Chapter 4
Date Palm Status and Perspective in Iraq

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Abstract Iraq is the birthplace of the date palm, and historically it was the domestication center of this crop. Moreover, for some years, Iraq was the largest producer of dates in the world. Many factors negatively have affected both the production and natural genetic diversity of the crop. However, efforts are being made by the Iraqi authorities and researchers alike to compensate for the serious damage the date palm sector has experienced over the past 30 years. New approaches have been introduced including biotechnology, grove management, pest control, and industrial practices. Production limitations have been diagnosed and constraints are on their way to be resolved. Date palm plantations are under stress from many biotic and abiotic factors including key insect pests like dubas bug, lesser date moth, trunk and stalk borers, and Old World date mite. Date palm diseases cause serious damages to date palm trees especially where stress factors are present such as palm weakness, soil salinity, high water table, borers, and tree aging. The use of plant tissue culture to support propagation by offshoots is necessary and started in the early 1980s. Both direct organogenesis and callus induction with subsequent asexual embryo formation protocols were achieved. Approximately, 600 date palm cultivars were grown in Iraq before 1980; however, currently their number is reduced to 500. Morphological

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traits have been used to describe genetic variation in these cultivars which are mainly related to the fruit, leaf, trunk, and other parts of the tree. DNA marker analysis in Iraqi date palm is at the developmental stage and began in 2000. Tree management and fruit handling improvements are required urgently for better quality production. Date trading has to be reassessed in Iraq in order to overcome the outmoded market chains.

Keywords Cultivar characterization • Diseases and pests • Genetic diversity • History • Micropropagation • Molecular markers • *Phoenix dactylifera*

4.1 Introduction

4.1.1 Historical and Current Agricultural Aspects

The date palm (*Phoenix dactylifera* L.) is one of the oldest cultivated fruit trees and was well known in Babylon, Iraq, 4000 B.C. The palms were celebrated during that period for their strength and majesty. People were heavily dependent on this tree to provide food and wood for making tools, furniture, and baskets. Figure 4.1 shows the blessed date palm during the Sumerian era.

While date palm trees numbered 32 million in the mid-twentieth century, this figure dropped dramatically to approximately 12 million by 2000. The decline was a result of numerous military conflicts in the date-producing regions since 1980. Iraq used to be the main exporter for dates, and dates represented the second largest export revenue after petroleum. The outskirts of Basrah, the country's main commercial hub in the south and the most fertile land for date palm growing, are now littered with trunks, dubbed a *palm tree desert*, which is a legacy of the 1980–1988 war with Iran. Just fewer than two million trees have survived. The embargo that followed in 1990 deprived farmers of modern agricultural equipment leading to poor management, while water became increasingly scarce as a result of a dam-building in neighboring Turkey, and Iran, which reduced the flow of the Tigris and Euphrates rivers on the Iraqi side. During the war of 2003, the date palm industry was substantially damaged. Now, Iraqi officials are promoting replanting programs to rehabilitate the country's date palms. The government is supporting a USD 150 million investment to triple the number of date palm trees by 2021. The program, which initially started in 2005, involved planting around 30 date palm farms and the Ministry of Agriculture established a new plant tissue culture laboratory for date palm micropropagation. Also, the government is encouraging the private sector to rehabilitate old date palm plantations, and private investors have been encouraged to cultivate additional sites in the Iraqi deserts. Overall, the Iraqi government program aims to increase the number of trees to 40 million in the next 10 years.

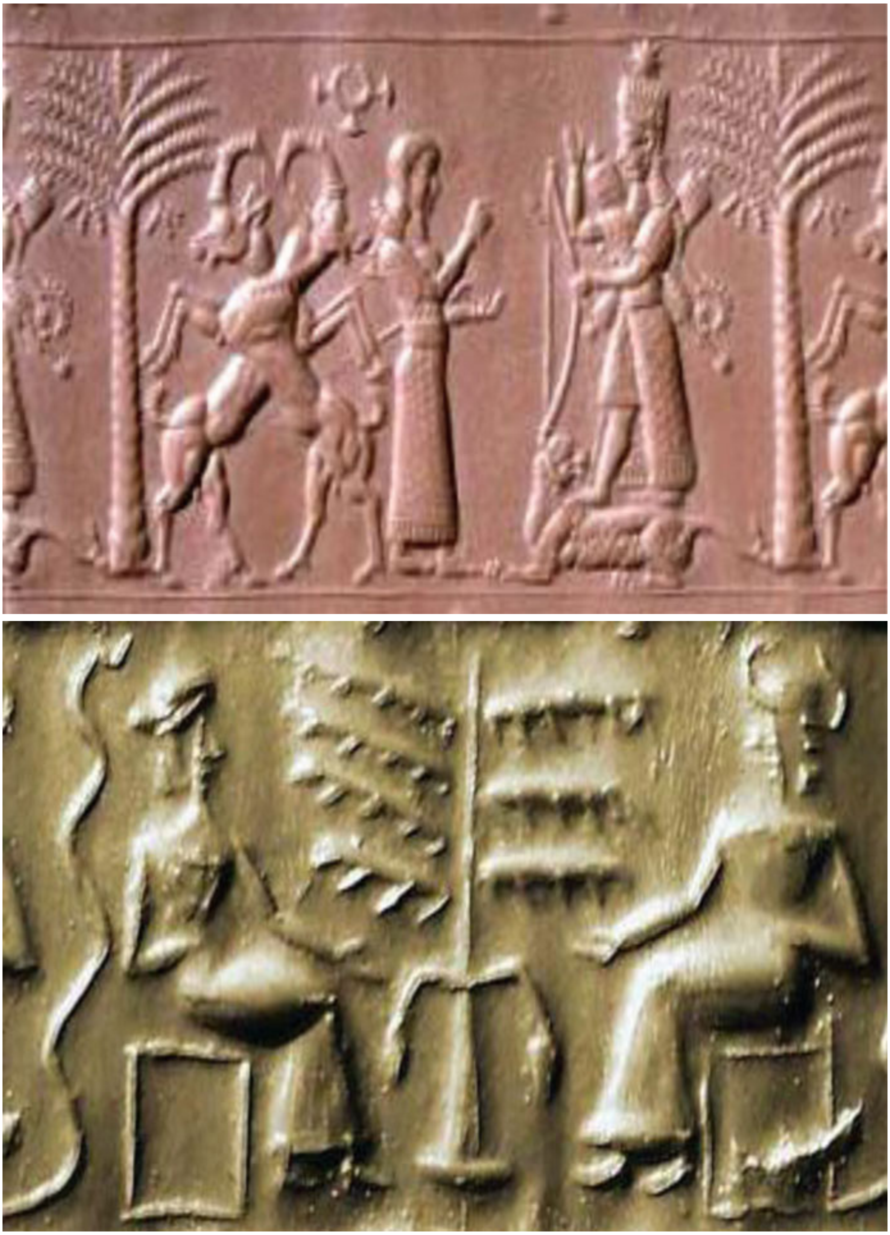

Fig. 4.1 The blessed date palm in the Sumerian era

Table 4.1 Date production and numbers of date palm trees grown in Iraqi governorates in 2012

Governorate	Production (mt)	Average yield per tree (kg) In production stage	Productive	Total number of date palms
Kirkuk	115	65.6	65.6	3,904
Diyala	83,792	63.6	63.6	2,498,128
Al-Anbar	43,196	82.1	84.2	618,943
Baghdad	93,782	67.5	67.5	2,555,207
Babil	100,343	78.6	78.6	1,753,364
Karbala	72,217	58.5	70.7	1,496,632
Wasit	43,649	87.4	87.8	739,496
Salah- Al-Deen	19,734	90.6	90.6	443,620
Al-Najaf	32,304	68.0	71.0	560,717
Al-Qadisiyah	31,436	75.1	75.1	710,536
Al-Muthanna	25,275	57.9	61.1	822,052
Thi Qar	40,086	60.8	64.3	1,026,675
Maysan	8,967	63.9	65.2	181,529
Basrah	60,554	60.4	64.9	1,353,793
All females	655,450	68.3	71.1	14,764,596
Males	–	–	–	523,814
Total	–	–	–	15,288,410

Source: Central Statistical Organization (CSO) (2012), Iraq

4.1.2 Importance to Iraqi Agriculture

The date fruit itself is a high energy food or feed item for people and livestock. Since ancient times, the date palm has been an important food source for Iraqis. Dates have proved to be the best resource to insure food security during food shortages and crises. The most commonly used parts of the date palm are its fruits, trunks, and leaves, for commercial and, in the case of fruits, for medicinal applications. Date fruits contain more than 70 % sugar at maturity. Dates are also processed into paste and date palm syrup (*dibis*) which are used in certain prepared food recipes. The tree is a spectacular palm for landscaping large areas. It provides shade, prevents soil degradation and desertification, and thus protects the environment.

Date palm groves are found in 14 of the 18 Iraqi governorates; tree numbers in governorates and date yields are given in Table 4.1.

4.1.3 Current Agricultural Problems

Iraq is considered the date palm's birthplace and the tree is symbolic of Iraq. More than 30 million trees existed in the early 1960s. As a result of wars, the number of trees declined by more than one-half. Additionally, more than 600 cultivars were known to exist; however, their numbers were reduced about 500. The decline in date palm plantations was caused by: (a) drought and water scarcity; (b) soil and water salinity, and loss of fertility, especially in the southern region of Iraq where groves are widespread; (c) insect pests and the shortage of spraying equipment; (d) poor management; (e) reduction in numbers of skilled laborers; (f) high input cost vs low output value; (g) urbanization; (h) low investment in the date palm sector; (i) no effective rehabilitation for overaged orchards; (j) problems associated with date processing and marketing; and (k) absence of an effective agricultural extension service. Those impediments have caused a significant decline in date palm production and industry.

4.2 Cultivation Practices

Iraqi farmers have long mastered the cultivation of date palm trees. They are skilled professional laborers in this field. New technologies have been introduced for tree management including pollination machinery although still at a limited scale. Bunch bending, fruit thinning, and harvesting practices are being conducted manually. Protection and control of pests are carried out as routine work using appropriate pesticides. Date processing and packaging is at an infancy stage; modern techniques are limited to a few investors. Iraq is ambitious to launch a policy for competitive production and export of high-quality dates.

4.2.1 Research and Development

Research work on date palm started early in Iraq and elite cultivars were identified and dispersed to other regions of the world. Al-Baker (1972) stated that the numbers of date palm trees in Iraq were the largest in the world at the mid of 1970s. Despite the decline in tree numbers which has occurred for many reasons, but mainly because of the continuous wars that destroyed palm groves, efforts are going on to restore plantations. Development of date palm tree management has attracted many Iraqi scientists to carry on research work in this vital subject (Hussain 2002; Ibrahim 1979, 1995, 1998, 2008, 2010; Khalaf 2002; Sahi 1986; Shalash and Hamood 1989).

Research has concentrated on date palm tree management, micropropagation, and molecular markers, in addition to industrial applications. A plan by the Ministry of Agriculture to conserve cultivars is already established in Iraq to propagate them in vitro. Experiment stations concerned with date palm production have been established in all date-producing governorates. A Date Palm Research Unit was recently established in the College of Agriculture, Baghdad University, for conservation and micropropagation of economically important cultivars.

4.2.2 Pollination

One of the important date palm characteristics is the metaxenia phenomenon that affects fruit morphology and quality. It has been observed that Iraqi date palm male cultivars differ in their pollen grain size ranging from large to small as follows: Khakri Kratley, Khakri Adi, Khakri Smasmi, Ghanami Ahmer, Khakri Wardi, and Ghanami Ahmer. It is worth mentioning that Ghanami Ahmer is superior in bunches and quality of pollen grains per cluster. Differences in fruit flesh and seed weight were recorded in Khadrawy cv. whereas no influence appeared on Maktoom cv. fruits. Pollen grains taken from Resasi males led to enhanced maturity in Khadrawy females; however, no effect was noticed in Maktoom fruits. Percentages of maturity in Halawy cv. were raised when trees were pollinated with Ghanami Ahmer, but this was not the case in Sukar cultivar (Ibrahim 2008).

4.2.3 Pest and Disease Control

The gradual decline in the number of date palm trees and low productivity in Iraq is due to a combination of factors, including the biotic factors represented by pests and diseases and other abiotic factors such as increased salinity, drought and climate changes, as well as the geopolitical events which have occurred in the last three decades. Among the most important pests directly responsible for the damage are dubas bugs, Old World date mite, lesser date moth, and borers, along with rot diseases. The production of dates has been reduced by more than 50 % due to the abovementioned factors (Al-Jboory 1999, 2001).

The increase in date palm services costs and the low prices in the Iraqi market, as well as the lack of institutions to handle date exports, have led to the farmers neglecting their orchards and the gradual deterioration of tree health due to pests and physiological factors. This case was clearly demonstrated in Basrah governorate where the date palm numbers plunged from ten producing palms to three million weak and low production trees. The Ministry of Agriculture took note when the drastic decrease in date palm numbers dropped to 50 % of the previously recorded number of 32 million trees. It was obligatory for the relevant authorities to implement a national program to increase, improve, and protect the present date palm orchards in Iraq.

In September 2000, the National Program for the Propagation and Improvement of Date Palm was approved, covering five research lines. Date palm protection was among the research topics adopted in this program which includes determining an effective solution to pest problems, replacing pesticides or reduction of their use to the minimum, and adopting biological, physical, and agricultural control methods. A team of experts targeted Integrated Pest Management (IPM) components as follows:

(a) Identify date palm pests and determine their economic importance.
(b) Survey and identify biological agents (parasites, predators, entomopathogenic agents).

(c) Monitor the crop and forecast the pest appearance by using pheromones, food, and light traps.
(d) Determine the economic threshold for the key pests.
(e) Use of appropriate pesticides and their formulations.
(f) Follow pesticides resistance management program.
(g) Utilize correct regulations with exact use of pesticide dosages and direct-spray techniques.

Based on the abovementioned points, the program has achieved significant results; however, this success unfortunately has not been continued due to the collapse in the political and administration structure since 2003. As a consequence, progressive deterioration led to a decrease in the productivity and numbers of date palms. In order to avoid this deterioration, the Iraqi government should invest maximum energies in a joint effort between the private sector and the owners of date palm plantations and also introduce regional or international expertise to restore the value of Iraqi date palms.

Studies of date palm pests began in 1912 when so-called aphids producing heavy honeydew were observed on date palms in the Baghdad area. This insect was identified later as the dubas bug (Anonymous 1912). Buxton (1920), Dutt (1922), Dowson (1936), Memarian (1947), Rao (1921), and Rao and Dutt (1922) all studied date palm pests in Iraq, focusing on dubas bug, *Ommatissus binotatus* Fieb., which appeared first in Basrah and later in all date-growing areas of the country.

El-Haidari and Al-Hafidh (1986) and Hussein (1974) categorized the insect and noninsect pests according to their taxonomic orders: Homoptera (dubas bug, mealy bug, scale insects), Lepidoptera (lesser date moth, greater date moth), Coleoptera (stem borers, fruit stalk borers, frond borers, and others), Hymenoptera (yellow and oriental red wasp), Orthoptera (locusts), Isoptera (termite), Thysanoptera (thrips), Acarina (Old World date mite, flat mite, eriophyid mite), and stored date pests.

A field survey of date palm pests in Iraq determined the most important pests and their severity. Table 4.2 includes the key pests attacking date palm in Iraq with reference to the degree of severity. In terms of the importance of borers and their great damage on date palm in the middle and southern provinces of Iraq, the infection percentage in Babel, Kerbela, and Basrah reached 90–100 %. Extensive field and laboratory work has been undertaken in Babil governorate, Mahaweel region (Al-Jboory and Saleh 2001b).

Dubas bug was investigated by Hasoon (1988) and Hasan et al. (2003). The biological and ecological parameters of Old World date mite (Ghobar mite) were studied by Al-Sewidi (2003) and Al-Sewidi and Al-Jboory (2006). Al-Bahili (2004) studied the biological and chemical control of longhorn stem borer in Basrah, while Al-Rubaee (2003) developed a local hydraulic apparatus to inject chemicals inside the trunk to control dubas bug and borers. Ghali (2001) studied the impact of *Chalara paradoxa* fungus on date palm productivity and various factors influencing the infection severity.

Various research groups have provided very important facts regarding the population dynamics of bores, in a survey of living creatures inside and surrounding the date

Table 4.2 Common insect pests infecting date palm trees in Iraq

Name	Scientific name	Order and family	Degree of important
Longhorn date palm stem borer	*Jebusaea hammerschmidti* Reich	Coleoptera, Cerambycidae	+++
Fruit stalk borer	*Oryctes elegans* Prell	Coleoptera, Scarabaeidae	++
Frond borer	*Phonapate frontalis* Fahraeus	Coleoptera, Bostrichidae	+
Dubas bug (Old World date bug)	*Ommatissus lybicus* de Berg.	Homoptera, Tropiduchidae	+++
Lesser date moth	*Batrachedra amydraula* Meyrick	Lepidoptera, Momphidae	++
Greater date moth	*Arenipses sabella* Hampson	Lepidoptera, Pyralidae	+
Termite	*Microcerotermes diversus* Silvestri	Isoptera, Termitidae	+ (+)[a]
Parlatoria date scale	*Parlatoria blanchardii* Targioni	Homoptera, Diaspidae	+
Ghobar mite (Old World date mite)	*Oligonychus afrasiaticus* (McGregor)	Acari, Tetranychidae	++ (+)[a]

[a]The importance of termite infection depends on the health condition of the date palm, while Ghobar mite infestation is higher during the dust storms which blow during summer associated with drought and low rainfall

palms. The borer population density during the period from 4/10/2000 to 10/10/2001 indicated that the longhorn stem borer is dominant in date palm trees, causing a significant damage compared to the fruit stalk borer. Borers carry pathogens either externally or in their excrement, entering into the palm trunk through the borer holes (Abbas and Muhee 1991). The longhorn date palm borer is mostly found at the growth point, the base of young leaves, and fruit bunch bases, while the stalk borers are present either at low density attacking the bunch stalk or inside the trunk. Khalaf and Al-Taweel (2014) mentioned that six different borer species attack date palm in Iraq causing economic damage; among them four belongs to *Oryctes* species.

In order to achieve the second point of the IPM component, the following bioagents have been collected and identified, and some tested either in the field or in the laboratory:

(a) Entomopathogenic nematodes on longhorn date palm trunk borer and date palm stalk borer in Iraq (Al-Jboory 2001)
(b) Survey and classification of mite species found in/on date palm (Al-Jboory and Saleh 2001b)
(c) New record of *Megaselia* sp., a parasite on the female of longhorn stem borer (Al-Jboory and Saleh 2002b)
(d) Isolation and identification of date palm borer pathogens, *Beauveria bassiana* (Al-Jboory et al. 2002, 2006), Poxviridae virus from longhorn stem borer (Al-Jboory and Saleh 2002a), and *Oryctes*-like virus from date palm stalk borer (Mohamed and Al-Jboory 2001)

Table 4.3 Pathogens infected date palm orchards in Iraq

Pathogen	Common name	Infected parts	Economic importance
Mauginiella scaettae	Inflorescence rot	Inflorescence, spathe	+++
Thielaviopsis paradoxa *Chalaropsis radiciola*	Black scorch (fool's disease)	Rachis, leaflets, growth point, trunk, inflorescence	+++
Diplodia phoenicum	Diplodia disease	Leaves, growth tip	++
Graphiola phoenicis	Graphiola leaf spot	Rachis, leaflets	++
Phytophthora sp.	Belaat disease	Frond, growth point rot	++
Alternaria spp.	Brown leaf spot	Leaflets, rachis, spines	++

New species of a dubas bug eggs parasitoid, *Pseudoligosita babylonica*, has been identified (Hasan et al. 2003) and many other predators on dubas bug and Old World date mite. This research activity unfortunately ceased after 2003, and many of the unique bioagents collected such as the two viruses and the nematodes were lost due to the electricity network collapse. Some trials are now proceeding on date palm borers, directed by the Ministry of Science and Technology and also at the Organic Agriculture Center, Ministry of Agriculture, testing *Bacillus thuringiensis* and in addition mass rearing *Trichogramma* parasitoid against the lesser date moth. Light traps and neem oil have been used recently as an alternative to conventional insecticides against borers and dubas bug (Hama et al. 2010).

Iraqi universities play a crucial role in conducting trials on date palm pests including dubas bug (Al-Abbassi 1987, 1988; Al-Dhamin 2002, 2008; Al-Rubeai et al. 2010; Hamad 2005; Hasoon 1988; Jassim 2007), on lesser date moth (Al-Delamy 2004; Al-Jorany and Al-Delamy 2010b, 2013; Al-Fahdawi 1988; Aziz 1990, 2005), on borers (Al-Ali and Ismail 1987), and on date palm diseases (Al-Asady 2003; Juber and Al-Mohamadawi 2010). Unfortunately there is no investment for such valuable applied results in the practical implementation.

Extensive investigations were conducted during 1992 when date palm disorders were observed in Baghdad and other date palm-growing areas in Iraq. The Ministry of Agriculture appointed a committee and together with FAO experts (Saaidi 1992) described four important types of diseases of date palm in Iraq: (1) neck bending disease and date palm destruction caused by four fungi, *Thielaviopsis paradoxa* (Al-Hassan and Abbas 1987), *Chalaropsis radicicola* (Abbas and Abood 1996; MOA 1992), *Chalara paradoxa* (Ghali 2001), and *Chalara radicicola* (Al-Hamdany et al. 2011); (2) dry rot and growth stunting caused by the same fungi as in the first; (3) frond malformation and dwarfing caused by *Alternaria* sp., *Fusarium* sp., and *Thielaviopsis* sp.; and (4) heart wet rot associated with many fungi, e.g., *Thielaviopsis* sp., *Fusarium* sp., *Helicocephalus* sp., *Sphaeropsidales* sp., *Thaminidium* sp., and *Helminthosporium* sp. The trunk and stalk borers were among the most important disposition factor for pathogen entrance (Abbas and Muhee 1991).

Common diseases infecting date palm trees in Iraq are listed in Table 4.3 with their economic importance (Abdullah et al. 2010; Al-Ani et al. 1971; Al-Badran 2008; Al-Beldawi and Hussain 1974; Al-Hassan and Shamseldeen 1975). Fungicides are the only available measure to control the most serious date palm fungal diseases in Iraq; however, beneficial fungi such as *Trichoderma* have been used with positive results against date palm diseases.

4.2.4 Agroforestry Utilization and Potential

Renewal of standing date palm plantations is regularly reviewed by governmental officials and farmers alike. Replacement of overage trees is one of the future plans adopted by the Ministry of Agriculture. Thus, date palm tissue culture laboratories have been established across the date palm-growing regions in an attempt to maximize the number of in vitro offshoots besides the in vivo plantlets. Date palm trees have been incorporated into landscaping urban and suburban areas in Iraq (Ibrahim 2006, 2008). An ambitious plan is under way to combat desertification in date-growing governorates which are mainly subject to dust storms.

Although Iraq has the potential to restore date palm groves over the long term, some limitations currently represent obstacles for such restoration. One of these limitations is the meager contribution of the private sector in investing and introducing new technologies. This may be due to the current insecure political situation. The quantity of produced offshoots, whether sourced from already established groves or produced by tissue culture, is not able to meet the current demand. Dust storms have badly affected date production causing the spread of Old World date mite and consequently affecting the fruit quality. Accordingly, it is recommended that new technologies be introduced to improve the date production quantitatively and qualitatively. IPM is required to reduce the potential damage both in date palm groves and during storage. Possible improvement is necessary in sorting and packaging of dates to compete other producers and exporters.

4.3 Genetic Resources and Conservation

According to numerous references, including Biblical texts, the date palm is believed to be the oldest domesticated fruit tree. Representations of the tree appear in hieroglyphics from the Neolithic civilizations of Mesopotamia and ancient Egypt. The earliest cultivation was found around 4,000 B.C. in Eridu, what is now Tell Abu Shahrain, near the Euphrates River, Thi Qar governorate, and lower Mesopotamia in Iraq. In addition date palm is mentioned in Akkadian and Sumerian cuneiform sources dated as early as 2,500 B.C. Historically date palm covered areas extending from the Indus Valley (now Pakistan) to Mesopotamia in the Tigris/Euphrates valleys (Iraq) to the Nile Valley, Southern Persia (Iran), and the Eastern Mediterranean.

The center of date palm origin is still debated with claims that it originated from Babel in Iraq, Dareen or Hofuf in Saudi Arabia, or Harqan and other islands of the

Arabian Gulf in Bahrain. The spread of date palms from the center of origin near present-day southern Iraq into other areas of the Middle East, Northern Africa, and Eastern South Asia resulted in the establishment of new date palm oases in these areas. These human-created oases probably resulted from the introduction of a relatively small range of genotypes. Subsequent clonal propagation by the planting of offshoots of desirable types resulted in distinctive fruit types being associated with the various oases. Even in the center of origin, selection pressure resulting from clonal propagation of desired types over a long period of time resulted in a certain amount of genetic erosion and the same association of characteristic cultivars with specific oases.

4.3.1 Research in Genetics, Breeding, and Conservation

Date palm is one of the world's first cultivated fruit tree and one of the classical Old World fruits. It has 36 chromosomes ($n=18$; $2n=36$). Worldwide, about 3,000 date palm cultivars have been named. The accurate identification of cultivars for breeding purposes is one of the pillars of any successful improvement program, as well as assessing the current genetic variability within the germplasm and creating resources. In date palm, traditional breeding objectives always include yield enhancement, disease and pest resistance, and tolerance of saline water, saline soil, and drought.

Efforts have been made to assess the available variability within the local germplasm in Iraq. Al-Salih and Bader in 1983 began a date palm breeding research program of Barhi cultivar. The female palm was pollinated by Ghanami Ahmer cv. in which seeds were used as a starting material. After 6 months, the seedlings were transferred to the field and left until fruiting stage after 4–5 years. Approximately 48 % were female and 52 % male (Al-Saleh and Bader 2013).

Many crosses between selected male and female trees were carried out in 1990 and progeny seeds were collected. F2 seeds were sown and maintained until flowering. Several new clones of cv. Barhi were produced; one was superior compared with its parents. Al-Saleh (1988) described a rapid method for breeding and improvement of five Iraqi date palm cvs., namely, Sayer, Khsab, Lilwi, Khastawi, and Barhi. Seeds of these cultivars were grown under the same conditions until flowering. Selection for some distinguished male and female new offshoots was done. The research concluded that propagation of date palm by seed is a useful, simple, and cheap method for obtaining new cultivars.

Genetic invariability must be assured in offshoots. However, great confusion in the discrimination process may occur if the new cultivar is growing very near to its mother palm, which is called an *off-seed* tree. It is believed that off-seed trees of all cultivars originated either from seed fallen near the mother tree and germinated along with its true offshoots or from a vegetative bud mutation as in case of sectorial mutation.

4.3.2 Threats and Degradation

Iraq remains one of the leading date-producing countries in the world. Before 1991, it was the world's largest producer (FAOSTAT 2004) and had the most extensive date *forest* in the world (MacFarquhar 2003). However, a serious decline over the past 30 years occurred due to numerous military conflicts since the 1980s. During recent wars, large numbers of date palm trees were destroyed. Water quality became crucial due to the harmful effects of the wars which destroyed date palm orchards in various regions, but especially in Basrah governorate, Shatt Al-Arab region. The abandonment and neglect by many date palm growers of their orchards was another reason for the decline, caused by low returns from date sales. An additional reason is that farmers depend on the traditional irrigation methods; lack of efficient drainage systems leads to salt accumulation in the soil which affects the growth and yield of date palm orchards. The high cost of agricultural practices such as pollination, pruning, pest control, harvesting, and marketing, along with a deficiency in the number of skilled laborers, were also significant reasons for the deterioration.

4.3.3 Germplasm Banks and Genetic Conservation Efforts

Iraqi date palm resources have been exposed to dramatic deterioration especially of date palm populations during the last 30 years. However, a project to establish new mother date palm orchards and offshoot nurseries in the 14 governorates which grow date palm has been proposed by the General Board of Date Palm (GBDP) and approved by the Ministry of Agriculture to stop the deterioration in date palm sector and overcome the decline in date palm groves (Husien et al. 2009). Each governorate will collect the cultivars grown within their respective areas, while the governorates of Thi Qar, Al-Samawah, and Al-Najaf will collect both local and international cultivars for conservation at their date palm stations (Fig. 4.2). Date palm offshoots will be grown in orchards at a spacing 5×5 m. Each orchard will contain 80 % commercial cultivars, 16 % rare ones, and 4 % male trees, maintained under drip irrigation and modern agriculture practices. The project began in the spring 2004 in two stages: the first stage was finished in 2011, while the second will continue until 2021 to establish producing date palm orchards. Technical teams are instructed to investigate the offshoot sources within each governorate and maintain records at each date palm station with information on the cultivars grown and the region where the offshoot originated and other relevant data.

A project for mapping date palm cultivars will be executed soon at the genetic engineering labs of GBDP to classify and establish standard names of the cultivars. The initial plant spacing of 5×5 m after 8 years will be modified to 10×10 m by mechanical removal of planted offshoots which will be used to establish new mother

Fig. 4.2 Najaf date palm station established in 2008

date palms. The objectives of the project are to maintain local and international cultivars and to provide researchers known cultivar collections to work with, as well as for agricultural extension objectives. The total number of mother date palm orchards established so far is 30, covering 13 governorates in Iraq with a total area of 4,594 Iraqi dunam (1 dunam = 2,500 m^2). More than 497 cultivars had been collected up to January 2009 and efforts are continuing to collect all the cultivars grown in the various regions of Iraq (Table 4.4).

As a result of cooperation with the GBDP, the Date Palm Research Unit (DPRU), University of Baghdad, was recently established, using another type of conservation through extraction of the total genomic DNA of over 220 core Iraqi collection cultivars. Quantitative and qualitative tests were carried out and ultimately the DNA conserved by cryopreservation. This type of gene bank is now available for all researchers who are interested in conducting molecular analysis projects of Iraqi cultivars. Very limited work has been carried out on the cryopreservation of date palm embryogenic cultures and therefore the development of innovative procedures is needed for an efficient preservation of genetic resources and the management of commercial propagation.

Preliminary studies have revealed that embryogenic cultures provide prime plant material for in vitro mutagenesis experiments and selection of useful mutants, for the generation of protoplasts and somatic cell hybridization, and for genetic engineering. Genetic materials may be affected by diseases, climate, natural disasters, etc., so ex situ collections should be maintained even when there is no an immediate threat of habitat loss. In order to make germplasm more accessible for researchers, ex situ collections are subjected to characterization and evaluation of germplasm and utilization in breeding programs and other research activities. Maintenance of

Table 4.4 Date palm establishments in various Iraqi date palm stations

Station name	Governorate	Area (ha)	Establishment date
Rashdeia	Baghdad	100	2004
Rabee	Baghdad	15.5	2005
Zaafarania	Baghdad	8	2004
Latefia	Baghdad	25	2005
Madaen	Baghdad	34	2005
Fallujah	Anbar	29	2004
Dawar	Anbar	25	2005
Dawar (tissue culture)	Anbar	9	2006
Eshaqi	Salah Al-Deen	27.5	2004
Mandeli	Diyala	37.5	2004
Kut	Waset	32.5	2004
Azizia	Waset	13	2005
Amarah	Maysan	58.75	2004
Akad	Dhi Qar	99	2004
Nuria	Diwaniyah	37.5	2004
Diwaniyah 1	Diwaniyah	25	2004
Diwaniyah 2	Diwaniyah	5	2004
Samawah desert (tissue culture)	Muthanna	125	2008
Khedher	Muthanna	25	2004
Najaf	Najaf	61	2004
Najaf (tissue culture)	Najaf	63.75	2008
Husania	Karbala	16.75	2004
Razazza	Karbala	32	2004
Razazza (tissue culture)	Karbala	18	2006
Mahaweel	Babel	12.5	2005
Abu Sdera	Babel	25	2005
Basrah	Basrah	30.25	2004
Burjesia	Basrah	35	2004
Qurna	Basrah	53.25	2005
Faw	Basrah	69.75	2005

Source: Central Statistical Organization (CSO) (2012), Iraq

germplasm in a disease-free state is also desirable, and this is often possible only in ex situ collections.

Assessment of the genetic vulnerability of any crop requires knowledge of the extent and distribution of its genetic diversity. This is acquired by systematic sampling and mapping of the flora of the geographical areas in which the species in question is found, as well as an assessment of ex situ collections. Unfortunately, information on natural and seminatural germplasm is often limited at the international level. This is due to the remoteness of some of the material, a lack of resources devoted to assessing these areas, and political considerations. In some cases, information may be available at the local or national level, but not to the international community.

4.3.4 Current Status and Prospects of Genetic Resources

The date palm sector in Iraq needs urgent rehabilitation through (a) supporting and encouraging farmers and orchard owners to care for their trees and orchards and apply modern technologies, (b) pest control in palm groves especially against dubas bug and borers, (c) establishment of numerous field stations for growing mother trees from different parts of the country, (d) mass production of elite cultivars using plant tissue culture techniques, and (e) collection and characterization of all Iraqi cultivars using different genetic markers.

An inventory and assessment for all locally grown cultivars, individual seed trees, and rare clones to compile a database are vital steps which can be relied upon in formulating policies, economic productivity or marketing, and selection of the best cultivars in terms of production and quality, followed by traditional propagation and tissue culture means. The continuation of joint work between the GBDP in collecting date palm cultivars from farmers and DPRU for molecular characterization and genetic relationships determination will lead to achieving the ultimate goal of generating mapping of cultivars grown in Iraq.

One of the major limitations of date palm genetics and traditional breeding is the lengthy life cycle of this special crop. Some of these challenges are of worldwide concern, while others are regional and country specific. To respond to these constraints, the objectives of the breeding programs are set according to short- and long-term goals. The short-term objective is to replace and provide date palm orchards with offshoots in order to sustain the perennial aspect of the culture. This goes along with the diversification of the genetic basis that has been narrowed in recent years due to the expansion of monoculture of elite international cultivars.

As for the long-term objective, the development of new cultivars using conventional and/or nonconventional approaches would lead hopefully to resolve some of the date palm constraints, especially dubas bug and red palm weevil, and respond to greater opportunities and understanding of the evolution of monocotyledonous families. Moreover, more detailed characterization and evaluation data are needed to adequately assess the actual amount of genetic diversity present. These data should include both descriptive data and molecular-level genetic analysis of germplasm existing both in situ and ex situ, such as abnormal somatic embryo differentiation, endophytic bacteria proliferation, and somaclonal variations.

4.4 Plant Tissue Culture

4.4.1 Role and Importance

Date palm cultivation has been expanding in Iraq, as it has in most Arab countries. Dates are propagated traditionally by seeds or offshoots, but because of heterozygosity that progeny produces from seeds, the resulted trees are not identical, are poorer in quality than the mother plant, and are approximately 50 % males. Therefore, propagation by offshoots is better, but the number produced from a tree is limited, especially from superior and rare cultivars, so it does not satisfy the need when farmers consider establishing new orchards.

The use of plant tissue culture to supplement offshoot propagation is necessary. Before 1981, Iraq was one of the top producers of dates and had the largest date *forest* in the world. A sharp decline over the past 30 years has occurred due to numerous conflicts, long-term soil salinization, shortages of electricity, and official negligence. While date palm trees numbered 32 million in the mid-twentieth century, that figure dropped to 16 million by 2000. Thus, exploitation of plant tissue culture is crucial for micropropagating distinguished cultivars toward effective rehabilitation of Iraqi date palm orchards.

Accordingly, the government has adopted many programs aiming to increase the number of date palms to 40 million trees in the next 10 years. On the other hand, a few private laboratories for commercial date palm micropropagation which are located in Baghdad (Iraqi Center for Plant Tissue Culture Ltd.), Nasriyah (Uruk Center for Date Palm Tissue Culture), and Basrah (Technical Tissue Culture Lab. and Fadk Company Lab.) have ongoing projects for scale-up production of several cultivars which hopefully will succeed and thus meet the country's demand for the required number of offshoots.

4.4.2 Research Progress

In Iraq, early attempts at date palm micropropagation began in the 1980s. The first took place in Basrah by Mater (1983) involving callus induction and subsequent asexual embryo formation. Other attempts were made in Baghdad by some researchers in the Iraqi Atomic Energy Organization (Omar and Arif 1985) and the Scientific Research Council (Bader et al. 1986) using zygotic embryos for callus induction. These efforts led to the development of a complete protocol for in vitro propagation of date palm (Mater 1986; Omar 1988b, 1992).

During the 1990s, military conflicts restricted the research efforts of many institutes. Nevertheless, a successful protocol was accomplished in the beginning of 2000s for direct organogenesis including axillary branching and enhanced adventitious bud formation from shoot tips (Hameed 2001). Meanwhile, the College of Science and the Date Palm Research Unit, University of Basrah, had also participated in date palm micropropagation efforts. Many factors were studied influencing date palm somatic embryogenesis and plantlet regeneration of several cultivars cultivated in Basrah (Al-Kaabi 2010; Al-Mayahi 2010; Al-Meer and Al-Ibresam 2008; Al-Meer and Al-Ibresam 2010; Al-Musawi 2001; Jasim et al. 2009; Al'utbi and Al-Husaibi 2007; Jasim 1999, 2000; Jasim and Saad 2001, 2003; Jasim et al. 2008; Muhsen 2007; Saleh et al. 2006).

In addition, factors affecting vegetative bud formation via callus tissues were also investigated (Abdul-Sameed 2009; Al-Khalifa et al. 2008, 2009). Khierallah and Bader (2007) reported a complete protocol for date palm micropropagation by organogenesis using shoot tips of Maktoom cv.; immature inflorescence explants were also utilized for in vitro propagation by Khierallah (2007) at the Date Palm Research Unit, University of Baghdad. The study comprised of direct organogenesis, callus induction and subsequent shoot regeneration, rooting, acclimatization, and genetic fidelity detection using amplified fragment length polymorphism (AFLP) analysis for Barhi and Maktoom cvs.

Since plant tissue culture techniques involve the possibility of undesirable genetic variability in the derived plants, which is not apparent until the fruiting stage, other markers were employed to detect genetic stability in tissue culture-derived date palm plantlets for Barhi and Maktoom cvs. using random amplified polymorphic DNA (RAPD) markers (Ali et al. 2007; Khierallah et al. 2008) and for Bream cv. using RAPD markers (Khierallah and Husien 2013).

4.4.3 Micropropagation Strategies

Since the initial attempts at date palm propagation by tissue culture (Reuveni 1972; Schroeder CA 1970), two strategies of micropropagation have been achieved: organogenesis and somatic embryogenesis.

4.4.3.1 Offshoot-Derived Explants

Selected offshoots should have a weight of 10–15 kg, be 2–3 years old and 80–100 cm in height. Offshoots should be dissected acropetally until the shoot tips appear. The excised shoot tip ought to be about 3–4 cm in width and 6–8 cm in length. Explant region (apical meristem with soft inner leaves) of 2 cm diameter is excised and placed in antioxidant solution. The explant region is usually sterilized using commercial bleach (sodium hypochlorite) 20 %. Other effective disinfection protocols are available according to Hameed (2001), Jasim (1999), Khierallah and Bader (2007), and Omar et al. (1992).

4.4.3.2 Somatic Embryogenesis

The most commonly used and widespread method for date palm micropropagation is somatic embryogenesis. In Iraq, several protocols are being implemented and can be summarized as follows: transfer disinfected date palm shoot tip explants to petri dishes where all leaf primordia are removed except for two pairs surrounding the apical meristem, which can be divided longitudinally into four equal segments aseptically and cultured on callus initiation medium. Modified MS medium was used for this purpose. Jasim and Saad (2001) produced high callus fresh weight with certain combinations of plant hormones.

Recently, Ibrahim (2012) initiated callus and transferred it to embryogenic callus proliferation medium. The medium varies from one researcher to another, for example, it can consist of MS salts and vitamins without hormones (Omar et al. 1992) or the same supplements described for callus induction medium (Jasim and Saad 2001 and Ibrahim 2012). Embryogenic calli have been produced by various researchers (Jasim and Saad 2001; Omar et al. 1992).

Low rates of somatic embryogenesis and germination have prompted researchers to enhance the processes. It was found that supplementing the culture medium with apple seed powder (Saleh et al. 2006), corn seed powder (Jasim et al. 2008), vitamin E (Al-Meer and Yaseen 2010), polyethylene glycol (Al-Mayahi 2010), and coconut water or casein hydrolysate (Khierallah and Husien 2013) or exposure to a laser beam (Al-Kaabi 2010) increased somatic embryogenesis and germination rates for several Iraqi date palm cultivars.

Mature or germinating embryos initiated roots on MS medium supplemented with 0.1 mg/l NAA plus 0.01 mg/l BA (Omar et al. 1992). Jasim and Saad (2001) used half-strength MS salts for Barhi cv (Table 4.5). Maintenance of plantlets longer in the culture medium increased their survival rate in soil.

4.4.3.3 Adventitious Organogenesis

Direct regeneration of vegetative buds minimizes the risk of somaclonal variation among regenerants. Moreover, the duration of the culture period is limited by frequent renewal of the plant material. Disinfected date palm shoot tips can be dissected as cultured explants. It is necessary that axillary buds to be used are suitable explants. On average 16–20 explants may be obtained from each offshoot shoot tip.

In general, MS medium is used for the initiation stage. Supplementation of plant growth regulators depends on the culture stage (Table 4.6). Cultures preferably are incubated in darkness to reduce phenolic secretions (Fig. 4.3a). They require four subcultures at 4-week intervals until bud initiation (Fig. 4.3b).

The formed buds subcultured on a liquid agitated multiplication medium raised the number of buds up to an average of 12.6 (Khierallah and Bader 2007). The physical status of the medium may be evaluated when the buds transferred to a liquid medium contain the proper combination of plant growth regulators obtained from the multiplication stage. Agitating the medium is better as compared with stationary or solid medium to increase the number of buds (Hameed 2001; Khierallah and Bader 2007). Hameed (2001) reported that MS stationary liquid medium produced a high number of shoots (Fig. 4.3c). Khierallah and Bader (2007) used MS medium a supplement for rooting. According to Khierallah and Bader (2007), acclimatization was reported. More than 85 % survival was achieved at the end of acclimatization (Fig. 4.3d).

Table 4.5 Plant growth regulators added to MS medium during callus induction, embryonic callus proliferation, embryo germination, and rooting medium of date palm micropropagation (values in parentheses are in mg/l)

Cultivars	Explant source	Callus induction	Embryonic callus proliferation	Embryo germination and maturation	Rooting	Reference
Ashrasi, Barban, Bream, Khastawi, Khadrawy, Maktoom, Suada Zahidi	Shoot tips, lateral buds, root tips leaf primordia, mantel meristem, bundle sheath	2,4-D (100), 2iP (3)	2,4-D (100), 2iP (3)	None	NAA (0.1), BA (0.01)	Omar et al. (1992)
Zahidi, Tibarzal, Barhi, Maktoom, Khastawi, Ibrahimi	Shoot tips, lateral buds, root tips leaf primordia, mantel meristem, inflorescence	2,4-D (10), 2iP (3) or NAA (20), 2iP (3)	2,4-D (20), 2iP (3) or NAA (40), 2iP (3)	NAA (0.1), BA (0.05) liquid	NAA (0.5)	Hameed (2001)
Askar, Barhi, Guntar, Halawy, Khadrawy, Sayer, Zahidi	Apical buds	2,4-D (100), 2iP (3) or NAA (30), 2iP (3)	NAA (30), 2iP (3)	NAA (0.1)	NAA (0.1)	Jasim (1999); Jasim and Saad (2001)
Bream	Apical buds	Picloram (50), 2iP (3)	Picloram (50), 2iP (3)	NAA (0.1), BA (0.05)	NAA (0.5), BA (0.1)	Ibrahim (2012)

Table 4.6 Plant growth regulators added to MS medium during initiation and multiplication stages of date palm micropropagation (values in parentheses are in mg/l)

Cultivars	Explant source	Initiation	Growth responses	Multiplication	Elongation	Rooting	Reference
Zahidi, Tibarzal, Barhi, Maktoom, Khastawi, Ibrahimi	Shoot tips	2iP (5) BA (5)	Enhancement of axillary branching	2iP (4) BA (4) NAA (0.5) (liquid)	–	NAA (0.5)	Hameed (2001)
	Shoot tips	ZT (1) NAA (2)	Adventitious bud formation	Zeatin (4) NAA (2) (liquid)	GA_3 (0.3)	NAA (0.5)	Hameed (2001)
Maktoom	Shoot tips	2iP (2) BA (1) NAA (1) NOA (1)	Adventitious bud formation	2iP (4) BA (2) NAA (1) NOA (1) (liquid)	GA_3 (0.3), NAA (0.1)	NAA (1)	Khierallah and Bader (2007)
Barhi, Maktoom	Shoot tips	BA (1) 2iP (2) NAA (1) NOA (1)	Adventitious bud formation	BA (1) 2iP (4) NAA (1) NOA (1)	GA_3 (0.3), NAA (0.1)	NAA (1)	Bader and Khierallah (2007)
Barhi, Maktoom	Immature inflorescence	BA (2) NAA (1)	Vegetative buds	BA (1) 2iP (1.5) NAA (1)	GA_3 (0.3)	NAA (1)	Khierallah (2007)
Sayer	Shoot tips	2iP (10) NAA (3)	Lateral buds	2iP (10) NAA (3)	–	NAA (1)	Al-Khalifa et al. (2008)

Fig. 4.3 Date palm organogenesis stages. (**a**) Shoot tip explants of Maktoom cv. cultured in darkness, (**b**) adventitious bud initiation, (**c**) elongation, and (**d**) acclimatization (Hameed 2001)

4.4.3.4 Micropropagation Using Inflorescence Explants

Inflorescence explants have proved to be a promising alternative explant source for micropropagation of elite cultivars, particularly rare ones. Khierallah (2007) described a stepwise micropropagation protocol relying on direct and indirect organogenesis for the two cvs. Barhi and Maktoom in early spring. Explants excised from spathes for callus induction were cultured in MS modified medium containing 100 μM 2,4-D plus 15.0 μM 2iP (Fig. 4.4a). Adventitious shoots were obtained after callus transfer to MS liquid agitated medium supplemented with 10.0 μM 2iP plus 5.0 μM NAA.

For direct organogenesis, spathes with spikes were cultured in MS medium. Direct organogenesis was achieved after 24 weeks (Fig. 4.4b). Multiplied buds

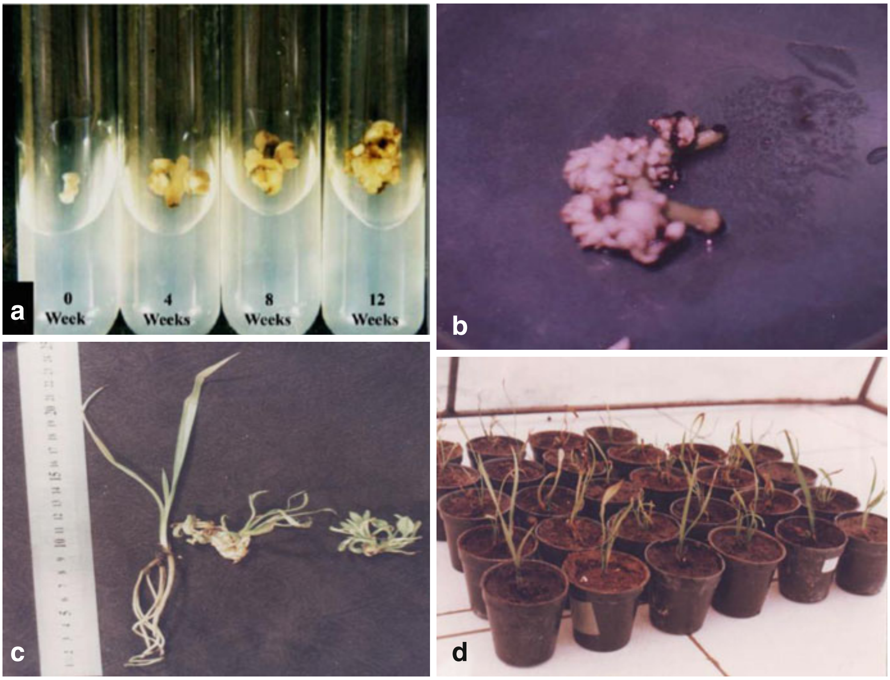

Fig. 4.4 In vitro micropropagation stages of date palm using inflorescence explants. (**a**) Callus formation after 12 weeks. (**b**) Adventitious bud formation and development from callus after 12 weeks. (**c**) Bud multiplication directly from floral explants, elongation, and rooting R. (**d**) Plantlet acclimatization under greenhouse conditions

increased by increasing the glutamine concentration using liquid agitated medium.

Several factors affecting rooting and plantlet acclimatization were investigated. Acclimatization of plantlets reached 70 and 80 % for Barhi and Maktoom cvs., respectively, after transfer to the greenhouse (Fig. 4.4d).

4.4.4 Genetic Conformity of Tissue-Cultured-Derived Plants

Plant tissue culture is considered a means of vegetative propagation in which phenotypically and genetically identical clones are produced rapidly. However, somaclonal variation is known to result from changes in the nuclear, mitochondrial, or chloroplast genomes of regenerants. Accordingly, detection of genetic stability of date palm plantlets is necessary to confirm genetic fidelity.

Ali et al. (2007) used RAPD-PCR technique for detection of genetic stability in regenerated plantlets of Barhi cv. Reproducible RAPD patterns were obtained using 30 primers. Three (OPC.16, OPG.O8, and OPN.16) produced polymorphic

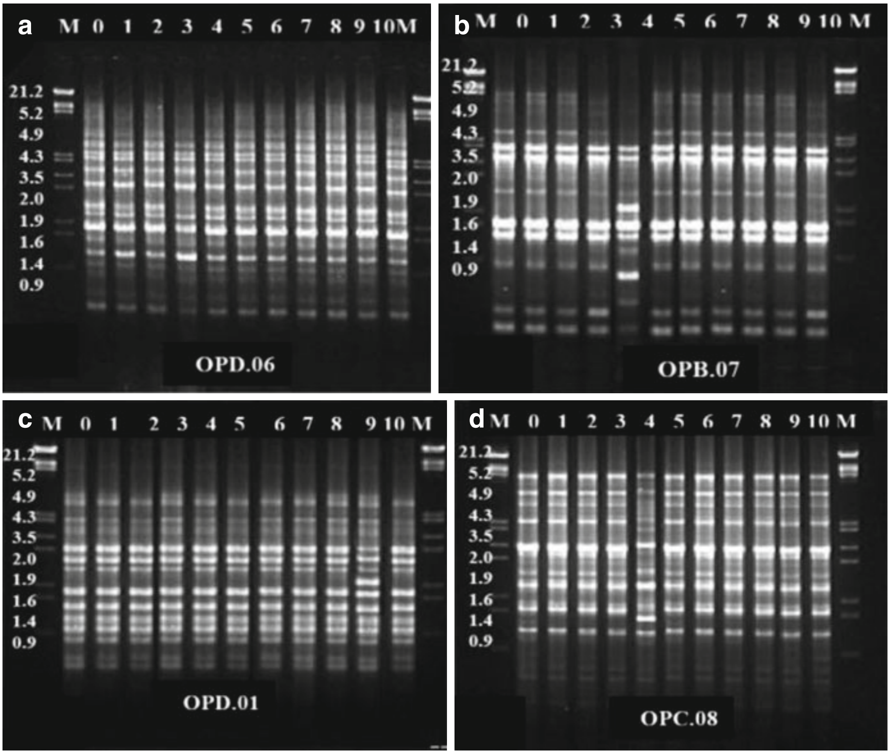

Fig. 4.5 (**a**) Monomorphic banding patterns of samples tested revealed by OPD.06 primer for Barhi cv., (**b–d**) polymorphic banding patterns using the primers (OPB.07, OPC.08 for Maktoom and OPD.01 for Barhi cv.). Numbers on the left indicate the fragment size of molecular weight markers (lane M) in kb. The lanes 0 are the banding pattern of the intact trees, while the lanes 1–10 are the banding pattern of the samples selected randomly from tissue culture-derived plantlets

bands in some of tested samples when compared with the DNA fingerprints of the mother offshoot suggesting the possibility of genetic variation among the resultant plants.

Khierallah et al. (2007) used RAPD markers and tested 25 universal primers performed on DNA extracted from fresh leaves of the mother tree and from samples randomly taken from plantlets derived from tissue culture for cvs. Barhi and Maktoom. Reproducible RAPD patterns were obtained with 20 primers; 17 primers showed completely monomorphic bands in all tested samples of the progeny (Fig. 4.5). Only three primers showed some polymorphic bands for both cultivars in some of the tested samples compared with the DNA banding pattern for the intact trees; these were OPD.01 primer for Barhi cv. and OPB.07 and OPC.08 for Maktoom. Meanwhile Khierallah et al. (2008) employed ALFP markers successfully to trace genetic fidelity of date palm in vitro plantlets cvs. Barhi and Maktoom derived from inflorescence explants (Fig. 4.6).

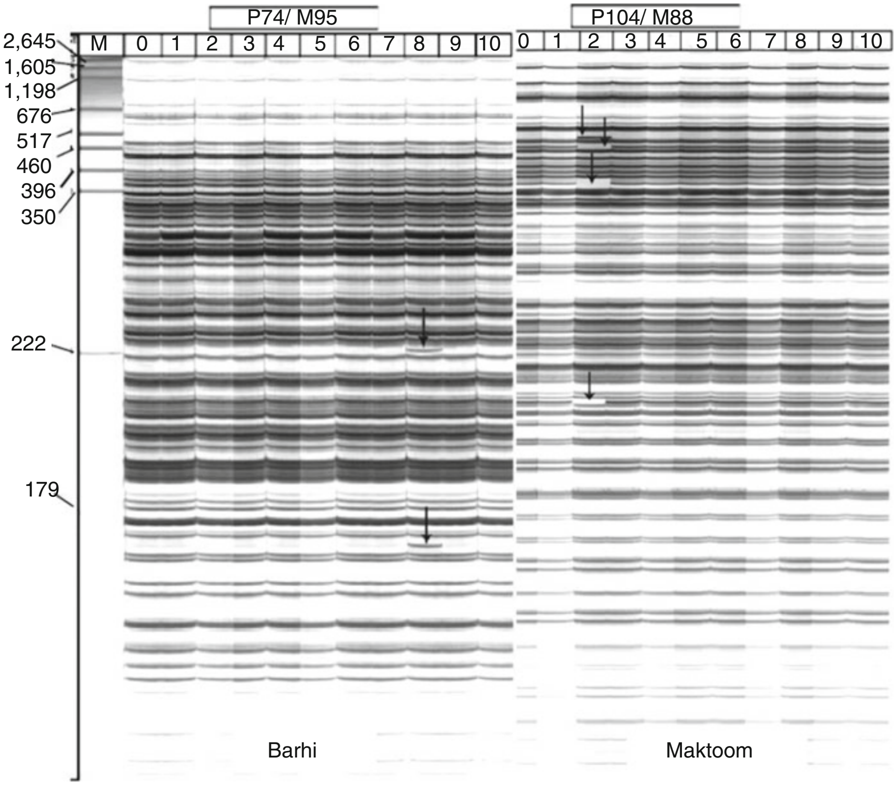

Fig. 4.6 AFLP banding pattern of the two date palm cvs. Barhi and Maktoom as revealed by primer combinations P74/M95 and P104/M88, respectively. Numbers on the left indicate the fragment size of molecular weight markers (lane M) in base pairs (bp). The lanes 0 are the banding pattern of the mother trees, while lanes 1–10 are the banding pattern of the samples selected randomly from direct organogenesis (Barhi) and indirect organogenesis (Maktoom)-derived plantlets

Recently, Khierallah and Husien (2013) generated RAPD pattern with 12 primers to identify genetic fidelity of date palm in vitro plantlets produced using picloram instead of 2,4-D for callus induction and some natural organic extracts (coconut water and casein hydrolysate) for somatic embryogenesis. Genetic variations may occur in plantlets derived from callus proliferated from shoot tips as well as in those derived from inflorescences. RAPD and AFLP appear to be an efficient technique and simple and fast DNA markers for the early detection of genetic variations in plants propagated by tissue culture.

4.4.5 Tissue Culture Limitations and Future Directions

Expansion of date palm cultivation is faced with propagation challenges of genetic improvement limitations. The heterozygous nature of this dioecious plant restricts the use of seeds which produce off-type seedlings and normally are not used to propagate elite cultivars. The limited availability of offshoots and the difficulties of establishing propagules from offshoots render this traditional propagation method unsuitable, particularly for large-scale propagation. Based on recent advances in plant tissue culture, micropropagation techniques have been developed for the rapid mass propagation of date palm.

Some limitations associated with genetic improvement have been circumvented by taking advantage of tissue culture and molecular methodologies. The scaling-up of tissue-cultured date palm in Iraq is still in flux for several reasons: the high cost of micropropagation technology; tissue culture of date palm, which is generally time-consuming; complicated biological events involved in each step of micropropagation; the lack of trained labor and management; poor planning; limited laboratory infrastructure; and mixing of research and production concepts.

Accordingly, investment should be made toward large-scale production of date palm in vitro. The government should offer facilities for investors in date palm production technology. On the other hand, further research is needed to reveal the most appropriate biochemical and molecular markers of embryogenesis in date palm since most of the molecular methods used to assess somaclonal variations have shown limitations. Indeed, cytogenetic analysis has not shown any alterations in genome structure, and isozyme markers are subjected to large ontogenic variation. Molecular markers are able to investigate only a small part of the genome and they are useless in the case of epigenetic changes. Very limited work has been carried out on the cryopreservation of date palm cultivars in Iraq with special reference to embryogenic cultures, and therefore the development of innovative procedures is needed for efficient preservation methods.

4.5 Cultivars Identification

Date palm is considered a crop of great socioeconomic importance in the Arabian region. The tree has been, and still is, at the center of the region's comprehensive agricultural development. It is believed that the date palm tree originated in Mesopotamia (Wrigley 1995). The numbers of known date palm cultivars that are distributed all over the world may be as high as 3,000, out of which about 600 are found in Iraq. Wars and economic sanctions imposed on Iraq have negatively affected both the production and natural genetic diversity of the crop and inhibited the much needed impetus to rebuild the date palm industry. The collection and genetic characterization of all Iraqi cultivars using different genetic markers is one of the important goals in date palm rehabilitation efforts. During the last few years, the General Board of Date Palm, Ministry of Agriculture, has collected over 510 date palm cultivars and planted them in 30 date palm stations dispersed in the south and middle parts of the country. Such a number of genotypes reflect the much-needed efforts to get powerful, accurate, and practical genetic markers that can be used in a high-resolution mapping for these cultivars. The success of any plant genetic conservation or breeding program depends on understanding the amount and distribution of the genetic variation present in the genetic pool. This understanding will be helpful in:

(a) Gathering date palm cultivars in newly established orchards using genetically diverse cultivars to avoid genetic vulnerability to various biotic and abiotic stresses
(b) Selection of the diverse parents in combination with the aim of segregating progenies with genetic variability
(c) Providing further gain for selection and molecular mapping

4.5.1 Research Progress in Morphological Descriptors

Morphological traits have been used to describe genetic variation in date palm cultivars, which are mainly related to the fruit, leaf, trunk, and other parts of the tree. An early survey of Iraqi cultivars using morphological description was done by Al-Baker (1962); he distinguished 531 cultivars and their origin, availability, and fruit quality. Another morphological identification was done on 110 Iraqi cultivars by Al-Jboory et al. (1971). In 1972, Al-Baker again described 627 Iraqi cultivars in his celebrated book in Arabic, *The Date Palm*, adding some fruit traits to the earlier description. Three decades later, Husien (2002) and Husien and Greab (2004) also gave a brief description of 36 and 50 cultivars, respectively. Al-Saleh and Al-Ansary (2005) adopted 12 phenotypic traits to describe 110 cultivars, documented with color photos. Genetic identification of date palm cultivars using morphological markers is usually not possible until fruits are produced and frequently requires a large set of phenotypic data that is often difficult to assess and is sometimes variable due to environmental influences.

4.5.2 Research in Molecular Descriptors

The development of molecular tools has changed the way in which individual cultivars can be identified and useful information concerning the genetic control of many agronomic characteristics can be analyzed. The ability to apply these molecular tools depends to some extent on the amount of other genomic information available for the specific plant species. Molecular marker technologies involve the use of isozymes followed by a series of DNA marker technologies and, most recently, by possibilities to compare complete genomes (Cullis 2011). Development of suitable DNA molecular markers for this crop may allow researchers to estimate genetic diversity, which will ultimately lead to the genetic conservation of date palm. The success of particular genetic conservation or breeding program is dependent on understanding the amount and distribution of the genetic variation already present in the genetic pool (Jubrael et al. 2005). In addition, biochemical studies including

Table 4.7 Names, gender and sources of collection of 30 date palm cultivars grown in Iraq

Cultivar	Gender	Cultivar	Gender	Cultivar	Gender
Collection at Al-Mahaweel date palm station					
Usta Umran	Female	Buliani	Female	Chipchab	Female
Tebarzal	Female	Leelwi	Female	Zahidi	Female
Um Al-Dihen	Female	Shwethi Ahmer	Female	Shwethi Asfar	Female
Guntar	Female	Jamal Al-Dean	Female	Khadrawy	Female
Khestawi	Female	Qul Husaini	Female	Baw Adem	Female
Bream	Female	Halawy	Female	Dayri	Female
Ashrasi	Female	Qitaz	Female	Barhi	Female
Maktoom Asfar	Female		Female		Female
Collection at Al-Zaafarania date palm station					
Meer Haj	Female	Ghanami Akhder	Male	Smeasmi	Male
Um Al-Blaliz	Female	Ghnami Ahmer	Male	Ghulami	Male
		Khekri	Male	Greatli	Male

isozyme and activity analyses of peroxidases have been used to characterize date palms in Morocco and Tunisia (Baaziz 1988; Baaziz and Saaidi 1988; Bendiab et al. 1998; Majourhat et al. 2002; Ould Salem Mohamed et al. 2001). As such, analysis does not reflect precisely the polymorphisms which have occurred (Al-Jibouri and Adham 1990).

DNA marker analysis in Iraqi date palm is still at the developmental stage. Employment of DNA marker to identify cultivars was started by Jubrael (2001) at the IPA Center for Agriculture Research, Baghdad. Random amplified polymorphic DNA (RAPD) markers were used to identify nine female cultivars, whereas (Al-Khateeb et al. 2001) used the same analysis to identify eight male cultivars. Amplified fragment length polymorphism (AFLP) markers were also been used for genetic fingerprinting of 18 Iraqi date palm cultivars (Jubrael et al. 2005). Microsatellite markers were also employed to assess genetic diversity in 30 Iraqi date palm cultivars (Khierallah et al. 2011b). As a member of the research team, Khierallah also used eight Iraqi date palm cultivars to evaluate the activity of over 1,000 simple sequence repeat (SSR) primer pairs developed by Hamwieh et al. (2010), mining genome sequencing data for this vital crop. This work was awarded the Khalifa International Date Palm Award for research in 2012. Recently, inter-simple sequence repeat (ISSR) markers were adopted to estimate genetic relationships among 17 Iraqi date palm cultivars (Khierallah et al. 2014).

4.5.3 *Molecular Strategies for Genetic Identification*

Leaves were collected from 30 well-defined reference Iraqi date palm cultivars grown in date palm stations of the Ministry of Agriculture (Table 4.7). A total of 22 female cultivar samples were collected from Al-Mahaweel Date Palm Station, Hilla governorate, 80 km south of Baghdad. The remaining eight cultivar samples were collected from Al-Zaafarania Station, Baghdad. Total genomic DNA was extracted from young and healthy leaves according to the procedure described by Benito et al. (1993) with minor modifications. After purification, the resultant DNA was quantified on 1 % agarose gel electrophoresis as described by Sambrook et al. (1989).

4.5.3.1 AFLP Analysis

According to Khierallah et al. (2011a), AFLP analysis was carried out for 18 of these 30 cultivars by following the method of Vos et al. (1995), with a few modifications. The total number of bands and those exhibited polymorphism were scored visually.

A total of 83 polymorphic AFLP fragments were detected with an average of 13.8 polymorphic fragments/primer combinations. Genetic distance was estimated using Jaccard's genetic similarity index and ranged from 0.07 to 0.75. Unweighted pair group method with an arithmetic mean UPGMA ordered date palm cultivars into two main clusters independent of their origin and sex. The first cluster consisted of three subclusters. The first one consisted of five female cultivars and one male, while the second subcluster consisted of five male cultivars. The third one consisted of five cultivars; four were females and one male. The second main cluster consisted of the remaining two female cultivars. Moreover, all primer combinations contributed to the discrimination of date palm cultivars, suggesting the efficiency of AFLP method in assessing genetic diversity in date palm. DNA fingerprinting techniques have an advantage in that the DNA content of a cell is independent of environmental conditions, organ specificity, and growth stage (Ainsworth et al. 1996). None of the diagnostic marker techniques so far applied to organisms has fulfilled all of the requirements in terms of cost and ease of use in cultivar identification. However, AFLPs satisfy more conditions than any other technique and are becoming the tool of choice for many applications, and the advantage of AFLP is that its utility can be assessed with a small number of primer pairs that can be extended for more studies.

AFLP is a powerful DNA fingerprinting technique that uses polymerase chain reaction (PCR) to amplify a limited set of DNA fragments from a specific DNA sample (Blears et al. 1998; Vos et al. 1995). The reliability of the restriction fragment length polymorphism (RFLP) technique is combined with the power of PCR. AFLP marker study showed that all primer combinations used in this study were effective in distinguishing date palm cultivars when used individually, revealing high level of polymorphism (Tables 4.8 and 4.9). Jaccard's genetic similarity index showed clusters consisted of five male cultivars. Two of them, Ghnami Ahmer and Ghanami Akhder, were very closely related with 85 % similarity reflecting high similarity in their morphological traits (Ibrahim 2008). Results also showed that there is large genetic diversity among the studied date germplasm. Jubrael et al. (2005) reported that high level of intervarietal polymorphism among another 18 Iraqi date palm cultivars could be partly due to the strong outcrossing mechanism in this species, which is likely to increase the degree of polymorphism.

Table 4.8 Number of fragments amplified, polymorphic bands, primer efficiency, and discrimination power of six primer combinations used for AFLP analysis

Primer combination	Total fragment (no.)	% Primer efficiency	No. polymorphic fragment	% Polymorphism	% Discrimination power
P11-aacg/ M88-tgc	63	25	12	19	14
P104-aagc/ M95-aaaa	33	13	7	21	8
P74-ggt/ M95-aaaa	46	18	26	57	31
P11-aacg/ M95-aaaa	31	12	5	16	6
P293-ggt/ M62-tgc	45	18	21	47	25
P101-aacg/ M95-aaaa	34	13	12	35	14
Total	252		83 (33 %)		

Source: Khierallah et al. (2011a)

Table 4.9 Major allele frequency, gene diversity, and polymorphism information content (PIC) estimated by AFLP markers in 18 date palm cultivars of Iraq

Primer combination	Major allele frequency	Range of gene diversity	Average of gene diversity	Range of PIC	Average of PIC
P11-aa/M88-tgc	0.75	0.10–0.48	0.29	0.10–0.36	0.23
P104-aagc/ M95-aaaa	0.78	0.10–0.48	0.29	0.10–0.36	0.23
P74-ggt/ M95-aaaa	0.72	0.10–0.50	0.30	0.10–0.38	0.24
P11-aa/M95-aaaa	0.75	0.10–0.49	0.30	0.10–0.37	0.24
P293-taca/ M62-ctt	0.72	0.10–0.50	0.30	0.10–0.38	0.24
P101-aacg/ M95-aaaa	0.70	0.20–0.50	0.35	0.18–0.38	0.28
Mean			0.31		0.25

Source: Khierallah et al. (2011a)

Although Iraqi date palm cultivars have been grown in Iraq for many years, Jaccard's similarity index and principal component analysis (PCA) revealed diverse relationships among them. In addition, the topology of the dendrogram and the distribution of cultivars by PCA analysis showed that a typically continuous genetic diversity characterizes Iraqi date palm germplasm (Fig. 4.7). In fact, the cultivars were clustered independently of their geographic origin in spite of their phenotypic distinctiveness.

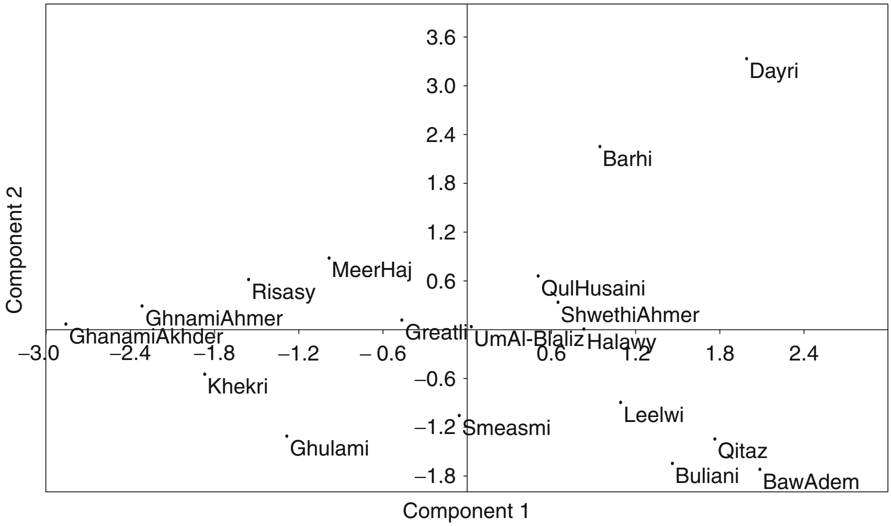

Fig. 4.7 Principle component analysis of the 18 date palm cultivars estimated by AFLP marker

4.5.3.2 Microsatellites Analysis

Microsatellites, SSRs, are ideal DNA markers for population studies and genetic mapping due to their abundance, high level of polymorphism, dispersion throughout diverse genomes, ease to assay by PCR, and ease to disseminate among laboratories (Udupa and Baum 2001). Microsatellite markers were used for investigating genetic diversity in date palm (Billotte et al. 2004). Zehdi et al. (2004) applied these markers to characterize Tunisian cultivars, while Al-Ruqaishi et al. (2008) utilized these primers to screen and analyze the genetic diversity among clonal genotypes of Omani cultivars. Recently, the technique spread to other date palm-producing countries. Elshibli and Korpelainen (2008) investigated genetic diversity in Sudan germplasm representing 37 female and 23 male accessions using 16 SSR primers. In Qatar, Ahmed and Al-Qaradawi (2009) employed 10 primers to analyze genetic diversity among 15 cultivars. Akkak et al. (2009) developed further 17 microsatellite markers, whereas Hamwieh et al. (2010) developed 1,000 SSR markers for date palm. A total of 33 date palm-specific primer pairs were tested, 16 of them were developed by Billotte et al. (2004) and 17 were developed by Akkak et al. (2009) as indicated in Table 4.10.

These microsatellite markers were employed to assess genetic diversity in 30 well-known Iraqi date palm cultivars (Khierallah et al. 2011b). Electropherogram data were analyzed by using Foundation Data Collection software (Genetic Analyzer Data Collection, Version 2.0, Applied Biosystems 3100). Allele size scoring was performed by GeneMapper software (GeneMapper® Software Version 3.7, Applied Biosystems, Carlsbad, California). The Jaccard similarity matrix (Jaccard 1908)

Table 4.10 Major allele frequency, number of genotypes that showed polymorphic bands, number of alleles generated, heterozygosity, gene diversity, and polymorphism information content (PIC) estimated by 22 SSR markers in 30 Iraqi date palm cultivars

Marker	Major allele frequency	Genotypes (no.)	Alleles (no.)	Heterozygosity	Gene diversity	PIC
mPdCIR010	0.204	19	14	0.852	0.890	0.880
mPdCIR016	0.500	8	5	0.529	0.654	0.602
mPdCIR025	0.224	15	8	0.690	0.822	0.798
mPdCIR032	0.333	13	5	0.815	0.772	0.736
mPdCIR035	0.481	10	7	0.519	0.695	0.659
mPdCIR050	0.370	17	12	0.926	0.813	0.797
mPdCIR057	0.909	3	3	0.136	0.168	0.160
PdCIR070	0.533	3	3	0.000	0.604	0.536
mPdCIR078	0.320	16	15	0.760	0.832	0.816
mPdCIR085	0.313	8	7	0.250	0.779	0.746
mPdCIR090	0.391	10	9	0.261	0.781	0.757
mPdCIR093	0.741	6	6	0.296	0.434	0.415
PDCAT4	0.407	13	7	0.556	0.738	0.701
PDCAT 5	0.276	13	7	0.862	0.816	0.791
PDCAT 6	0.231	21	21	0.654	0.903	0.897
PDCAT 11	0.600	7	7	0.100	0.598	0.566
PDCAT 12	0.850	5	4	0.100	0.269	0.256
PDCAT 14	0.220	19	10	0.960	0.865	0.850
PDCAT 15	0.440	8	6	0.480	0.732	0.699
PDCAT 17	0.385	11	9	0.500	0.774	0.746
PDCAT 18	0.140	19	19	0.560	0.923	0.918
PDCAT 21	0.731	6	4	0.269	0.431	0.394
Mean	0.436	11.364	8.545	0.503	0.695	0.669

Source: Khierallah et al. (2011b)

was used for cluster analysis using the unweighted pair group method arithmetic average (UPGMA) to study the genetic relationships among the cultivars. Jaccard similarity index, major allele frequency, heterozygosity, gene diversity, and polymorphism information content (PIC) estimation were done using a software package (PowerMarker Version 1.31) (Liu and Muse 2005). The phylogenetic diagram was drawn by PAST software Version 1.91 (Hammer et al. 2001) on the basis of the Hamming similarity index with 100 bootstrap (Fig. 4.8). PCA was performed according to Euclidean similarity index using the PAST software (Fig. 4.9). The 33 primer pairs of Billotte et al. (2004) and Akkak et al. (2009) were tested for their ability to generate expected SSR banding patterns in Iraqi date palms. A total of 22 primers successfully showed polymorphic bands among the 30 cultivars (24 female and 6 male) (Table 4.10). The genetic diversity was widely varied among cultivars ranging from 0.168 to 0.923 at loci mPdCIR057 and PDCAT 18 estimated number of 600 cultivars.

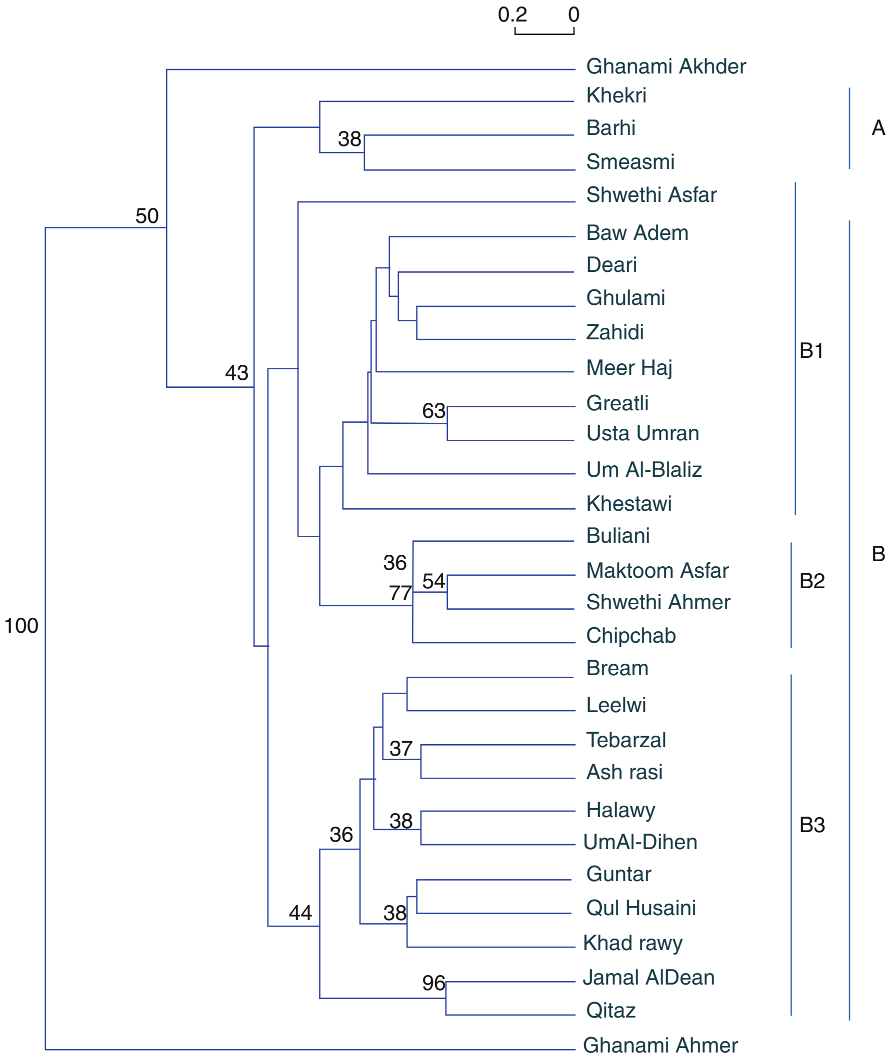

Fig. 4.8 Genetic relationships among 30 Iraqi date palm cultivars based on 22 microsatellite loci with 100 bootstrap (*Source*: Khierallah et al. (2011b))

Discrimination between cultivars is based on phenotypic differences, which are often influenced by the environment. In this study, microsatellite genotyping was used to display the genetic diversity and relationships among 30 widely grown cultivars in Iraq. Although the frequency of microsatellites varies among species, they are abundant and dispersed throughout the genome and show higher levels of polymorphism than other genetic markers. These features, coupled with their ease of detection, suggest their use as molecular markers. Their potential for automation and inheritance in a codominant manner are additional advantages when compared with other molecular tools (Holton 2001).

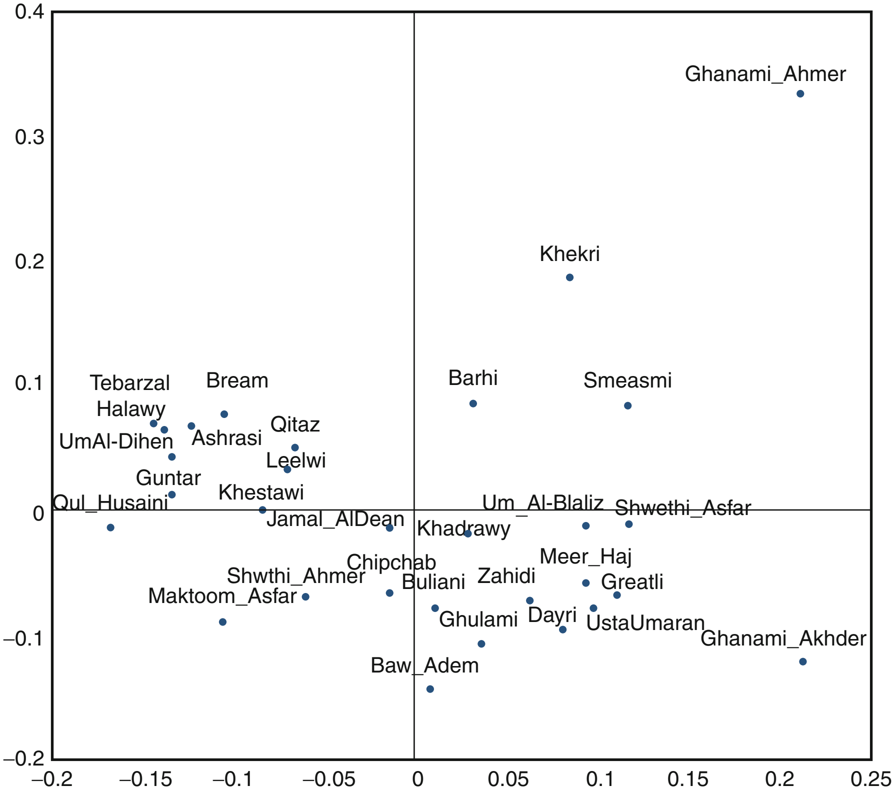

Fig. 4.9 Principal coordinate analysis (PCA) of 30 Iraqi date palm cultivars based on 22 microsatellite loci

The microsatellites examined in this study showed highly polymorphic patterns with a great number of alleles (188) distributed in 30 date palm cultivars. The number of detected alleles per locus in this study (8.54) was higher than 7.6 alleles per locus scored by Zehdi et al. (2004) in 46 date palm cultivars cultivated in Tunisia and those studied by Ahmed and Al-Qaradawi (2009) representing 15 cultivars grown in Qatar. The mean heterozygosity value detected in the Iraqi cultivars was 0.503, indicating the presence of high genetic diversity. Date palm growers believe that Ghanami Akhder and Ghnami Ahmer are two clones belonging to the same cultivar. However, the present investigation revealed high divergence between those two cultivars, suggesting they are independent cultivars and confirming the results of Al-Khateeb and Jubrael (2006) that used RAPD markers for the same purpose. Jubrael et al. (2005) and Khierallah et al. (2011b) suggested a common genetic basis among date palm genotypes in spite of the differences in fruit characters and tree morphology. Other authors reported similar results in Tunisian date palms (Sedra et al. 1998; Zehdi et al. 2004).

The long history of date palm domestication of an unknown origin (Wrigley 1995) and the nature of date palm culture may have played an important role in the composition of date palm genome (Elshibli and Korpelainen 2008). New cultivars may appear as a result of the continuous selection carried out by farmers following sexual reproduction. Exchange of propagules, which are a mixture of vegetative and seed-propagated materials, is conducted between farmers. All these processes together may result in a mixed genome within the same country (Elshibli and Korpelainen 2008). SSR analysis showed a high level of polymorphism among Iraqi cultivars. However, cultivar nomenclature and classification still remains based on fruit characters, including morphological, physical, and chemical traits.

4.5.4 Prospective of Germplasm Identification

Many Iraqi date palm cultivars collected from date palm stations are currently now at a juvenile growth stage. They will take some years to reach fruiting stage and be characterized by genetic markers. In addition, many farmers hesitate to give offshoots or even information about their cultivars. Undoubtedly, this will restrict cultivar identification efforts.

Iraqi date palm germplasm requires further investigation and adoption of proper markers to assist in identifying the economically and agronomically important cultivars. RAPD, AFLP, SSR, and ISSR markers are powerful methods to discriminate date palm genotypes and to assess genetic diversity in this fruit crop. Obviously, this would be enhanced by using more primer sets and/or a larger number of female and male cultivars. Work is currently in progress to find DNA markers linked to agronomic traits. Such markers would be important to assist in the selection and improved cultivation of this historic tree. The network (www.Iraqi-datepalms.net) was established in 2007, created and managed by Ibrahim Al-Jboory; it targets the collection of all scattered information on Iraqi date palm archives, past and present. The number of visitors to the website has exceeded one-half million. This website is a reference for researchers, farmers, and industry from different parts of the world, providing they are able to read Arabic.

4.6 Cultivars Description

4.6.1 Growth Requirements

The date palm tree is adapted to climates of long dry summers and mild winters. It has unique characteristics to thrive in deserts and oases where temperature are high but with underground water close to the surface (Al-Baker 1972). Under these circumstances the tree is described as having its feet in running water and its head in the fire of the sky.

Date fruit production and full ripening is dependent on the availability of certain heat requirements, according to cultivar. Most dry fruit cultivars are found in the dry areas, whereas soft and semidry ones are confined to more humid and semidry areas. During winter, temperatures may go below 0 °C. The low vegetative growth point of a date palm is 7 °C, and at above that level, growth is active and reaches an optimum at about 32 °C (Zabar and Borowy 2012). The growth rate remains continuous and stable until the temperature reaches 38–40 °C when it starts decreasing.

When the temperature drops for a certain period to below 0 °C, it causes metabolic disorders which lead to partial or total damage to leaves. At −6 °C, pinna margins turn yellow and dry out. Inflorescences are also heavily damaged by frost. When a frost period is forecast, inflorescences should be protected with craft paper bags, put in place immediately after pollination. At temperatures of −9 to −15 °C, leaves at the middle and outside of the tree canopy will be damaged and dry out (Zabar and Borowy 2012). If these low temperatures continue for a long period (12 h to 5 days), all leaves will exhibit frost damage and the tree will look as if it was burnt (Dowson 1982).

The date thrives in sandy, sandy loam, clay, and heavy soils but requires good soil drainage and aeration. The tree is remarkably tolerant of alkali soils. A moderate degree of salinity is not harmful but excessive salt stunts growth and lowers the quality of the fruit (Al-Baker 1972).

4.6.2 Cultivars Distribution and Production Statistics

About 600 date cultivars were grown in Iraq before 1980; however, the number has been reduced to about 500 cultivars now. Cultivars can be identified by many characteristics such as fruit appearance, texture, size, and shape. Fruits are of three general types: soft, semidry, or dry. The type of fruit depends on the glucose, fructose, and sucrose content. The classification is based on the texture or consistency of fruit under normal conditions of ripening. Soft dates are distinguished by soft flesh, high moisture, and high sugar content. Semidry dates feature a firm flesh, fairly low moisture, and high sugar content. Dry dates are characterized by high sugar content and low moisture.

Many Iraqi cultivars are considered to be commercial, such as Zahidi, Halawy, Sayer, Khadrawy, Khastawi, and Dayri. The distribution of cultivars across the date-producing provinces is detailed in Table 4.11 and illustrated in Fig. 4.10. Percentages of the leading cultivar production are shown in Table 4.12. It is clear that Zahidi occupies first place with 57.4 %, while other cultivar production is much lower. The distribution of cultivars over Iraqi date-producing provinces is shown in Table 4.13. Babylon governorate comes in first in production; others fluctuate in their yield and vary in the type of cultivar.

Table 4.11 Iraqi dates production by cultivars and provinces for the year 2012

		Production (mt)						
Governorate	Grand total	Zahidi	Dayri	Halawy	Khadrawy	Sayer	Khastawi	Others
Kirkuk	115	48	2	1	16	–	3	45
Diyala	83,792	47,327	4,986	256	2,048	3,499	10,511	15,165
Al-Anbar	43,196	34,248	14	11	164	31	7,568	1,160
Baghdad	93,782	56,963	323	274	1,717	248	11,467	22,790
Babylon	100,343	76,081	1,829	219	1,286	593	12,710	7,625
Kerbela	72,217	56,140	320	61	518	98	9,534	5,546
Wasit	43,649	24,063	370	565	1,736	285	6,588	10,042
Salah Al-Deen	19,734	10,796	67	504	368	188	2,756	5,055
Al-Najaf	32,304	23,063	246	424	1,466	791	3,724	2,590
Al-Qadisiyah	31,436	24,227	293	380	916	689	1,357	3,574
Al-Muthanna	25,275	10,078	1,739	968	2,027	1,366	1,508	7,589
Thi Qar	40,086	7,800	4,541	582	10,193	5,954	1,421	9,595
Maysan	8,967	1,733	612	135	2,320	1,902	656	1,609
Basrah	60,554	3,589	4,487	19,803	4,366	9,008	1,684	17,617
Total	655,450	376,156	19,829	24,183	29,141	24,652	71,487	110,002

Source: Central Statistical Organization (CSO) (2012), Iraq

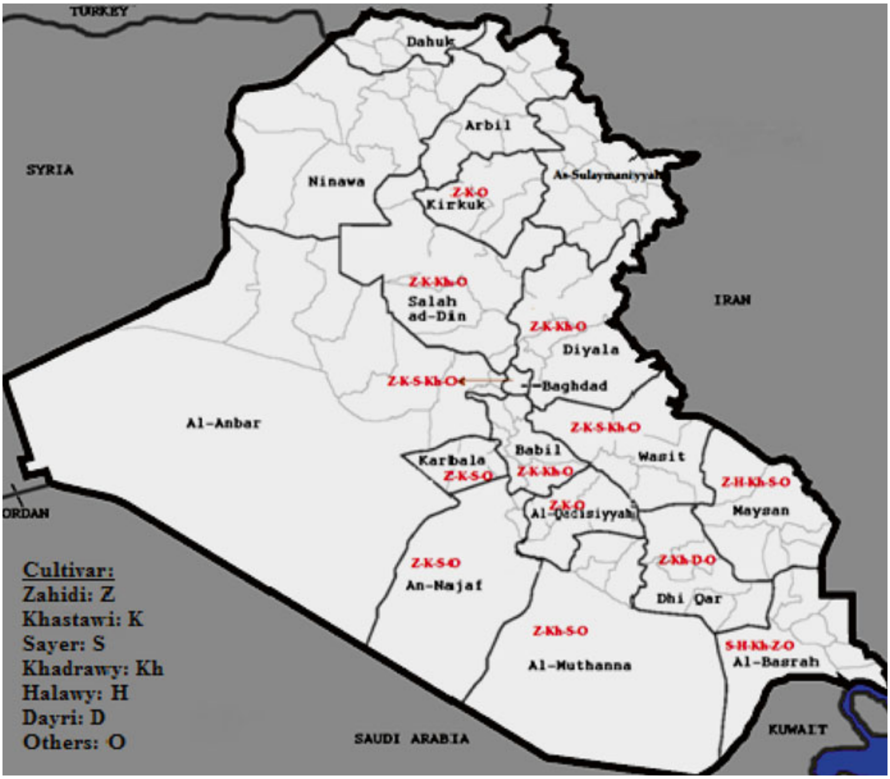

Fig. 4.10 Distribution of date palm cultivars in Iraq

4.6.3 Nutritional Aspects

The high nutritional value of dates is well documented; it has been said that dates can be a full meal since they contain reasonable quantities of macro- and microelements essential for human health. Minor variations in sugar content occur among cultivars, with a few exceptions (Table 4.14). Zahidi cultivar contains almost three times the amount of sucrose as compared with others, while Sayer contains approximately four times the amount of ascorbic acid than other studied cultivars. Other components exhibit similar trends. Generally, dates represent a rich source for primary and secondary metabolites especially with vitamins (Table 4.15).

4.6.4 Cultivars Description

Cultivars can be classified by characteristics of fruit appearance and texture and fall into three types:

(a) Soft dates: These are distinguished by a soft flesh, high moisture content (>30 %), and high sugar content; main cultivars belonging to this type are Maktoom, Barhi, Khyara, Shwethi, and Leelwi.

Table 4.12 Date palms, average yield, and production by cultivars grown in Iraq for the year 2012

Cultivars	٪	Production (mt)	Average yield kg/palm		Palms in production stage			Planted in 2012	Young palms	Total palms
			In stage of production	Productive	Total	Productive	Not productive			
Zahidi	57.4	376,156	73.3	77.2	5,134,681	4,872,271	262,410	206,471	625,271	5,966,423
Khastawi	10.9	71,487	67.7	67.7	1,055,577	1,055,577	–	95,211	210,232	1,361,020
Sayer	3.8	24,652	55.3	60.8	446,028	405,669	40,359	247,276	210,431	903,735
Khadrawy	4.4	29,141	58.1	62.2	501,861	468,848	33,013	51,774	130,242	683,877
Halawy	3.7	24,183	58.6	63.2	412,903	382,883	30,020	58,527	98,444	569,874
Dayri	3.0	19,829	64.2	64.9	308,898	305,320	3,578	407,815	259,822	976,535
Others	16.8	110,002	63.4	63.7	1,735,623	1,725,926	9,697	1,366,373	1,201,136	4,303,132
Total	100.0	655,450	68.3	71.1	9,595,571	9,216,494	379,077	2,433,447	2,735,578	14,764,596
Males		–	–	–	481,736	481,736	–	9,109	32,969	523,814
Total		–	–	–	10,077,307	9,698,230	379,077	2,442,556	2,768,547	15,288,410

Source: Central Statistical Organization (CSO) (2012), Iraq

Table 4.13 Date palms, average production allocated by cultivars and provinces for the year 2012

		Average yield						
	Grand total	Zahidi	Dayri	Halawy	Khadrawy	Sayer	Khastawi	Others
Kirkuk	65.6	79.3	60.6	71.4	71.1	–	49.2	55.3
Diyala	63.6	62.5	62.0	68.0	69.0	57.0	62.5	70.0
Al-Anbar	82.1	85.3	69.7	74.8	67.8	77.1	72.0	72.0
Baghdad	67.5	78.5	61.3	62.7	58.0	57.1	60.5	53.0
Babylon	78.6	83.9	60.5	73.9	63.0	70.0	64.5	69.0
Kerbela	58.5	56.3	47.0	56.6	55.0	52.2	70.0	67.0
Wasit	87.4	90.7	64.0	72.0	77.0	86.1	99.5	78.0
Salah Al-Deen	90.6	95.2	82.6	88.0	89.9	91.0	94.0	81.0
Al-Najaf	68.0	68.5	58.0	69.0	65.0	64.0	67.0	69.0
Al-Qadisiyah	75.1	83.2	58.1	55.1	52.0	50.0	55.0	60.0
Al-Muthanna	57.9	69.6	48.6	58.0	45.2	51.0	56.0	54.0
Thi Qar	60.8	69.1	66.1	68.5	56.3	59.7	63.1	58.0
Maysan	63.9	75.2	53.2	59.3	62.9	62.5	60.8	63.2
Basrah	60.4	61.5	83.0	57.2	54.2	49.8	72.0	68.0
Total	68.3	73.3	64.2	58.6	58.1	55.3	67.7	63.4

Source: Central Statistical Organization (CSO) (2012), Iraq

Table 4.14 Nutritional value of four Iraqi date palm cultivars

Components	Halawy	Sayer	Khadrawy	Zahidi	Mean
Element (mg.kg^{-1})					
P	160	130	150	140	145.0
K	8,540	8,330	8,940	8,870	8,670.0
S	100	200	140	210	162.5
Ca	1,840	2,030	1,330	2,070	1,357.5
Mg	560	580	600	590	582.5
Cl	2,600	3,120	2,660	3,420	2,950.0
Fe	52.6	32.1	45.0	103.7	58.4
Mn	58.6	52.5	51.4	51.6	53.5
Cu	27.7	28.9	25.4	27.5	27.4
Zn	13.9	18.2	12.9	7.4	13.1
Co	7.6	9.6	9.6	9.5	9.1
Fe	2.0	1.2	1.4	1.2	1.5
Sugar (% d.w.)					
Total sugar	87.9	86.1	87.7	86.8	87.1
Reducing sugar	82.7	82.6	81.9	73.4	80.2
Sucrose	4.8	3.5	4.5	12.7	6.4
Glucose	43.7	44.8	44.8	32.8	41.5
Fructose	37.2	38.0	38.0	39.2	38.23
Vitamins (mg. 100 g^{-1} d.w.)					
Thiamine	99.0	130.0	94.0	80.0	100.8
Riboflavin	173.0	135.0	149.0	167.0	156.0
Biotin	4.6	4.7	4.1	5.7	4.8
Folic acid	57.0	70.0	43.0	63.0	58.2
Ascorbic acid	3.6	17.5	3.2	2.4	6.7
Other components					
Moisture (% f.w.)	7.3	7.5	9.5	8.3	8.1
Total soluble solid (% f.w.)	84.2	81.3	80.8	82.1	82.1
Total insoluble solid (% f.w.)	17.9	10.0	9.5	9.2	11.7
Protein (% d.w.)	2.3	2.8	2.4	2.2	2.4
Fat (% d.w.)	0.5	0.3	0.5	0.4	0.4
Ash (% d.w.)	1.9	1.8	2.1	1.8	1.9
Crude fiber (% d.w.)	1.8	1.7	2.3	2.5	2.1

Source: Yousif et al. (1982)

(b) Semidry dates: These have a firm flesh, fairly low moisture content (20–30 %), and high sugar content; this type includes Zahidi, Dayri, and Khadrawy.
(c) Dry dates: These have a high sugar and low moisture (<20 %) content; their flesh is dry and hard; this type includes Banafsha and Bedray.

Detailed descriptions of the most important cultivars grown in Iraq are presented in Table 4.16 and Fig. 4.11, showing the variability in fruit morphology of the best-known Iraqi cultivars.

Table 4.15 Chemical composition of dates in 100 g fresh weight

Component	Content (%)	Minerals	Content (mg)
Moisture	18	Ca	167
Total sugar	80	P	13.8
Sucrose	5.9	K	798
Glucose	39	S	14.7
Fructose	35	Na	10.1
Total soluble solid	82	Cl	2,71
Total insoluble solid	12	Mg	53.3
pH	6.0	Fe	5.3
Protein	2.2	Mn	4.1
Fat	0.37	Cu	2.4
Ash	1.7	Zn	1.2
Fiber	1.9	Co	0.9
		Fe	0.13
Vitamins	Content (μg)		
Thiamine	93		
Riboflavin	144		
Biotin	4.4		
Folic acid	5.3		
Niacin	5.3		
Ascorbic acid	61,000		

Source: Yousif et al. 1982

Table 4.16 Characteristic of the most important date palm cultivars grown in Iraq (Al-Baker 1972)

Cultivar	Description
Zahidi	Semidry date, native to Iraq. Medium size, cylindrical, light golden brown, very sugary; sold as soft, medium-hard, and hard. Distinguished by its large seed in proportion to the fruit itself. This date lends itself well to processing and softening by steam hydration. This date is known for its high invert sugar level and is widely used to make diced dates and date sugar products. It features a crunchy and fibrous flesh. Industrial uses
Sayer	The most prevalent cultivar in Basrah, dry, dark orange-brown, medium size, soft, and syrupy; oval curved to one side; industrial uses. Originates in Iraq
Halawy	Soft. Extremely sweet, small to medium in size. Thick flesh, caramel taste, is somewhat wrinkled in appearance, with a yellow color ripening to a light amber and then to a golden brown. Originally from Iraq. Fresh or industrial markets
Khastawi	Leading fresh date in Iraq; it is syrupy and small in size, prized for dessert. For fresh market
Khadrawy	Semidry, very dark date. Originally from Iraq, it has many desirable qualities. It cures well; it ripens to amber and is then cured to reddish brown, with a caramellike texture and a sweet flavor. Industrial uses for export and fresh consumption locally
Barhi	Nearly cylindrical, light amber to dark brown when ripe; soft, with thick flesh and rich flavor; of superb quality. For shipment needs refrigeration as soon as picked, then curing and special packing. Native to Iraq

Fig. 4.11 Variations in fruit morphology of common cultivars of date palm in Iraq (*Source*: www.Iraqi-datepalms.net)

4.7 Dates Production and Marketing

4.7.1 Practical Production Approaches

4.7.1.1 Pruning

To optimize date yield, several cultivation practices are followed in the groves. Pruning is an important agricultural practice to remove dry leaves and leaf bases, as well as fiber, spines, and high offshoots. Pruning reduces insects and the spread of diseases. It also facilitates workers when they maneuver to perform other basic agricultural practices such as pollination, thinning, pulling down bunches, and bagging. Moreover, it enhances lighting thus decreasing the humidity around the bunches. Pruning is usually carried out once a year after harvesting, along with pollination or when the bunches are pulled down. This operation can be done manually or mechanically using a hydraulic lift and/or ladder.

4.7.1.2 Bunch Management

For effective date palm management, three practices should be carried out on bunches: thinning, bending, and pulling down bunches and bagging.

Thinning is the first practice and it provides more nutrients to a fewer number of fruits. It increases the fruit size, enhances the quality, prevents delay in ripening, and reduces the weight and compactness of the fruit bunch. Thinning also decreases fungal infection and mechanical damages. This will benefit both harvesting and packing operations. There are three different methods of thinning: the first reduces the number of strands from the central part of each bunch, the second reduces the number of bunches per palm, and the third reduces the number of fruits per strand. Thinning can be also carried out either by certain chemicals, by using diluted pollen grains, or by mechanical means (Soliman et al. 2010).

Bending and pulling down bunches is the second important management practice. Most Iraqi date palm orchards carry out this process (Fig. 4.12). The bunch is bent over the leaves and the fruit stalk is tied to the midrib of one of the lower leaves. Pulling down bunches to release them from among the leaves should be done carefully to avoid breaking the fruit stalk. Bunches should not be pulled down until the fruit stalk is thick and sufficiently long. This process facilitates harvesting and bagging.

Bagging is the third practice relying on covering of fruit bunches with a certain type of paper or cloth bag. These bags protect fruit from dust and sunburn, while also decreasing the loss or damage from insects or birds (Al-Obeed and Harhash 2010; Kassem et al. 2010).

Fig. 4.12 Bunches bent down in date palm

4.7.2 Date Palm Fruit Storage and Packing

Date fruits are an important and nutritional food as they contain high percentages of sugars, minerals, and vitamins. Date fruits can spoil easily, in particular the softer cultivars; care in handling must be taken during harvesting, gathering, and grading according to the cultivar. Most Iraqi date cultivars are harvested by cutting the entire bunch when most of the fruits are ripe. Skilled palm grove workers cut the fruit bunches, lower them to the ground, and place them on mats. Dates are then removed from their bunch and carefully packed. Some growers fumigate fruits while they are in the field to protect them from insects and various diseases. Storage is considered an important factor for marketing to increase sales and income. Date fruits are normally stored on the farm in centrally located, cooled storage areas and/or in regular storage areas of a packing house. Usually, as part of the preparation process, date fruits are fumigated to control insect populations. Packaging is a crucial process in date fruit marketing locally and abroad and must be done according to international standards to make the product suitable for consumers and more profitable to the producer.

4.7.3 Date Palm Fruit Processing and Pressing

In Iraq, processing of date fruit into various products is still at an early stage of development. Although fruit processing can be very profitable, Iraqis are still using primitive implements and methodology. *Dibis* production, alcohol, vinegar, liquid sugar, bread yeast, and citric acid are a few examples of products derived from processed dates. Previously, Iraq had the largest packing and pressing factories for date fruits and its various products. Different types of packaging were used, including plastic, cardboard boxes, and wooden crates. In the 1990s, the number of pressing factories grew to 250; however, since 2003, this sector has suffered from severe neglect leading to the closing most of the pressing facilities. This sector, therefore, should be given high priority to reactivate this important division of date palm fruit processing (Zabar and Borowy 2012).

4.7.4 Marketing Status and Research

Date fruit marketing represents an obstacle for Iraqi producers because of current regulations as well as the additional reasons, including the following: (a) The wholesale price of dates is rather low compared with the high cost of production. This has led to the neglect of trees or poor management, and this reflects negatively on fruit quantity and quality. (b) As the standard of living in Iraq has risen dramatically during the last 5 years in Iraq, wages have increased and consequently the costs to maintain date palm groves have increased. (c) The shortage of modern machinery has negatively affected the cost input, including tree management and fruit packaging.

Despite all of that, the Iraqi government has intervened and raised the price of Zahidi cultivar fruit from IQD 190 per kg (USD 0.15) up to IQD 450 (USD 0.675), which is considered to be a promotional amount; however, it still is undervalued. Nevertheless, more attention has been paid to date growers, as reflected in an increase in production over the last 2 years. A study in 2008 by FAO, using a matrix analysis, revealed that the profitability of date growers has increased several times. Research is now underway by different specialized institutions on handling, harvesting, storage, processing, and marketing of dates. This will lead to improve date production and enable competing on the international market with better fruit quality. The private sector should invest strongly in this vital economic aspect. Government loans are available for the private sector which may encourage date processing industry in the near future.

4.7.5 Current Import and Export

Iraqi date production was low before 1993 (Fig. 4.13); however, exports represent a high proportion of the dates produced. When Iraq was under economic sanctions, most of dates were consumed locally. A general increase trend was obvious in 2002–2004, accompanied with a slight improvement in export. As stated earlier, poor fruit quality, lack of infrastructure, inferior packaging, and the slow and inefficient routines of export facilities are one of the main causes for the deterioration of date trading. Recently the government has made facilities available for use by the private sector with the hope of stimulating exports.

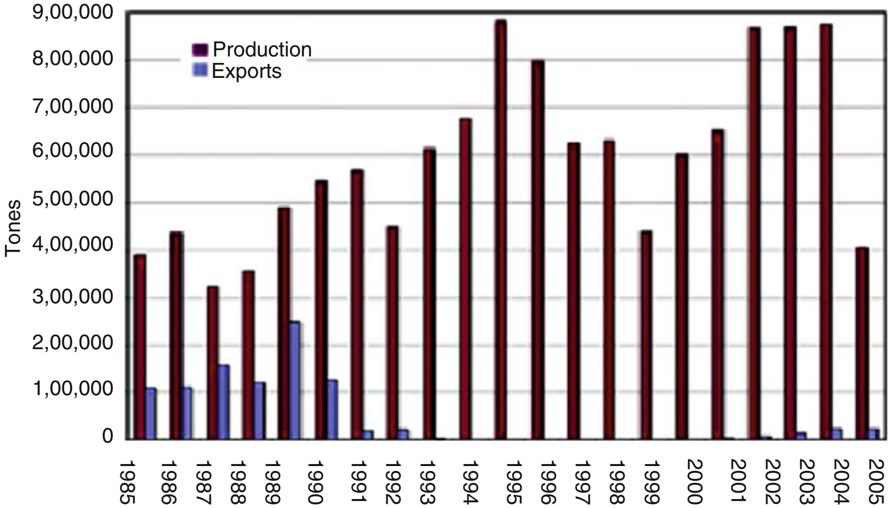

Fig. 4.13 Date production and exports (mt) in Iraq 1985–2005 (*Source*: FAOSTAT 2009)

4.8 Processing and Novel Products

4.8.1 Industrial Processing Activities

Although commercial date palm populations have declined significantly in Iraq over the last 30 years, some industrial activities are still going on. Government authorities are encouraging date growers by offering incentives, such as increasing the price of dates purchased by the government date processing factories. Zahidi is the most commonly grown cultivar across in Iraq. Its fruits are used in several manufacturing activities. *Dibis* processing factories are located in several Iraqi governorates. Some of these are run by the General Establishment of Dates, of the Ministry of Agriculture. Others are run by the private sector. The *dibis* product is consumed domestically and any surplus exported. Traditional date and tree products are fully utilized in date-producing areas especially in the southern governorates. These activities make use of all parts of the date palm tree producing furniture, folk tools, and simple raw materials for building houses.

4.8.2 Commercial Dates Processers

No current accurate survey is available on date fruit processors in Iraq, although several are distributed across the country. Date processing is the only manufacturing activity supervised by the Ministry of Agriculture and has a wide spectrum of activities including *dibis* production and fresh date packaging. Tens of factories belonging to the private sector are located in the date palm-growing regions, but most are not registered with the Ministry of Planning.

4.8.3 Secondary Metabolites

Date fruits are practically the richest in calories and nutrients among the various types of fruits. Ibrahim (2008) stated that 100 g of dates contains 274 cal, 72.9 g sugars, 2.3 g fibers, 59 mg Ca, 63 mg P, 3.0 mg Fe, and 648 mg K, although those are cultivar dependent. In addition to vitamins, dates are also rich in secondary metabolites including pectins, tannins, green pigments, carotenoids, anthocyanins, organic acids, and volatile compounds. Research in Iraq has focused on full utilization of the date palm tree, and numerous papers have been published on the subject by Iraqi researchers with special reference to extracting valuable materials for industrial, nutritional, and pharmaceutical purposes. Such scattered research work is rather difficult to summarize; however, it can be said to document the potentially wide applications in food and feed alike (Ibrahim 1998).

4.8.4 Bioenergy

Date palm is a principal agricultural crop in the Middle East and North Africa. Date palms are abundant yielding about 3,316,500 mt of palm secondary products per year including palm midribs, leaves, stems, and fronds (Taha et al. 2001). In Iraq, 16 million trees are grown in the middle and southern portions of the country, resulting there in a surplus production of dates and other secondary biomass such as leaves and sheaths.

Dates have high sugar content (55–70 %/wt.). Traditionally they are used for food or to produce sweets, *dibis*, vinegar, and alcohol products. In Iraq, a portion of the biomass waste of all these industries is used as animal feed. However, in the rural areas where local primitive *dibis* factories are located, biomass waste is usually dumped without treatment, while it could be used as a biofuel for domestic use especially for operating generators. Power generators could serve thousands of local inhabitants, save fossil fuel, create new jobs, and sequester CO_2 to keep a cleaner environment. Date waste biomass mainly consists of cellulosic compounds with some sugar, fats, and minerals. That makes it a high potential resource for biofuel production through fermentation. This potential has been recently considered in the Middle East and Arabic regions. The technology has been used in many agricultural countries such as India, China, Thailand, and Brazil since at least 2006. In Iraq the trend toward bioenergy is still in the primary stages. To the best knowledge of the authors, only a small amount of research work has actually been done on the date palm biomass as a biofuel resource thus far. In some seasons biomass waste is burned in the open or left to decay. Bioenergy may be generated from pruning remains of date palm trees. These include dry leaves and fruit pits that could be utilized to produce local thermal and electrical power in the rural areas without the need for long distribution grids and large power stations. Research work should be undertaken to investigate date palm fresh fruits, pits, and leaves for composition and biomass value assessment.

Jaafar and Baldwin (2010) studied Zahidi cv. as a source for biomass since it is the most abundant in Iraq, representing nearly 60 % of the country's production. The cellulosic, hemicellulosic structural sugars and lignin contents of Iraqi Zahidi cultivar date pits were investigated, including extractable components for functional food and nutrition. Structural sugars were measured to evaluate the date pits as a biomass resource for food or bioenergy. Total lignin was 15.32 %, mainly acid-soluble lignin, and structural sugars 59.87 %, mainly arabinose (51.6 %). This was the first study documenting such a high content of this sugar in date pits. The results reveal the high potential of date pits and leaves for biofuel production. Nevertheless, further investigations are still needed to achieve an adequate economic capacity of such potential renewable energy resources in Iraq.

The economic and environmental impacts of bioenergy production can be summarized as follows: (a) it supports local and national economies; (b) it is carbon neutral; (c) it is a cheap and renewable resource; (d) it is relatively friendly to the environment; and (e) energy can be produced locally instead of by expensive power-generating units.

4.9 Conclusions and Recommendations

Iraq is the oldest historic domestication center of date palm. Whereas the country had over 32 million date palms in the mid-twentieth century, this figure dropped dramatically to a low of approximately 12 million by 2000. The decline has come as a result of numerous conflicts in the date-producing regions since 1980. Thus, the government had adopted many programs aimed at increasing the numbers up to 40 million trees in the next 10 years. Plant tissue culture to support propagation by offshoots is essential to increase date palm numbers of desired cultivars as well as for cultivar identification using DNA marker technology. Date palm pests and diseases—dubas bug, lesser date moth (Humera), and Ghobar mites—are also responsible for the decline in a number of palms and deterioration in production of up to 50 % in some seasons. The Ministry of Agriculture, scientific institutes, and universities have conducted extensive investigations, together with FAO experts, to control these pests in Iraqi date groves. Accordingly, it is recommended that new technologies be introduced in order to improve the date production quantitatively and qualitatively. Integrated pest management is vital to reduce the potential damage in both date palm groves or during storage. Possible improvement is necessary in sorting and packaging of dates to compete with other producers and exporters to expand global date marketing.

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