4. EGYPTIAN HENBANE
SAKRAN سكران

Hyoscyamus muticus
Family: Solanaceae

The genus *Hyoscyamus* comprises numerous species. One of them is *Hyoscyamus muticus* L.

The plant is a perennial stout fleshy plant. It is richly branched and an individual plant covers an area of 2 sq. m. or more. The plant extends horizontally and the lateral branches go upwards reaching a height of some 60-100 cm.

The leaves are broad, thick, fleshy; radical leaves reach 15-20 cm in length; margins are dentate. The upper leaves are smaller, toothed, with short petioles. Flowers are arranged in dense spikes; funnel-shaped and dark violet. The fruits are unarmed capsules opening by a lid, included in the persistent calyx. The plant has a characteristic odor, bitter taste and is slightly acid and salty.

Each fruit contains a tremendous number of seeds, which can be collected from desert areas in early summer. It is possible also to collect seeds all the year around, but in smaller amounts.

Distribution:

Hyoscyamus muticus L. is a widespread plant in the deserts of the Middle East.

The plant occurs in the desert in patches occupying depressions in sandy areas which receive runoff water. It grows in areas where the measured rainfall averages 20 mm or more per year. Water runoff increases the water resources in habitats supporting the wild plant.

Active constituents:

The Egyptain henbane leaves contain the alkaloids hyoscine and hyoscyamine up to a value of 1.34%, mainly hyoscyamine.

The dried leaves, *folium hyoscyami mutici,* and the smaller stems and flower tops are the official drug.

The amounts of active constituents vary according to the type of soil, the availability of water and salinity. When irrigation is minimized and the tillage operations are reduced to minimize the costs, the yield produced will be small, but quality of the drug will be high.

Transplanting:

Transplanting should be in moist soil.

Irrigation:

Hyoscyamus is a sensitive plant to water. It grows rapidly with irrigation, but with very low alkaloid content. Irrigation could be every month in summer and every month and a half in winter.

After the establishment of the plant and the roots reach the permanently wet layer at a depth of 60 cm or more, there is no need for irrigation. This plant has particular application in areas near irrigated fields.

Harvest:

The proper time for cutting the herb is during flowering and before fruiting. Cutting is performed to leave a stump of 5 cm above the ground level.

Drying and preparation:

The dry herb yield amounts to 7-8 tons per feddan. The alkaloid content is higher in plants growing in the desert than those growing in less arid regions.

The plant exhibits good growth in light soils and the alkaloid content is higher under limited water supply.

The plant is a water-economic desert plant.

Cultivation:

The plant is best cultivated by transplants. Seeds are sown in the nursery dur-

ing the period February-April or September-October. Transplanting starts 45 days after sowing. Transplants should be eight cm high and have at least three leaves. Cultivation in summer is preferred as the growth rate is higher with high temperature.

Rate of seeding:

For one feddan, 150 gm seeds are needed to be sown in the nursery. The seeds are minute, so this amount may produce almost 20,000 transplants.

5. SQUILL

Squill, Basal Faraon, Ishkil, Onsol

Urginea maritima (L.) Baker

[SYN: *Scilla maritima* L.-*Squilla maritime* Steinh.]

Family: Liliaceae

A bulbous plant with rosetted leaves. The broad, lanceolate leaves appear at the beginning of winter. They disappear by the advent of the dry season. Flowers appear in autumn. The plant is polymorphic with various varieties and forms.

The part used is the dried fleshy scales of the bulb collected after the withering of the leaves. The plant is an item of the Egyptian Pharmacopoeia (1984) and the British Pharmacopoeia (1988). Numerous pharmaceuticals are produced from the drug.

The bulb is used in folk medicine in many countries of the region. The plant is usually cultivated along the field borders as a marker.

Bulbous plants, autumn flowering, with rosetted leaves appearing after the flowers. The bulb is huge, frequently white, rarely red, growing in clumps of 40-70 together, each more than 10 cm across and weighing over 1 kg. Scape 1-1.5 m, densely beset with small flowers from the middle upwards. Flowers pink or white perianth segment free, spreading in star-shape. Capsule ellipsoid, 3-angled, seeds several, flattened, with a shiny brownish - black to black testa.

The white bulbed variety is the official one. The dried bulb slices are the needed drug from which extracts or active constituents are prepared.

Distribution:

Mediterranean Europe (Portugal, Spain, S. France, Italy, Malta, Yugoslavia, Albania, Greece), Cyprus, Syria, Lebanon, Palestine, Israel, Egypt, Turkey, S. Iran, North Africa, (Morocco, Algeria, Tunisia, Libya and Canary islands).

Active constituents:

Cardenolides: Scillarin A and Scillarin B; mucilage,sinistrin and xanthoscillide.

Uses:

The plant was recognized since ancient times, and used medicinally by the ancient Assyrians, the Sumerians, the ancient Egyptians and the ancient Greeks. It is one of the oldest recorded medicinal plants.

The active principles of white squill are used in the treatment of heart diseases. The cardiac glycosides contained in the bulbs (Scillarin A & B) are the effective constituents. It is used also in the preparation of cough mixtures, and as a diuretic; in strong doses it is used as emetic. In folk medicine, the fresh slimy bulbs are applied to wounds and tumors to hasten healing, used as an expectorant in bronchitis, chronic catarrh and pneumonia. Fresh bulbs are vesicant, rubefacient, anthelmintic, useful for rheumatism, oedema and gout; its cardiac action is like that of digitalis, slowing down the pulse and increasing its strength.

6. CAPER
LASAF

Capparis spinosa L.
Family: Capparaceae, Capparidaceae

Capparis spinosa, a wild and cultivated bush which grows mainly in the Mediterranean countries. Caper bush is grown commercially for the flower buds (capers); used as a condiment in salads and sauces or in the manufacture of cosmetics and medicines.

Capers probably originated from dry regions in west or central Asia. Their origins trace back over 7500 years to prehistoric roots in what is now Iraq. Known and used for millennia, capers were mentioned by Dioscorides as being a marketable product of the ancient Greeks. Capers are also mentioned by the Roman scholar, Pliny the Elder.

As early as the first century A.D., the Greek physician Dioscorides explained the medicinal properties and use of capers in his treatise "The Medicinal Use of Capers". Cleopatra had dishes spiced with capers served to Caesar.

Morphological Features:

The plant is a sprawling or ascending much-branched shrub, when isolated c. 20-75 cm high and up to c. 2 m across, with a stout, woody, thickened rootstock, much branched, and robust or sometimes more slender and graceful. Flowers white or tinged mauve or pink, solitary produced at intervals along the stem in the axils of the upper leaves; pedicels stout to rather slender, 2-4 (-5.5)cm. Fruit oblong-ovoid to ovoid-pyriform, usually rather abruptly narrowed below, c. 1.2- 4 × 1.3-2.5 cm, epicarp rather leathery, distinctly 5-6-ribbed, splitting open at maturity to reveal a pale or reddish pulp.

Flowering: March to June. Each flower lasts for one day.

Ecology:

Capparis spinosa grows spontaneously in cracks and crevices of rocks and stone walls. Plants grow well in nutrient-poor, sharply-drained gravelly soils. Mature plants develop large extensive root systems that penetrate deeply into the earth. Capers are salt-tolerant and flourish along shores within sea-spray zones; especially var.inermis. They are also wind-tolerant. The caper's vegetative canopy covers soil surfaces, which helps to conserve soil water reserves.

Capparis spinosa is a slow growing perennial shrub. It is cultivated for production of capers. Dry heat and intense sunlight are the preferred environment. Plants are productive in zones having only 200 mm annual precipitation (falling mostly in winter and spring months) and easily survive summertime temperatures higher than 40°C (105° F). However, caper is a cold tender plant and has a temperature hardiness range similar to the olive tree (-8°C, 18°F.)

Geographical Distribution:

All North African countries, Arabia (Jordan, Palestine, Saudi Arabia, Qatar, United Arab Emirates, Bahrain, Kuwait, Yemen, Oman), the Levant, Mediterranean countries, Iraq, Turkey, and Iran.

Area of the Species:

Mediterranean region, West and Central Asia to Afghanistan and India. In Africa, from the Mediterranean region till Central Sahara.

The plant is cultivated in many countries, e.g. in Morocco.

Constituents:

The crude extract of the flower buds contain numerous volatile constituents of which isothiocyanates, thiocyanates, sulphides and their oxidative products have been identified as the major components.

The root contains glucobrassicin, neoglucobrassicin and 4-methoxy-glucobrassicin. The root bark contains stachydrine, rutic acid and a volatile substance with garlic odor. The root bark and leaves contain stachydrine and 3-hydroxystachydrine.

The leaves and seeds contain glucocapparin and glucocleomin. The seeds are rich in protein, oil, and fiber and showed similar composition between them with a high content in unsaturated fatty acids, suggesting that they may be valuable for food uses. The main fatty acids identified by gas chromatography were palmitic, oleic and linoleic acids.

Capparis spinosa L. was found to contain the pharmacologically active compound rutin, in all aerial parts.

Traditional Uses:

Root diuretic, astringent, tonic. Root bark, which has a bitter taste, is used as appetizer, astringent, and tonic. It is also used to prevent diarrhea and to treat hemorrhoids. In a poultice or orally it is used in spleen disease. The bark is used for gout and rheumatism, expectorant, for chest diseases. Infusion of stems and root bark antidiarrheic, febrifuge.

Fresh fruits are used in sciatica, and dropsy. Dried and powdered fruit combined with honey is used in colds, rheumatism, gout, sciatica and backache. In decoction it is said to be efficient against gastric pain. Applied on the whole body this decoction is said to be good in epilepsy.

Seeds are used in feminine sterility and dysmenorrhea. Crushed seeds for ulcers, scrofula, and ganglions. Seeds are used in Morocco in a mixture of spices called Ras El Hanout which means the "head of the shop."

Flowers in a poultice are used in eczema. In the Sahara, the steam of the plant's decoction is said to clean eyes. In Sinai, Egypt, the steam is used for rheumatism.

Leaves are crushed and applied in a poultice on the front against headache, on the face against toothache. Leaves heated in butter are used against external parasitic disease of the camels.

The medicinal properties of the root have been widely known since ancient times and are still recognized by the Bedouin in the region. A decoction of the root taken orally is reputed as an alleviant for rheumatism.

Capers of commerce are immature flower buds from *Capparis spinosa* L. which have been pickled in vinegar or preserved in granular salt. These are grown principally in Europe. They have a sharp piquant flavor and add pungency, and saltiness to comestibles such as pizza, fish, meats and salads. The flavor of caper may be described as being similar to that of mustard and black pepper. In fact, the caper strong flavor comes from mustard oil: methyl isothiocyanate (released from glucocapparin molecules) arising from crushed plant tissues.

Semi-mature fruits (caper berries) and young shoots with small leaves may also be pickled for use as a condiment. Caper berries are edible, piquant delicacies processed like the buds.

The plant is grazed by camels, donkeys, sheep and other animals in the desert; the ripe fruit is often eaten by the people. The flower buds are used as a condiment; and other parts, such as the flowers, fruits and young branch shoots are widely preserved as a domestic pickle.

7. HOLY THISTLE- MILK THISTLE
QORTOM- HARSHAF BARRY

Sylibum marianum (L.) Gaertn.
[SYN: *Carduus marianus* L.]
Family: Compositae

Morphological Description:

Biennial or annual thistle, stout herb, up to 2 m high, almost glabrous. Stem, striate, branched. Leaves with spiny margins and characteristic which veins and spots. Basal leaves, very large, petiolate, forming rosettes, pinnatifid. Upper leaves, sessile, clasping, auriculate. Heads, large with spiny involucral bracts. Flowers, purple or white. Achenes have yellowish pappus. The fruit is about 6.7 mm long, ca 3 mm wide, and ca 1.5 mm thick

Distribution:

All North African countries, Central and Southern Europe, Southern Russia, Asia Minor, North and South America, South Australia.

Parts Used:

The fruits without pappus.

Folk Medicinal Uses:

Herb bitter appetizer, tonic, febrifuge, resolvent, antimalarial, emmenagogue and in disorders of uterus and spleen. Tincture from seeds used for liver disorders, jaundice, gall stones, peritonitis, cough, bronchitis, congestion of uterus and varicose veins.

Pharmacopoeias:

Deutsches Arzneibuch 10.1991.

Economic Potential:

The plant is and will continue to be of high economic potential for the widespread use of its flavolignans as antihepatoxic agents. Trials for cultivating the plant in farms in the Delta have been undertaken. Pilot experiments for the use of the fruits and the herb were done in some Egyptian pharmaceutical companies.

Cultivation:

The plant can easily be cultivated in the delta with achenes collected from the common wild plants along the canals.

8. ALOE

الصبار

Aloe ferox Miller and *Aloe Vera* L.
[*Aloe ferox* Miller, SYN: *Bachydendron ferox* Humb. et Bonplc.
Aloe vera L., SYN: *Aloe barbadensis* Mill., *Aloe vulgaris* Lamk., *Aloe indica* Royle]

The genus *Aloe* comprises numerous species; many of them grow wild in South Arabia, East and South Africa and Socotra.

Aloe vera is one of the ten herbs unique in composition. The gel and the dried juice produced by the leaves have been used medically for centuries. *Aloe vera* is nearly stemless with inflorescence in clusters pressed close to a stem of 50 cm, small yellow flowers of 20-25 mm.

Aloe ferox is a shrub with a single stem of 10-15 cm in diameter and 3-4 m in height, crowned by a large rosette of numerous leaves which are sea milkwort green, oval lanceolate, of 30-40 cm by 10-12 cm, thorny on the ridge and the edges. Inflorescence in cluster of 60 cm in height.

Simple or with ramifications; flowers with perianth of 2.5 cm tinged with yellow and purplish-blue, striped with red and green.

The Drug:

Aloe is a solid residue obtained by evaporating the liquid which drains from the cut leaves of *Aloe ferox* Miller and its hybrids, known in commerce as Cape Aloe, or of *A. vera* known in commerce as Curacao Aloes, or of *A. perryi* Baker, known in commerce as Socotrine of Zanzibar Aloes. It has a characteristic and disagreeable taste, bitter or faintly sour.

B- DESERT FORAGE PLANTS

Panicum turgidum Forssk.

THUMAM ثمام

Family: Gramineae

The genus *Panicum* comprises many species; the most important for dry lands is the desert grass *Panicum turgidum***.**

This desert grass grows in dense bushes up to 1 m high or more. Culms are woody and densely branched, with clusters of brown, dense leaf - sheaths at the swollen roots. Rootlets are often covered with a sheath of sand and thus have a corky appearance. Inflorescence has spreading branches carrying a small number of spikelets.

The plant is widespread in the deserts of the region. It is abundant in sandy and even stony desert areas. It flowers in late spring. Due to overgrazing in many localities, the plant becomes stunted and the soil collected by it is eroded. In many cases, overgrazing prevents the plant from flowering and setting fruits.

Distribution:

It is widely distributed in the deserts of the Middle East and North Africa. It dominates a widespread community in many areas.

Characteristics and Uses:

This tufted desert grass is a much prized fodder for camels and other animals. It is eaten by all animals when green and by camels and donkeys even when dry. It has been considered one of the summer fodders in desert regions.

In the Sahara, where the grass grows on dunes, the grain is reported to be collected and used like millet for human consumption.

The plant is drought resistant and its germination is usually stimulated by high temperature. It flourishes at such high temperatures; it is a C4 plant with high optimum temperature for photosynthesis. It forms sizeable mounds around its vegetative growth and serves as a good sand binder and stabilizer.

Cultivation:

Five-month old seedlings can be used as transplants. In experiments, those seedlings were put in soil in December in the North coastal region of Egypt, namely Fuka. Survival and growth were excellent depending on natural rainfall and some runoff water.

Fifteen months later, the plants provided considerable cover. Each individual plant covered almost 1.73 sq m, with a fresh weight of 1950g and dry weight of 810g, while the water content was 1.41g/g dry weight (slightly over 40% dry matter). The average plant height was

114"2.5 cm and the survival rate was 95%.

The most favorable habitat for cultivation has the following characteristics:

a. Deep alluvial and fine-textured soil
b. Receiving runoff water in addition to the rainfall (the rainfall in that area is about 150 mm/year)

Another method for cultivation is the use of cut parts of the mature wild plants, i.e. parts of the vegetative growth with parts of the underground rhizomes. These could be planted in June under natural conditions with slight irrigation. After cuttings are established, they can be left without further care, except to protect them from grazing during the first year; low level grazing could be allowed in the summer of the second year. The sprouting and production of new branches and infloresences have been observed in some experiments.

One feddan cultivated with transplants or offsprings of *Panicum* and getting supplementary irrigation during the first year and once or twice in the summer every year, is expected to produce a 3000 to 4000 kg of green fodder, with a dry weight of 1200-1600 kg.

Cultivation of *Panicum turgidum* will give a good fodder supply with minimal water consumption and will protect the soil from erosion.

It is recommended that a belt of land around each farm be devoted to cultivation of *Panicum*. This will provide a good supply of green fodder during summer when supplies are usually short. The seepage of irrigation water will be sufficient for sustaining the life of this desert fodder.

Seeds and cuttings could be collected from naturally growing *Panicum*.

C- AGRO-FORESTRY

MULTIPURPOSE TREES

In arid lands, when there are trees, there is always life.
When the climate makes agriculture difficult, the tree is there to help the farmer

Considering Agro-forestry in arid and semi-arid lands, one can distinguish different objectives:

a) Use of multipurpose trees and shrubs on cultivated land: *Ziziphus spina-christi* and other *Ziziphus* species, *Acacia tortilis*, *A. raddiana*, *A. senegal* and other *Acacia* spp., and *Balanites aegyptiaca*. Trees and shrubs for grazing are important in arid and semi-arid lands.
b) Use of woody perennials to protect crops from the effect of wind: *Eucalyptus camaldulensis*, *Casuarina* cf. *equisetifolia*, *Feidherbia albida*, *Balanites aegyptiaca*, *Acacia tortrilis*, *Ziziphus spina-christi*, *A. niltica*, *A. Senegal*, *Azadirachta indica*, *Tamarix* spp., *Prosopis* spp.
c) Use of trees and shrubs specifically for producing firewood: *Faidherbia albida*, *Acacia seyal*, *A. raddiana*, etc.
d) Use of woody plants for sand fixation: e.g. *Leptadenia pyrotechnica*, *Acacia tortilis*, *Salvadora persica*, and *Retama raetam*.

The choice of woody species depends on several factors:

- where they are placed
- the way they are managed
- the main purposes that they are required to fulfill within the system

The quality of a woody perennial used for windbreaks is:

- Adaptability to the local soil
- Drought resistance
- Tolerance of salinity
- Resistance to wind, browsing, pests and diseases
- Ease of planting
- Regular habit
- Rapid growth
- Leaf retention for maximum period
- Little development of creeping roots
- Production of wood, forage, fruits, etc.

Examples of trees cultivated in dry lands:

Acacia albida, *Faidherbia albida*, *A. nilotica*, *A. raddiana*, *A. seyal*, *A. tortilis*, *A. senregal*, *Balanites aegyptiaca*, Desert date tree, *Egyptian myrobolan*, *Cassia* spp., *Causuarina equisetiflia*, *Eucalyptus camaldlensis camal*, *Faidherbia albida* (Del.) *A. Chev. (kadd-haraz-gao-balanzan)*, *Phoenix dactylifera* L., *Prosopis juliflora* (Sw.) DC and other species, *Retama raetam* Webb., *retam*, *Salvadora persica* L. arak, *Tamarix* spp., *Ziziphus spina-christi* (L.) Desf. Jojoba tree, Christ thorn, *Z. mauritiana* Lam. Jojoba tree.

The advantages of browse plants over grasses for forage can be summarized as follows:

- because of their generally deeper and more spreading root systems, woody perennial plants are better able to exploit the poor water resources in the soil and to withstand one or more droughts
- a good number of woody plants form their leaves before the rainy season and if they are palatable help bridge the lean time at the end of the dry season, when the grass cover has disappeared or has very little nutritional value
- certain parts of woody plants are significantly richer in proteins than are grasses, especially in dry season, to such an extent that without woody plants it is likely that many animals would not survive
- the plants create protected microclimates in which evapotranspiration is reduced, enabling grass to grow around them

In addition to these forage advantages, woody perennials have other remarkable qualities: they help to reduce wind speeds, they break the monotony of the landscape and create landmarks, and they protect soil against erosion.

Compared to other production systems, agro-forestry systems present to varying degrees a certain number of advantages:

- They contribute to the supply of firewood better than monocropping, (except for certain types of tree monocropping)
- Thanks to their deep roots, woody perennials are less affected than herbaceous plants by temporary water deficit, and hence agro-forestry systems make it possible to increase directly (for example, *Faidherbia albida*/millet) or indirectly (for example, woody shrub windbreaks or browse/grazing trees) the production of food, both in quality and quantity, notably by greater product diversity
- Through this product diversification, they often also contribute to increased stability in the food supply
- Their effect on the environment is positive and lasting; they contribute to the maintenance and fertility of soils, to reducing wind speeds, to creating micro-climates favorable to crops and to load capacity
- Woody perennials in agro-forestry systems are chosen not only because they give wood but they can also provide

many other products such as forage, fruits, cordage, tannin, flowers, medicines, dyes, etc.
- By intensification of balanced soil utilization, with fertility preservation, agro-forestry systems contribute to the improvement of economic and social conditions in rural areas, not only by increasing profitability, sustainability and crop security, but also by creating jobs
- Agro-forestry systems encourage cultural exchange by combining traditional experiences with advanced technologies and by researching modern solutions that are compatible with the socio-cultural customs of the populations concerned

MULTIPURPOSE TREES

1. **Forage and sand fixation:** *Arak, Prosopis*
2. **Windbreak, fodder, and soil fertility:** *Acacia*
3. **Food, forage, fuelwood, windbreak:** *Argania*, *Balanites*, *Ziziphus*
4. **Sand binder:** *Retama*, *Tamarix*
5. **Sand binder and windbreaks:** *Eucalyptus*, *Casuarina*, *Tamarix*

1. FORAGE AND SAND FIXATION

1.1 Tooth Brush Shrub

ARAK-MISWAK TREE شجرة المسواك–آراك

***Salvador persica* L.**
Family: Salvadoraceae

Shrub with white branchlets and opposite pale green, coriaceous, oblong leaves. Flowers minute, in a rich terminal panicle. Fruit a small green drupe, turning pale purplish, globose, of pungent taste.

The plant is grazed by camels and the stolons are used as tooth brushes. It usually grows in extensive dense thickets of about man's height or more. The plant is palatable and is a good sand binder. It has some ecotypes which are salt tolerant. Thousands of hectares are cultivated with this plant in the United Arab Emirates (Abu Dhabi) using drip irrigation with water having more than 5,000 ppm. The plant can be propagated by seeds or cuttings.

1.2 *Prosopis jiliflora*

Family: Leguminosae

Prosopis juliflora is a very good sand stabilizer and can tolerate great heat and poor and saline soils; it can survive on 150-700 mm precipitation a year. The fruits are edible. They contain up to 27% glucose and 17% protein. The leaves are eaten by animals, except those varieties with high tannin content.

The wood is excellent for burning. Root and allelopathy would prejudice the growth of grass cover; therefore it should be used with caution in agro-forestry.

2. WINDBREAK, FODDER, AND SOIL FERTILITY

2.1 Acacia

SAMAR-SANT-SYAL سمر–سنط–سيال

***Acacia* spp.**

(Family: Leguminosae)

There are numerous desert species of Acacia growing in various parts of the region. Being a Sudanese tropical element, *Acacia* spp. is not frequently observed in the Mediterranean region.

Wild desert *Acacia* species are cut for fuel-wood. In addition to the desert conditions which represent a main constraint to tree growth, cutting contributed to the elimination of the plant from numerous areas.

The cultivation of Acacia trees in dry land is useful, at least to compensate the already cut trees. These trees can provide a wind break and a good source for fuel-wood. The leaves and fruits of all species are palatable. There are many economic uses for this tree. Also, being a leguminous plant, it contributes to enriching the soil with nitrogen.

The most common wild Acacia species in the deserts of the region include: *Acacia raddiana* Savi (*Acacia trotilis* spp. *raddiana* (Savi) Brenan). It is a tall tree, ca 6-8 m, with round irregular crown. Stipules spiny; leaves compound. Flowers in heads; fruits are contorted or spirally twisted, flat.

The seeds can be collected from the relatively dense population of this species growing in desert wadis. Problems in germination may be ascribed to the attack of the seeds by insects and/or hard impervious seed testa. The latter case could be abolished by simple treatment, e.g. scarification or acid treatment.

There is a great need to establish nurseries for this plant. Seeds can be collected in summer and sown in October or November; seedlings are transplanted to the field, when they reach considerable size, using some irrigation. It is preferable to perform transplantation in February, so the natural rainfall will help in establishing a considerable row of Acacia trees around the farm.

It is noted *Acacia raddiana* grows naturally in areas with rainfall of ca 30 mm and even less. But one should take into consideration that it grows only in sites receiving considerable runoff water. This redistribution of water resources due to differences in local topography is a major factor affecting the growth of desert plants in wadis and depressions. One expects that areas with runoff 10 times the recorded rainfall would sustain a good stand of Acacia trees, i.e. about 300 mm/year.

3. FOOD, FORAGE, FUELWOOD, WINDBREAK

3.1 Argan, Argan Tree

أرجان

LOUZ EL BERBER لوز البربر

***Argania spinosa* (L.) Skeels**

Family: Sapotaceae

Argania spinosa (L.) Skeels is a very unusual thorny tree almost exclusively native to the geographical area of south-west Morocco. The Argan tree is unusual even within its own plant family. Within the 1100 or so *Sapotaceae* species, Argan is not only an arid zone plant in contrast to the other *Sapotaceae* species which are trees and shrubs of the wet tropics, but it is also the only species occurring north of the Sahara desert. The tree probably originated in Argana, a village north-east of Agadir. It lives longer than the olive and requires no cultivation.

The Argan tree, is the next big hope for the forests of Morocco. This tree covers an area of 820,000 hectares in southwestern Morocco. The forests of Argan support more than three million inhabitants, by providing them with wood for heating, feed for livestock, and edible oil for cooking, cosmetic and medicinal purposes. The forest also plays a major role in the fight against soil erosion and desertification.

Morphological description:

A thorny, evergreen tree with small, green, lanceolate leaves. It can reach heights of up to ten meters and lives approximately 150-200 years. The fruit is green and fleshy like an olive, but is larger and rounder. Inside, there is a nut with an extremely hard shell, which in turn contains one, two or three almond-shaped kernels. A thin, fleshy and hard to peel layer surrounds the nut. The fruits of the Argan can take up to one year to ripen. The seeds contain a valuable edible oil rich in essential fatty acids.

Propagation:

Primarily and easily by seed.

Geographical distribution

Morocco and Algeria

Constituants:

Argan oil is a deep golden color, often with a reddish tinge. It is lighter in weight than nut and olive oil, having a weight and body similar to seed oils like sesame or pumpkin.

Folk medicine and indigenous knowledge:

In folk medicine, Argan oil is highly regarded for its reinvigorating effects and as an aphrodisiac. Moroccan women have been using it for centuries to prevent the skin from drying out. Argan oil is also used to treat acne, skin allergies, chicken pox and burns. It is used to treat hair and give it strength and shine.

The skin protecting properties are used in the local treatment of skin problems and in dermatological creams and medicines. Internationally, there is some interest in its possible cosmetic uses.

The wood is for construction and heating ovens or water for bathing.

The leaves serve as feed for goats and camels.

The exterior pulp of the Argan fruit is removed during the processing of seeds and is given to animals as feed. The broken shell is also used as fuel.

Most importantly, the seeds are pressed to produce an oil that has culinary, cosmetic and medicinal properties.

Production:

The Argan tree bears fruit according to its age, the density of the tree population, the environment, and the amount of rainfall. One hectare of Argan trees can produce 800 kilos of ripe fruit, which will later yield 40 kilos of nuts or about 18 liters of oil.

Harvesting:

Fruits may be collected by hand or by goats. In the latter, the trunk of the Argan tree is often twisted and gnarled, allowing goats to clamber along its branches and feed on the leaves and fruits. When goats eat the fruits, the fleshy part is digested but the nuts, because of their hard shell, are excreted during rumination. The nuts are then collected by farmers.

3.2 Egyptian Balsam, Myrobalan

HEGLIG هجليج

***Balanites aegyptiaca* (L.) Del.**

Family: Balanitaceae, Zygophyllaceae

The Balsam tree is drought and fire resistant and withstands up to two months flooding in areas near the river. In the Sudan, *Balanites* was formerly protected by law as well as by the local inhabitants who believe that *Balanites* trees bring the rains. This belief has given protection to the tree even in mechanized crop production schemes where all tree species were cleared for farming purposes.

Balanites aegyptiaca is an evergreen thorny shrub or tree with alternate compound leaves, each composed of two leaflets. Branches are yellow-green. It sheds leaves heavily during the dry season. Flowers small, green 5-fid in axillary corymb. Fruit an edible drupe of about plum size, green, turning yellow when ripe.

This tree grows in the Sudan, North African countries and South Arabia. It is a Sudanese-Sahelian tree. It grows mainly on clay soils under rainfall of 500 mm. However, it occurs on sandy soils with rainfall of 250 mm. *Balanites aegyptiaca* is a multipurpose tree. The tree produces edible fruits and provides good shade in the desert; it produces timber and fuel-wood. The fruit is used for numerous purposes in folk medicine. The kernel extracts have low activity against the snail that harbors schistosomal worms. Fruit kernels and fruits are mild laxatives; the fruit is considered to be an antidote to arrow poison. Leaf cleans malignant wounds; bark fumigant heals circumcision wound; root extract is used for malaria.

In the Sudan, the fruit is edible and the seeds are crushed to produce oil for cooking. Both the fruit and the oil are used for medicinal purposes. The kernel (10%) contains 40%-58% of liquid glyceride oil. The mesocarp contains 38% sugars, 15% organic acids and 46% other organic substances. In Uganda the seed yield kernels 48.8% of golden yellow oil for soap-making.

It is recommended that seeds be sown in a nursery. The transplants could be spread in the fields along canals, new settlements, etc. The tree provides good shade and is drought tolerant.

The studies on seed germination

proved that the best treatment for *Balanites* seeds is hand scarification, followed by acid treatment and then soaking in tepid water. However, for practical purposes soaking of seeds in tepid water for 72 hours can be adopted at less cost than other treatments.

The previous studies showed that sowing of whole fruits inhibits germination while sowing of seeds with pulp delays it. Positioning of seeds at sowing has an influence on emergence; horizontal positioning at sowing proved to be best compared to vertical position with embryo placed either upward or downward. It is therefore recommended to clean seeds, treat by soaking in tepid water for 72 hours and sow in horizontal position.

As for vegetative propagation of *Balanites aegyptiaca*, winter hardwood cutting proved to be better than autumn and summer cutting.

3.3 Christ's Thorn

NABQ TREE, SIDR السدر–شجرة النبق

Ziziphus spina-christi (L.) Wild.
Family: Rhamnaceae

This tree is usually armed with spines (var. *divericatus*) in the wild, but is unarmed in the cultivated variety (var. *rectus*). Leaves oblong elliptic, with three conspicuous nerves. Fruit globose, 1.3-1.8 cm diameter, yellow. The fruit is edible. The plant is a desert tree, which has been cut for fuelwood in many places or disappeared due to changes in its habitat.

In some countries, e.g. India, Oman and other Gulf states, varieties which have been improved for yield and fruit quality are grafted on the wild species and provide a reasonable cash crop from land which is otherwise unsuitable for cultivation. Popularizing the growing of ber, or jojoba trees (*Zizphus mauritiana*) has been wide spreading in the arid zones. The hardy, extremely drought tolerant species of *Zizphus* which are a component of the natural vegetation of the desert are used as rootstock to be grafted with *Z. mauritiana* which gives oblong fruits bigger than the round small ones of *Z. spina-christi*.

4. SAND BINDER

4.1 Retem, Desert Broom

Retama raetam (Forssk.) Webb. & Berthel.
[SYN: *Genista raetam* Forssk., *Retama duiraei* (Spach) Webb., *Lygos raetam* (Forssk.) Heywood]
Family: Leguminosae

A leafless desert shrub with long varigated whip-like branches. Flowers white. Fruits one-seeded, seeds brown to black. The plant is common in the deserts of the region, especially deserts north of the Tropic of Cancer as well as the Mediterranean countries.

4.2 Tamarisk

TARFA-ATHL طرفاء–أثل

Tamarix spp.
Family: Tamaricaceae

Trees or tall shrubs with very small scale like leaves and white or pink flower in spike like racemes each supported by a small bract; seeds with a tuft of hairs at the tip.

The genus *Tamarix* comprises numerous species. Among these, the following are important: *T. aphylla* (L.) Karst L. (= *T. orientalis* Forssk.), *T. articulate* (Vahl.); *T. tetragyna* Ehrenb., *T. nilotica* (Ehrenb.) Bge and *T. amplexicaulis* Del. ex Desv.

In general, tamarisks are quick growing, deep rooted, drought resistant and tolerant. They provide shade and their wood is used for fire and as a source of charcoal. They are useful as windbreaks, especially *T. aphylla*, which may be 15 m high or more.

The plant is cultivated by long cuttings. This practice has been very successful in the countries of the Arab region. It has been used for dune fixation, e.g. in Al-Hasa, Saudi Arabia.

It is suggested that the plant is used in saline areas which cannot be used for conventional agriculture.

It is to be noted that the different species have different temperature requirement; hence the choice of the species to be cultivated should have temperature requirement available in the site to be cultivated with *Tamarix*.

5. SAND BINDER AND WINDBREAKS

5.1 Camal
Kafour, Keena

Eucalyptus camaldulensis Denhardt
Family: Myrtaceae

This is a well-known species. It has been cultivated all over the region under different environmental conditions

5.2 Casuarina, Filao

Casuarina equisetifolia Forssk.
Family: Casuarinaceae

This is a well-known species. It has been cultivated all over the region under different environmental conditions

5.3 Tamarisk

TARFA-ATHL أثل–طرفاء

Tamarix spp.
Family: Tamaricaceae

see above

D- FIBER PLANTS

1. AGAVE, SISAL

Agave sisilana Perrine
Family: Agavaceae, Amaryllidaceae

The plant has multiple uses. The fibres are of economic value and the juice is medicinally valuable. The cultivation of Agave will create employment opportunities and small industries will be established, e.g. cutting, extraction, fiber weaving etc.

Perennial plant with short stem, numerous leaves (in rosette) which are thick, fleshy, thorny and which can reach two m in height and 15 cm in width; inflorescence in panicles at the apex of a hardy and long central stem of 3 to 8 m; greenish-yellow flowers which rarely develop into capsular fruits and into seeds, but produce a lot of plantlets that ensure the fast propagation.

Part Used:

Leaf for fibres or leaf waste (sludge) for medicine, stripped from the leaves during the removal of the fibres.

The Drug:

The leaf has no odor, but has a slightly bitter mucilaginous taste. Sludge is the juice of the leaf concentrate, which is allowed to ferment for several days, then steamed at high pressure to complete the hydrolysis and liberation of hecogenin, by filtration and drying. Sludge contains not less than 2 per cent w/w hecogenin.

Constituents:

Steroidal sapogenins (e.g: hecogenin, sisalagenin, tigogenin, neotigogenin, etc.), also mucilage, pectins and reducing sugars.

Appendix 6.2 Protected cultivation in some countries in the CWANA region

Gulf area:

The most important resource in the region is the radiation both in day length and light intensity. This is advantageous for photosynthesis, soil disinfection and passive heating. It may also be important for enhanced ventilation by creating a hot front that induces a chimney effect and improves air circulation. The plastic houses in this region are used for the winter production of vegetables, the reason being that high relative humidity values reduce evaporative cooling efficiency. The second reason is that summer production utilizes more water, which is a major concern in these local conditions. Finally, the market competition from Europe and the Mediterranean for summer production is high.

The introduction of greenhouse activities was as early as the sixties in the Gulf area. Protected cultivation area has increased substantially during the last decades. The increase in protected cultivation area during the last ten years was as much as 95% in some of the Arab countries like Syria and Egypt. The types of protected cultivations varied from low plastic tunnels to sophisticated glass houses with heating and cooling capabilities. The most common house type is the plastic tunnel covered with polyethylene sheets of 200 micron. As for the low plastic tunnels, it is a simple structure of metal covered with untreated plastic of 60 microns.

The cost of plastic houses varies from one country to the other and the average cost is about 13 dollars per square meter. Climate modification of greenhouses varies much upon the needs of different countries. The special requirements of the Arab Peninsula countries are generally related to the high temperature and, in many cases, the high relative humidity which reduce the potential of using the evaporative cooling system.

Irrigation systems in the greenhouses are mainly localized and pressurized systems such as drip or trickle irrigation, low-pressure sprinklers and mist irrigation.

Most of the countries use soil cultivation techniques, while in other cases soil less culture and hydroponic systems were introduced on commercial basis. The soil and soilless culture practices are related to the quality and availability of irrigation water.

As for the protected crops, the main crops are vegetables such as tomato, pepper, cucumber, cantaloupe, green beans, squash, eggplant, watermelon and strawberry. Some ornamentals are cultivated in many countries but on a rather limited scale. The productivity of the crops vary a lot from one country to the other and depend on the cultivation technique and the infrastructure used for production. Some crops are produced according to international standards in terms of yields while other crops are below the international average.

The inputs of protected cultivations are largely dependant on imported materials such as seeds, fertilizers, pest and disease control chemicals and soil disinfection chemicals which pose constraints on the economics of production.
The production of high quality fruits that can compete on the international markets can be improved in the future.

Oman:

The work in the net houses and the plastic houses in the nursery established

in the royal farms sets the example for the successful protected cultivation business under local conditions. The successful propagation unit for fruit trees and ornamentals indicated a viable utilization of protected cultivation. Through the experience gained in this operation, several valuable observations were noticed related to protected cultivation practices. The cooling system was successfully used with the double layer plastic houses. The main condition for proper insulation is to allow at least 20 cm of blown air between the two plastic layers. This can be done by stretching the inner layer of plastic and leaving the outer sheet a little loose to allow air to inflate the space without damaging the plastic.

The cultivation of pineapple in plastic houses is successful. This plant requires a hot and humid climate. Some valuable information was observed on the propagation and growing conditions of pineapple. Observations on pests and diseases of such crop under local conditions in relation to climatic factors were made and could be adapted to other crops.

Oman is one of the countries that can develop a very promising business in protected cultivation. Looking at the thousands of kilometers covered with seasonal streams of wadi waters that sink to the gulf, the potentials for hydroponic systems are very high. Low cost water tanks can be designed to harvest huge amounts of fresh water that can be utilized in recirculated hydroponic systems. The same idea could be applied at the ends of Aflaj, where the water could be collected in reservoir instead of run off to the gulf. This water could then be utilized in hydroponic system of production.

Qatar:

Several greenhouse farms of different scales are in business in Qatar. Some of the farms use sand-bags to avoid the soil diseases and nutritional complication. The cost of sand-bags versus the cost of hydroponic systems should be considered and carefully estimated. A problem of salinity of the sand media was noticed and some attempts were made to wash the sand. Even in large companies, with the high infrastructure cost, the irrigation water is applied according to "experience". Plants of different ages show different symptoms of water imbalance. Technology transfer is badly needed to improve cultivation conditions and allow better utilization of the greenhouse farms in this area.

Bahrain:

A leading effort to improve house microclimate was done in Bahrain. It is possible to improve the growth conditions by improving the ventilation through some modification of the structure to allow proper side and top ventilation that provide at least 20% of the plastic area. The concept of ecological agriculture may be useful under such conditions. The use of appropriate varieties of specific crops may reduce the need for climate modifications. For example, pepper and cucumber crops tolerate the high temperature of the early summer better than tomato, therefore, growing pepper or cucumber may require less cooling and can do better with only good ventilation.

The use of solar energy is of great potential for soil disinfection. The past experience in this respect is quite promising. Water requirements and nutritional requirements are not practiced either on the governmental farms nor in the big plastic house farms. Many symptoms for water application inefficiency prevail even in very well-managed farms. Potential for improvements in this direction are evident. The use of pan evaporation or climatic stations for the calculation

of evapotranspiration is required. ICARDA's project for protected cultivation has installed automatic weather stations in several trial locations and the data can easily be accessed by several methods both locally and regionally using the Egyptian experience in this respect. The utilization of such data may not be limited only to water requirements, but it can also be extended to crop management, pest and disease forecast, resource management and agricultural damage forecast.

It is known that green bean plants are very sensitive to salinity. In spite of this fact, the farmers in Bahrain grow it successfully. This indicates that some facts of production can be altered substantially under specific microclimates and ecosystems. Further studies on this point may provide new scientific knowledge.

The importance of creating an efficient extension service for protected cultivation and demonstration site that can attract the attention of the growers was confirmed from both the visit to the successful farm and the visit to a small shop that sells the agricultural input. If the extension was left to the private sector it may involve the risk of misleading information to the growers to improve the sales.

United Arab Emirates:

One of the most impressive operations related to protected cultivation in UAE is the MIRAK Agricultural Services. The farm includes a protected (shaded) nursery and a large area of vegetables under low plastic tunnels. The operation is quite successful, and due to export its revenue is relatively high. The unit also contains a glass house to produce vegetable transplants. The farm is an example for the successful operations that utilize the local climatic condition for production that meets a significant market opportunity.

Kuwait:

Climate modification required for greenhouses is quite developed in Kuwait. The special conditions in Kuwait are generally related to the high temperature and in many cases the high relative humidity which reduces the potential of using the evaporative cooling system. It is also related to the water quality, which reduces the pad and fan cooling system efficiency substantially. Irrigation systems in greenhouses are mainly drip or trickle, low-pressure sprinklers and the mist. In Kuwait, soilless culture and hydroponic systems were introduced on a commercial basis. The soil and soilless culture practices are very much related to the availability and quality of irrigation water. Nevertheless, water requirements for different crops are not properly followed. A reliable and applicable system for estimating and monitoring water-use efficiency in greenhouses is needed. It is also recommended to critically examine the economics of the structures and crop rotation, in view of production cost and water use. The main protected crops are vegetables such as tomato, pepper, cucumber, cantaloupe, green beans, squash, eggplant, watermelon and strawberry. Ornamentals are also grown in Kuwait on a rather limited scale. Productivity of the crops varied a lot from one location to the other. Some growers can achieve international productivity levels. A large margin of improvement is still possible by improving the techniques of cultivation and greenhouse management through applied research. Inputs of protected cultivation are largely dependant on imports such as seeds, fertilizers, pest and disease control chemicals and soil disinfection chemicals which pose constraints on the economics of production.

Egypt:

The introduction of plasticulture in Egypt was started by the Ministry of Agriculture in 1965 through a research program subsidized by FAO followed by another project funded by the International Development Bank in 1979 to cover two hectares by plastic houses in Kaha Vegetable Research Station. During the aforementioned periods other work was going on the Faculty of Agriculture, Ain Shams University and Kafr El-Sheikh University.

As for 1995, 1996 the total covered area amounted about 18,200 hectares. The area devoted to mulching was about 1000 hectares, while it was 1200 hectares for plastic houses and 16,000 hectares for low tunnels. In 2000-2001 the total protected area was increased and reached 28,000 hectares. The area devoted to plastic-house, low tunnels and mulching were 2000, 25,000 and 1000 respectively. Vegetable production under low tunnels highly increased under Egyptian condition. It is used mainly for early production of cucumber, tomatoes, cantaloupe, sweet peppers, melons, strawberries and beans for local consumption and export. This is due to its simplicity in application and management, as well as to its low cost.

The total area cultivated under greenhouses in Egypt in 2000-2001 was about 2000 hectares, the dominant type was single plastic tunnel (8.5-9.0 × 59 × 3.25m) with a round arch shape that occupied about 990 hectares, while walk in tunnels (4-6 × 36 × 1.8m) covered an area of about 85 hectares. Increased portion of this is for double and multi span houses with side ventilation (16 × 31 × 3.40m). Multi-span, saw tooth (saw tooth width 6.1-7 × 3.66) inter spacing (95.16m maximum length) cover about five hectares and wooden house with different frame types cover 60 hectares.