Chapter 11
Date Palm Status and Perspective in Bahrain

Thuraya A. Almansoori, Mohammed A. Al-Khalifa, and Abdulaziz M.A. Mohamed

Abstract Throughout human history, the date palm (*Phoenix dactylifera* L.) has been an integral part of the rich heritage of the Kingdom of Bahrain. Dates have played a fundamental role in the economy and the social life of Bahrain's patrimony. However, the revolutionary changes that have accompanied the discovery of oil have had a massive impact on the cultivation of date palms. A number of factors have reduced interest in making investments in date palm cultivation; among them are socioeconomic changes, climatic conditions, limitation of freshwater, salinization of agricultural lands, and the spread of indigenous and invasive alien pest species. Over the last decades, the number of date palm trees has decreased from 892,000 to 534,600; those remaining are currently distributed over the five governorates of the Kingdom. In spite of the challenges, Bahrain is striving to care for date palms as a state symbol and national treasure. Ex situ germplasm gene banks, in vitro facilities, and quarantine regulations and legislations have been established for the date palm. Nevertheless, Bahrain's annual yield does not exceed 16,000 mt. Consequently, improving date palm industry is a necessity to emphasize that the date palm tree is a valuable asset that unites and integrates the variant parts of the ecosystem and keeps it intact as a stable, well-defined, and sustained entity. Long-term sustainable development demands modernization of the currently performed conventional practices of date palm care, harvesting and postharvesting processes, trading, and marketing, which have not risen to the standards required. In this regard, this chapter describes the current status of the date palm cultivation in Bahrain and the threats confronting the date palm conservation and industry development and aims to highlight potential resolutions and prospects.

T.A. Almansoori (✉)
Department of Biology, College of Science, University of Bahrain,
Box 32038, Sakhir, Kingdom of Bahrain
e-mail: talmansoori@uob.edu.bh

M.A. Al-Khalifa
Department of Agriculture Affairs, Ministry of Municipalities Affairs and Urban Planning,
Box 251, Budaiya, Kingdom of Bahrain
e-mail: shmohamedalkhalifa@gmail.com

A.M.A. Mohamed
Department of Life Sciences, Arabian Gulf University,
PO Box 26671, Manama, Kingdom of Bahrain
e-mail: amamohamed@agu.edu.bh

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11.1 Introduction

The existence of human settlement in Bahrain Island, which was historically dubbed as Dilmun, Tylos, or Awal, dates back more than 6,000 years as shown by archaeological evidence (Bibby 1972; Larsen 1983). An abundance of natural freshwater from surface wells and natural springs, along with its fertile land, made agriculture an important activity and form of income for the inhabitants of Bahrain at that time.

The agricultural areas of Bahrain are concentrated in the north and northwest coast of the island with isolated areas in the north, central, and along the east coast. These coastal areas boast good water quality and potential irrigation, along with numerous date palm plantations, which constitute the majority of the agricultural land in Bahrain (Al-Basheer and Haroon 1997; Al-Khalifa 2009; Doornkamp et al. 1980).

Date palm, *Phoenix dactylifera* L. (Arecales: Arecaceae), played a significant role within the culture of Bahrain's early Dilmun people. This is supported by many inscriptions and historic texts from ancient Sumaria, which reveal that date palms were utilized in Bahrain since the second millennium B.C. (Nesbitt 1993). The strategic location of Bahrain played a vital role of benefit to traders traveling between ancient Mesopotamia and the Indus Valley Civilizations which made it an ideal trade route stopover between both civilizations to acquire freshwater and dates for expeditions (Nesbitt 1993; Noor Al-Nabi 2012).

Bahrain was known for its vast date palm plantations throughout history. Date palm trees were grown not only for their nutritious fruits but in the pursuit of efficiency, every single part of the palm tree had a worthwhile purpose. Date palms were a fundamental source of life for Bahrainis. They relied on the palm trees in many and various aspects of living. For example, the trunk was used as timber for building structures and as well as for fuel; the leaves were exploited to construct traditional houses, locally known as *barusti*, in addition to fences for farms and chicken coops; and the leaflets were a source of natural material to weave mats, baskets, and hand fans. The leaf midribs (i.e., rachis) were utilized to assemble fish traps and bird cages; they made use of the leaf fibers as fuel and for weaving rope. The fruit spikelets were used to make hand brooms, baskets, and fish cages. Bahrain was and is still very well known for a customary and refreshing drink, which is extracted from the male spathes and pollen. Even the cull date fruits and seeds were used as cattle feed.

From an environmental standpoint, Bahrainis used date palm trees as shelter sanctuaries for birds. In addition to all of the above, currently date palm trees have become an important element of landscaping projects in Bahrain (Ahmed 1978; Al-Khalifa et al. 1994; Barreveld 1993).

Table 11.1 Estimated number of date palms in the governorates of the Kingdom of Bahrain 2010

Governorate	No. date palm trees
Capital	66,763
Muharraq	36,472
Central	113,110
Northern	253,110
Southern	65,145
Total	534,600

Source: Annual Agricultural Statistics Bulletin (2008)

At the beginning of the twentieth century, revolutionary changes of industrialization and rapid modernization accompanied with the discovery of oil inevitably cast their effects on the agriculture sector in general and on date palm cultivation in particular (Al-Rumaihi 1975). Trained workers abandoned date palm cultivations, and replacing them was challenging due to the reluctance of the youth to join that sector and the preference of the industrial sector, which lured them with the promise of a better income (Anon 2011). Additional and harmful effects derive from the modern economic boom, emergence of oil industries, accelerated urbanization, scarcity of freshwater, and increasing soil salinity. All these factors combined have greatly and negatively impacted the agricultural lands and their productivity (Al-Basheer and Harron 1997). As a result, the number of date palms decreased dramatically from 892,000 at the beginning of the 1970s to about 534,600 which are currently distributed over the five provinces of the Bahrain (Table 11.1).

With the current Bahrain government policy toward promoting interest in the agriculture sector, date palms have been receiving increasing and special attention. The government has established ex situ germplasm gene banks and in vitro facilities to conserve the local germplasm, as well as having issued quarantine regulations and legislations to protect date palms, which have and always will be considered the quintessential symbol and national treasure of the Kingdom of Bahrain.

This chapter aims to carefully describe the present status of date palm trees in Bahrain. Date palm cultivation practices, genetic resources, conservation efforts, tissue culture, cultivar identification and description, as well as date production and marketing situations will be discussed. Threats confronting date palm conservation and industry development and potential resolutions and prospects will be indicated.

11.2 Cultivation Practices

The total land area of the Kingdom of Bahrain is about 76,700 ha, of which the cultivable land is estimated to be 6,400 ha (i.e., 8.3 % of the total area). Currently only 3,516 ha, representing (55 %) of the arable land, are under cultivation. The cultivated area is distributed among three major crop plants: date palms (2,330 ha); vegetables, both in open field and protected agriculture (572 ha); and forages (614 ha).

Fig. 11.1 The agroecosystems of date palm in the Kingdom of Bahrain (Credited to PWD, Agric. Affairs). (**a**) Intercropping of the alfalfa between the date palm rows, (**b**) intercropping of leafy vegetables between the date palm rows, (**c**) date palms grown at the edges of the vegetable beds, and (**d**) date palms planted as a border between plastic houses and open vegetable beds in an open field

In old date palm plantations, growers tended to plant the palms close to each other and sometimes in uneven rows, making the use of agricultural machinery difficult. However, the agroecosystem existing today (Fig. 11.1) reveals that the current common practice relies on the intercropping of cash crops like forages, vegetables, and/or other fruit trees between the date palm rows. Agricultural land is divided into beds (2.5×6 m) with date palm offshoots planted in the middle or towards the edges of the beds, and the inner spaces are utilized to plant forages or vegetables. As for monocrop date palm plantations, the land is divided into rows with a space of 6–7 m in between, and the offshoots are planted in these rows at fixed intervals (Ahmed 1978; Al-Khalifa et al. 1994).

Proper date palm cultivation requires following several practices considered important to attain effective growth rate and fruit quality. These practices are performed by skilled farmers with extensive experience. Commonly performed practices (Al-Khalifa et al. 1994; Mohamed 2000) are summarized below.

11.2.1 Dethorning

The process of thorn or spine removal from the base and sides of the new leaves is known as dethorning (i.e., *tarwies*). This process is important to permit easier access to the spathes during pollination and the fruit bunches during harvest. In Bahrain, this practice has been frequently performed at the beginning of the season, which ranges from January to February, prior to pollination.

11.2.2 Pollination

In order to achieve adequate fertilization, date palm growers tend to implement artificial pollination (i.e., *tanbeet*), where they transfer male pollens to the female flowers once the male spathes has opened. Traditionally, as soon as pollen spathes are open, growers collect the male inflorescences and shake a bunch of them over the female inflorescences to release pollen. Then, the male inflorescence cluster is tied in the middle of the female flower bunch using a palm leaflet. The pollination period in Bahrain ranges from February to March.

An investigation was carried out to study the effect of liquid pollination on fruit quantity and quality. However, the statistical analysis revealed no significant variation when compared to the traditional methods in use (ICARDA 2011). Regardless, implementing this practice is highly recommended in Bahrain. In recent years and due to the lack of trained workers and increased wages, some of the growers began the liquid pollination technique, where the female flowers are sprayed with solution containing male pollen (1 g of pollen per liter of water) using either manual or mechanical sprayers. In this way, pollination can be accomplished without having to climb to the top of the tree. This process is performed after the spathes are fully opened, and the whole procedure is repeated three times, with a period of 3–7 days between applications, depending on the cultivar. This process has many advantages compared to the traditional method. In addition to being a quick and efficient procedure, it reduces the risk of climbing the tall trees, helps to overcome the scarcity of the skilled labor, and minimizes the overall cost of the pollination process.

11.2.3 Bending

The growers bend the fruit branches downwards (i.e., *tahdeer*) and tie them to the adjacent leaves. This practice is done to ensure that the fruit branches are secured and will not break in response to the wind and their own weight. This procedure has

the added benefit of allowing easier access to the fruits during the harvesting period. Bending is usually performed two months after pollination during April and May when the fruits are small and green at the kimri stage.

11.2.4 Thinning and Pruning

This process is executed to reduce the weight of the fruit bunch and give the fruits more space to grow larger in size. This process also increases aeration and minimizes damage caused by moisture accumulation. This process is achieved either by reducing the number of the fruits bunches per tree (i.e., *alkhaf*) or by reducing the size of the flower spikelets and hence reducing the number of the fruits per spikelet.

Growers tend to remove dry fruit spikelets, dry and damaged leaves, and any remaining petioles (i.e., *taghleeq*). This is usually done in December and January in preparation for the new season.

11.2.5 Harvesting

Date palm offshoots usually start bearing fruits 3 years after planting and reach maximum production at 10 years of age and continue bearing fruits for many years thereafter. In Bahrain, dates are harvested during khalal and rutab stages, which are usually consumed fresh. Due to the multiple cultivars, the harvest season begins in July and ends in November. With young date palms, hand picking is easy; however, as the tree grows older and taller, the harvesting process gets more laborious and time consuming. Since not all of the fruits ripen at the same time, but rather in stages, skilled labors need to climb the palm to reach the crown to harvest the ripe fruits several times per season to avoid yield loss. If this has not been accomplished and the ripe fruits are not harvested in time, they may become infested or ruined by pests such as birds, insects, and rodents, which reduce their market value drastically. For that reason, harvesting is accomplished in several stages that coincide with the maturity of the fruits. This makes the process costly and dangerous, especially if the palms are old and tall.

11.2.6 Pest and Disease Control

In addition to abiotic stresses, date palms in Bahrain are susceptible to biotic stress caused by pests of both indigenous and invasive species that can cause severe damages if left uncontrolled. Pest control measures have not received proper attention from growers. However, the government has taken effective steps to help in

combating date palm pests through an Integrated Pest Management (IPM) program implemented by the Plant Wealth Directorate, Agricultural Affairs, and Ministry of Municipalities Affairs and Urban Planning. Other commitments comprise enforcing the implementation of plant quarantine regulations, providing growers with the service of pesticide sprays at low cost, providing technical advice to individual growers for insect identification and control, and conducting surveys of the indigenous and invasive pest species.

A number of date palm pests are recognized locally; however, the burgeoning international trade and the ease of movement of large numbers of people across borders have escalated the problem of unintentional introduction of new invasive species. The introduced species of concern are the red palm weevil *Rhynchophorus ferrugineus*; the rhinoceros beetle, *Oryctes* sp., (*Coleoptera*: *Scarabaeidae*); the inflorescence beetle, *Macrocoma* sp. (*Coleoptera*: *Chrysomelidae*); and the scale insect, *Fiorinia phoenicis* Balachowsky (*Homoptera*: *Diaspididae*), which have all been accidentally introduced into one or more of the Gulf Cooperation Council (GCC) countries (Gassouma 2004) and require considerable efforts to manage and control. The risk from such introductions is extremely high with some have already begun to threaten the existence of the date palms (Mohamed 2010).

Reducing the risk of introducing and spreading of other invasive species is one of the most important steps of quarantine regulations (i.e., legislative control) (Horn 1988). To prevent and slow down the introduction of date palm pests, the government of Bahrain has taken several initiatives to strengthen plant quarantine regulations and services. As a consequence, a number of laws and ministerial resolutions were issued regarding date palm protections, which require continuous political support to enforce their observance to ensure date palm protection and sustainability. The laws and the ministerial resolutions include the Decree by Law No. 21 of 1983 regarding palm protection; Resolution No. 13 of 1984 regarding date palm removal permission; Plant Quarantine regulation (Law) of the Gulf Cooperation Council (GCC) countries issued by Law No. 5 of 2003; Resolution No. 3 of 2006 amending Resolution No. 4 of 2004 prohibiting importing date palms and other palm species from countries affected by palm pests, amended by Resolution No. 9 of 2005; and Resolution No. 6 of 2007 regulating the movement of mature date palms and offshoots within the Kingdom without permission.

These laws and resolutions give regulatory authority to the Plant Quarantine and Protection Department, Plant Wealth Directorate, and Ministry of Municipalities Affairs and Urban Planning, the power to apply quarantine measures on all imported and exported plants and their products, and prohibit the entry of quarantine pests at ports of entry (i.e., Bahrain International Airport, King Fahd Causeway, Khalifa Sea Port, Salman Sea Port, Post Office), coordinating and cooperating with international, regional, and local organization concerned with plant protection, issuing phytosanitary certificates, carrying out control actions against the pests present in the country. These measures played a significant role in reducing and preventing the entry and the spread of date palm pests through importing or through movement of trees within the country.

Implementation of plant quarantine measures provokes major anxiety due to the lack of professional capacity and undeveloped laboratories. Recently, the government of Bahrain has taken various initiatives for strengthening and improving plant quarantine services and facilities to comply with its legal commitments and meet the international trade requirements. The initiatives include the development of quarantine capacities and inspection operational manuals and procedures and laboratory facilities; development and skill upgrading of the technical capacity of the staff; computerization and networking between the plant quarantine and the customs at the ports of entry.

A faunal survey of insects and mites associated with date palm plantations was carried out from 2009 to 2011, in an attempt to classify them according to their importance and to assess the impacts of the invasive species on date palm trees. The survey results revealed the presence of 311 species in date palm plantations, among which 18 species were associated with date palm trees (Mohamed et al. unpublished). The identified species were categorized according to the parts of the tree they attacked (Table 11.2). Three species including the lesser date moth, *Batrachedra amydraula* Meyrick (Lepidoptera: Cosmopterygidae); the Old World date mite (ghobar mite), *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae); and the red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) are considered the most detrimental pests of date palm fruits and stems in Bahrain (Mohamed et al. unpublished). Little attention has been directed to the biology, ecology, economics, and the management of the pests with the exception of the red palm weevil. However, further studies are obligatory for better understanding of the life cycle of the pests in question to monitor and verify the threshold sizes of their populations. In addition, further studies on date palm pathogens in Bahrain are needed to determine their economic impact.

The red palm weevil (RPW) is an invasive species posing extremely high risk to the Kingdom's date palms. This weevil is a native of southern Asia and Melanesia and was accidentally introduced into Bahrain in 1995. Immediately upon the discovery of the pest, a task force was set up to minimize its impact on date palms. The surveillance and establishment of a pest control management project to combat the pest was initiated in 2009. The project was based on applying the IPM approaches by utilizing all available technology and management tools so as to minimize the impact on the nontarget organisms, environment, and human health. The project began with the implementation of three programs including surveying, monitoring, and managing and/or controlling *Rhynchophorus ferrugineus* (Mohamed 2012). The first phase of the project focused on the Kingdom's areas most vulnerable to the RPW, which are the western and northwestern portions of the Northern Governorate, where about 47 % of the date palms are growing. Taking the necessary procedures for assessing the date palm conditions and determining the management strategies to control the RPW is essential for the preservation and the prosperity of the date palm trees. The management process of the RPW involves treating and eradicating the infested date palm trees based on the infestation status assessment and the preventive spraying of the date palms to reduce the risk of infestation. Infested palm trees are identified by the existence of tunnels in the trunk, presence of sap oozing

Table 11.2 List of the major insect and mite pests associated with date palm trees in Bahrain

Common name	Scientific name	Family	Order
Major pests of date palm fruits			
Cigarette beetle	*Lasioderma serricorne* (F.)	Anobiidae	Coleoptera
Dry fruit beetle	*Carpophilus dimidiatus* F.	Nitidulidae	Coleoptera
Two dots dry fruit beetle	*Carpophilus hemipterus* (L.)	Nitidulidae	Coleoptera
Saw-toothed beetle	*Oryzaephilus surinamensis* (L.)	Silvanidae	Coleoptera
Greater date moth	*Arenipses sabella* Hmps.	Pyralidae	Lepidoptera
Lesser date moth	*Batrachedra amydraula* Meyer	Batrachedridae	Lepidoptera
Yellow wasp	*Polistes hebroeus* F.	Vespidae	Hymenoptera
Dust mite	*Oligonychus afrasiaticus* (McGregor)	Tetranychidae	Acari
Major insect pests of date palm leaves and stalks			
Parlatoria date scale	*Parlatoria blanchardi* (Targioni-Tozzetti)	Diaspididae	Homoptera
Date palm red (wax) scale	*Phoenicoccus marlatti* (Ckll.)	Diaspididae	Homoptera
Pink hibiscus mealy bug	*Maconellicoccus hirsutus* (Green)	Pseudococcidae	Homoptera
Dubas bug	*Ommatissus binotatus* de Bergevin	Tropiduchidae	Homoptera
Fruit stalk borer	*Oryctes* spp.	Scarabaeidae	Coleoptera
Rhinoceros beetle	*Oryctes agamenon* (L.)	Scarabaeidae	Coleoptera
Leaf borer	*Phonopate frontalis* F.	Bostrychidae	Coleoptera
Sulfurous jewel beetle	*Julodis euphratica* Castelnau and Gory	Buprestidae	Coleoptera
Major insect pests of date palm trunk			
Longhorned date palm stem borer	*Jebusaea hammerschmidtii* Reiche	Cerambycidae	Coleoptera
Red palm weevil	*Rhynchophorus ferrugineus* (Olivier)	Curculionidae	Coleoptera

Source: Mohamed et al. (unpublished)

from the openings, and/or the sawdust near the tunnels or at the base of the trunk (for a review, see Murphy and Briscoe 1999). Under these conditions, the infested tree should be removed, especially if the trunk interior was severely damaged. However, early detection of the infestation mandates simpler treatment. This can be achieved by identifying the tunnels on the trunk, cleaning the inside and outside the tunnels, and inserting three to eight tablets of aluminum phosphide (Phostoxin) per tunnel depending on the severity of the infestation. After that, the tunnels should be sealed to kill the remaining larvae inside. In addition, preventive treatment is carried out by spraying the whole palm trees with a recommended insecticide such as Diazinon 60 % EC, Ethion 48 % EC, Fenpropathrin 10 % EC, and Imidacloprid 20 % EC to reduce the risk of infestation. Over the 3 years of the survey (2009–2011), the

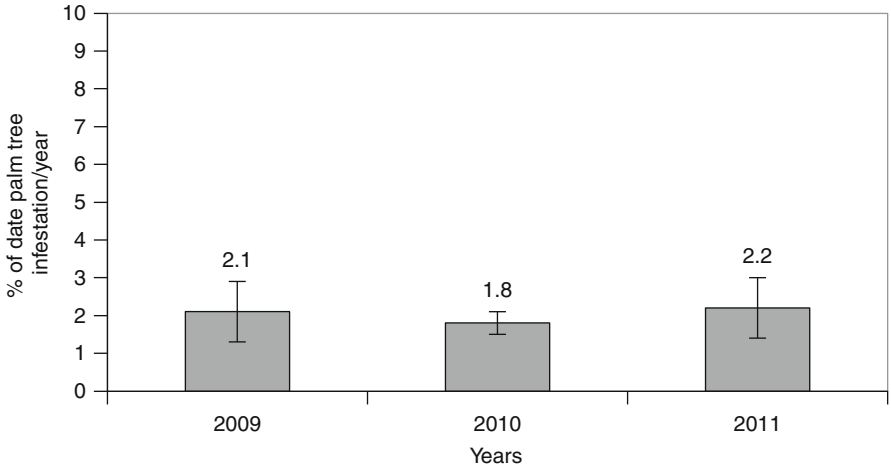

Fig. 11.2 Percentage of date palm infestation by *Rhynchophorus ferrugineus*, Bahrain, 2009–2011 (*Source*: Mohamed 2012)

estimated average of mature date palms and offshoots examined, treated, and eradicated was 264,585, 1085, and 1525, respectively (Mohamed 2012). The average annual infestation rate by RPW was about 2 % over the 3 years of the survey (Fig. 11.2). This infestation rate was close to that reported in Saudi Arabia, which was estimated to be 2.5 % (Vidyasagar et al. 2000a, b), and Oman, with an average of 1.7 % (Azam et al. 2001).

Monitoring adult RPW seasonal activities using baited aggregated pheromone traps was carried out in 2010–2011. The total number of adult weevils collected from the traps (176 pheromone traps distributed among 43 date palm plantations) during the monitoring years was 12,823 and 12,764, respectively. Adult RPW were found to be active throughout the year in Bahrain with a period of increased frequency in January to April (Fig 11.3). After that, the decline of the weevils coincides with the rise of the ambient temperatures (Mohamed 2012). These results support the findings of Kaakeh et al. (2001), Khalifa et al. (2001), and Abbas et al. (2006) in United Arab Emirates. However, in Saudi Arabia, the increase in the number of the adult RPW was found to be more prominent during May, with a second peak during November, and activity was observed to be lowest during August and February (Anon 1998). This variation could be related to the differences in the micro- and the macro-environments of the red palm weevil. Without a doubt, monitoring the weevil via pheromone traps can facilitate locating the spread of the weevil (Gunawardena and Herath 1995; Murphy and Briscoe 1999; Oehlschlager et al. 1995) and assessing the efficiency of the pest control programs in each monitored area within the country. Furthermore, the pheromone traps can help in disrupting the weevils' oviposition by reducing the chances of mating due to the mass traps of the weevils (Abraham et al. 2001; Abuagla and Al-Deeb 2012; Al-Asfoor 2012; Al-Saoud 2010; Faleiro 2000; Kaakeh et al. 2001).

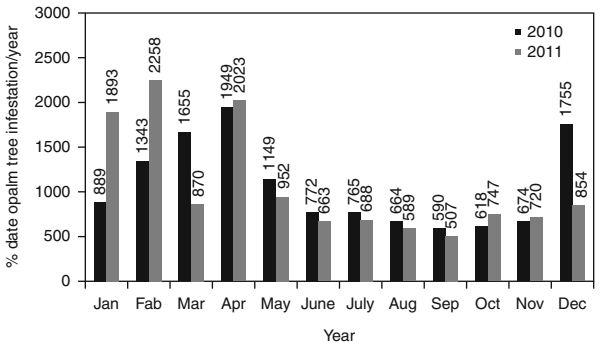

Fig. 11.3 Seasonal abundance of *Rhynchophorus ferrugineus* adults collected by pheromone traps from date palm plantations, Bahrain, 2010–2011 (*Source*: Mohamed 2012)

The survey program was expanded beyond the areas where the red palm weevils were discovered to reach a total of 28 locations in Bahrain by 2011 (Fig. 11.4). The expansion of the infestation in Bahrain was due to two factors: the first related to the ability of the adult red palm weevil to fly and the second factor a result of human activities for illegal translocation of date palm trees to areas free of weevil infestation. In conclusion, the red palm weevil infestation can be controlled through (a) expanded use of the pheromone traps at the rate of two traps per hectare as recommended and (b) intensified awareness campaigns for the growers and nurseries so as to disseminate the practical approach and information that facilitate date palm plantation management, including eradication of the abandoned palm trees, detachment of the offshoots from them and other trees, and avoidance of overwatering. It is also of the utmost importance to publicize that moving date palms and offshoots from infested areas is forbidden without notifying the Plant Wealth Directorate for inspection and treatment prior to translocation.

For best control results, it is recommended to prune during the low insect activity periods, from June to November (Fig. 11.3), spray both the healthy and the infested palm trees during the high activity period, and implement the IPM measures in healthy date palm plantations of neighboring plantations with infestation history. Furthermore, a Geographic Information System (GIS) has been used for the first time as a part of the IPM program in Bahrain to produce digital maps (Mohamed 2012). These maps can be used to assess the weevil distribution and the effectiveness of the control measures on the reduction of the infestation and for improving the red palm weevil control strategies (Al-Asfoor 2012; Massoud et al. 2011; Mohamed 2010, 2012; Pontikakos and Kontodimas 2010; Soroker et al. 2013).

11.3 Genetic Resources and Conservation

Despite its small land area, Bahrain is rich in genetic resources of date palms. There are more than 100 date palm cultivars in Bahrain (Al-Khalifa 2010; Al-Khalifa et al. 1994). It is believed that the structure of the gene pool of date palm has been shaped in response to natural and human selection pressures. Conditions, such as climatic,

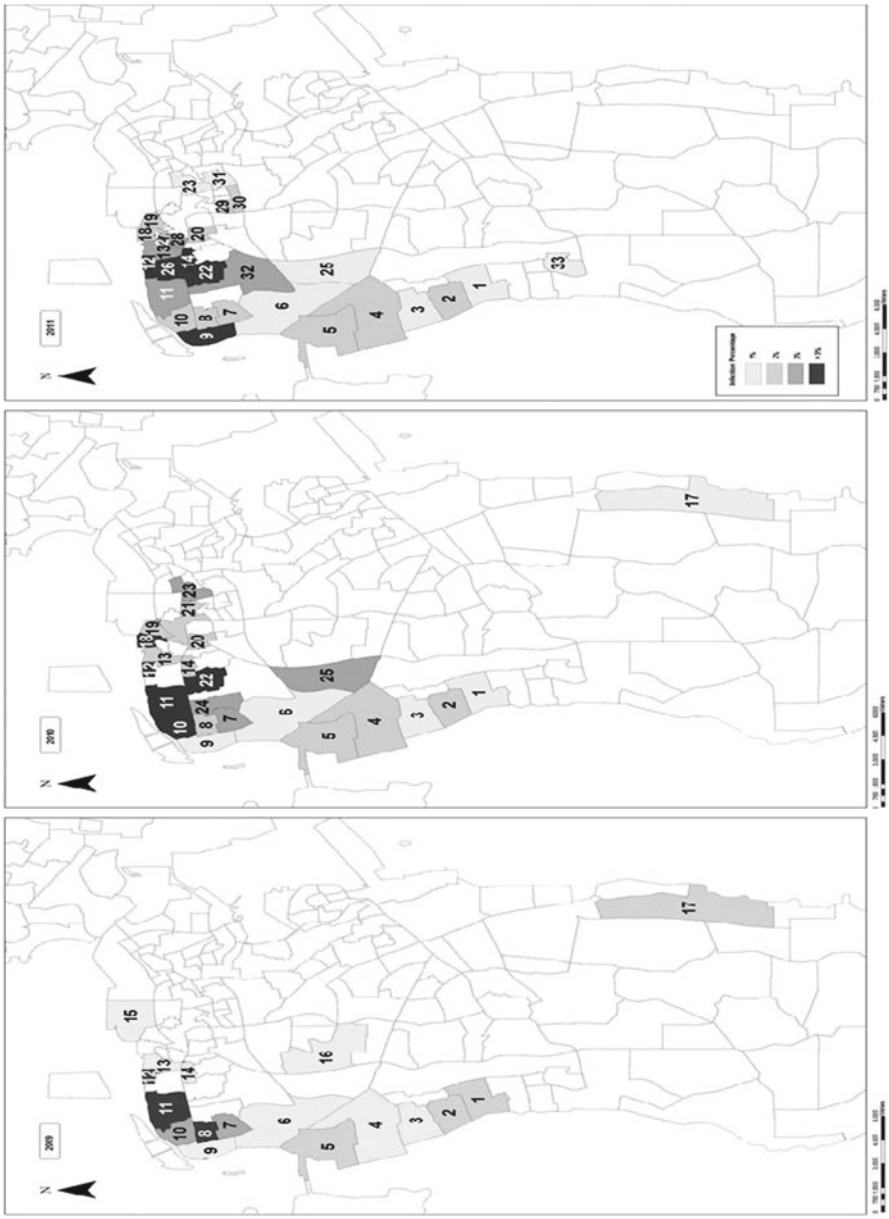

Fig. 11.4 Distribution and infestation levels of *Rhynchophorus ferrugineus* in date palm plantations, Bahrain, 2011 (Modified from Mohamed 2012). *1* Malkiya, *2* Karzakkan, *3* Damistan, *4* Al-Hamalah, *5* Al-Jasrah, *6* Janabiyah, *7* Al-Qurayya, *8* Bani Jamrah, *9* Budaiya, *10* Al-Diraz, *11* Barbar, *12* Jid Al-Haj, *13* Karranah, *14* Abu Saiba, *15* Al-Seef District, *16* A'Ali, *17* Jau, *18* Al-Qal'ah, *19* Karbabad, *20* Al-Qadam, *21* Jidhafs, *22* Muqabah, *23* Alburhama, *24* Al-Markh, *25* Buri, *26* Jannusan, *27* Hillat Abd Alsaleh, *28* Almaqsha, *29* South Sehila, *30* Adhari, *31* Bilad Al-Qadeem, *32* Sar, *33* Dar Kulaib

Table 11.3 Ex situ conservation of date palm genetic diversity in Budaiya Botanical Garden

Cultivar	Ripen maturation	No. of trees
Buchairah	Early	8
Gharrah	Early	8
Hilali	Early	4
Khudari	Early	6
Muwaji	Early	8
Barhi	Middle	1
Khawaja	Middle	4
Khalas	Middle	37
Khunaizi	Middle	34
Rzaiz	Middle	11
Hilali	Late	8
Khasbat-Asfoor	Late	6
Nabtat Saif	Late	1

Source: Directorate of Plant Wealth (unpublished)

edaphic, and socioeconomic, as well as fruit phenotypic traits, yield, and quality, have significantly influenced the choice of cultivars currently grown in the country.

Presently, the native date palm germplasm is threatened by various factors. The scarcity of rainfall, drying of freshwater wells along with the salinization of irrigation water and agricultural soil, combined, has had a dramatic effect on present date palm cultivation. Moreover, the authenticity of the local germplasm is endangered by the invasive cultivars, which have been imported from different countries, neighboring and from afar. These invasive strains are genetically diverse and may dominate and exert pressure on the indigenous genetic resources. Furthermore, some native cultivars, like Salmi, Sitrawi and Tayar, are the most likely to be threatened due to their adverse fruit taste and quality, which does not meet the standards required by the growers and the consumers.

As explained above, conservation of the native cultivars is crucial to maintain the genetic resources of the local date palms. In this regards, to enforce date palm protection and conservation, the Agriculture Affairs, Ministry of Municipalities Affairs and Urban Planning, has established field gene banks in Tubli, Hawarat Aali, and the Budaiya Botanical Garden for ex situ conservation of the genetic resources of date palm cultivars (Table 11.3).

In line with the above ex vitro conservation efforts, Agriculture Affairs has established a tissue culture laboratory and adopted specialized programs for micropropagation and conservation of some of the native cultivars in Bahrain (BFNRCBD 2006).

In order to further an initiative of Her Royal Highness Princess Sabeeka Bint Ibrahim Al-Khalifa, wife of HM the King, and President of the Supreme Council for Women, for agricultural development, the Ministry of Municipalities Affairs and Urban Planning founded a national campaign dubbed *Date palm for every home*. This campaign aims to inform Bahrain's citizens on date palm cultivation and maintenance, dissemination and conservation of the valued Bahraini cultivars, and

fostering afforestation and improvement of the environment in residential neighborhoods. The total number of the households which benefited from the campaign reached 3,913 for the years 2011–2012.

In addition, companies interested in environmental management and protection, like the Gulf Petrochemical Industries Co. (GPIC) and the Bahrain Petroleum Company (BAPCO), conserve ex situ date palm genetic diversity either on their company sites, for example, GPIC hosts more than 400 date palms, or in specialized parks, such as the Princess Sabeeka Park in Awali, developed by BAPCO which includes 560 date palms. However, it should be pointed out that not all of the palms cultivated by the two companies are indigenous cultivars; many are imports from neighboring countries.

As presented earlier (Table 11.3), the ex situ conservation facilities comprise a limited number of cultivars compared to the total native genetic resources of the country. In order to protect the overall genetic diversity against degradation, which may be the consequence of biotic, abiotic, and anthropic stresses, and to provide a means to initiate essential breeding programs, it is recommended to implement the modern biotechnology tools available worldwide (Jain 2011; Rao 2004). Researchers should be encouraged to monitor, survey, and identify the genetic diversities among the Bahraini date palm populations using advanced molecular markers. Furthermore, mass production by tissue culture techniques, in vitro cold storage of date palm tissue at various developmental stages, and cryopreservation are additional biotechnological tools which can be adopted to conserve the heritage and the genetic resources of Bahraini date palms. These methods have to be implemented with care and in harmony with relevant molecular aspects to avoid genetic variations that may result from somaclonal variations. This conveys an urgent need to establish a center for date palm genetic resources and conservation in Bahrain. Chief among this center's objectives should be conservation of the genetic diversity of Bahraini date palm trees, providing pertinent field logistics and ultimately conducting, promoting, and emphasizing research focusing on exploring innovative techniques to sustain local germplasm.

11.4 Plant Tissue Culture

Tissue culture refers broadly to the technology that depends on in vitro aseptic culture of plant cells, tissues, and organs under defined chemical and physical conditions; it can be a strategic choice for sustainable date palm development and conservation in Bahrain. This technology has proved its numerous applications both in basic and applied researches, as well as commercial implementation in many countries (Al-Khalifa et al. 2013; Badawy et al. 2005; Zaid and Arias 1999). Mass production of genetically identical, true-to-type, pest and disease-free plantlets of elite cultivars makes tissue culture a dependable technique for rapid development of the date palm production industry (Alkhateeb 2008; Zaid and Arias 1999).

The first Bahraini plant tissue culture laboratory was established in 1988, through a joint venture between the Agriculture Affairs and the Taiwan Technical Mission in Bahrain. In 1993, through the Arab Organization for Agriculture Development (AOAD), date palm tissue culture was initiated in the laboratory. The laboratory was provided with facilities to accommodate 12,000 plantlets, with further expectations to increase the capacity to 50,000 plantlets (AOAD 2004). No significant progress was achieved until 1999, when further steps were taken to improve date palm tissue culture facilities in the Agriculture Affairs (Al-Khalifa 2004). In 1999, a project aiming at mass production of three elite Bahraini date palm cultivars, Khalas, Khunaizi, and Merziban, was initiated. However, due to limited financial resources and the fact that the laboratory was equipped with only very basic facilities that could not support large-scale production, the project resulted in focusing on a single cultivar, Khunaizi (Al-Khalifa 2004). The laboratory results obtained are promising as the plantlets produced were acclimated successfully in the Agriculture Affairs greenhouses and field sites tests. Currently, new cultivars, Khalas, Muwaje, and Hilali, were introduced and micropropagated successfully.

Plant tissue culture research facilities were established at the Arabian Gulf University, Manama, and the University of Bahrain. Date palm micropropagation techniques were investigated in the above laboratories (Al-Issa 1992; Al-Mansoori 2001). The Al-Issa (1992) project aimed for mass production of date palm cv. Khunaizi using tissue culture techniques. The author demonstrated complete protocols for date palm micropropagation via somatic embryogenesis and direct and indirect organogenesis. Al-Mansoori (2001) described an inclusive practical method for mass production of four Bahraini date palm cultivars via somatic embryogenesis. The method executed by Al-Mansoori (2001) is based on Tisserat (1979). This method could be one of the most prominent and central protocols for date palm propagation. However, precautions have to be taken prior to adopting the technique for commercial production as the high level of the 2,4-D added into the induction media can generate undesired genetic variations by increasing the risk of somaclonal variation (Alkhateeb 2008; Saker et al. 2000).

Tissue culture techniques have been implemented to screen date palm genotypes for salinity tolerance and to investigate the physiological mechanisms retaining salt tolerance at the cellular and whole plant levels. The results revealed differential cultivar performance and suggested the validity of implementing tissue culture techniques to screen date palm cultivars for salt tolerance at the cellular and whole plant levels of organization (Al-Mansoori 2001; Al-Mansoori et al. 2007).

However, to the present, plant tissue culture techniques have not been adopted for commercial production of date palms in Bahrain. Limitation of facilities, lack of trained technicians, and the value of the marketable product, in addition to the strong competition from the neighboring countries, have constrained the interest of investors leading them to import acclimated tissue-cultured date palms and trade as distributers rather than being producers (Table 11.4).

Despite the efforts expended on date palm tissue culture in Bahrain, the resources and the technologies available and currently in use are limited and not up to par. In this context, there is an undeniable and urgent need for capacity building and

Table 11.4 Number of tissue-cultured date palms imported into Bahrain and the suppliers, 2008–2012

Year	Saudi Arabia		United Arab Emeritus		United Kingdom		Total	
	No. of shipments	No. of plants	No. of shipments	No. of plants	No. of shipments	No. of plants	No. of shipments	No. of plants
2008	–	–	–	–	1	215	1	215
2009	2	3,060	2	7,000	1	600	5	10,660
2010	–	–	1	4,000	–	–	1	4,000
2011	1	1,000	–	–	–	–	1	1,000
2012	3	155	1	4,000	–	–	4	4,155
Total							12	2,0030

Source: Directorate of Plant Wealth (2012)

establishment of a national center specialized in date palm tissue culture and biotechnology. This center should aspire to introduce the most advanced technology available today in order to save Bahrain's native date palms and furthermore incorporate the date palm industry as a part of the overall economic growth of the country. This calls for the combined efforts and cooperation of all governmental and nongovernmental bodies dealing with date palm industry in Bahrain.

11.5 Cultivars Identification

Although there are more than 100 date palm cultivars in Bahrain, only 33 have been definitively identified. Commonly and traditionally, variations among the cultivars were described based on morphological traits. Some of the most common phenotypic traits used to identify the Bahraini cultivars are summarized in Table 11.5. However, phenotypic traits are not consistent and can be affected by environmental conditions and cultivation practices. In addition, these traits cannot be detected precisely before the maturation (fruiting) stage of the palm (Elshibli and Korpelainen 2009).

In Bahrain, phenotypic variations have been detected within individual cultivars (Al-Khalifa 2010). For example, Khalas cultivar possesses three distinct strains, which vary in mature fruit size, shape, and color. Variation in ripening time was recorded within Hilali cultivar, and this was attributed to the effect of relative humidity, which significantly influences the quality of the yield. In addition, two discrete strains of Khasbat-Asfoor are well known to Bahraini date growers. The Arabi strain bears fruits until the beginning of November, whereas the Hasawi strain extends the fruiting season to the beginning of December. Further variations were recorded in fruit phenotypic traits within Muwaje, Merziban, and Khunaizi cultivars.

Al-Ruqaishi et al. (2008) showed that the phenotypic traits may not be reliable. They reported that due to phenotypic similarities, different cultivars were given the same common name. For example, the Omani Khalas and the Bahraini Khalas have

Table 11.5 Selected morphological traits and descriptors used to identify date palm cultivars in Bahrain

Organ	Phenotypic trait	Descriptor
Fruit	Color	Yellow, red, greenish yellow, pinkish
	Shape	Oval, inverted oval, rectangular-oval, cylindrical, spherical, spherical with flat ends, convex rectangular, elliptical
	Mass	Very low (<7.5 g), low (7.5–10.5 g), medium (10.5–13.0 g), high (13.0–16.5 g), very high (>16.5 g)
	Size	Very small (<7.99 cm^3), small (8.0–10.99 cm^3), medium (11.0–13.99 cm^3), large (14.00–16.99 cm^3), very large (>17.00 cm^3)
	Length	Very short (<3 cm), short (3.0–3.49 cm), medium (3.5–3.99 cm), long (4.0–4.49), very long (>4.49 cm)
	Diameter	Very thin (<2 cm), thin (2.0–2.24 cm), medium (2.25–2.49 cm), thick (2.5–2.74 cm), very thick (>2.74 cm)
	Texture	Soft (>30 % water content), semidry (20–30 %), dry (<30 %)
	Ripening time	Early (June–early July), medium (July–August), late (September–early December)
	Quality	Excellent, very good, good, medium, poor
Fruit bunch	Color	Yellowish green, greenish yellow, yellowish orange, reddish orange
	Length	Short (<90 cm), medium (90–150 cm), long (>150 cm)
Trunk	Diameter	Thick (≥70 cm), medium (50–69 cm), thin (≤49 cm)
Leaf	Length	Long (>427 cm), medium (427–335 cm), short (<335 cm)
Leaflets	Color	Pale green, dark green, shiny green, and waxy green
	Length	Short (<60 cm), medium (60–75 cm), long (>75 cm)
	Width	Thin (<3.8 cm), medium (3.8–4.4 cm), wide (>4.4 cm)
Spines	Number	Few (<20), medium (20–30), many (>30)
	Length	Short (<10 cm), medium (10–15 cm), long (>15 cm)
Petiole base	Girth	Small (<30 cm), medium (30–40 cm), large (>40 cm)
Canopy	Shape	Open, integrated, tilted, and erect

been given the same common name. However, molecular markers revealed genetic variation among the two cultivars, where Omani Khalas was genetically interrelated to Buhabisha, Fard, and Bahlani cvs., whereas the Bahraini Khalas was genetically related to Merziban.

Pathak and Hamzah (2008) found that using morphological and biochemical markers to detect genetic diversity among date palm cultivars was demanding, laborious, and time consuming. Accordingly, they used molecular markers, in particular Random Amplified Polymorphic DNA (RAPD), to study the genetic diversity among various populations of date palm in Manama City, the capital of the Kingdom of Bahrain. The analysis of the molecular variance revealed 52 % genetic similarity between the palms examined. The results indicated moderate genetic variations among the tested palm trees.

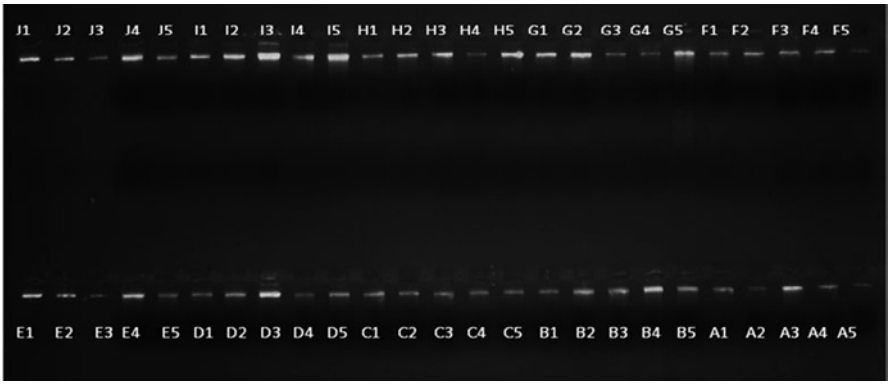

Fig. 11.5 The genomic DNA concentration of five date palm cultivars (*1* Gharrah, *2* Khunaizi, *3* Khalas, *4*Khasbat-Asfoor, *5* Hilali) grown in ten different regions of Bahrain (*A* Al-Budaiya, *B* Karana, *C* Karzakkan, *D* Howarat A'ali, *E* Al-Hamalah, *F* Askar, *G* Sanabas, *H* Al-jasrah, *I* Jid Ali) in Bahrain (*Source*: A. A-Mamari, MOAF, Oman)

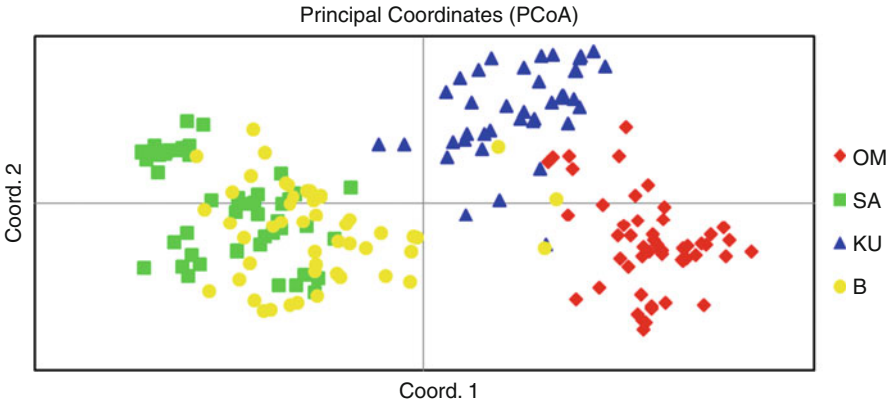

Fig. 11.6 Principle Coordinates Analysis (*PCoA*) of date palm accessions from Oman (*OM*), Saudi Arabia (*SA*), Kuwait (*KU*), and Bahrain (*B*) using 19 microsatellite primers (*Source*: A. A-Mamari, MOAF, Oman)

In Oman, as a part of a Molecular Genetic Diversity of Date Palm sub-project of the Development of Sustainable Date Palm Production Systems in Gulf Cooperation Council Countries Project (ICARDA 2011; MAF 2012), microsatellites, simple sequence repeats (SSRs), have been used to investigate the genetic diversity among five date palm cultivars of four Gulf Cooperation Council (GCC) countries, including Bahrain. The Bahraini cultivars tested were Gharrah, Khunaizi, Khalas, Khasbat-Asfoor, and Hilali (Fig. 11.5). Results indicated that the cultivars of the GCC countries exhibit genetic variation, with Bahraini cultivars being genetically closer to the Saudi Arabia cultivars, followed by Kuwait and Oman cultivars, respectively (Fig. 11.6). The similarities recorded were attributed to the higher rate of date palm

germplasm exchanges between the studied countries. In addition, the in vitro derived progeny of the above cultivars proved to be genetically identical when analyzed using SSR markers (ICARDA 2011).

From the above, it can be seen that the desired information pertaining to date palm molecular identification and phylogeny is inadequate in Bahrain. As stated earlier, there is a strong need to establish a center for date palm biotechnology and genetic resources and conservation. The center should be equipped with suitable facilities and empowered with expertise to convey precise analysis and field logistics, and it must endeavor to identify the genetic diversity among the native cultivars using the most recent molecular technologies and to ensure that the derived progeny of the in vitro micropropagation techniques in use is genetically identical and true to type. Cooperation of all related scientific bodies, including research institutions such as the University of Bahrain and the Arabian Gulf University, is crucial to achieve the target goals.

11.6 Cultivar Description

11.6.1 Growth Requirements

11.6.1.1 Climatic Conditions

Bahrain has suitable climatic conditions for date palm growth and yield. The Kingdom is situated in the subtropical arid and hot zone. Its climate is characterized by high ambient temperature and elevated relative humidity and evapotranspiration rates. The average air temperature ranges from 14 to 41 °C. The annual rainfall, which is confined to a rainy season that extends from November to April, is inconsistent and sparse with a range of 39–128 mm (BFNRCBD 2006).

The high relative humidity in summer, which is the fruit ripening season, has shaped date palm germplasm in the Kingdom. It propelled the domination of cultivars that bear soft and tender fruits, which cannot be left on the tree to dry out; instead, they have to be picked as soon as they are ripe to avoid rotting. On the other hand, the pollination and flowering seasons, which extend from February to March in Bahrain, need moderate temperature and no rainfall, as heavy rain impedes the pollination process. Accordingly, date palm growers tend to pollinate the female flowers in the morning but after full sunrise when the flowers are moderately dry and the relative humidity are lower (Al-Khalifa et al. 1994).

11.6.1.2 Soil

Date palms are known for their ability to grow in various types of soil. However, they thrive in nonsaline soils, which are rich in mineral nutrients and have appropriate drainage. Accordingly, date palm plantations are widespread in the northern and

the western parts of the Kingdom, which are characterized by having nonsaline sandy soils which are rich in organic matters and where there is a high water table. Although date palms are salt tolerant trees, the continuous exposure to saline soil and water exerts a dramatic effect on their growth and productivity. In Bahrain, salinization of the underground water along with poor drainage increases the salinity of the soil, which in turn affects date palm plantations drastically, especially in the central and the eastern parts of the Kingdom (Ahmed 1978; Al-Basheer and Harron 1997; Al-Khalifa et al. 1994).

11.6.1.3 Fertilization

Like any plant, the date palm requires essential mineral nutrients to grow, thrive, and bear sufficient yield. However, there are no standard schedules for fertilization and compost application of mature date palm trees in Bahrain. Only offshoots are fertilized in their early stages by adding organic manure (cow or domestic animals fertilizers) to the soil. The vast majority of date palms are not fertilized specifically; instead they may acquire their needs from fertilizers added to the intercropped vegetables or forages (Ahmed 1978; Al-Basheer and Harron 1997).

Currently and in collaboration with ICARDA, the effect of chemical and organic fertilizers on date palm growth and yield has been investigated. Results revealed no significant improvement in plant growth and yield. This was attributed to the technique implemented during the fertilization process (ICARDA 2011).

11.6.1.4 Irrigation

Generally, there is not a specific irrigation schedule adopted for mature date palms. Usually, the dates obtain their water needs from the forage or vegetable crop beds when they are flood irrigated or by drawing from water channels used as a part of other plant irrigation systems (Ahmed 1978; Al-Basheer and Harron 1997; Al-Khalifa et al. 1994). High summer temperatures prompt a dramatic effect on the evapotranspiration rate, which affects the amount of water needed by the plant. Accordingly, during the summer, date palms are irrigated once or twice each week, whereas during winter, they are irrigated only once every 2 weeks. It has been recorded that date palms can survive on 10 m^3 of irrigation water per tree per year. However, to reach their optimum potential yield, they need approximately 50 m^3 of water per tree per year (Al-Khalifa et al. 1994). For newly transplanted offshoots, date palm growers tend to irrigate the young offshoots on a daily basis until they harden and establish a well-defined root system (Ahmed 1978; Al-Khalifa et al. 1994).

Currently, modern date palm plantations are characterized by the execution of water saving irrigation practices, such as bubbler irrigation. However, such methods are still poorly operated with no irrigation schedules and imperfect management (Al-Basheer and Harron 1997; Al-Khalifa et al. 1994).

Table 11.6 Estimated numbers and areas of the agricultural holdings in Bahrain

Type of plantation	No. of holdings	Total area, ha	% of total area
Vegetables	7	54	1.3
Forage	4	50	1.2
Date palm plantations	90	437	10.2
Intercropped date plantations	1,114	3,759	87.3
Total	1,215	4,300	100

Source: Al-Basheer and Haroon (1997)

11.6.2 Cultivars Distribution in Bahrain

Although date palms are distributed over all five governorates of Bahrain (Table 11.1), the main plantations are situated on the northern coastline, the northern region of the western coastline towards Zallaq village, and the northern region of the eastern coastline of the main island of Bahrain towards Sitra Island. Al-Khalifa (2010) revealed that the slight variation in the climatic conditions between the coastlines and the dryer inlands affects the distribution of the cultivars to a degree. The author states that early fruits ripening cultivars, like Muwaji, favor the wet coastline areas to avoid fruits curling and crimping, whereas Um-Rahim and Barhi favor relatively dryer areas, such as Al-Hamalah, Aali, Bori, and Riffa.

In Bahrain, there are a total of 1,215 agricultural holdings occupying 4,300 ha (Table 11.6). Among 1,204 of these holdings, which represent 97.5 % of the total area, date palms are intercropped with vegetables and/or forages or as sole fruit trees. The majority of the holdings are located in the Northern Governorates, which is a rural area characterized by water availability and soil fertility (Al-Khalifa 2009; Al-Khalifa et al. 1994; Doornkamp et al. 1980; Nesbitt 1993). It is important to note that none of the orchards are specialized in a particular date cultivar; instead, they comprise various cultivars, which are usually intercropped with other cash crops.

11.6.3 Cultivar Production and Economics

In Bahrain, date harvesting extends from June for early fruit ripening to early December for late fruit ripening cultivars. Nevertheless, the main harvesting period is confined to the months of July and August, when the entire fruits of the medium cultivars ripen simultaneously (Al-Khalifa 2010). During the season, dates are mainly harvested at two distinct stages: khalal (fully colored stage) and rutab (wet and soft ripe stage). In Bahrain, dates cannot be left to dry on the trees and cannot be harvested as tamar dates. Instead, dates at the wet and soft ripen stage are hand-picked and if needed, sun dried to tamar.

The average annual production per tree varies from 40 to 80 kg depending on the cultivar with an actual production that may exceed 150 kg/tree. It was recorded that the most productive cultivars (70–80 kg) are Buchairah, Khunaizi,

Table 11.7 Average annual production of Bahraini date palm cultivars

Maturity season	Cultivar	Percentage of total date palms	Average annual production per tree (kg)
Early	Tayar	0.1	50
	Muwaji	6	60
	Buchairah	1.3	70
	Mubashir	0.3	40
	Gharrah	2.1	55
Medium	Khalas	3.5	60
	Khunaizi	11	80
	Shishi	0.7	65
	Setrawi	0.1	60
	Hatimi	0.2	65
	Sils	0.2	50
	Amari	0.1	60
	Rzaiz	0.2	65
	Banat-Alssyid	0.2	70
	Merziban	13.2	75
	Banat-Alabade	0.1	45
	Shabibi	0.2	65
	Brismi	0.2	55
	Khawaja	1	65
	Hallaw	1.3	75
	HallawTaroot	0.4	65
	Barhi	1.1	70
	Tanjoob	0.1	60
	Humri	0.1	65
	Fardh	0.2	65
Late	Mudallal	0.1	45
	NabtatSaif	0.5	60
	Ashhal	0.1	60
	Um-Rahim	0.5	70
	Jabiri	0.3	70
	Hilali	1.2	70
	Selmi	4.4	65
	Sabo	0.4	65
	Shambari	0.6	65
	Khasbat-Asfoor	2.9	70

Source: Al-Khalifa et al. (1994)

Banat-Alssyid, Merziban, Hallaw, Barhi, Um-Rahim, Jabiri, Hilali, and Khasbat-Asfoor. The least productive cultivars (40–50 kg) include Tayar, Mubashir, Sils, Banat-Alabade, and Mudallal (Table 11.7). Khunaizi and Merziban are the most dominant cultivars. They exemplify 11 and 13.2 % of the total number of date palms in Bahrain, respectively (Table 11.7).

The date fruits of the early and the late cultivars have proved to be the most profitable, as they supply consumers with early and late season dates, whereas the medium cultivars are the least cost-effective, unless they are of high quality. The retail price of dates ranges from 350 Files/kg for the medium cultivar Khunaizi during August to 1,500 Files/kg for the early-bearing cultivar Gharrah (Table 11.8). Similarly the wholesale price ranges from 300 Files/kg for the Merziban during the peak of the season to 1,330 Files/kg for Gharrah during the early part of the season (Table 11.8) (1,000 Files = 1 Bahraini Dinar = USD 2.65).

The lower price of the medium cultivars is related to numerous factors including the nature of the fruits produced by the majority of the local cultivars, which are wet and soft and cannot mature to the tamar stage without further artificial processing. Dependence on the local market, where most of the products are tendered fresh, is another critical element causing a marked reduction in the price of these dates. The large supply within a specified period of time compared to the limited local market demands significantly diminishes their profit. The low profit achieved results from poor postharvest operations and ineffective marketing strategies in Bahrain.

11.6.4 Nutritional Aspects

Physicochemical analyses of date palm fruits have been carried out in many countries (Hasnaoui et al. 2011; Sawaya et al. 1983), but very limited data are available regarding the chemical composition of the various date cultivars in Bahrain. Ahmed (1978) indicated that dates at tamar stage are considered as essential sources of sugars (70.6 %) and fiber (10 %), whereas proteins and lipid constituents are found in considerably lower percentages (2.5 and 1.1 %, respectively).

Allaith (2008) investigated the antioxidant activity, phenolics, and ascorbic acid constituents of 16 Bahraini date palm cultivars at various ripening stages. His findings showed that the antioxidant activity is highest in the khalal stage, followed by the rutab stage, and the least activity was recorded in the dried tamar stage. Variation in antioxidant activity was significant between the various cultivars at the khalal and rutab stages. It was recorded that the average phenolics and ascorbic acid for khalal stage were 196.8 ± 72.1 and 6.6 ± 2.4 mg (mean ± std) per 100 g fresh weight, respectively, whereas the same constituents at rutab stage were 116.7 ± 44.1 and 3.3 ± 1.3 mg per 100 g fresh weight, respectively. The author suggested that phenolic composition plays a significant role in the antioxidant activity of date palm fruits. Al-Laith (2009) reported that the total antioxidant activity, phenolics, and ascorbic acid decline as fruits ripen from khalal to rutab. It was reported that the decline in the above phytochemicals follow a pseudo-first-order reaction.

As in many date-growing countries (Abdillah and Andriani 2012), date seeds have been used as staple food, as well as for an ersatz coffee drink in Bahrain. Ali-Mohamed and Khamis (2004) analyzed the chemical composition of the seeds of six Bahraini cultivars. Results revealed significant variations among the cultivars studied. Merziban cv. seeds exhibited the most abundant mineral nutrients, whereas

Table 11.8 Average retail and wholesale prices (Fils/kg) of some date palm cultivars in 2010

Cultivars	January	February	March	April	May	June	July	August	September	October	November	December	Average
Retail (Fils/kg)													
Muwaji	–	–	–	–	–	1,000	500	–	–	–	–	–	750
Buchairah	–	–	–	–	–	1,350	–	–	–	–	–	–	1,350
Gharrah	–	–	–	–	–	1,500	700	–	–	–	–	–	1,100
Khunaizi	–	–	–	–	–	–	650	380	–	–	–	–	515
Merziban	–	–	–	–	–	–	700	450	–	–	–	–	575
Khalas	–	–	–	–	–	–	1,350	950	–	–	–	–	1,150
A. Asfoor	–	–	–	–	–	–	–	–	500	500	700	–	567
Others	–	–	–	–	–	–	633	555	517	517	750	–	600
Wholesale (Fils/kg)													
Muwaji	–	–	–	–	–	850	450	–	–	–	–	–	650
Buchairah	–	–	–	–	–	1,150	–	–	–	–	–	–	1,150
Gharrah	–	–	–	–	–	1,330	600	–	–	–	–	–	965
Khunaizi	–	–	–	–	–	–	500	350	–	–	–	–	425
Merziban	–	–	–	–	–	–	650	300	–	–	–	–	475
Khalas	–	–	–	–	–	–	1,200	800	–	–	–	–	1,000
A. Asfoor	–	–	–	–	–	–	–	–	450	450	600	–	500
Others	–	–	–	–	–	–	628	471	418	418	500	–	487

Source: Agriculture (2014)

Khawaja exhibited the least concentrations of essential mineral ions content. They revealed that date palm seeds are rich in essential macro- and micronutrients including potassium (K^+), magnesium (Mg^{2+}), sodium (Na^+), calcium (Ca^{2+}), iron (Fe^{2+}), manganese (Mn^{2+}), zinc (Zn^{2+}), copper (Cu^{2+}), nickel (Ni^{2+}), cobalt (Co^{2+}), and chromium (Cr^{3+}). In addition, lead (Pb^{2+}) and cadmium (Cd^{2+}), which are considered pollutants, were recorded in the studied seeds. However, the investigation revealed that their concentration in date palm seeds is lower than that found in coffee and barley seeds. Moreover, the level of the daily intake of minerals from date palm seeds is within an acceptable dietary intake range.

11.6.5 Description of Cultivars Grown in Bahrain

As stated earlier, there are over 100 different date cultivars in Bahrain. Al-Khalifa (2010) defined the differences between cultivars, which include fruit characteristics, such as quality, shape, size, color, length, width, as well as ripening time and tree morphology, including trunk diameter, shape of the canopy, leaf length, color, petioles base, curvature of the leaves and shape of the leaf tip, spine numbers, length, thickness, durability, as well as the thickness of its base. Furthermore, the variations encompass the leaflets position, length and width, and hardness and curvature and color, size, and length of their fruit bunches, which may have different lengths of spikelets as well (Table 11.5). Descriptions of some cultivars are summarized in Table 11.9, whereas Fig. 11.7 illustrates the morphological variations among the fruits of some Bahraini cultivars.

Among the early-bearing cultivars is Gharrah, which is known for its superior fruit quality. This cultivar bears commercially profitable fruits, which are characterized by being large, rectangular, light yellow in color, and sweet in taste both at khalal and rutab stages due to the low tannin levels in their tissue. This cultivar has a thin trunk, medium leaves, leaflets, and spines. Its leaflets are yellowish green in color. Another cultivar that ripens early is Buchairah. It is known for its preferred yellow fruits, which are mainly consumed at rutab stage. It is characterized by having a thick trunk and long leaves, leaflets, and spines. Mubashir has satisfactory fruits, which are mainly consumed at rutab stage as well. This cultivar is characterized by having a medium-sized trunk, leaves, leaflets, and spines (Al-Khalifa 2010; Al-Khalifa et al. 1994).

The medium fruit ripening cultivars include one of the most desired cultivar, the Khalas. This cultivar has fruits which are considered to be the most popular, not just in Bahrain but in several Arabian Gulf Countries as well. The fruits of this cultivar are large, oval, shiny, and yellow in color. They are sweet at the rutab stage and acceptable at the khalal stage. It has an average to large trunk with long leaves and spines. The color of its leaflets is light green. Khunaizi also ripens at around the same time. This cultivar is very widespread, because it tolerates various types of soil and water quality. It is characterized by having oval, dark red, sweet fruits at both khalal and rutab stages. It has a medium to large trunk, dark green leaflets, and

Table 11.9 The main characteristics of the major Bahraini date palm cultivars

Maturity season[a] and cultivar name	Fruits characteristics						Leaf length (cm)	Leaflets length (cm)	Spine length (cm)
	Quality	Shape	Color	Length (cm)	Width (cm)	Weight (g)			
Early maturing									
Buchairah	Medium	Oval-rectangular	Yellow	3.0–3.6	1.4–2.5	9.0	300–350	45–65	12–14
Gharrah	Excellent	Rectangular	Yellow	3.4–3.9	1.9–2.4	7.3–9.2	270–290	65–72	12–15
Mubashir	Medium	Rectangular	Yellow	3.5–4.0	1.8–2.9	5.5–9.9	300–360	50–56	9–22
Muwaji	V. good	Rectangular	Red	4.0–5.0	2.0–2.6	10–13	270–300	60–65	14–18
Tayar	Poor	Rectangular	Yellow	3.2–4.4	1.9–2.8	7.2–9.3	290–310	70–75	5.9–13
Medium maturing									
Amari	Poor	Oval-rectangular	Yellow	3.2–3.5	1.9–2.3	7.5–8.0	310–320	40–60	11–20.0
Banat-Alabade	Poor	Rectangular	Yellow	2.5–3.0	1.8–2.0	6.0–6.5	180–220	48–50	9–12.0
Banat-Alssyid	Medium	Oval-spherical	Yellow	2.8–3.4	1.9–2.5	7.0–8.5	350–360	38–59	7–13.0
Barhi	Excellent	Oval	Yellow	2.9–3.9	2.2–2.5	8.0–8.5	370–400	45–65	7–12.0
Brismi	Medium	Rectangular	Red	2.6–3.2	2.1–2.4	7.0–8.4	310–330	44–60	9–16.0
Fardh	Good	Rectangular-oval	Red	2.8–3.5	1.9–2.3	7.2–8.5	370–375	65–67	8–11.5
Hallaw	Good	Rectangular	Light red	3.5–3.8	1.2–2.3	5.5–9.3	300–310	34–37	9–10.5
Hallaw Taroot	Medium	Rectangular	Red	3.7–3.9	2.0–2.2	5.2–8.7	300–320	43–50	8–14.0
Hatimi	Good	Oval	Yellow	2.8–3.2	2.3–2.5	7.5–8.0	300–320	38–48	11–18.0
Humri	Medium	Oval	Red	2.8–3.1	1.1–2.2	6.8–7.2	330–335	40–60	14–22.0
Khalas	Excellent	Oval-rectangular	Yellow	3.5–3.9	2.2–2.6	9.0–11.5	265–300	56–67	6.5–12.0
Khawaja	Excellent	Rectangular	Yellow	3.1–4.3	2.0–3.0	11–11.5	370–390	47–55	8.5–14.5
Khunaizi	V. good	Rectangular	Red	2.0–3.5	2.0–2.5	6.0–6.5	270–300	49–57	9–18.0
Merziban	Good	Rectangular	Yellow	3.0–4.2	2.0–2.4	10–11	300–312	30–42	4.5–9.0

Rzaiz	Good	Oval-rectangular	Light red	3.2–3.9	1.9–2.2	7.0–8.5	310–320	45–50	8–14.0
Setrawi	Poor	Rectangular	Yellow	2.8–3.5	1.9–2.1	7.5–8.5	310–350	40–64	9–23.0
Shabibi	Good	Rectangular	Yellow	3.0–3.2	2.1–2.4	9.5–10	280–300	40–48	8–16.0
Shishi	Good	Rectangular	Yellow	2.8–3.5	2.1–2.5	10–11	300–310	45–50	10–12.0
Sils	Poor	Rectangular	Red	3.0–3.4	1.8–2.0	6.0–6.5	330–340	34–50	8–17.0
Tanjoob	Medium	Rectangular-oval	Red	3.0–3.8	2.2–2.3	7.9–8.2	308–360	46–59	8–13.0
Late maturing									
Ashhal	V. good	Oval	Light red	2.8–3.1	2.2–2.4	8.3–9.0	360–365	40–60	20–30
Hilali	Excellent	Oval	Yellow	2.5–2.9	2.1–2.6	7.0–9.0	245–265	40–45	9–15
Jabiri	V. good	Oval	Yellow	2.1–2.7	1.7–2.9	6.4–6.8	300–320	30–40	8–12
Khasbat-Asfoor	V. good	Oval-spherical	Red	3.2–3.7	2.2–2.6	7.0–8.5	290–310	47–55	8–19
Mudallal	Excellent	Rectangular	Yellow	3.8–4.1	1.9–2.1	7.9–8.8	270–280	45–55	15–22
Nabtat Saif	Excellent	Oval	Yellow	2.5–3.0	2.2–2.4	7.5–8.5	370–390	60–65	12–25
Sabo	Good	Rectangular	Yellow	3.0–3.3	2.2–2.6	7.5–8.0	290–300	45–50	6–12
Selmi	Poor	Oval	Yellow	2.8–3.0	2.1–2.2	6.5–8.0	300–310	61	9–22
Shambari	Good	Oval-spherical	Yellow	2.2–3.0	1.8–2.3	6.5–7.0	280–300	34–60	9–22
Um-Rahim	Good	Oval	Yellow	2.9–4.4	2.3–2.5	8.0–8.5	330–345	44–62	9–15

[a]Maturity season: early maturing (pollination Jan–Feb, maturation June–July), medium maturing (pollination Feb–Mar, maturation July–Aug), and late maturing (pollination Feb–Mar, maturation Sep–Oct)

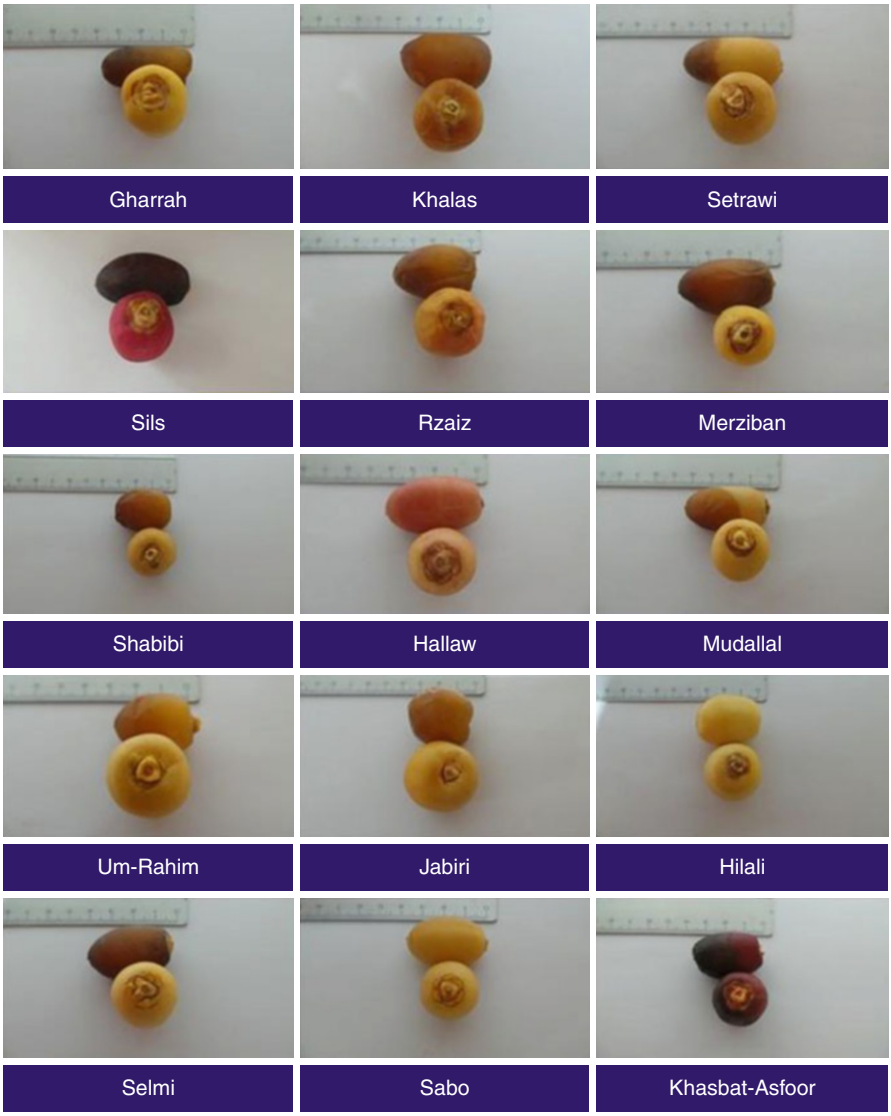

Fig. 11.7 Morphological variations between fruits of some Bahraini cultivars

dense thick spines that are located at the base of the leaves. The other most widespread cultivar is the Merziban. This cultivar is distinguished by its medium to large, yellow fruits, which are consumed at rutab and tamar stages. Trees of this cultivar have an average size trunk along with long leaves, leaflets, and spines. Its extended harvest period makes it a remarkable cultivar.

Among those that ripen late is the most famous cultivar of all, Khasbat-Asfoor, which bears average-sized, oval to round, red fruits. This cultivar is consumed late

in the season as khalal and rutab. The tree of this cultivar is very strong with thick trunk and long and strong leaves. It has broad leaflets, which are yellowish green in color and very strong alternate spines that are located mainly at the base of the leaf (Al-Khalifa 2004, 2009, 2010).

11.7 Date Production and Marketing

In Bahrain, the average annual date production reaches 16,000 mt, with a yield range of 50–150 kg per tree, depending on the cultivar, environmental conditions, and the technical practices (Al-Khalifa 2009). Some 70 % of the fruits are consumed fresh, locally at the stage of khalal and rutab (Table 11.10). Due to the high relative humidity during the fruit ripening season, farmers lose a large portion of their yield due to infestation of pests and from diseases. To overcome this problem, some growers tend to dry the ripened rutab of certain cultivars to tamar stage using traditional methods. Of the total annual production, only 10 % is consumed as dry fruits (tamar). In addition to the direct consumption, dates of certain cultivars have been utilized to extract molasses (date syrup = dibs). Also, to the present, this process is being done via traditional methods, and only 1.0 % of the total annual production is used for molasses production (Table 11.10). The remaining 19 % is used for cattle feed due to the quality of the fruits.

Due to the small size of the agricultural holdings, which usually do not exceed 50 ha, harvest mechanization has not yet been adopted. Instead, the normal traditional harvesting approach is followed. For the first 10 years of the palm's life, fruit harvesting can be accomplished manually, by handpicking. However, for older and taller trees, harvesting requires climbing the tree. This process is traditionally achieved via locally made apparatus called an *alkar*, which is made of strong ropes to hold the body of the climber. This procedure is laborious and time consuming and requires high skill and courage. The worker needs to climb the tree several times to harvest the ripe fruits, which do not ripen simultaneously. Failure to accomplish the process on time makes the fruits susceptible to bird pecking, pests, and diseases, making the fruit unsuitable for direct human consumption and greatly reduce the marketing value (Al-Khalifa 2009).

Table 11.10 Date fruit consumption in Bahrain

Consumption	Consumption/mt	% of consumption
Fresh dates	11,200	70
Dry dates	1,600	10
Date syrup	200	1
Animal feed	3,000	19
Total	16,000	100

Source: Al-Khalifa (2009)

Table 11.11 Treated Sewage Effluent (TSE) utilization under various crops

Crops	Area (ha)	TSE utilized in 2013 (m^3/day)
Dates and other fruits	1,720	20,000
Fodder	590	22,000
Vegetables	650	27,343
Total	2,960	69,343

Source: Directorate of Agriculture Engineer and Water Resources (2013)

Among the challenges that face date palm cultivation and achieving optimum yield is the availability of fresh irrigation water. In an attempt to overcome the current status, the government began a program of wastewater recycling for irrigation purposes. It has been reported that the total quantity of Treated Sewage Effluent (TSE) pumped for the agricultural and landscaping sectors increased from 4,192 m^3/day in 1988 to 110,000 m^3/day in 2012 (Directorate of Agriculture Engineer and Water Resources, Agriculture Affairs). Today, there are 540 farms, covering an area of 2,960 ha, all connected to the TSE distribution network. The overall daily TSE utilized for the agriculture purposes represents 69,343 m^3/day, of which 20,000 m^3/day are allocated for date palms and fruits (Table 11.11).

Besides the above and in order to protect and encourage date palm plantation, the government supports farmers interested in date palm cultivation with easy and flexible loans (Al-Basheer and Harron 1997; BFNRCBD 2006). At present, no modern packaging factories are available. In 1981, the government founded a date packaging factory, which was intended to subsidize date palm growers through commercial support of their output. The factory was involved in food industry through frozen and dry dates packaging and molasses extraction. The factory persisted for 10 years prior to privatization and subsequent collapse. The inability of the private sector to sustain a profitable packaging factory could be related to the limitation of the local market place and the strong competition with the neighboring countries, which tend to produce dates with superior quality, along with better packaging and lower prices. Recently, the Ministry of Industry and Commerce has licensed two date production and packaging factories. One factory would sustain a production capacity of 6,000 mt/year, whereas the second would support a production capacity of only 40 mt/year. It is worth mentioning that both factories are under construction.

Due to high internal demand, Bahrain relies on importing dates from various producing countries, with majority from Saudi Arabia, United Arab Emirates, and Oman. The total quantities of dates imported by Bahrain in 2009–2011 were around 678, 618, 976 mt, respectively (Foreign Trade 2014).

In Bahrain, there is no well-structured strategy to ensure that the returns from investment in the date palm industry are in line with the efforts and costs it takes to maintain a date palm plantation and fruit processing and marketing. In order to establish a well-functioning and competitive market that could benefit fully from the ongoing globalization, several actions should be considered. Improving the quality of the fruits by focusing on growing cultivars, which are economically rewarding; capacity building including manpower as well as the infrastructure; and supporting and encouraging scientific research together can boost the return on investment in the Bahrain date palm industry.

11.8 Conclusions and Recommendations

In conclusion, there is the need to find ways to improve the date palm sector in Bahrain. The long-term improvement of the date palm industry requires a radical shift from the traditional cultivation, harvesting, and postharvesting methods toward new practical and well-designed alternatives which can reduce economic, social, and environmental costs.

The following actions are strongly recommended to develop the date palm sector in Bahrain:

(a) Launch a national strategic development plan aimed at reinforcement and supporting the date palm sector.
(b) Establish a center of research and training dealing with various aspects of date palm including cultivation, postharvest management, and marketing.
(c) Establish modern date palm plantations to insure higher field income.
(d) Replace poor cultivars and old trees. In order to boost plant production and yield, it is essential to replace the poor cultivars and old palms with superior more productive cultivars.
(e) Promote capacity building. This includes well-trained manpower and highly innovative modern techniques. Introducing and implementing state-of-the-art technologies and motivating the youth to engage in the date palm sector are key elements to boost date palm industry.
(f) Encourage and support scientific research in various fields concerning date palm production from cultivation to marketing by providing expertise and required funding.
(g) Foster and subsidize entrepreneurs concerned with the date palm industry.
(h) Promote the exchange of experience with other date palm growing countries, in particularly the neighboring GCC countries, in the various aspects of the date palm industry.
(i) Encourage founding new private units for date fruit postharvest packaging, processing, and marketing.
(j) Facilitate the adoption of modern cultivation and postharvest technologies and biotechnologies.

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