Chapter 15
Date Palm Status and Perspective in Spain

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Abstract The date palm (*Phoenix dactylifera* L.) is an archaeophyte in Spain and is the iconic species of an introduced mixed irrigated agricultural system of food crops, animal feed, grasses, and livestock. Traditionally, date palms are propagated from seed and grown for their fruits, as well as for products derived from the leaves and stem wood. The seedling date palm populations in Spain represent a diverse pool of genetic resources with potential to improve the crop in general. Depending on the local microclimate, 20–50 % of date fruits in Spain do not fully ripen on the tree because of cooler temperatures late in the growing season. Artificial ripening techniques have been devised to deal with this situation. Local genotypes are under study for the best fruit types for expanded marketing, as a gourmet fresh fruit product in Europe, to enhance farmer income and to sustain the traditional production system. Tissue culture of selected genotypes is contributing to sustainability of the palm groves. New commercial date products are under study to broaden economic possibilities. The exotic red palm weevil pest represents the main threat to the palm grove and control measures are being pursued. Historic palm groves persist in Spain, especially in Elche and Orihuela, as well as presumably naturalized feral palms exhibiting distinctive morphological characteristics described as

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P. iberica. Phoenix palms are protected and continue to provide commercial fruits and palm leaves for religious ceremonies and to enhance the local landscape. Elche, the largest palm grove, is a World Heritage Site and a major tourist attraction.

Keywords Artificial ripening • Elche • Genotype • Germplasm • Red palm weevil • Seedling dates • Tissue culture

15.1 Introduction

15.1.1 Historical and Current Agricultural Aspects

The date palm, *Phoenix dactylifera* L., is generally considered an archaeophyte in Spain; it is unknown when and where it was first introduced, but certainly in ancient times. It is almost impossible to trace the origins of date palm cultivation in Spain. Although archaeological remains in the form of carbonized or mummified date seeds exist, these were never radiocarbon dated and thus their adscription to a chronology is hypothetical. Furthermore, it cannot be ruled out that some of these findings may correspond to more recent imports (Rivera et al. 1988). Transformed or simplified images of date palm trees are frequent in late Iberian pottery (third to first century BC) (Fig. 15.1) and in silver and bronze

Fig. 15.1 Representation of a date palm tree on an Iberian pottery fragment from Zama, Hellín, Albacete (Photo: Museo de Albacete, by Marian Vencesla (with permission))

Fig. 15.2 The *Palmeral de Elche*, Alicante, a palm grove of one of the numerous rural parishes into which the municipality of Elche is divided. Only a few among these were included in the historical area declared by UNESCO as a World Heritage Site (Photo: D. Rivera)

coins from *Quart Hadast* (presently Cartagena), *Baria, Sisapo*, and *Tagilit* (third century BC). As Rivera et al. (2013) have shown for the introduction of date palm to the Americas after the fifteenth century, it is likely that introduction of different seedling cultivars into Spain occurred repeatedly since the prehistoric period and through intentional or unintentional germination of seeds from dates imported for food.

The historic *Palmeral de Elche* contains about 180,000 adult date palms (Fig. 15.2). Total date fruit production for Spain was reported at 4,000 mt in 2012 (FAO 2013); however, since 1995 only about 100 mt are marketed from Elche for human consumption (Ferry et al. 2002). The *Palmeral* covered 550 ha in 2004 which represented about 3 % of the agricultural land of Elche. Other date production areas in Spain are Abanilla and Huerta de Murcia in Murcia and Albatera, Alicante, Callosa, Crevillente, and Orihuela, Comunidad Valenciana, which contribute to the overall date production of Spain. The traditional Elche palm grove was inscribed as a UNESCO World Heritage Site in 2000 and intended to be maintained as a unique European example of an introduced oasis system, with the date palm as its key agricultural species (Johnson et al. 2013).

15.1.2 Importance to Country Agriculture

In terms of cultivated area, the date palm is almost marginal in Spain. Of the 30.6 million hectares cultivated in Spain in 2009, only 830 were reported as palm groves producing dates (FAO 2013; INE 2013). Since the 1970s, thousands of adult date palms have been transplanted from traditional palm orchards (e.g., Abanilla, Cuevas de Almanzora) to new urban developments and resorts for ornamental use along the littoral of continental Spain and the Balearic Islands; this strongly reduced the expansion and relevance of palm cultivation for date-fruit production. During the last four decades, the great demand for adult date palms as ornamentals led to decreased local availability and higher prices for date palms, resulting in the importation of mature Egyptian date palms.

15.1.3 Production Statistics and Economics

During the last 50 years, date production in Spain has steadily decreased, with slight fluctuations, from 12,000 mt in 1961 to 3,741 mt in 2011 (FAO 2013). Almost 100 % of Spanish dates are sold fresh in local markets (Fig. 15.3). Depending on quality and fruit size, retail prices reach EUR 4–15/kg.

At present, it is impossible in Spain to earn a stable and sufficient income for a family or company based solely on the production and marketing of date fruits. Therefore, this activity is complemented by the exploitation of other parts of the palm. The leaves are *encaperuzadas*, whereby young shoots are covered with black plastic bags (*caperuzas*) and protected against sunlight for months, yielding pale leaves without chlorophyll, which afterwards can be whitened, processed, and fashioned into traditional handcrafts. Most of this production is specifically made for religious and other ceremonial purposes. The shoots are referred to as *palma blanca* in Spanish and *white palm leaves* in English.

Most of the date palm growers who produce white palm leaves in Elche and surrounding areas do so because they do not make a profit from the fruits and still have the expense of pruning old leaves. With white palm production no additional tree maintenance is necessary and in 1983 each palm generated ESP 1,000 annual income, which in 2003 equaled about EUR 42 (in Elche, Alicante) but in 2010 came down to EUR 14 (in Abanilla, Murcia). In 1983, about 25,000 Elche date palms were *encaperuzadas*, producing approximately 250,000 white palm leaves of different size and quality. Some of the production was used locally for Elche's elaborate Easter pageant (Fig. 15.4), some were shipped to

Fig. 15.3 Dates sold at Fira de Sant Blai (or *porrat*' de Sant Blai), in Albal, Valencia (Photo: E. Laguna)

Fig. 15.4 Selling palms for a religious festival, Elche, Alicante (Photo: C. Obón)

Barcelona, and about 80,000 leaves were exported, particularly to the UK. In 2003, the number of palms *encaperuzadas* in Elche reached 70,000 (Brotons 1989; Gracia 2006).

15.1.4 Current Agricultural Problems

There are three very serious issues affecting date palm agriculture in Spain leading to the abandonment of palm groves: the lack of markets interested in stocking locally produced dates, the significant impact of recently introduced red palm weevil pest (discussed below), and the appreciation of the agricultural land occupied by the palm groves as area for urban growth and/or conversion to more profitable crops.

15.2 Cultivation Practices

15.2.1 Chronological Account of Research and Development

Cavanilles (1793) described, under the name *Phoenix excelsior* Cav., the main date type grown in Elche with the vernacular name Candits and its cultivation practices. Date palm groves in Elche and Orihuela were traditionally irrigated with water

unsuitable for use on other crops because of its high salt content particularly sulfates. The *palmerales*, large areas of palm tree cultivation, are often associated in Spain with and take advantage of runoff thermal springs of medicinal waters.

For decades, there was no interest in promoting genetic improvement of the date palm trees. Lack of a breeding program can be explained by taking into account the marginal climatic conditions in the area of cultivation and traditional orchard management. In the 1970s, with the creation of ICONA (Nature Conservation Institute) and IRYDA (Institute of Agrarian Reform and Development), there arose an interest to improve date palm cultivation, although following the classical route of introducing well-known exotic cultivars. By 1974, selected seedlings and offshoots were introduced from the USA, presumably from Indio, California, and planted in the nurseries of the ICONA forest service at Santa Faz, Alicante (García Lidón A, personal communication, 2012). By 1984 dozens of individual palms had survived, notably several which produced sweet green fresh dates, although it appears that this introduction had little impact in the large *palmerales*. Introductions by the Phoenix Station in Elche included Sphinx (an American cv.) as well as cvs. Barhi, Medjool, and Thoory.

15.2.2 Description of Current Cultivation Practices

The structure of a typical Elche palm grove (*tahúlla*) consists of an area of about 1,000 m^2; on average, each usually has 35 adult date palms irrigated with salty water. The few new palm groves in the Elche vicinity have imitated the structure of the old orchards (Brotons 2001).

Date palm is usually propagated by seed, leading to high phenotypic diversity. Date palm cultivation can be problematic in areas such as Elche, due to low temperatures for fruit ripening as well as high humidity at the time of ripening which is detrimental to the fruit quality; some years the dates may not ripen fully. Thus, date palms are usually combined with other crops in a two- or three-layered arrangement, allowing for a higher output than a monoculture would provide. The date palm is considered a multipurpose tree and its value resides not only in fruit for human consumption but also for products such as animal food, *palma blanca*, and building materials (Ferry et al. 2002); consequently, date palms which do not bear palatable dates may still be profitable.

Trends appear to have changed in the late twentieth century, thanks to the combined efforts of the local Phoenix Station, INRA (National Institute for Agricultural Research-France), the University of Alicante, Miguel Hernández University of Elche, and local administrations. Tissue-culture protocols were developed as well as the selection of genotypes for replacement plantings in the Elche palm groves. Genotypes for tissue culture involved Confitera and the introduced cv. Medjool (Ferry et al. 2002), as well as genotypes Lucerga and Léon. This led to clonal populations on small monoculture plantations of date palms which is a novelty within the traditional agricultural system of the local *palmeral*.

15.2.3 Pollination, Fruit Quality, and Metaxenia

The traditional *palmereros* (farmers or farm workers who care for the date palms) of Abanilla and Elche, in selecting male inflorescences for pollination, usually look for the frequency of bees around the flowers. Apparently, large numbers of bee visitors are an indication of fully developed male flowers with no defective pollen. Traditional management of palm groves includes the practice of *macheo*, where certain male individuals are much sought after because of the high quality of their pollen and its positive influence (metaxenia) on the quality and size of date fruits; those male palms are therefore selected for artificial pollination (Rivera et al. 2008).

15.2.4 Pest and Disease Control

Date palm can be damaged by numerous pests and diseases and comprehensive world reviews have been published (Abdullah et al. 2010; Blumberg 2008; El-Shafie 2012; Howard et al. 2001; Zaid et al. 2002). Historically in Spain, no major incidences of pathogens or pests are known, probably due to the relative isolation of the date palm groves, local climatic conditions, genetic heterogeneity of seed-derived palms, and the distinctive agricultural practices used. However, this situation has dramatically changed in recent decades.

New exotic pest threats have appeared as a result of date palm importations from other countries (Gómez 1999). Most serious are the red palm weevil (*Rhynchophorus ferrugineus* Oliv.), palm borer (*Paysandisia archon* Burm.), and a few others. The two named pests reached Spain when infested adult date palm trees were imported for landscaping and ornamental use, especially in new urban developments. Among other pests, red date scale, *Phoenicococcus marlatti* Cock., was first detected in Spain at Elche in the winter of 1993/1994, an explosive development being reported a few years later (Gómez et al. 1996). Because *P. marlatti* attacks the leaf bases and may cause tissue necrosis, the production of the traditional white leaves can be affected (Ferry et al. 2002). It may also cause dryness and mortality of the infested palms. Although application of thiamethoxam by trunk injection has been successfully assayed (Muñoz-Irles et al. 2008b), chemical control of *P. marlatii* is difficult and sometimes ineffective because of the concealed sites in which the scales are located. For that and environmental reasons, biological control of red scale has been attempted in the area. Local predators *Rhyzobius lophanthae* Blais. and *Chilocorus bipustulatus* L. have been identified and a protocol for mass rearing under controlled conditions using *Aspidiotus nerii* Bouche as a host has been developed for *R. lophantae*. The first release assays in the palm grove at Elche showed promising results (Gómez 2002; Muñoz-Irles et al. 2008a).

The most harmful pest of the date palm is the red palm weevil which was first detected in Spain on *Phoenix canariensis* H. Wildpret in 1995; between 2003 and 2009 it explosively spread on the Spanish mainland and to the Balearic and Canary

Islands. Evidences suggest that its expansion in Spain was due to date palm importation from Egypt and movement of infested palms and offshoots (Ferry and Gómez 2002). During 2003–2006, around 15, 000 mt of palms were annually introduced into Spain. Red palm weevil has caused severe damage and destroyed thousands of trees. Damage to date palms is mainly produced by larvae but visible symptoms are not apparent until infection is extensive. The main symptoms are holes in the crown or trunk, usually covered with fibers, oozing brown viscous liquid, a rotting odor, extrusion of chewed up fibers, destruction of vascular system, and, eventually, collapse and death (Zaid et al. 2002). Despite intensive efforts, management of this pest is complicated, mainly due to difficult early detection, lack of quarantine treatment, or ineffective destruction of affected palms. Preventive and curative chemical control has been made by foliage spraying with fenitrothion, chlorpyrifos, diazinon, or methidathion and trunk injection with carbaryl and imidacloprid, all with variable results. Mass monitoring and trapping of adults with pheromones has also been successfully assayed (Esteban-Duran et al. 1998; Martínez-Tenedor et al. 2008; Sansano-Javaloyes et al. 2008), but risks may arise from using it in uninfected areas. Biological control with *Steinernema carpocapsae* Weis (Gómez et al. 2008; Llácer et al. 2009) and *Beauveria bassiana* (Bals.-Criv.) Vuill (Dembilio et al. 2010; Güerri-Agulló et al. 2010, 2011) has been recently developed with promising results. Prophylactic measures such as quarantine regulations, early detection by visual checking and regular monitoring by trained experts or bioacoustic sensors (Gutiérrez et al. 2010), pruning (in winter, only dry leaves), and removal and destruction of damaged palms (cutting, transportation to specific areas, and shredding) are strongly recommended. Legal restrictions against palm movement such as the current EU plant passport are also important. In summary, although intensive efforts are being made from local, central, and European governments and from research institutions, a completely efficient red palm weevil control is still unavailable. It is necessary to adopt an integrated pest management strategy including measures to avoid new palm devastation and consequent economic and cultural losses.

Paysandisia archon (Burm.) is a moth belonging to the family Castniidae, which occurs naturally in Argentina, Brazil, Uruguay, and Paraguay, where its larvae feed on palms, mainly of the genus *Trithrinax*. In Europe, it has become a serious threat for numerous species of ornamental palms. Adult individuals of this species have been observed flying in and around Valencia in mid-summer. The Generalitat Valencian in June 2003 issued an official declaration of the pest and prescribed specific phytosanitary treatments. However, there is no evidence yet concerning the impact on individuals of *Phoenix* species in the zone (Montagud 2004). On the contrary, the impact on palms of the native genus *Chamaerops* seems to be significant and tentative treatments include biological control with the nematode *Steinernema carpocapsae* (Soto and Duart 2013).

Other minor damaging pests detected in Spain (Gómez 1999) are the date stone beetle *Coccotrypes dactyliperda* Fabr., which makes round holes, sometimes reaching the seed, which makes dates unmarketable. The injured fruits usually fall prematurely. Its incidence is variable in Spain and no particular management is reported to be applied. The nitidulid beetles *Carpophilus hemipterus* L. and *C. dimidiatus*

Fabr. can attack ripe fruits, preferably the decayed or damaged ones. Protection of fruit bunches with dense plastic nets and early harvesting is suggested as efficient prevention methods. Larvae of *Arenipses sabella* Hamp., the greater date moth, feed upon young leaves, inflorescences, and immature dates. Although biological control with *Braconidae* and *Bacillus thuringiensis* Berl. is used in other countries, no particular management is reported to be used in Spain.

As far as diseases are concerned, new data on incidences have been reported, but they do not cause significant damages in Spain. Inflorescence rot disease has been recently detected in Elche (Abdullah et al. 2005; Gómez 1999). Brownish or rusty-colored lesions appear on unopened spathes, producing destruction of the flowers and strands. The pathogen was identified as *Mauginiella scaettae* (Cav.) Maire but *Fusarium* spp. or *Botrytis* sp. were also present in some samples. Cutting and burning affected bunches and applications of cupric products are control strategies. A high incidence of *Thielaviopsis paradoxa* (de Seynes) Hohn. and *T. punctulata* (Hennebert) Paulin, Hamington, and McNew was found in soil from date plantations at Elche. These fungi are involved, among others, in root rot and heart bud rot diseases which suggest the possibility of infection of newly transplanted offshoots (Abdullah et al. 2009). *Graphiola phoenicis* (Moug.) Poit. can be found forming subepidermal spots on young leaves in nurseries (pers obs and Laboratory of Plant Protection, Balearic Islands). Propagation of these fungi is favored by humid conditions; however, damage to date palms is relatively limited.

15.2.5 Agroforestry Utilization and Potential

Rivera et al. (1997) described *Phoenix iberica* as a type of date palm growing spontaneously in ravines and salt marshes of Murcia and Alicante provinces. It has a large trunk with numerous basal offshoots (Fig. 15.5), short glaucous leaves with strong and

Fig. 15.5 Group of palms, *Phoenix iberica*, Rambla de la Parra, Abanilla, Murcia (Photo: C. Obón)

relatively short acanthophylls, rigid leaflets, and small fruits with very thin flesh. In addition, date seeds of local *P. dactylifera* types spontaneously germinate in natural and seminatural habitats of the littoral and in the valleys of Almeria, Murcia, Alicante, and Valencia, where there is sufficient groundwater. Therefore, the date palm is a relevant tree species of areas in the Chicamo, Segura, Vinalopó, and Almanzora river valleys. The date palms suffer no great damage, overcoming frequent recurrent fires which occur in those areas. But these spontaneous date palms are threatened by red palm weevil since the palms are not subject to any preventive or curative treatment.

Phoenix dactylifera (perhaps with some proportion of hybrids with *P. iberica*) was used for forest restoration and stabilization of the sand dunes of Guardamar del Segura, Alicante, in the early years of the twentieth century. In afforestation, it was the main species for planting in saline depressions between dunes where, besides helping to stop dune migration, helped drain temporary standing water, at that time important to help prevent the spread of malaria.

In the early 1950s, the issue of dealing with spontaneous *Phoenix* palms fell to the forest service because the palms were growing in no man's land (agricultural and forestry) for which a specific forest category, palm forests (*montes palmerales*), was created. This category included a few examples such as the palm groves of Elche, Orihuela, and Alicante. However, *Phoenix* palms were difficult to manage in administrative terms as crops, as they did not function according to the standards of orange groves or orchards. Furthermore, when date palm production was focused on white palm leaves for religious ritual use, the palms were even more difficult to relate to fruit or vegetable production.

15.2.6 Date Palm Mycorrhization

Mycorrhization has successfully been tested in *Phoenix* to improve hardiness and yields. *Phoenix dactylifera* has been shown to be mycorrhizal (Dreyer 2004; Khaliel and Abou-Heilah 1985; Oihabi et al. 1993; St. John 1988). The mycorrhizal potential to enhance plant growth, shown for palms under low-nutrient conditions (Janos 1977), is of great interest for the management of cultivated date palms.

Arbuscular mycorrhizal (AM) colonization in date palm is restricted to the inner cortex of the third-order roots, except for the pneumatorhizas and the short thick roots (Dreyer et al. 2010). The first- and almost all the second-order roots of this palm species were not colonized by AM fungi. In terms of mycorrhizal colonization, the root system presents a division of two different specialized types of third-order roots: (1) mycorrhizal thickened roots where the arbuscules form and (2) mycorrhiza fine roots with only intraradical hyphae and spores, but without arbuscules, and pseudomantles of spores anchored in the pneumatorings of the second-order roots, which were described for the first time by Dreyer et al. (2010). The mycorrhiza formed by *Phoenix dactylifera* is intermediate between the Arum and the Paris types and is characterized by intercalary arbusculate coils and not only by intracellular but also by intercellular fungal growth (Dreyer et al. 2010).

The date palm is native to arid and semiarid regions and is characterized by a very low number of AM fungal spores in the soil (Dreyer 2004). A low spore number is also typical in the rhizosphere of other plants of arid or semiarid Mediterranean ecosystems (Azcón-Aguilar et al. 2003). Indeed, in these soils, the main source of inocula is extraradical mycelium (Requena et al. 1996). The strategy developed by *Phoenix* spp. to increase propagule numbers by developing different root types and structures, such as the pseudomantle, is a notable example of adaptation between host and fungal partner in response to such conditions (Dreyer et al. 2010).

The introduction of AM fungi into date palm nursery production systems guarantees a higher growth than non-mycorrhizal date palms, decreasing the time spent in nursery and therefore reducing costs. The AM fungi *Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trap. (≡ *Funneliformis mosseae*) and *G. intraradices* Schen. and Sm. (≡ *Rhizophagus irregularis*) have been very effective in promoting date palm growth at low fertilization levels (Dreyer 2004). Date palm responds to the inoculation of many AM fungal species and is less selective in fungal terms than other palm species like *Phoenix canariensis,* the Mexican blue palm (*Brahea armata*), or the European fan palm (*Chamaerops humilis*).

15.3 Genetic Resources and Conservation

15.3.1 Chronological Account of Research in Genetics, Breeding, and Conservation

Although accounts of historical cultivation of date palm can be traced back to the fifteenth century, the earliest systematic research into date palm cultivation is found in Muñoz-Palao (1929), where a few types grown in the southeastern provinces of Spain are mentioned, such as Candits, Verdales, Tenaos, and Negros. Further research late in the twentieth century revealed local names for date palm ethnovarieties, such as Moscatel, Rojos, and Largo (Rivera et al. 1997). The status of these ethnovarieties is questionable and research under way suggests that the names may allude only to the fruit characteristics in a particular year, rather than fixed characteristics and genetic identity (unpublished results).

In Spain, date palm improvement has relied on conventional methods, particularly obtaining seedlings from selected female palm individuals. From the 1940s to the 1980s, conventional breeding programs were developed in Elche at the Estación Experimental Agraria; however, no definite result in terms of relevant seedlings or cultivars was reported. In the early 2000s, a pilot study was conducted to select the seedling female date palms bearing the best quality edible fresh fruit. One hundred local ethnovarieties were selected for further study, based on fruit flavor, aroma, and texture, as a fresh perishable fruit at the khalal or rutab stages. Once superior ethnovarieties were ascertained they should be propagated by offshoots to create new cultivar palm groves to be established outside the boundary of the historic *Palmeral*

de Elche. The overall objective was to produce attractive fresh dates for the European gourmet food market (Johnson et al. 2013; Orts and Johnson 2007). Since 2000, the Phoenix Research Station in Elche has produced about 30,000 tissue-cultured plants for commercial fruit cultivation, for use on surrounding farms not subject to regulations governing conservation of the historic *Palmeral*. Date palm cultivation beyond the protected *Palmeral* was expected to form a beneficial buffer zone and to extend the palm landscape of Elche. Plantlets produced are of the introduced cv. Medjool and cvs. Confitera and Léon both allegedly derived from local ethnovarieties (Gómez and Ferry 2010). All three produce soft dates. Fruits are harvested by cutting the entire bunches at the rutab stage for artificial ripening before being sold (Johnson et al. 2013).

15.3.2 Current Status and Prospect of Genetic Resources

To analyze the threats to genetic resources of the date palm in Spain, a distinction must be made between wild and cultivated populations. Up to three species have been recognized (*Phoenix canariensis, P. iberica,* and *P. dactylifera*), each with specific threats and conservation solutions. Although the specific rank of *P. iberica* is not accepted by Govaerts et al. (2011), independent of the taxonomic level, the conservation status of its populations is pitiful. In addition, for the feral/wild species (*P. canariensis* and *P. iberica*), the distribution data and conservation risks are very different. Both wild and cultivated specimens for agricultural purposes (excluding clear ornamental use) have had a modest amount of protection given since 1956, by the former Law on Forests, which declared them to be forest trees. In the case of date palms as crops—for fruits, leaves, and other products—the larger plantations have been considered as palm tree forests, even though of artificial origin.

The Canary Islands hold the entire native population of the endemic *Phoenix canariensis*, mainly concentrated on La Gomera and Gran Canaria (Fig. 15.6), forming natural palm groves in ravines and deep valleys and on rocky slopes. A census revealed more than 140,000 individuals, and some sites hold exceptionally rich populations of old palms (Rigueiro 2005). The natural groves of this species declined markedly after the Spanish occupation in the fifteenth century, and most of their ancient sites have been considerably transformed or destroyed because of land reclamation for agricultural and expanding urban uses, overgrazing, fuel extraction, and recurrent fires (Naranjo et al. 2009; Sosa et al. 2013). Locally some palm tree groves have suffered in the past decades from overexploitation, caused by the intensification of the traditional extraction of sap, obtained by making cuts in the leaf bases near the apical meristem. The sap is used to produce *guarapo* or Canarian palm tree honey. A major threat to the species in its natural areas is the historical hybridization with the introduced *P. dactylifera* (González-Pérez and Sosa 2002; Gonzalez-Perez et al. 2004a, b). To regulate and protect the natural populations, in 2006 the Canarian regional government issued a Decree which provides for strict protection of the wild palms and also forbids the transfer of native palm trees among the different islands to preserve the genetic identity of

Fig. 15.6 Palms in a *barranco* (ravine), *Phoenix canariensis*, Sorrueda, Gran Canaria, Canary Islands (Photo: E. Carreño)

the local races. *Phoenix canariensis* is the main indicator species of the habitats protected under the European Union Directive of Habitats.

In Spain, wild or feral specimens of *Phoenix* aggr. *dactylifera*—including isolated individuals of *P. iberica*—were considered as forest trees beginning in the late nineteenth century. The Spanish Forest Law (Ley de Montes) in force from 1956 to 2003 maintained this designation which forbade the cutting and extraction of wild trees, as well as those in large historic plantings. During the first half of the twentieth century, the most representative artificial palm tree crops in Spain, the so-called *palmerales*, were declared artistic gardens or picturesque sites, loose designations for seminatural protected areas. For these sites, specific rules to maintain the traditional uses (dates for food and leaves for handcrafts) were passed, forbidding tree removal and requiring the replacement of dead trees. The two most extensive palm groves in Alicante province, the *Palmeral de Elche* and the *Palmeral de Orihuela*, were protected. This protection was maintained only until 1975, replaced by a new Spanish law on protected areas. The Spanish Constitution empowered the Autonomous Communities (ancient cultural regions) to protect and manage a variety of protected sites for natural or cultural reasons. In 1986, the Valencian Parliament passed a regional law to protect the large *Palmeral de Elche*; in 2000, this site was officially inscribed as a World Heritage Site (Cremades 2009).

Some *Phoenix dactylifera* palms studied at Elche and Orihuela were found to be highly valued for their dates and receive individual names other than those already mentioned. These plants, both male and female, are the basis for further breeding and selection. The field research associated with building a National Germplasm Collection of *Phoenix* revealed the enormous seedling diversity within the *palmerales* of Elche, Orihuela, Valle de Ricote, Murcia, Alicante, and others. This rich diversity is not only restricted to the Spanish mainland. Formations of *P. canariensis* (wild, feral, and cultivated) on Fuerteventura (Canary Islands) are extraordinarily diverse both from the morphological and genetic viewpoints.

15.3.3 Threats and Degradation

Outside its natural habitat, *Phoenix canariensis* is a major species for ornamental purposes, represented by hundreds of remarkable trees in Spanish gardens. The main present threat is the red palm weevil. At this time, most of the cultivated *P. canariensis* at low elevations in Spain are severely affected, and many majestic Canarian date palms survive thanks to the regular application of specific biocides.

Phoenix iberica, a taxon virtually extinct in wild, is mostly maintained through isolated individuals scattered through *ramblas* (dry ravines), gardens, or cultivated palms and is suspected to house introgressions with *P. dactylifera* (according to the variability of offspring). Several private orchards managed by horticulturists linked to nongovernmental conservation organizations began some years ago to produce new specimens in Murcia and Albacete, with seeds harvested from the last wild individuals found in the Chícamo river valley near Murcia. However, recovery of pure forms of this species, after selected crosses among the newly obtained individuals, could take 20–30 years. Good remaining sites with stands of historic date palms such as small coastal bays, saline rivers, and wadis must be selectively monitored in the future to find new representative specimens.

For cultivated specimens of *Phoenix*, the protection of older trees depends on legislation of the Autonomous Communities, which has established, in some cases, lists of protected specimens or minimal sizes, in order to declare them as strictly protected trees. For instance, the Law on Monumental Trees in the Valencian Community, passed in 2006, protects all the date palm trees more than 12 m in height. The main problems facing Spanish *Phoenix* palm tree populations are as follows:

(a) Introduction of any foreign palm trees (not only *Phoenix* species) for ornamental purposes which are vectors of pests and diseases such as *Rhynchophorus* and *Paysandisia*
(b) The control of already-introduced existing pest populations of *Rhynchophorus* and *Paysandisia*
(c) Clonal propagation for large date palm plantations using only a few cultivars, which can lead to a significant reduction of the rich diversity of local ethnovarieties or seedlings
(d) Loss of traditional economic uses of palms and palm products (Picó 1997)
(e) Urban developments on traditional *Palmeral* properties (Gracia 2006)

15.3.4 Conservation Efforts

For 80 years, governmental actions have been taken at the national and provincial levels to protect Spain's historic palm groves and the *Phoenix* palms they contain. A Decree of March 8, 1933, declared the Elche palm grove to be of social interest for conservation and entrusted implementation of the provisions to the

Ministry of Agriculture, Industry, and Commerce. A Board was established by an order dated March 28, 1942, and subsequently restructured by another order dated October 18, 1967. The latter gave the Ministry of Agriculture authority to include the historic palms on a list of species in Article 228 of the Rules of Forestry. The rules regulated use of the groves and the issuance of felling licenses and made them subject to inspection and supervision by the Forest District Headquarters.

As far as the cultural viewpoint is concerned, Decrees of July 31, 1941, and July 27, 1943, declared the palm grove of Elche to be an official artistic garden. Under the auspices of the Ministry of National Education and the Board for the Protection of Artistic Gardens, state supervision was to be exercised by the Ministry of Education under the Artistic Treasure Act and the initial Decree. Broader urban aspects were considered which led to enactment of municipal ordinances in 1951 which were included in the General Urban Plan of Elche in 1962 and thereafter pursuant to the Act Regulating Land Use and Urban Planning. As a result, a Special Development Plan was drafted for the palm tree gardens and an order of October 11, 1972 included in the 1973 revision of the Plan.

Phoenix dactylifera became a protected species within the municipality of Elche under Generalitat Valenciana Law 1/1986, of May 9, which regulates and protects the *Palmeral de Elche*. The objective of this Act was the protection and promotion of Elche's date palms and their areas of growth, by regulating their use, purpose, and consumption, in order to ensure the historical continuity of the natural and cultural values they represent and to promote their cultivation. The Board of the Elche Palm Grove was created as the implementing body for the provisions of the Act. The Board depends, structurally and functionally, on the Valencia Council of Culture, Education, and Science and is based in Elche. Composition of the Board is as follows: Chairman, the Counselor of Culture, Education, and Science; Vice Chairman, the Mayor of Elche; four additional members from public agencies; and one date-grower representative. The Board meets at least once per year.

Date palm groves are considered an important historical legacy and deeply ingrained in the landscape and culture of Alicante and Murcia. In Alicante, the governmental actions taken in the twentieth century set the stage for the *Palmeral de Elche*'s inscription by UNESCO as a World Heritage Site in 2000. This designation recognized the unique historical landscape created in Europe by the exotic date palms and the associated irrigated agricultural system introduced from North Africa by the Moors during the period of Arab domination of Iberia. It also strengthened the legal framework for sustainable management and protection of the palm grove which typifies the city of Elche. In the Autonomous Community of Murcia, *Phoenix dactylifera* has the status of a protected species and is subject to obtaining authorization for certain uses. These policies have led to the transformation of palm groves into gardens. Little effort is focused on protecting traditional management practices, which carries with it the risk of losing the essence of the complete agricultural system with its associated crops and the subsequent degradation of the landscape (Gracia 2006; Larrosa 2003).

15.3.5 Germplasm Banks of Genetic Resources

At the beginning of the current century, the lack of a germplasm bank of date palm genetic resources in Spain became evident. Authorities of the Valencia Regional Government promoted field activities by Miguel Hernandez and Murcia universities to focus on the study and conservation of date palm populations related to *Phoenix iberica*. This work provided core genetic material for the beginning of the National Germplasm Phoenix bank. For 6 years, INIA (National Institute for Agrarian Research) and FEDER (European Fund for Regional Development) of the European Commission sponsored activities to collect *Phoenix* palm accessions (fruits and seeds) within the territory of Spain and to produce seedlings. At present this bank includes over 700 living accessions of *Phoenix* (almost all seedlings) which are maintained at the Escuela Politécnica Superior, Campus de Desamparados, Universidad Miguel Hernández, Orihuela, and in 25 acres of the park *Soto I6* on a meander of Segura river, with the cooperation of Confederación Hidrográfica del Segura and Ayuntamiento de Orihuela.

The *Phoenix* living germplasm bank has accessions represented by plants derived from selected seeds collected in traditional *palmerales* of Almería, Murcia, Alicante, and Valencia, as well as in the Balearic and Canary Islands; included are the 25 different seedling types known from southeastern Spain (Rivera et al. 1997). Accessions also include specimens germinated from seeds collected from important *Phoenix* individuals (selected for their age or singularity) cultivated in gardens, streets, and parks of Spain, France, and Italy. Attention was paid to the diversity of *Phoenix canariensis* under cultivation. A protocol for desiccation of seeds and conservation at low temperatures (4 °C) was developed; the germinative capacity of seeds stored under these conditions was tested with positive results.

15.3.6 Quarantine Regulations

Spain has taken several legal measures relative to the phytosanitary status of *Phoenix* palms. At the national level, Decree 131/2003, of July 11, established comprehensive phytosanitary protection for palm groves of historic, economic, social, and cultural relevance. A subsequent Decree 58/2005 of January 21 (BOE 19, of January 22, 2005, pp. 2583–2665) adopted protective measures against the introduction and spread in the country of organisms harmful to plants or plant products, as well as for export and transit to third countries. Under this measure, all imports of *Phoenix* species are prohibited, although seed and fruit imports are permitted. Decree B.O.E. 247 (of 13/10/2004) prohibited the import of all kinds of *Phoenix* to the Canary Islands (APA/3281/2004).

In Valencia, an order dated December 22, 2009, empowered the Department of Agriculture, Fisheries, and Food of the Valencian Council to establish mandatory phytosanitary measures for the control and eradication of the pest *Rhynchophorus*

ferrugineus. Article 11 provides specific rules on palm movements in historic *palmerales*. Article 11.1, in accordance with the provisions of Decree 131/2003, of July 11 of the Council, established a comprehensive security plan for *palmerales* of historic, economic, social, and cultural relevance in the Valencian area. For the purposes of all the provisions in the Decree, it recognized the palm groves of Monforte del Cid, Aspe, Crevillente, Albatera, Catral, Dolores, San Fulgencio, Santa Pola, and Guardamar del Segura, as well as those of Elche, Orihuela, and Alicante.

15.4 Plant Tissue Culture

15.4.1 Role and Importance

Date palm has conventionally been propagated either through seeds or offshoots. In Spain, however, propagation has been based seeds. Due to the lack of sufficiently high temperatures in the fall, dates do not generally ripen fully or well, and therefore, date palms have been cultivated for several uses other than just for fruit. This explains why there has been no need to select and propagate date palms by offshoots. Nevertheless, due to the date palm's long life cycle and its strong heterozygous nature, seed propagation might be undesirable. This is the case of the variable field performance or the poorer quality of fruits. Offshoot propagation is also limited due to the small number of offshoots produced during the tree's lifetime, resulting in low propagation potential. Another characteristic of the palm groves in Spain, particularly in Elche, is the age of trees, since the majority of them is more than 50 years old and includes rare genotypes (Ferry et al. 2002; Johnson et al. 2013).

Since 1970, extensive efforts have been made worldwide to improve mass propagation of date palm through tissue culture, in order to develop efficient and adequate propagation methods (Al-Khayri 2007; Jain et al. 2011). Because of the presence of rare and interesting genotypes for commercial date production and the scarcity of offshoots due to pruning at the palm base, the research and development of tissue-culture technology makes sense in Spain (Ferry et al. 2002).

15.4.2 Chronological Account of Research and Development

Research on palm tissue culture in Spain has been developed mainly at the Phoenix Station in Elche. Initial work was to study the structural biology of adult date palms, particularly the production of axillary buds from the shoot tip (Ruiperez and Ferry 1996). Then, in vitro propagation by organogenesis was carried out, and high percentages of explants were obtained by culturing them in liquid media (Ruiperez et al. 1995) although the majority of them led to the development of floral organs. Propagation through other initial explants such as young spikelets or small leaves was also attempted. In vitro plants were obtained either by indirect or direct somatic

embryogenesis or by adventitious organogenesis with the proliferation stage maintained without callus (Navarro et al. 1999). A mixed embryogenesis/organogenesis method (Ferry et al. 2000) was also suggested to be a very effective procedure. Indeed, research on in vitro propagation by organogenesis was also carried out with 11 date palm cultivars (Medjool, Zahidi, Thoory, Bouffegous, etc.) provided by the GRFP (French Date Palm Research Group).

15.4.3 Scale-Up Production and Other Tissue-Culture Applications

In vitro–cultured palms have been effectively produced in recent years in response to local demand. Several cultivars with high economic potential (Medjool, Confitera, Lucerga, and Léon) have been propagated, the latter three from quality adult date palms grown in the *Palmeral de Elche* (VitroPalm Technology 2013).

The first plantation of about 1,500 palms was established in 2001 and planting increased steadily in the following years. In 2004, around 2,200 plants were distributed among local farmers, and in 2006, the first flowerings occurred and the initial harvest of tissue-culture-derived palms achieved. In 2008, the COOPELCHE and SAT ELX cooperatives participated in the marketing and sale of dates from in vitro-produced palms.

Since 2000, the Phoenix Station has produced and distributed about 30,000 tissue-cultured plants for use on surrounding farms outside the limits of the World Heritage Site and for export to other countries such as Morocco, Mali, Niger, Mauritania, and Djibouti. However, the Elche City Council prohibited to sale these plants in Spain to individuals who were not native to or living in Elche.

In vitro palms have also been used for research. For instance, Phoenix Station provided in vitro plants to Alicante University for research on the identification of palm cultivars based on amplified fragment length polymorphism (AFLP) markers (Diaz et al. 2003) and on date palm responses to colonization by entomopathogenic fungi (Gómez et al. 2009).

15.4.4 Survey of Research and Commercial Labs

Research on date palm micropropagation in Spain was initiated and developed by the Phoenix Station at Elche. The Station was established in 1991 with the support of the Elche City Council and in collaboration with Alicante University, Miguel Hernández University, the Generalitat Valenciana, INRA-France, and CIRAD-France (Centre for International Cooperation in Agronomic Research for Development). After functioning for two decades, in March 2012, the Phoenix Station was closed by the Elche City Council. Researchers moved to the Phoenix Station Association in nearby Aspe, where they continue some of the former activities.

VitroPalm Technology is a company in Elche devoted to date palm tissue culture. The technical team, field experience, and tissue-culture protocols were originated from the Phoenix Station. The company offers consulting in the selection of cultivars and genotypes based on commercial interest, design of laboratory facilities to produce in vitro culture plants, staffing requirements, laboratory establishment, training services for technicians, and so on. They offer the application of the acquired technology to the multiplication of any cultivar of date palm derived from adult or juvenile palms (VitroPalm Technology 2013). However, the 2010 economic crisis led to a discontinuity in its activities.

15.4.5 Recommended Protocols

Several studies have reported protocols for date palm propagation through somatic embryogenesis or organogenesis (Al-Khayri 2007; Jain et al. 2011; Zaid and Arias 2002). The protocols used in Spain are mainly based on organogenesis (VitroPalm Technology 2013). The technique has been improved over several years and adjusted to ensure true-to-type plants and good productivity. Propagation is made from offshoots, using portions of the terminal apex as explants. A few months later, the first shoots appear, from which the proliferation explants are obtained. Procedures have also been optimized to achieve the multiplication of adult date palms using their terminal apex as explants. In this sense, new local cultivars (e.g., Confitera, Lucerga, and Léon) have been created from high-quality selected samples.

A new propagation protocol has been developed to be applied when there are insufficient numbers of offshoots for regeneration. In this case, the terminal apex of the date palm with between four and six leaves is used to renew the proliferation series. Inflorescences are also used as explants both for the organogenesis and embryogenesis techniques. The elongation, development, and rooting phases do not present major problems and high parameters are usually achieved. The acclimatization phase is achieved in 8 weeks with about 90 % survival rate.

In vitro multiplication of date palm has both advantages and disadvantages. High-quality plants, a large quantity of plants in a short time, early date production, and production of healthy plants that avoid spreading damaging organisms are some of the advantages. In the particular case of the seedling date palm groves of Elche, tissue-culture techniques allow propagation of elite ethnovarieties, rare quality genotypes, or genotypes without offshoots (Ferry 2011).

However, there is also a risk of accelerating agrodiversity erosion by cloning a small number of cultivars selected only for their interest in date-fruit production and to replace autochthonous or local cultivars with exotic materials. This could increase susceptibility to exotic pests and diseases or to adverse climatic conditions.

Another factor limiting tissue culture is the production of abnormal plants obtained with somatic embryogenesis; therefore, this technique must be used very carefully. For that reason, some authors recommend avoiding use of the embryogenesis approach, whereas organogenesis assures genetic stability (Ferry 2011).

15.5 Cultivar Identification

15.5.1 Role and Importance

It is noteworthy that the traditional selection of date palm trees in Spain has been through the organoleptic and preservation features of fruits that were considered of good quality. Their seeds were sown, but *palmereros* agree that seeds from a good date palm may not yield seedlings of the same type and quality as the mother palm. What they usually did was find a use for each type of date fruit. If these were small or had very large seeds and thin flesh, they were used as animal feed; if strongly astringent (high polyphenol contents and others) they were artificially ripened with vinegar (Obón et al. 2009). Dates that matured on the palm were directly consumed fresh; these were the most sought after and propagated. Vegetative characteristics were less influential, although in the most important *palmerales* at Elche and Orihuela, offshoot production was a problem and they were systematically destroyed; palms producing few or no offshoots were preferred for sowing.

15.5.2 Research in Morphological Descriptors

Hernández-Bermejo et al. (2012) recorded from medieval writers of Al-Andalus (Moorish Iberia) the names of different date ethnovarieties such as Aywaa, Barni, Sahriz, Wadiyya, Yabbara, etc. Cavanilles (1797) distinguished in Elche two ethnovarieties: Candits, sweet, becoming wrinkled when they ripen on the palm, and eaten without artificial ripening techniques (*adobo*), and Ásperos, harsh, which need to be sprinkled with vinegar and keep covered for 2 days to be artificially ripened; at 6 days they become fermented and sour. The first modern descriptions of date palms from southeastern Spain were provided by Escribano (1884) who distinguished six types. Later, Muñoz-Palao (1929) and more recently Orts (2004) comprehensively described the known date types of Elche. Complementing those accounts, Rivera et al. (1997) described date palm seedlings grown in the Segura and Chicamo river basins in Murcia and Alicante.

A total of 112 descriptors/characteristics (qualitative, quantitative, and allometric) totalizing 517 states are used in the National Phoenix germplasm collection for describing Spanish date palms. These characteristics are organized into physiological (2); phenological (2); vegetative, stem (9); vegetative, leaves (32); reproductive, male inflorescences (12); reproductive, female inflorescences (16); and fruits (39). These are applied to the description of the mother plants and the offspring because the collection consists almost exclusively of seedlings.

15.5.3 Research on Molecular Descriptors

The earliest works focus on varietal identification, and testing of the integrity of tissue-culture-developed palms through AFLP markers was based on material from the palm grove of Elche (Diaz et al. 2003) at the Phoenix Station. The development of simple sequence repeat (SSR) markers (Akkak et al. 2009; Billotte et al. 2004) stimulated interest in the study of diversity in date palm groves throughout southeastern Spain (Carreño 2012; García-Martínez et al. 2010, 2012) as a basis for selection. High diversity within the sampled palm groves of Alicante, Murcia, and Almería provinces is the common denominator, due to seed propagation rather than by offshoots, as well as the evidence of imported material within the different areas surveyed, be it adult plants, dates, or pollen (Rivera et al. 2008). Recent works attest to a growing interest in the study of date palm diversity with molecular markers in southeastern Spain (Agulló 2009; Carreño 2012; Sánchez 2009) (Fig. 15.7). Molecular characterization of *Phoenix canariensis* in the Canary Islands and the search for specific markers for the species was developed by Gonzalez-Perez et al. (2004a, b).

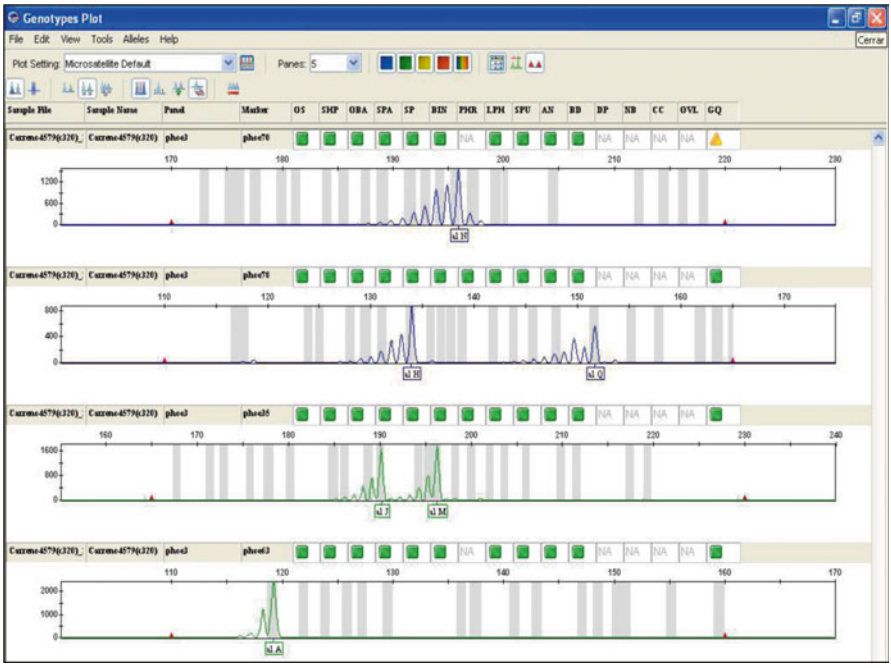

Fig. 15.7 Electropherogram of *Phoenix* samples. An electropherogram is a plot of results from an analysis done by electrophoresis automatic sequencing (Photo: E. Carreño)

Research into genetic diversity and identification of genetic resources of interest for agriculture has barely scratched the surface in Spain. More extensive fieldwork together with identification with molecular markers is needed. Although some genotypes of interest for breeding have already been identified, their characteristics are not widely known by the public, making commercialization difficult. Protection measures can be a double-edged sword, since they do not usually allow for substitution of old palms with selected ethnovarieties from local genotypes, which could be an incentive for farmers to maintain orchards. Joining forces with local administrations and producers and pooling resources would be of great interest for the development of future breeding programs as well as for conservation.

To maintain the traditional diversity of palms, it is recommended to continue the planting of seeds and rejuvenate traditional and historic *palmerales*, which are aging and are suffering from infestations of the red palm weevil and the palm borer, already described. The future of those date palm groves within urban environments such as Elche is linked to revitalization of agriculture for fruit production in harmony with the ornamental and landscape value (Picó 1997).

15.5.4 Survey of Research and Commercial Labs

Current research is focused on controlling the red palm weevil, by the Phoenix Station Association in collaboration with INRA-France, as well as the study of local genotypes as a basis for selection, carried out at Miguel Hernández University and Murcia University. Local names for date palm ethnovarieties, such as Candíos, Moscatel, Rojos, or Largo, have been previously identified (Rivera et al. 1997). The status of these ethnovarieties is questionable and research under way with SSR markers (Akkak et al. 2009; Billotte et al. 2004) points out that some among these names may allude only to the fruit characteristic in a particular year, rather than fixed characteristics and genetic identity (unpublished results). VitroPalm is a new business venture aimed at commercial production of plantlets of cv. Medjool as well as local genotypes, such as Confitera, Lucerga, and Léon.

15.6 Cultivar Description

15.6.1 Growth Requirements

Traditional local date palm seedlings were planted on the margins of agricultural fields along the canals. Seedlings only need care in their early years such as weeding and digging the soil in autumn and spring to add some fertilizer, along with annual pruning at the waning January moon. When the palms reach a height of 60–80 cm, they only require watering in summer and annual pruning of three to four whorls of their fronds for its development (Escribano 1884).

15.6.2 Cultivar Distribution

Modern cultivars as previously described are restricted to areas surrounding the historic *Palmeral de Elche*. Traditional seedlings/cultivar distribution is strongly overlapping with the maximum diversity in the *Palmeral de Elche* as a World Heritage Site (Fig. 15.8). The most relevant seedlings are Candits (candíos, maduros de la palmera, maduros), Tenats (tenaicos), and Tendres (tiernos); these are frequent in the orchards of Elche and Orihuela in Alicante and Abanilla in Murcia. Traditional seedling dates can also be found in Alicante, in Valle de Ricote, and even in Almería and Valencia in the form of isolated individuals.

15.6.3 Nutritional Aspects

Date fruits of the Negros type from the *Palmeral de Orihuela* have maturity index values of 45.33, due to an increase in solid soluble contents and a decrease in acidity (Serrano et al. 2001). Date fruits from the *Palmeral de Elche* in the rutab stage have a sucrose concentration of 1–5/100 g, but these dates have a similar amount of fructose and glucose of 17–28/100 g and therefore are a good energy source (Amorós et al. 2009). These were compared with samples of other *Phoenix* species by Amorós et al. (2014).

Besides the fruits, terminal buds (hearts) are sometimes consumed fresh in salads and called *palmito*. Commercial exploitation of *palmito* is limited to local festivals (San Antón, c. 17 January) in Elche and Orihuela and has a very low impact on date palm populations. Local informants from Abanilla and Murcia report that *palmito* is eaten when harvested from palms felled by strong winds.

15.6.4 Description of Spanish Seedling Dates

Candíos is a group of seedling dates sharing fruit characteristics, especially the ability to naturally ripen fruit on the tree without artificial processes, under the average climatic conditions of the Spanish *palmerales*.

Phenology Flowering (March) April–May (June). Ripening (September) November–December (February).

Vegetative Morphology Stem 5–20 m tall; 22–40 cm in diameter. Offshoots below ground level 1–4. Offshoots on the trunk above the ground level rarely present. Crown with 50–90 leaves in adults; leaf 310–500 cm long; leaf rachis 20–30 cm wide at base. Leaf base green (bright or dull), or somewhat glaucous,

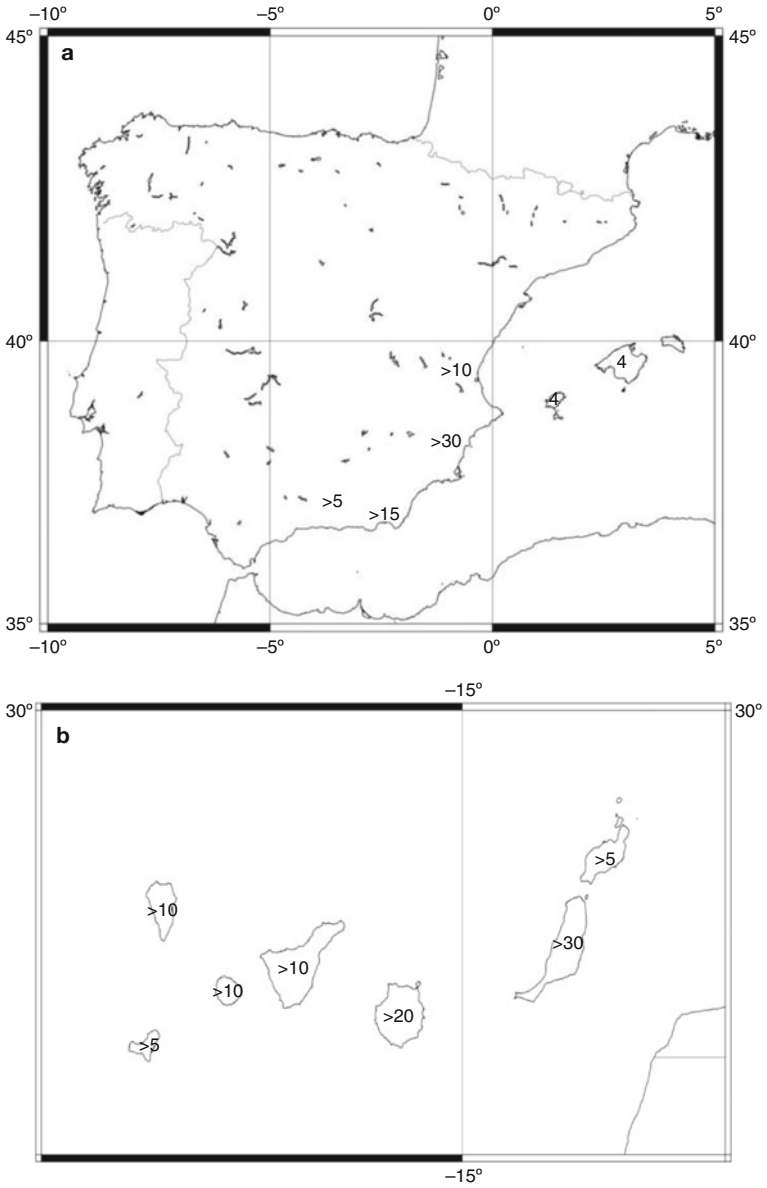

Fig. 15.8 Assessment of palm diversity in terms of number of different cultivars or seedlings in palm groves and forms in wild populations including *Phoenix canariensis*. (**a**) Iberian Peninsula. (**b**) Canary Islands. Maps (Maps were drawn by F. Alcaraz using Quantum GIS (2014) for digitizing polygons and GMT (2014) to generate the final maps)

with a glaucous cast (Fig. 15.9), or with faint yellowish-red tinge, old leaves with reddish-maroon discoloration regularly on edges, or with slight mottling of maroon appearing vertically in the center. Leaf sub-glaucous; haut brown; pseudopetiole 50–150 cm long. P/L (pseudopetiole vs. leaf length): 0.2–0.4. The *haut* is defined as a structure unique to the genus *Phoenix*, thus to the Palm family, formed by the coalescence in early development of the adaxial folds in the leaf (Fig. 15.10). Just before sword leaf emergence, the haut atrophies and then disintegrates on emergence, detaching itself from the V-shaped folds that form the leaflets (Dransfield et al. 2008). Basal pulvinula of spines not noticeably swollen. Divergence between basal pulvinula of spines 30–90°; basal neck in the upper spines of adult leaves 0–25 mm long; spines solitary or paired; 2–15 spines on each side of the rachis; spines 4–20 cm long and 0.4–0.8 cm wide; spines green; distal part of spines concolor. Basal pulvinula of leaflets not noticeably swollen; divergence between basal pulvinula of leaflets 60–90°; leaflets solitary, or in pairs, or in groups of (3) or (4); 40–90 leaflets on each side of

Fig. 15.9 Candíos palm tree grown by Francisco Serrano at Elche (Photo: D. Rivera)

Fig. 15.10 The remnants of the brown haut on a Candit seedling exhibiting a brown coloration. The haut color varies in other *Phoenix* spp. and is an aid to species identification (Photo: D. Rivera) (Color figure online)

the rachis; leaflets at the midpoint of fully developed leaves 40–66 cm long; leaflets 1.7–4 cm wide; leaflets arranged along the rachis regularly and spreading in the same plane or irregularly in clusters and spreading in different planes (quadrifarious); leaflet consistence feathery or stiff. Leaflet apex very sharp needlelike; apical leaflet similar in shape and dimensions to the subapical leaflets. Leaf blade anatomy. Prominent marginal veins in leaflets lacking; tannin-filled sclerotic cells in the margin of leaflets lacking. Abaxial ramenta lacking in young and adult leaves.

Fruit Morphology Perianth in ripe fruits 2.5–4.5 mm high × 7.5–9 mm wide. Remains of perianth (in fresh fruits) yellow or orange. At khalal stage, fruit shape in side view oblong-elliptical and fruit shape in section circular. Fruit apex obtuse. Apical stigmatic remains inconspicuous or very short. Fruit base rounded or oblique. Fruit 25–45 × 15–30 mm. Ratio fruit breadth to fruit length 0.5–0.6. Fresh crunchy fruit yellow or orange; soft ripe fruit (rutab) black or amber brown; fruit flesh 3–5 mm thick. Fruit consistency soft (moisture over 50 %) or semidry (moisture 20–50 %). Epicarp (peel) not adherent to the flesh. Fruit quality as food good. Seed 15.5–25 × 7–9.5 × 6–8.5 mm. Ratio seed breadth to seed length 0.35–0.56. Ratio seed thickness to seed breadth 0.75–1. Seed weight 0.5–1.22 g. Seed shape elliptical-oblong or cylindrical-narrow, apex obtuse, base obtuse, mucronate, or oblique, surface irregular.

Tenats mostly differ from the above for their late ripening and lower water content, which permits longer conservation. These also differ by the epicarp adherent (Fig. 15.11). Vegetatively, the date palm tree is similar. Tendres are characterized by their lower astringency and larger and more globose dimensions, which permits their consumption at an earlier ripening stage. Furthermore, these are late ripening and can be found fresh in the markets from late December to mid-January (Fig. 15.12).

Fig. 15.11 Tenats dates, from Tabalón Alto, Elche (Photo: D. Rivera)

Fig. 15.12 Tendres dates, commercialized at Elche (Photo: D. Rivera)

15.7 Date Production and Marketing

15.7.1 Practical Approaches

The date production and marketing approach taken in Elche was to create cooperatives for the production and marketing of dates. These were created as a result of introducing new cultivars selected at the Phoenix Station. A facility was created to carry out post-harvest artificial aging and to establish distribution channels through gourmet product lines such as El Corte Inglés, the large Spanish department store group.

In parallel the local company Huerto de Elche (formerly Huerto del Cura) is focused on commercialization of local Candit dates produced in Elche and ripened naturally on the tree and served fresh, initially at the restaurant of the Millennium Garden Hotel in Elche and later in various renowned Spanish restaurants such as Martin Berasategui's (Michelin 2 stars) and Rodrigo de la Calle's, inspired by an initiative termed *gastrobotany* and led by Santiago Orts (González 2011). In 2012, fresh Elche dates were presented at the most important gastronomic fair in the Middle East, Gourmet Abu Dhabi, by Santiago Orts (Romero 2012).

15.7.2 Optimization of Yield

Performance is optimized by each individual date palm due to the great diversity of palms in the Spanish *palmerales*. Planting of selected individuals, cloned, began in Spain with the distribution of the material obtained by the Phoenix Station after the year 2000.

Fruit size is very important in the wholesale price received by farmers; therefore, the *palmereros* reduce the number of infructescences on the tree and the number of dates per infructescence to produce larger fruits, a fairly common practice in date growing. Usually, superior male date palms are selected to artificially pollinate the female palms to achieve large, good-quality dates.

15.7.3 Harvest Mechanization

In Spain, mechanization is rare or lacking in the harvest of dates. Instead, harvesting and other manual cultivation tasks are carried out by skilled workers, the *palmereros*. They climb palm trees and manage leaves and infructescences and cut bunches of ripe dates. The *palmereros* climb the palms using traditional ropes looped around the trunk, modern climbing techniques, or ladders.

15.7.4 Postharvest Operations

The processing which follows the date harvest depends greatly on the characteristics of the fruits, whether these are soft, semidry (Candíos), or dry (Tenaicos). At present, the usual form of conservation is freezing at −1 to −5 °C, removing dates from the freezers according to market demand. Once thawed, the dates become stale in 2–3 days. Candits dates left on the fruit branch may be stored at 20 °C for 2 weeks and Tenats for 2 months or even more, without losing their organoleptic characteristics, but they do gradually lose moisture.

A joint venture between INRA (France), IVIA (Valencian Institute for Agricultural Research), and the Elche City Council led to the development of a treatment procedure for dates, patented in 2005 (Vilella et al. 2005). This process comprises one or more of the following steps: (a) cold storage of immature dates, (b) ripening of dates, and (c) cold storage of wet ripe dates. The procedure allows, on the one hand, improvement of current methods of harvesting and processing of dates in the factory and, on the other hand, offers to the market a fresh fruit, i.e., moist rather than the date dry, or even preserved as a confit, which is the essence of the current date fruit supply. This method was associated with the development of cultivation of fruit bearing clones such as cvs. Medjool and Confitera.

Researchers of the Polytechnic University of Cartagena have developed techniques with NaClO, UV-C, ozonated water, and alkaline and neutral electrolyzed water to decrease carob moth (*Ectomyelois ceratoniae*) infestation and maintain date-fruit quality and give a longer shelf life (Jemni et al. 2014). The treatment of dates with NaClO, UV-C, O_3, and electrolyzed water showed a positive effect for lowering their natural infestation by *E. ceratoniae* as well as the microbial growth after 30 days of storage at 20 ° C. In particular, UV-C and neutral electrolyzed water were the most effective against moth proliferation without an adverse effect to objective and subjective quality attributes. Independent of sanitizing treatments, the phenolics concentration significantly increased throughout storage, while the antioxidant activity determined by the DPPH method remained quite constant. The quality attributes of dates were maintained after 30 days at 20 °C.

15.7.5 Marketing Status and Research

In southeastern Spain, especially in Elche, traditional exploitation has been and still is conducted by *palmerero* families, among them the largest producer is Francisco Serrano (*Sopascures*), who manages about 2,000 date palms. Numerous *palmereros* are not owners of the palm groves they care for (Pomata 1984), but are instead hired for their services.

Since at least the Middle Ages, Spanish dates have been a good commodity of maritime trade in both the Mediterranean Sea and across the Atlantic Ocean (Bover and Roselló 2008; Rivera et al. 2013). However, presently Spanish date marketing is very local and restricted to nearby markets and fairs. Recently the advertising and promotion of dates reached prestigious restaurants and gourmet establishments. Naturally ripened Elche dates were presented at well-known gastronomic fairs such as Madrid Fusion.

Date-fruit marketing is being associated with symbolic images: the historic artistic garden, Huerto del Cura; the *Palmeral de Elche* as a World Heritage Site; and the Iberian figure of the Lady of Elche all provide images which identify with the dates of Elche.

15.7.6 Current Import and Export

Spanish dates have long been a traditional food resource to combat hunger in the region of the *palmerales*. Currently the Spanish date is becoming a food consumed by people with high purchasing power, when, traditionally, it has been a resource for poor people.

Due to the minimal economic importance of date consumption in Spain, statistics are not reported individually for dates; they are included under *Other Goods* within the category of dry fruits in the available import/export statistical information. Market surveys show that dates in Spain are mainly imported from Tunisia, Deglet Noor cv. dates, and from Israel as fresh large Salomon or Jumbo Medjool cv. dates as well as yellow (khalal) Barhi cv. dates. Other frequent sources are California (USA), Algeria, and, to a lesser extent, Iraq and Namibia (cf. Mili 1993 for older data).

15.8 Processing and Novel Products

15.8.1 Industrial Processing Activities

Researchers of Miguel Hernández University of Elche are developing technologies to use date fiber as an ingredient in food and nutraceuticals. Of particular importance was presentation in 2012 of a date paté that helps lower cholesterol and

combat anemia. The addition of 10 % Confitera date paste in the formulation of champagne-type pork liver pâté leads to the enhancement of moisture, fiber, and phenolic compounds, and it was enough to avoid lipid oxidation during 4 days after the elaboration process. Color was the most affected parameter; however, in terms of overall acceptability, panelists preferred samples with added date fruit (Martín-Sánchez et al. 2013).

Another novel product under investigation by researchers at Miguel Hernández University is a date paste made with by-products from fresh dates. The addition of up to 15 % date paste in the formulation of Bologna-type meat products leads to the enhancement of the nutritional (lower fat content and higher fiber content than control) and technological quality (redder-colored and less hard, chewy and cohesive product than the control) together with a satisfactory sensory quality (Sánchez-Zapata et al. 2011).

15.8.2 Survey of Commercial Date Processers

The earliest and latest maturing ethnovariety fruits fetch a higher price in the market, especially those sold in local festivals and fairs, for these are preserved dates of better quality, both in size, color, and sweetness. Festivals where the dates are sold in southeastern Spain are St. Anthony Day (January 17 at Orihuela, Albacete, and Elche), San Sebastian Day (January 30 at Orihuela), Candlemas Day (February 2, at Murcia), St. Blaise Day (February 3 at Albal), St. Agatha Day (February 5 at Catral), All Saints' Day (November 1), and Holy Face Day (second Thursday after Easter, at Alicante) (Jaén 1994), this being the last day in which fresh dates are widely sold. In all cases, processers are small enterprises and family businesses. However, Tunisian dates, e.g., Deglet Noor cv., have been commercialized fresh, dried, or candied, in Spain in large quantities since at least 1919, by medium-sized enterprises such as El Monaguillo, located in El Campello, Alicante.

15.8.3 Secondary Metabolites and Health Benefits

The medicinal uses of date palm and its products were relatively common in Spain; it reached top of diversity and importance during the Middle Ages, both in Al-Andalus and the Christian territories of the northern border, but have been lost progressively. Rivera et al. (2014) reviewed the historical evolution of medicinal uses of date palm and the Canary Island date palm in both the Iberian Peninsula and the Canary and Balearic Islands, from first century AD until present times. Main categories of uses are summarized in Fig. 15.13 for *P. dactylifera* and Fig. 15.14 for *P. canariensis* in terms of percentage of records in the data base.

At present there are very few persisting uses. Dates were the palm product most commonly used, but the sap, pollen, and tender buds are also used. The dates of

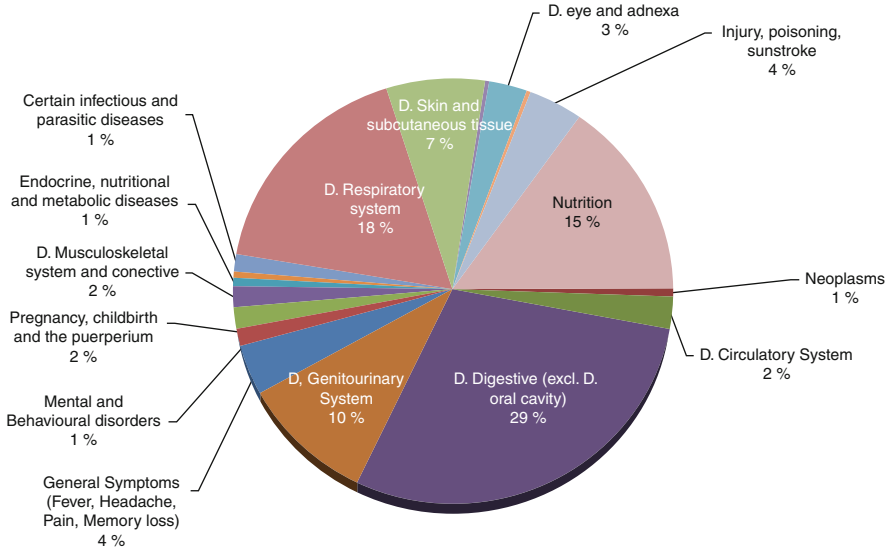

Fig. 15.13 Medicinal uses traditionally adopted in Spain for *Phoenix dactylifera* including fruits, seeds, inflorescences, and spathe. Classes of diseases and related health problems according to Version 2010 (ICD-10 2010). *D* diseases (*Source*: Rivera et al. (2014))

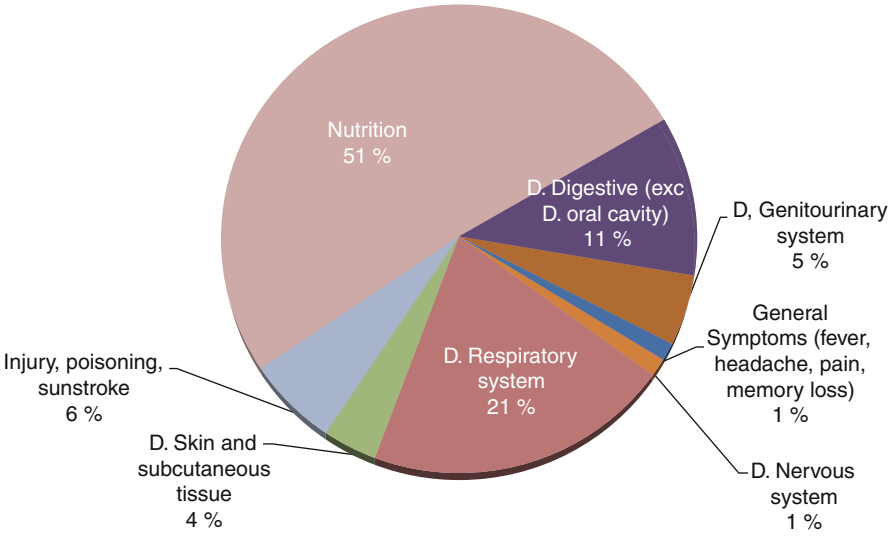

Fig. 15.14 Medicinal uses traditionally adopted in Spain for *Phoenix canariensis* including fruits, sap, seeds, inflorescences, and spathe. Classes of diseases and related health problems according to Version 2010 (ICD-10 2010). *D* diseases (*Source*: Rivera et al. (2014))

Phoenix dactylifera were used as an analgesic, to treat anemia and digestive disorders or to strengthen the gums, in the treatment of erectile dysfunction and as an aphrodisiac, to facilitate childbirth, and to soothe postpartum pains and treat matrix prolapse or excessive menstrual flow. Dates were also used as diuretics and in dysuria and bladder disorders and are still used for the treatment of various respiratory problems. Externally they were used to treat skin problems, wounds, bleeding, and hemorrhoids. Canary palm (*Phoenix canariensis*) raw sap, or concentrated sap, or fermented sap (palm wine) are consumed, especially in the island of La Gomera, as food and are also used as diuretic; remedy for genitourinary, digestive, and oral infections; expectorant; antitussive; and treatment of oral cavity and throat irritation disorders.

In Toledo of Al-Andalus, spathes of *P. dactylifera* were used, almost a thousand years ago, in the treatment of weakness, pain, nephritis, bladder diseases, liver disorders, diarrhea, digestive disorders, pain in the abdomen and stomach, excessive menstrual bleeding, skin ulcers and scabies, joint pain, and heart disorders. Rational phytotherapy should pay attention to this resource, consider the available scientific evidence (pharmacological and even clinical), and incorporate it into our modern therapeutic repertoire.

Date fruits from the *Palmeral de Elche* could provide a good source of natural antioxidants, since they have high hydrophilic total antioxidant activity (HTAA) as compared to other fruits, with a maximum value in khalal state of 200–1,000 mg Trolox eq./100 g depending on the cultivar. These dates also have a high phenolic content, with values of 125–400 gallic acid eq./100 g, which is correlated to HTAA content (Amorós et al. 2009).

The processing of dates yields high volumes of blanching water. Blanching water from Confitera date processing has an important content of phenols and flavonoids, which confer interesting antioxidant properties, as well as organic acids and sugars extracted during blanching. The use of blanching water for reconstituting skim milk powder showed that it is suitable for direct use in the manufacture of yogurt by increasing the content of natural antioxidants and organic acids and has a promising future as a functional food ingredient (Trigueros et al. 2012).

15.8.4 Bioenergy and Other Uses

Several studies are ongoing at Miguel Hernandez University to develop composite building materials from *Phoenix* palm leaves. For example, the Canary Islands palm is pruned up to twice a year in Spain, producing huge amounts of biomass now disposed of in landfills. García-Ortuño et al. (2012) have investigated the performance of particleboards made from pruning residues and a commercial potato starch as a natural binder. The average values of modulus of rupture, modulus of elasticity, internal bond strength, and thermal conductivity suggest that it is completely feasible to manufacture acceptable eco-friendly particleboards for

general purposes using the leaf bases of Canary Islands palm (*P. canariensis*) as an alternative lignocellulosic raw material. Very likely, the same applications are possible with leaves of the date palm.

Increasing use of the date palm as an ornamental species in the gardens of Spanish cities, like Elche and Orihuela, generates a large amount of waste. The date palm leaves are a recalcitrant material which is difficult to compost. Martinez et al. (2011) have developed a method of composting this waste along with grass trimmings, vegetable crop residues, and sheep manure as a source of inoculum to facilitate the composting process. The compost obtained has macronutrients and micronutrients in amounts similar to that found in other materials frequently used as organic amendments, such as urban organic waste and manure, and compost quality was verified as adequate for plant development (Moral et al. 2012).

15.9 Conclusions and Recommendations

Efforts underway to improve upon the traditional seedling date area in Elche represent a significant step forward for the utilization of seedling date palms and may well serve as a model in other locations such as Marrakech, Morocco. Unfortunately, excessive focus on clonal germplasm, irruption of introduced pests, funding cuts, and subsequent closure in 2011 of the Phoenix Station at Elche seriously disrupted the commercial development of novel cultivars.

It is also important to assess environmental, economic, and social issues before any massive tissue-culture production program is to be initiated. In many countries, the low productivity of palms is due to agronomic causes such as deficient irrigation or inadequate fruit storage techniques, more than genetic limitations. On the other hand, an effort on mass propagation should be accompanied by efficient trade and marketing that ensures date sale and consumption.

Research into genetic diversity and identification of *Phoenix* genetic resources of interest for agriculture in Spain is at its starting point. Although some genotypes of interest for breeding have already been identified, their characteristics are not widely known and limited to a locality or a particular farmer, making commercialization difficult.

Phoenix dactylifera and *P. canariensis* palms are socioeconomically important for local populations in southeastern Spain and in the Canary Islands, not only because of the nutritive value of dates but also for the ecological services of palm shelter for other crops and the multiple uses of palm leaves and trunks.

Innovative approaches combining agroecological perspectives, rural tourism, and gastronomy may focus on stratified mixed crops and recovery of local and heirloom vegetable and fruit cultivars traditionally associated with date palm cultivation to offer future opportunities to farmers to increase their incomes and preserve the sustainable use of the Spanish *palmeral*.

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