

## REVIEW ARTICLE

# Seedling date palms (*Phoenix dactylifera* L.) as genetic resources

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## Abstract

An accelerating worldwide trend toward planting elite cultivars is leading to genetic erosion and a narrowing of the gene pool upon which the date-palm industry is based. Large numbers of seedling dates are known in many major date-growing countries, as well as in naturalized populations in Spain and the Americas where the palm was intentionally introduced. Seedling dates growing under different climatic conditions from those of the major production areas represent potential genetic resources that should be evaluated for desirable traits. Utilizing modern biotechnology, traits such as disease and pest resistance, hardiness, tolerance of salty soils and improved fruit quality and quantity potentially can be transferred to elite cultivars to sustain and further improve fruit production. Specific examples of important seedling date palm populations in Spain, Peru and Mexico are discussed, as well as new cultivars derived from seedlings in the United States. Research on seedling date populations is recommended, along with the establishment of ex situ germplasm collections of promising specimens as living plants, cold storage of seeds or cryopreservation.

Key words: Artificial ripening, Cultivar, Ethnovariety, Germplasm, Khalt, Mexico, Offshoot, Peru, Spain, USA

## Introduction and Background

Based upon archaeological evidence, the date palm (*Phoenix dactylifera*) was domesticated some 6,000 years ago in the Mesopotamian Region (Zohary and Hopf, 2000); present-day Iraq, along with adjacent portions of northeast Syria, southeast Turkey and southwest Iran.

Tree-crop domestication appears to have taken place at the advent of agriculture and is presumed to have been a slow and incremental process. The initial stage of domestication involved wild populations, with fruit gatherers preferentially selecting fruits from highly-productive trees bearing large fruits of good quality. Fruit gatherers likely returned to the same more productive trees season after season and encouraged the natural regeneration of seedlings beneath them by eliminating competing vegetation. Under such circumstances of limited management, the trees are considered at the stage of semi-domestication. To attain full domestication, date seeds had to be

retained from the harvests and germinated to establish intentional new plantings at a chosen location. Studies of plant domestication in general have speculated that the initial example of seed planting may have been inadvertent; seeds discarded near a dwelling place which germinated spontaneously, and were recognized as desirable plants, protected, given some care and ultimately provided fruit. Alternatively, seed planting may have been intentional, iterative of what was observed in the wild. Intentionally or unintentionally, domestication is achieved when cultivated plants begin to exhibit, over succeeding generations, characteristics which distinguish them from their wild progenitors. Larger fruit size would have been the most desirable trait in the case of the date palm.

Seeds were the means to intentionally reproduce date palms for millennia in Mesopotamia, and later in North Africa, from native wild species or through seed introductions from Mesopotamia. From these two areas, seeds were transported, in association with human migrations or invading armed forces, east to present-day Pakistan, into southern Europe, and later to South and North America, into southern Africa, and to distant Australia and New Caledonia (Johnson, 2010). Wherever environmental conditions were favorable, date palms flourished

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and provided fruit for subsistence purposes or for commerce. Untended or abandoned plantings spontaneously reproduced by seeds and offshoots and became naturalized. In some locations, date palms were planted as ornamental trees.

Two biological characteristics of the date palm played key roles in domestication. Early on, Mesopotamian farmers recognized that date palms were dioecious: female plants produced fruit while male plants produced only pollen. Seed propagated date palms yield approximately equal numbers of male and female offspring. During the early years after reaching sexual maturity, both male and female palms produce basal offshoots (also known as suckers) (Figure 1), which if left intact grow into mature trees. At some point, perhaps in southern Mesopotamia, an astute farmer discovered that it was possible to separate basal offshoots from a mother palm and transplant them to another location. Priority in implementing this technology would certainly have been given to female palms known to produce large good-quality fruits. Apparently, no historical record exists about the time and place for this important technological breakthrough. It was a momentous step for the date palm, nonetheless, giving rise to its vegetative propagation and the ability to carry forward to succeeding generations desirable fruit characteristics (Johnson, 2011). However, this practice has a negative consequence as well, for over time it has reduced the diversity of the general date germplasm pool. Without sexual reproduction, there are no opportunities for new genotypic combinations to occur.



Figure 1. Date palm cultivar with several offshoots. Indio, California.  
Photo: D. Johnson.

Another undocumented event in date palm development was the innovation of assisted pollination of female trees to enhance fruit production. In the process, observant farmers noticed that pollen from certain male trees was superior in bringing about enhanced fruit production. When it was learned that a single male palm produced enough pollen to fertilize up to 50 female trees, the number of male trees in fields could be significantly reduced, allowing more space to grow female trees. The significance of certain male palms as pollen sources also led to their propagation by offshoots.

There emerged from these innovations certain types of female and male cultivars (cultivated varieties) recognized to possess desirable characteristics and those palms came to be assigned distinctive names for identification purposes. According to tradition, in what is now southern Iraq, Zahidi was the first named female date cultivar and Khikri the first male (Dowson, 1923). The naming of cultivars proliferated wherever dates were grown from offshoots and in some instances the same cultivar was assigned a different name when cultivated in a new area where a distinct dialect or language was spoken. It has been estimated that there are 3,000 date cultivars in the world (Zaid, 2002), but it is widely suspected that many of the names represent synonyms.

Thirteen species of *Phoenix* are recognized by scientists; all are dioecious and hybridize easily (Barrow, 1998). Therefore it is possible, although not common, that seedlings in date-growing areas thought to be offsprings of *dactylifera* may in fact represent natural hybrids between different species. This may occur if other *Phoenix* species are growing (wild or cultivated) in the vicinity of a plantation. A natural hybrid between *P. canariensis* and *P. dactylifera* was observed near Winterhaven CA, exhibiting the typical crown and thick trunk of *canariensis* but bearing basal suckers (D. Johnson, pers. comm., 2012) (Figure 2). Evidence of the commonplace occurrence of hybrids in *Phoenix* is given by Bergman (2005) who described and provided photographs of four spontaneous interspecific *Phoenix* crosses among four different species. This ease of crosspollination within the genus may have potential value in date improvement. Sudhersan and Al-Shayji (2011) used male pollen of the dwarf date palm (*P. pusilla*) to fertilize female date palm (*P. dactylifera*) flowers and create a short-stature date palm. Offsprings derived through embryo culture techniques are under field evaluation in Kuwait.



Figure 2. Natural hybrid of *Phoenix canariensis* and *P. dactylifera*, near Winterhaven, California.  
Photo: D. Johnson.

This study examines relevant historical aspects of seedling date palms and their contemporary role for fruit production, as well as their germplasm potential and conservation, for the future sustainability and development of date palm cultivation. The worldwide trend in commercial date palm production toward planting elite cultivars inadvertently contributes to genetic erosion and the narrowing of the gene pool. Greater recognition of the potential role of seedling date palms will strengthen the sustainability of this important tree crop. Jaradat (2010) pointed out that sustainability of date palm oases is largely dependent upon a highly diverse genetic base of the date palms.

Standard date-industry terminology is used in this paper with regard to seedling date palm fruits. Date palm fruits on the tree pass through four stages of development as they mature; *kimri* is the first stage when the fruits are small, green, hard and immature; at *khalal* stage fruits attain their full size and take on a yellow or red skin coloration, but are

still somewhat hard; upon reaching *rutab* stage the fruit begins to soften and take on a typical amber or brown color; at the *tamar* stage the fruits are firmer, cured and the skin becomes wrinkled, and can be stored without fermenting or souring. Cultivars are traditionally classified as *soft*, *semidry* or *dry*, based upon fruit consistency when ripened normally.

A seedling date palm may also be referred to as a marginal date palm, *khalt* or *deglet*, according to the fruit qualities. The meaning of the Arabic term *khalt* may be “mixed,” “dry,” or “seedling.” The Arabic term *deglet* (*deglat*, *deglah*) may refer simply to a “date,” “a date of poor quality of unknown origin” or a “seedling.” *Khalt* and *deglet* usage and meaning vary from country to country; both appear as part of cultivar names, particularly in North Africa, with different meanings altogether. For example, In Tunisia, *Khalt Mouachem* is a soft cultivar date, neither dry nor a seedling (Kearney, 1906; Rhouma, 2005). In the Jerid oasis of Tunisia, all seedling dates with dry fruits are called “*khalt*” while all seedling dates with soft fruits are referred to as “*chekken*” (A. Othmani, pers. comm., 2012). As for the term “*deglet*,” the well-known *Deglet Noor* of Algeria is a semidry cultivar date, neither of poor quality nor a seedling. Clearly, these Arabic terms must be interpreted with care.

Included in this study is a discussion of modern seedling-derived dates propagated by offshoots for research purposes (i.e. germplasm collections) and commercial fruit production. Clear examples of the latter are the American cultivars grown on a small scale in California and Arizona (Hodel and Johnson, 2007).

It could be argued that it is the seedling date that is emblematic of this important world commercial palm species, for no single named cultivar can fulfil that role. A direct link between past and present date palm growing became known in 2005 when a 2,000-year-old date palm seed, recovered from an archaeological site in the Judean desert of Israel, was germinated successfully. In late 2011, the Judean date palm was transplanted to an outside location at the research station where it was grown and can now be viewed by the public (Figure 3). Initial genetic studies of the palm reveal that it shares about 50% of its DNA with contemporary date palms. Unfortunately, the Judean date palm appears to be a male plant, requiring time consuming backcrossing experiments to incorporate its traits into other date palms (AAAS News, 2008; The Daily Plant, 2012).



Figure 3. Judean date palm (*Phoenix dactylifera*), Borick Natural Medicine Research Center, Jerusalem.  
Photo: B. Glazner.

### Seedling date palms

Seedling date palms occur spontaneously wherever date palms are grown; when they occur in modern plantations they are considered weeds and eliminated. There is an opinion shared among most date palm specialists that seedling dates are of no significance for commercial fruit production, owing to the heterogeneity of open-pollinated female palms and the great assortment of fruit size, shape, color and flavor. Standard sources on date palm cultivation discuss the value of seed propagation for breeding experiments, as well as ornamental use, but recommended against them for commercial fruit production because of the advantages of offshoot propagation in terms of genetic fidelity as well as greater fruit quantity and good quality.

Assessments of seedling date palms typically fail to take into account their value at the local level as a source of subsistence food and for animal rations. Nixon (quoted by Dowson and Aten, 1962), agreed that seedling dates were inappropriate for fruit production in the established date palm countries of the Old World, with the exception of those grown for research. However, Nixon strongly believed that in marginal areas elsewhere, planting seeds of selected varieties would be beneficial. He also held the strong view that seedling genotypes could profit from a testing and breeding program for marginal areas.

Relative to whether seedling date palms were worth cultivating, an interesting exchange occurred between two of the leading twentieth century date palm specialists, V.H.W. Dowson (1896-1980) and Roy W. Nixon (1895-1976), regarding the degree to which seedling dates resembled those of the mother palm. Dowson and Aten (1962) stated that a female

date seed would “bear dates of unpredictable qualities. The chances are many thousands to one against their resembling those of the mother. Moreover, it is exceedingly unlikely that the dates borne by the seedling will be any good at all...” Nixon, who appears to have reviewed Dowson’s manuscript before publication, responded: “There are certainly very large odds against getting a seedling identical with the parent variety, but there are often strong resemblances of seedlings to the parent variety. ...we have [in the USA] at least half dozen new varieties that originated from seeds...that are definitely superior to 90 percent of the varieties we imported from the Old World...” To his credit, Dowson included in his book Nixon’s dissenting view.

Despite the disadvantages of variable fruit quality and quantity, seedling date palms are grown for fruit production, apparently even in areas where cultivar date palms predominate. In the Nizwa groves of Oman, for example, small quantities of seedling date fruits called Qash Nabhani are produced. These reportedly delectable fruits are large, soft, red-orange in color and have white flesh streaked with yellow (Nabhan, 2008).

Date palm seeds of undocumented origin were planted successfully in Australia for fruit production, as early as the 1880s. A few seedling palms from the early plantings reportedly have been preserved at the Mecca Date Garden near Alice Springs in Central Australia (Tanswell, 1999).

Small commercial quantities of seedling-derived dates are marketed in Spain, Mexico and Peru. In the USA, date fruits from American cultivars, derived from seedlings of introduced cultivars, are sold. These will be described in detail later in this paper.

In date palm plantations, viable unharvested fruits may fall to the ground and germinate to produce seedlings near the base of the mother tree. Seedling date palms growing at the base of trees may be mistaken for mutant off-type suckers. Nixon (1953a) recounts the instance of a farmer who had a female tree of cv. Deglet Noor which had two large offshoots bearing male flowers, which he believed were off-types, because the offshoots had no obvious leaf differences from the mother tree. However, when the soil was removed to expose the roots it became apparent that they were seedling date palms. Off-type suckers, nonetheless, do occur on occasion and may be of interest to breeders if they exhibit desirable characteristics. Off-types may originate as bud variations; Mason (1930) suggested that in date palm they are best termed *sectorial mutations*.

Seedling date palms can be distinguished from offshoots during the first year or two of growth by their different leaf form, but later they may be mistaken for offshoots.

Conducting a census of date palms grown on a formal plantation is simple because the trees are planted at a regular spacing; offshoots are removed for transplanting or simply eliminated to maintain spacing and to facilitate agricultural operations, leaving only single stems to count. In dealing with untended or feral seedling date palm populations, however, the situation becomes complicated if offshoots remain attached to the mother palm until they mature and produce fruit. In such cases, one original tree may multiply into several. In making estimates of seedling date palm population numbers, the most common practice is to enumerate producing trees as individuals, even if they are still attached to the mother tree.

In Egypt, seedling date palms account for some two-thirds (or 2.3 million) of the date palms grown in the Fayoum depression, the largest oasis in the country, and in the valley of the Nile from above Cairo to Aswan (Riad, 1996). These numbers are noteworthy in that currently Egypt is the world's leading date producer. Seedling date palm populations also predominate in countries such as Mauritania, where the ancient Adrar palm groves contain about 120,000 producing trees (Bonte, 2010; Munier, 1955).

Two ancient cities are celebrated for their old date palm groves. One is Marrakech, Morocco, at the northern foot of the Atlas Mountains, with its historic date palm grove of about 100,000 trees (Elhoumaizi et al., 1998). A study of Moroccan palm groves found that nearly 80% of the Marrakech trees were of seedling origin. The same study found that on average more than 50% of all 11 groves included in the study were made up of seedling date palms (Bendiab et al., 1998). The climate of Marrakech is marginal for ripening dates and therefore palms that bear fruit early in the season are preferred (El Houmaizi et al., 1993).

A second example of a historic date grove is in Tadmor (or Palmyra), Syria, the "city of palms," located in an oasis northeast of Damascus. An estimated 130,000 seedling date palms are growing in Tadmor. Studies are underway on seedling propagation to select superior Syrian genotypes for offshoot propagation (Ibraheem, 2012). These examples strongly suggest that other traditional date-growing countries also hold significant numbers of seedling dates.

Although not native, date palms have been cultivated since ancient times in what is now Pakistan and India. Introduction of date palm seeds probably took place in the eighth century or even earlier (Jatoi et al., 2009). Bonavia (1885) describes 12 locations where seedling date palms were present in the Awadh (Oudh) district of what is now Uttar Pradesh state in North India. He described these populations as fully acclimatized and bearing fruit. Traditional date palm cultivars in both countries originated from these early seed-propagated date palm populations. A large area of seedling date palm groves exists in the western part of the India, in the Kachchh region of Gujarat state. Established some 200 years ago, the planted area contains about 1.4 million seedling date palms. Fruit production is low and variable. Because the monsoon rains occur before the fruits can fully ripen, farmers have selected certain date palms which yield non-astringent fruits at the khalal stage, which are sold in Mumbai. Vashishtha (2003) states that the seedling date palms of Kachchh represent a rich gene pool.

In general, information about the fruit and other characteristics of seedling date palm groves and of individual seedling date ethnovarieties is variable and incomplete. It is obvious that they have not received much research attention.

Following Rivera et al. (2006) the term *ethnovariety* in reference to seedling date palms is used to refer to infra-specific diversity in cultivated plants as understood and managed by farmers.

### **Seedling date palm propagation**

Once established, female date palms are able to reproduce naturally by both seeds and offshoots, male palms only by offshoots. When left untended, the palms develop dense thickets composed of seedlings and offshoots. These feral date palm stands provide shade, habitat and food for birds and small terrestrial animals, and their fruits may be harvested by local people for food or to feed to livestock. Date palm thickets can be thinned, most male palms eliminated and minimal management adopted to enhance fruit production.

Seedling date palms are cultivated for two major reasons: breeding and germplasm conservation. The U.S. Department of Agriculture supported a date palm breeding program in the period 1948-1978. In 1965-1975, backcrossed male palms were bred and selected for promising metaxenia effects, followed by a major effort in the 1970s to produce female clones bearing fruit which could be harvested and processed mechanically. The latter experiments involved 12 imported and 2

American cultivars, each with desirable characters. However, none of the nine selections proved to be an appropriate substitute for Deglet Noor, the most common cultivar grown in the USA. The breeding program was concluded in 1978 in anticipation of the closing of the U.S. Date and Citrus Station in Indio, which occurred in 1982. The most promising commercial female and male selections from the research station are conserved in the National Date Palm Germplasm Repository in Thermal, California (Carpenter, 1979; Hodel and Johnson, 2007).

An investigation in Oman is making use of seedling date palms as germplasm sources to enrich the local gene pool (El Kharbotly et al., 2010). Another example of date palm breeding began in Morocco and Algeria, also in the 1970s, seeking to identify genotypes with resistance to bayoud disease, caused by *Fusarium oxysporum* f. sp. *albedinis*, as well as producing high quality fruit. Selected wild male and female genotypes with desirable characters were crossed to create new genotypes for field testing, but these have not given anticipated positive results. The major difficulty is that backcrossing to generate F1 and F2 progeny requires as many as 30 years (El Hadrami et al., 2011). Conventional breeding has been eclipsed by dramatic developments in plant biotechnology over the past decade which have opened the possibility for molecular breeding of date palms (Abdulla and Gamal, 2010; Al-Dous et al., 2011; Arabnezhada et al., 2012; El Hadrami and El Hadrami, 2009; Hider and Nabulsi, 2012; Jain, 2012; Khanam et al., 2012; Yang et al., 2010).

A second reason for cultivating seedling dates is to maintain living germplasm collections of certain male and female seedling types with desirable traits for conventional breeding purposes and as sources of genetic material for molecular breeding. A review by Bettencourt et al. (1992) found that worldwide there were only 15 formal field date palm genebanks, the largest in Algeria, India, Iraq, Nigeria and the USA. A more recent study by Krueger (2011) notes the existence of a field genebank in UAE to study salt-tolerant varieties, along with collections in Saudi Arabia at Al Qasim University and at the Wadi Quriyat Date Palm Research Station in Oman. Most of the accessions in these collections appear to be elite cultivars. An exception is Nigeria where five field genebanks were established in the 1980s, with accessions of seedling date palms from different parts of the country's date palm belt. Fruit produced by these palms compare favorably with named cultivars from elsewhere; the palms should be fully evaluated to assess their germplasm value (Ataga et

al., 2012). Date palm germplasm collections in the USA are also an exception because they contain elite cultivars along with 11 American cultivars derived from seedling dates (Hodel and Johnson, 2007).

The value of seedling date palms in Morocco was highlighted by Baaziz et al. (2000) and Baaziz (2003), who pointed out that encouraging commercial cultivars and discouraging seedling date palms leads to a loss of genetic diversity within date palm groves; they also reasoned that seedling date palms should be conserved because they may contain genes resistant to bayoud disease, as well as other diseases and pests. It was estimated that Morocco overall has more than 2.5 million seedling date palms bearing good fruit quality which could contribute genetic material to solve the bayoud disease problem.

Ornamental use is a third way in which seedling date palms may be utilized, taking advantage of existing mature palms and transplanting them to landscape shopping centers, buildings and as street trees. However, because of the variability they exhibit, preference is given to cultivar dates where the goal is to achieve a uniform appearance of palms in a landscape setting. Seedling and cultivar date palms are important components of the vegetation landscape in all of the traditional date-growing countries of the Middle East, North Africa and the Persian Gulf countries (Figure 4). In California and Arizona, where seedling date palms are rare, cultivar date palms are used as ornamentals, with a preference for cvs. Medjool and Zahidi.



Figure 4. Date palm cultivars used in landscaping, Hofuf, Al-Hassa, Saudi Arabia.  
Photo: J. M. Al-Khayri.

Published references on date palm provide only a minimal of detail about seed propagation for whatever purpose. Date palm seeds can be germinated by direct planting in the field or in a nursery with subsequent selection of the healthiest seedlings to transplant to the field. Popenoe (1913)

recommended collecting seeds from trees with desirable fruit characteristics, discarding small seeds, and then soaking them in water for a week to accelerate germination. In the field, seeds are planted 3-5 cm in depth, at distances of 10 x 10, 10 x 9 or 10 x 8 m, giving densities of, respectively, 100, 121 or 125 palms per ha; the position of the seed in the hole is not important. Seed germination in the nursery commonly consists of a single seed in a polybag to facilitate potting up as the plants develop. Holding seedlings in the nursery for a year or two permits a useful selection and culling prior to transplanting into the field.

In vitro seed germination provides a controlled environment to examine the response of date palm seedlings to various growth-limiting factors as well as to study the response to stress conditions like drought and high soil salinity (Sané et al., 2005). Excised embryos from mature seeds also have proved useful for screening for abiotic stress (Ibraheem et al., 2012).

For successful in vitro germination of date palm seeds, Sané et al. (2005) recommended scarification of the seed with 96% sulfuric acid for 5 min and washing 5 times with sterile distilled water prior to densification in 1% mercuric acid for 3 min and then rewashing with sterile distilled water. The seeds were soaked in water for 48 h and then sterilized a second time with 5% calcium hypochlorite for 4 min and rewashed with sterile distilled water. The seeds were cultured in Murashige and Skoog (1962) basal salts supplemented with Nitsch and Nitsch vitamins (1969), 0.2 mg/l glutamine and 30 g/l sucrose. The medium was adjusted to pH 5.7 and solidified with 8 g/l of Agar. Recommended incubation was 80  $\mu\text{E s}^{-1} \text{m}^{-2}$  with a photoperiod of 12 h at 30°C.

Spontaneously occurring date palms are a dubious seed source. If the seedlings are found beneath a female palm, they are most likely from that palm. However, wild animals may transport fruits to other locations, consuming only the mesocarp pulp and leaving the viable seed to germinate. Similarly, whole dates are eaten by domestic animals such as goats, sheep, cattle and camels, with the seeds passing through their digestive system and deposited in random locations (Barrevel, 1993).

Hypothetically, date palm seeds will yield equal numbers of male and female plants, but gender cannot be determined until the palm flowers at 4-6 years of age or later. Hence, a high percentage of male palms must be removed from a directly-planted field. It is more practicable to make a selection in the

nursery of healthy females, along with a few healthy males, to establish a seedling-date plantation. Current molecular studies (Aberlenc-Bertossi, et al., 2010; Ageez and Madboly, 2011; Bekheet and Hanafy, 2011; Cherif et al., 2012; Elmeer and Mattat, 2012; Moghaieb et al., 2010; Younis et al., 2008) are expected to provide the means to identify the gender of seedlings at an early stage and thereby simplify propagation and breeding. Early selection of young seedlings could enhance date palm breeding programs and generate experimental male and female genetic stocks (Siljak-Yakovlev et al., 1996). Molecular markers would facilitate the identification and selection of good male pollinators for use in breeding programs and could be used to select date palm with desired traits such as high yield and improved physical and chemical fruit characteristics (Elmeer and Mattat, 2012).

### Male seedling date palm

For centuries, it was presumed that all male date palm pollen was of equal quality and that the source of pollen was therefore inconsequential to the fruits resulting from natural or artificial pollination. However, it was suspected by some date specialists, that pollen quality influenced fruit production. Studies by Nixon (1926, 1927) and Swingle (1928) showed that the quality of pollen was indeed an important determinate of fruit quality and quantity; Swingle is credited with coining the term *metaxenia* to describe this effect.

In many areas, seedling date palms continue to play their most prominent role in commercial date cultivation through male palms serving as pollen sources; the pollen exhibiting a wide range of variation. In certain areas of seedling date palm cultivation, such as Marrakech, Morocco, farmers rely upon natural pollination by insects and wind within the groves of mixed female and male palms. Under natural pollination, fruit set is reduced, but in the Marrakech example, economic incentives do not justify the expense of artificial pollination (Zaid, 2002).

Research has been done in various countries on male seedling date palms. An Egyptian study involved 50 male seedling date palms which were evaluated for their pollen grain weight and viability, number of spathes produced, number of flowers and the length of the spathe burst (Moustafa et al., 2010a). A subsequent investigation took five of the selected males and compared the metaxenia effect in cv. Seewy in terms of fruit set, fruit quality and yield. Three of the male date palms produced the best overall results, confirming the importance of a superior

pollen source (Moustafa et al., 2010b). In Saudi Arabia, Taha et al. (1989) evaluated 600 male date palm seedlings to identify superior pollen providers, and a similar study in Pakistan involved 15 male date palm seedlings (Iqbal et al., 2009). The objective of these investigations was to identify superior male date palms for offshoot or tissue culture propagation to establish stable male cultivars.

#### **Other uses of seedling date palms**

Date palm seedlings are playing a role in biotechnology as laboratory test plants. In recent studies they were used to ascertain if magnetic fields (Al-Enezi et al., 2012) or X-radiation (Dhawi and Al-Khayri, 2011) can influence growth parameters of young palms. Positive results could bring about new protocols for more rapid growth of tissue-cultured plants. Moreover, mutations induced by irradiation of seeds could benefit the expansion of the gene pool available for selection in date palm breeding schemes. Male and female seedling date palms were used by Majourhat et al. (2002) in Morocco to study the diversity of leaf peroxidases and their potential as genetic markers.

#### **Seedling date palms in Spain and the Americas**

Important seedling date palm populations are found in Spain, Peru and Mexico. Date palms were introduced to those locations in historic times by seeds and the trees grown for fruit production. Date palms became naturalized in these locations, partially or fully ripening fruit depending upon climatic conditions, and reproducing by seeds and offshoots. In a number of other locations, such as the Caribbean Islands, fruit production failed because humid conditions during the ripening period caused fruit rot. In areas marginal for fruit production (e.g. Italy), date palms are grown for ornamental purposes comparable to the way the Canary Islands date palm (*Phoenix canariensis*) is cultivated.

Each of the three seedling date palm populations described in this study has a unique history. Also included is an account of the historic seedling date palms in the USA and how in the twentieth century new cultivars were derived from seedlings of imported cultivars.

The history of date palm introductions to the Americas, especially the provenance of the seeds the Spaniards brought to the New World, is being investigated by an informal international group of date palm scientists, under the leadership of Dr. Diego Rivera, University of Murcia, Spain. The research includes DNA analysis of samples from the naturalized populations in Baja California,

Mexico and Peru and comparison to the DNA of date palms from Spain and North Africa, in an attempt to ascertain affinities and suggest origins. The results are not yet ready for publication.

#### **Seedling date palms in Southeast Spain**

Early in the period of Arabic domination of the Iberian Peninsula, which began in 713 A.D., Berbers from North Africa introduced the huerto (fruit and vegetable garden) oasis system to Spain. It was modelled on systems in use in Africa at that time, to produce fruits, vegetables and grains under irrigation and to sustain livestock. Planted from seeds, date palms became the keystone species of the huertos. Elche, located in coastal south-eastern Spain and enjoying the mildest climate in Europe, developed into the largest area for date palm cultivation. The huertos (each with an individual name) and their date palms were maintained for centuries and now form the contemporary Palmeral de Elche, all derived from seedling date palms. For unknown reasons, propagation by offshoot separation was not a tradition. Historically, in Elche, the practice of collecting seeds from female trees bearing fruit of good quality was used for replacement plantings in the huertos.

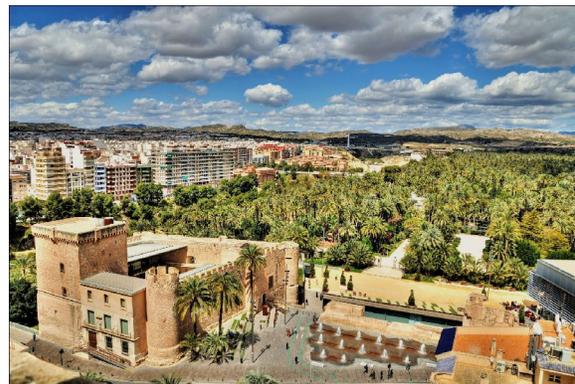


Figure 5. Elche, Spain, traditional palm grove, now a World Heritage Site.  
Photo: iStockphoto.

The historic Palmeral de Elche contains about 180,000 adult date palms (Figure 5). Total date fruit production is reported by FAO at 5,200 mt in 2010; however, only about 100 mt are marketed for human consumption (Ferry et al., 2002). The area of the traditional Elche palm grove was inscribed as a UNESCO World Heritage Site in 2000 with the long-term objective to maintain it as a unique European example of an introduced oasis system, with the date palm as its key agricultural species.

The climate of Elche (at 38° 35' N. Lat.) provides only 792°C of heat units, making Elche marginal for ripening date fruits. Munier (1973) concluded that a minimum value of 1,000°C heat units were necessary to produce ripe fruits. Fruits produced by the ethnovarieties found in the Elche palm grove display a wide range of color, size, shape and flavor (Figure 6). Typically, they are harvested at the rutab stage and artificially ripened. Several ethnovariety fruits ripen naturally on the tree in Spain; these are referred to as *cándidos* and are characterized by balanced sugar content, are nonfibrous and have somewhat dry flesh not inclined to fermentation (D. Rivera, pers. comm., 2012). Ethnovarieties have not been described in detail, although the more important ones have been classified according to fruit consistency. Table 1 lists ten of them, their names typically derived from the huerto where they are grown.

Artificial ripening has been investigated in Elche to better utilize local seedling date fruit production. The studies referenced below are worth noting because they represent results from seedling date palms grown in Elche. Studies of the artificial ripening of cultivar date fruits have been done; for example on cv. Dkakki in Pakistan (Saleem et al., 2005) and cv. Khuneizi in Iran (Yektankhodaei et al., 2007), but those results may not be directly applicable to seedling date palm fruits.

One study of artificial ripening in Elche involved fruit at the khalal stage from the Caqui, Los Cherros and Los Olmos huertos. Experiments were conducted with acetic acid, freezing and vaporization treatments using parameters of fresh weight, firmness, total soluble solids, acidity, ripening index, color and sensory properties, before and after the treatments. The best results were found in fruit from the Caqui and Los Olmos huertos which ripened to good fruit quality using treatments of acidic acid and freezing (Amorós et al., 2007). Another study showed that Elche seedling date fruits consumed at the khalal stage have a high hydrophilic total antioxidant activity and are nutritional. The research involved seven ethnovarieties from Algorós and Caque huertos and included fruit measurements from medium khalal to full rutab stages. The range in weight was 6.1-12.8 g; length 33.9-43.6 mm and diameter 18-21.7 mm (Amorós et al., 2009). Gracia and Ortiz (1996) found that the date fruits in Elche, which represents 95% of Spanish date production, ranged in length from 26.9 to 52.6 mm. On average, the seed represented 7.5% of the fruit weight. These data indicate that Elche seedling date palm fruits are

smaller than those borne by cultivar date palms, which is to be expected.



Figure 6. Seedling date palm fruits, Elche, Spain.  
 Photo: S. Orts.

Table 1. Elche date palm ethnovarieties according to fruit consistency.

Ethnovariety name	Phenotypic groups based upon fruit consistency
De Aob	Soft
Bollior	Semidry
Candit	Semidry
Confitera <sup>#*</sup>	Soft
Léon <sup>#</sup>	Soft
Marraner	Semidry
Negre/Dora/Verdal	Soft
Tenat	Dry
Tendre	Soft
Tendre Dolz	Semidry

<sup>#</sup> Considered to be a cultivar since it is propagated by offshoots.

<sup>\*</sup>According to unpublished molecular studies conducted at Miguel Hernández University, Elche, Confitera is unrelated to local date palm ethnovarieties but correlates with North African material; therefore, it is not a traditional Elche date palm (D. Rivera, pers. comm., 2012). Source: Ferry, 1999; M. Ferry, pers. comm., 2012.

A study in Elche of physicochemical changes of Negros ethnovariety fruit at 16 ripening stages of maturity found that plant hormone ethylene was responsible for changes in color, firmness, soluble solids content and acidity (Serrano et al., 2001). Blanching is a ripening technique used in Elche with cvs. Medjool and Confitera fruits. Blanching water accumulates soluble solids and organic acids which can be used to reconstitute skim milk powder to produce yogurt (Trigueros et al., 2012).

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 of fruit flavor, aroma and texture, as a fresh

perishable fruit at the khalal or rutab stages. When superior ethnovarieties have been ascertained they will be propagated by offshoots to create new cultivar palm groves to be established outside the boundary of the historic Palmeral. The overall objective is to produce attractive fresh dates for the European gourmet food market (Orts and Johnson, 2007).

Also 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 is forming a beneficial buffer zone and extending the palm landscape of Elche. Seedlings produced are of the introduced cv. Medjool and cvs. Confitera and Léon both 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 (M. Ferry, pers. comm., 2012)

In the Rio Segura Valley, just west of Elche, a comprehensive field study of seedling dates was carried out by Rivera et al. (1997). The findings, summarized in Table 2, represent the most detailed information about ethnovariety date fruits in Southeast Spain.

Efforts underway to improve upon the traditional seedling date area in Elche, Spain 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.

Table 2. *Phoenix* spp. seedling date palm ethnovarieties, Río Segura Valley, Spain\*.

Species	Ethnovariety	Fruit characteristics and notes
<i>chevalierii</i> *	De Adobo	Fruits ripen slowly, extending availability for table consumption. Edible only after being marinated in vinegar. Trees being replaced by more desirable cvs. Becoming scarce.
<i>chevalierii</i>	De Berberia	Fruits small ovoid 2 cm in length. Skin smooth to rugose, very dark reddish brown. Flesh dark, farinaceous, sweet and aromatic. Ripe from early November.
<i>chevalierii</i>	Verdal	Fruit small oval, elongated, 2.8-3.5 x 2 cm or more, apiculate. Skin smooth and fine, green, turning brownish green when mature. Ripe from mid November.
<i>dactylifera</i>	Cándidos	Fruits of average size, 4-4.5 x 2 cm, cylindrical. Skin smooth yellowish, at full maturity dark reddish brown. Flesh firm, smooth, granulose and farinaceous, taste sweet and pleasant. Used in desserts when fully mature but spoils easily. Ripe from early November.
<i>dactylifera</i>	Candíos Puntigudos	Fruits of average size, 3.5-4.5 x 2 cm, cylindrical but narrowing toward the apex. Skin smooth yellowish turning reddish brown at maturity. Flesh firm, smooth granulose and farinaceous, taste sweet and pleasant. Harvested from mid November but if left until tamar stage become brownish.
<i>dactylifera</i>	Largos	Fruits large, 5 x 2 cm, cylindrical, smooth brownish yellow. Skin smooth, shiny, strongly adhering to the mesocarp. Flesh white, fibrous, sweet, and slightly sour. Consumed fresh and in dry sweet confectionery. Ripe from mid December. Similar to cv. Ghars (Rhars) of North Africa (Algeria).
<i>dactylifera</i>	Moscatel	Fruit of average size, cylindrical to 4 cm. Skin yellow, shiny, turning reddish-brown when mature, rugose. Flesh farinaceous and consistent, yellowish-green, very sweet when mature. Ripe from mid November. Dubious resemblance to cv. Deglet Noor of Tunisia and cv. Halawi of Iraq. Also, could be related to cv. Khalasa from the Arabian Gulf because the flesh is amber and without fibers.
<i>dactylifera</i>	Rojo	Fruits large 4.5-5 x 1.8-2.5 cm, elongated oval. Skin shiny red, turning brownish at maturity, smooth and shiny. Flesh white, fibrous-fleshy, juicy and sweet, taste a bit sour. Eaten fresh. Ripe from early November. Similar to cv. Aruri of Egypt, known for its large fruit size.

Table 2. Contd..

Species	Ethnovariety	Fruit characteristics and notes
<i>dactylifera</i>	Tiernos	Fruits spoil easily starting from the end, hence they are eaten before fully mature.
<i>iberica</i> *	De Espiga	Fruits average size 4 x 2 cm. Skin yellow, straw-colored to shiny-reddish, smooth shiny and consistent, dense and strongly adhering to the flesh, which is firm, fibrous, somewhat dry, sweet-sour. Ripe from early December. Resembles cv. Fardh of Oman.
<i>iberica</i>	De Rambla	Fruits small 2.4-2.6 x 1.5-1.8 cm. Skin yellow, straw-colored shiny-reddish, smooth, consistent, firm and strongly adhering to the flesh, which is firm, fibrous, somewhat dry, sweet-sour.
<i>iberica</i>	De Sol	Fruits only suitable for livestock feed, although after freezing they are fit for human consumption.

Note: An expanded study is in preparation to cover all of southeastern Spain which is expected to name about 25 ethnovarieties (D. Rivera, pers. comm., 2012)

\* Govaerts and Dransfield (2005) treat species *chevalierii* and *iberica* as synonymous with *dactylifera*, a classification which stands until further studies are done to prove otherwise.

Source: Rivera et al. (1997).

### Seedling date palms in Canary Islands, Spain

Date palm seeds were introduced to the Canary Islands during the Norman-Castillian conquest of the fifteenth century, possibly originating from Spain; however, there is some evidence that the palm may have arrived earlier, with seeds brought in by the Phoenicians, Punics or Arabs. From those early introductions, small populations of naturalized *Phoenix dactylifera* still exist today near the ports of Fuerteventura, Gran Canaria and La Gomera. (Santana and Rodríguez, 1999). The climate of the island group is not warm enough to fully ripen date fruits. It is not documented, but some of the true date seeds carried to the New World may have come from trees in the Canary Islands, collected when Spanish explorer ships were provisioned for the last time at one of the aforementioned ports, before sailing west (Johnson et al., 2011).

*Phoenix canariensis*, the Canary Islands date palm, is endemic and the only palm native to the islands. It occurs as single palms or in small groups over the entire island group; also, it is a popular temperate zone ornamental in many places around the world. This *Phoenix* species does not produce basal offshoots and must be propagated by seed. The fruits are edible, but are small having only a very thin mesocarp and are sometimes fed to livestock (Rivera et al., 1997); birds consume the fruits and are an identified dispersal agent (Nogales et al., 1999). Near the stands of true date palm, some natural hybrids between the two *Phoenix* species have been observed (Morici, 1998). The

emblematic tree of these Spanish islands, *P. canariensis* is depicted on the official flags of the islands of Gran Canaria and La Palma.

### Seedling date palms in Peru

The Central Coast of Peru represents a location in the Americas where seedling date palms have been growing for four centuries. Ripe date fruits in the Rio Pisco Valley were observed by the Jesuit scholar Bernabé Cobo in 1612, writing in 1653 (Cobo, 1964). The Spanish Colonial capital of Lima was founded in 1535; date seed would have had to arrive no later than around the end of the sixteenth century for Cobo to make his initial observation. Cobo compared the date fruits in Peru to those brought in from the Barbary Coast of Africa, currently the countries from Morocco east to Libya, suggesting that region as the seed source.

The climate of Coastal Peru and the adjoining area of Northern Chile provide from 2,000-5,000°C heat units, more than enough to ripen date fruits. The total seedling date palm populations of Peru and Chile are not known, but it has been estimated that in the area of Pisco and Ica, Peru alone, there are 50,000 producing palms; however, 90% of them are abandoned and feral (Pavez et al., 2007).

According to the FAO, date fruit production in Peru in 2010 amounted to 337 mt. Production comes from seedling date palms and a modern cultivar date palm plantation, Huerto Alamein near Ica (Letts, 2003). It should be noted that seedling date palms in Peru receive no pruning, irrigation, assisted pollination or pest control (Figure 7). Fruits are harvested at the late khalal or early rutab

stages; fruit bunches are cut and taken for storage in an enclosure of adobe, palm trunk and leaves with a dirt floor. Fruit bunches are suspended on racks to ripen, being covered in foggy weather and at night. Midday temperatures reach 58-61°C within the structure. Ripening takes less than a week. Ripe fruits are removed individually from bunches and packed in baskets for sale. There is no tradition of eating tamar stage dates in Peru, but dry dates are fed to livestock. Most of the fruits of the seedling dates are consumed locally, a small amount reaching markets in nearby cities or Lima, but in general dates as fresh fruits are virtually unknown in Peru (Pavez, 2003).

Some efforts have been made in Peru to valorize the seedling date palms as well as to establish modern cultivar plantations, but thus far little has been achieved. Climatic, soil and water conditions in a number of areas of the country are very favorable to large-scale production; moreover, Peru is free of the major date palm pests and diseases (Pavez et al., 2007).



Figure 7. Feral seedling date palms Peru.

Photo: A. Pavez Wellmann.

Unpublished studies in Peru have generated some information about the more popular seedling date palm fruits. Table 3 presents the results of a survey in Ica of nine named ethnovarieties. Over four centuries of relatively isolated sexual reproduction, Peru's more than 50,000 producing seedling date palms must certainly contain a number of ethnovarieties with desirable traits.

Table 3. Seedling date ethnovarieties in Ica, Peru.

Spanish name (English translation)	Fruit description	Notes
Calvario (calvary)	Dark-red color, long and cylindrical, soft, translucent and shiny when mature. Weight 10-20 g, although some palms produce fruits of 35-38 g and 7-8 cm in length.	Only seedling date palm developed and propagated by local farmers.
Melacocha (molasses); Carmelo (caramel) or Meloso (honeyed)	Dark-red color, flesh caramel-like and translucent. Fruit only eaten fresh, perishable and subject to insect attack.	Names generally given to soft and syrupy dates that ooze honey when ripe.
Italia (Italian)	Fruit green color at rutab. Flesh thick, soft, translucent, aromatic and very sweet.	Name derived from its resemblance to Italian grapes. This date is renowned in Rio Grande and Ingenio.
Moscatel (muscatel)	Fruit purple at khalal, turning black when fully ripe, flesh soft and thick with thin seed and very aromatic. 7 cm in length, up to weight 40 g.	This seedling date palm is found exclusively in Rio Grande. Best date in Peru
Huando (seedless)	Fruit seedless; lack of pollination?	General name for seedless (parthenocarpic) fruit. Reported to be result of a genetic mutation. These palms are scarce.
De Mascar (chewy)	Fruit generally yellow, semidry, exhibits wide range of shapes and sizes. Sweet at khalal and can be eaten directly from the tree without further ripening.	Name applied to semidry dates that are sweet at khalal and can be eaten directly from the tree.

Table 3. Contd..

Spanish name (English translation)	Fruit description	Notes
Chocho or Pasa (raisin)	Fruit dry; neither softens nor becomes translucent at rutab, ripen directly to tamar when they wrinkle and dry, can remain unharvested on tree.	Despite self-preserving quality and extraordinary resistance to insects, fungi and diseases, fruits considered worthless and generally fed to livestock or palms cut down.
Chochón	Fruit dry, egg- or pear-shaped, with tough skin, weight over 25 g. Very difficult to ripen and dry, hence generally discarded.	No English translation for “chochón.” If ripened, peeled and seeded, ideal for stuffing with sweetmeats and covered with chocolate, grated coconut or sugar to make a delicious sweet.
Colorado (red); Negrito (blackish) or Morocho (fresh)	Fruit blackish, reddish or crimson at khalal, turning dark red or velvet-colored at rutab, small size, weight 6-10 g. Some sweet and honeylike.	Names are general terms for date fruits of this type. Because of their size and color not considered to have commercial potential. Generally fruit not harvested or harvested for livestock feed.
Chuccos (pleasant)	Fruits small, flesh chewy with tough skin, weight 5-8 g. Fruits often infested with insects and gnawed by rodents.	General term for date fruits from wild palms growing on uncultivated land without any care. One advantage of this ethnovariety is that it ripens after falling on sandy or salty soil and is well adapted to industrial processing.

Source: Pavez, 2003.

### Seedling date palms in Mexico

Along with Christianity, Spanish missionaries brought agriculture to Mexico’s Baja California Peninsula, and the date palm was part of the crop assemblage. The native peoples of the peninsula did not practice agriculture, sustaining themselves by fishing, hunting and gathering. The first of a chain of missions, established at natural oases, was founded in Loreto in 1697. Sometime in the middle decades of the eighteenth century, date palms appear in the historical record at mission sites. The origin of the date palm seeds introduced to Baja California is not documented, but most likely it came from Mainland Mexico where there were some date palms at the time (Johnson et al., 2011); the mainland was the departure point for the Spaniards who colonized Baja California.

A field survey of seedling dates was carried out in 2004 covering the State of Sonora from Nogales at the US border south to Álamos. Only occasional seedling date palms were seen, typically at active or abandoned farm sites. Mature seedling date palms

were observed as roadside plantings in beach areas west of Hermosillo; the palms had obviously been transplanted from other locations. The largest population found was in Madero Park in Hermosillo, which has a grove of over 100 seedling date palms, laid out as a plantation. The grove is said to have been established about a century ago for ornamental purposes. On a small scale, the Hermosillo grove resembles the ancient seedling date palm groves of North Africa (D. Johnson, pers. comm., 2012). The seedling date palms seen in Sonora are all likely descended from the original introductions during the Spanish Colonial Period.

In Baja California, Loreto, Mulegé (Figure 8), San Ignacio and Comondú are the major mission oasis sites for seedling date growing. In these locations, and several smaller ones, date palms naturalized and have flourished for about three centuries. Temperatures during the ripening season are sufficient to bring the fruits to maturity, although formal calculation of heat units appears lacking. Seedling date palms in Baja never have

been given much in the way of care, such as pruning and elimination of excessive male palms; offshoot propagation was not practiced. The date palms grow on their own in mixed production systems, with fruits harvested for local human consumption and for livestock feeding. As is typical of the fruit of seedling dates, they are varied in size and color. “The dates in the peninsula represent all types, large, small, large fat seeds, long narrow seeds, red, yellow, dark, black, caramel colored, sweet, astringent...” (Routson, 2012). Harvested fruits are dried in the sun before being packed in small baskets, typically woven from date palm leaves. Local people do not have names for the different seedling fruit types, but refer to them as *criollo caramelo* or *Mission* dates, to distinguish them from the fruit of cultivar dates, grown in two major locations: Datilera Del Desierto near San Luis Río Colorado in the extreme northwest corner of Sonora State and Ejido Bonfil near San Ignacio in Baja California Sur. Both plantations were established using offshoots from California.



Figure 8. Naturalized seedling date palms, Mulege, Baja California Sur, Mexico.

Photo: D. Johnson

As canopy trees of the Baja California oases, date palms provide welcome shade, and the leaves and stems are used for fencing, building materials and fuelwood. Prior to the introduction of date palms, the oases were dominated by the native Mexican fan palm (*Washingtonia robusta*). Because farmers more highly valued the date palms, the native palms have been significantly reduced in numbers in the oases, but still can be found, especially at the edges of the date palm areas. The historical importance of seedling dates in the peninsula is evident by the palm being depicted

on the Coat of Arms of the Loreto municipality. Date palms have been present in Baja California for so long that local people are surprised when told that they are not native.

The number of seedling date palms in Baja California is not known with precision. Popenoe (1926) estimated that there were at least 100,000 palms in Baja California and Sonora. Nixon (1953b) made an arduous field trip down the peninsula in 1949 to study the date groves. He made a rough estimate of the number of trees producing fruits or pollen in the following locations: San Ignacio 50,000; Mulegé 25,000; Comondú 20,000; Purísima 15,000; Loreto 15,000 and possibly 20,000 elsewhere in the peninsula. The estimated total of 145,000 may be understated, for Nixon only visited the major seedling date areas mentioned above. Recent field research on the crops of the Baja oases in general, supplemented with satellite imagery, puts the number of producing seedling date palms at several hundred thousand (Routson, 2012)

Mexico's date fruit production in 2010, according to FAO, was 4,150 mt. Nearly all is from modern cultivar date palm plantations near the California border. Seedling date fruit production probably does not exceed a few hundred tons annually and is all consumed on the peninsula.

## United States of America (USA)

### Introduced cultivars

The history of seedling date palms in the United States began when the current states of California and Arizona were still part of the Mexican nation. It is documented that the Spanish missionaries introduced date palm seeds from Baja California to San Diego, California in 1769 (near the present US/Mexico border) and to Ventura in 1782 (300 km to the north), along with a few other mission locations. Because the missions were on or near the coast, the climate was unsuited to ripening fruit. The date palms apparently were maintained for their historical and ornamental value. Purportedly the last original seedling date palms from the mission period in San Diego survived until 1957 (Trent and Seymour, 2010) and until the 1960s in Ventura (Dolan, 2005).

After the U.S. - Mexican War ended in 1848, and the United States gained control of what is now California and Arizona, numerous American settlers moved to the new territory and an indeterminate number of date palm seeds were planted. In one documented introduction, seeds of the Amzi (probably Amri) cultivar were collected in 1878 from the Nile Delta of Egypt and sent to the

USA; there is no information about the result of the introduction. Plantings also originated from date fruits imported for food (USDA, 1878). Scattered plantings of date palm seeds began bearing fruit in the late nineteenth century (Nixon, 1955). A program by the USDA, begun in about 1900, brought date palm offshoots of named cultivars from North Africa and the Middle East, to establish the modern commercial date industry. In the same period (1909-1913), the USDA also distributed some 3.8 million imported date palm seeds for planting (Paul, 1924). These seed introductions took place during a time when it was still believed that seed propagation of desirable cultivars was a commercial option. Popenoe (1926) estimated that there were perhaps 150,000 seedling dates in Southern California and Arizona. In the early decades of the twentieth century, cultivar date palms began to replace seedling date palms.

At the first annual meeting in 1924 of the Date Growers' Institute in Coachella California, seedling dates were among the topics discussed. Reeves (1924) recommended seven criteria in selecting seedling dates for propagation: ability to tolerate climatic conditions; fruit size and shape; fruit-packing quality; heavy-bearing palms; palms easily propagated by offshoots; fruit color and fruit of high sugar content. The author was obviously considering offshoot propagation from candidate seedling dates. Suggestions also were made at the meeting by Swann (1924) on the selection of good seedling palms for seed propagation, and by Goar (1924) on seedling date fruit cleaning by dry or water methods, grading, vacuum fumigation and heating before being packed.

The first importation of date palm offshoots from Algeria and Egypt were infested with the date palm scale insect (*Parlatoria blanchardii*), which attacks the leaves. The insect was detected when the shipment arrived in Washington, D.C., and the offshoots were treated with chemicals before shipment to the American southwest for trial plantings (Shamblin, 1924). Unfortunately, neither the treatment in Washington nor subsequent attempts in California and Arizona were able to control or eradicate the pest. Subsequent offshoot imports in the 1920s were likewise infested with date palm scale, exacerbating the situation and the insect became a major pest problem for date growers for nearly four decades.

Beginning in the late 1920s, a joint California state and federal program was launched to eradicate date scale. The program focused on both seedling and cultivar date palms. The date scale eradication

program targeted destruction of numerous seedling date palms in both states, to eliminate potential host reservoirs of the pest. In the cultivar date palms, success was finally achieved in 1936 by defoliation and blow-torching the palm stems to kill the pest and its eggs, followed by careful inspections to assure there were no recurrences. The measures taken were harsh but effective since there has been no reappearance of date scale. To prevent inadvertent introduction of it or other pests as well as diseases, California interior quarantine regulations prohibit all plant materials of the genus *Phoenix* from being taken into the counties of commercial date growing (CDA, 2010). Similar regulations are in force in Arizona (ACAH, 1923).

A few populations of seedling date palms, some distance from the commercial growing in Southern California, escaped destruction. A small stand of seedling dates established in 1857 near Winters, California (38° N. Lat.) began to bear in 1877 (Nixon, 1950). Seeds were reportedly obtained from fruit purchased at a food market in San Francisco (Klee, 1883). The surviving palms are now part of the University of California Davis's Wolfskill Ranch Experimental Orchard; they bear fruit (albeit seedless because there is no male among the 8 mature female palms) and appeared in good condition in 2008 (D. Johnson, pers. comm., 2012). Typical of unpollinated (parthenocarpic) date palm fruits, the Wolfskill fruits are small and not fully developed. The Wolfskill seedling date palms are likely the oldest extant in California.

A stand of seedling date palms can be seen at China Ranch Date Farm, near Tropic, California (at 35° N. Lat.), where seedling and cultivar date palms are grown on a small scale for commercial purposes. The seedling date palms were planted in the 1920s; the ethnovariety fruits are marketed as China Ranch Dates.

In the present day, occasional ornamental date palms, male and female, can be seen along roads in the Indio, California area and also farther to the south in the state, and in the Yuma, Arizona area. It is highly likely that the male palms are of seedling date palm origin, the females could be of seedling or cultivar origin. Possibly, these seedling palms originate from after the eradication program of the 1930s.

#### **American cultivars**

Seedling dates can become cultivars via offshoot propagation, and that is what has occurred in the southwestern USA. Roy Nixon's research work provided much of the scientific basis for the development of the US date industry. He published a

detailed study describing 140 cultivars imported as offshoots into the country (Nixon, 1950). Although the study is on cultivar date palms, it is also relevant to seedling date palms because it includes some notes on them.



Figure 9. American date palm cv. Empress, Indio, California.  
Photo: D. Karp.



Figure 10. American date palm cv. Empress fruit, Indio, California.  
Photo: D. Karp.

Table 4. American date cultivars\* grown in the USA.

Cultivar	Origin	Fruit characteristics	Notes
Abada	Uncertain, resembles cv. Deglet Noor	Khalal deep red; rutab and tamar glossy black with bloom. 48-52 x 20-22 mm. Flesh soft and melting with sweet flavor. Fruit subject to checking.	Early ripening. Has characters desirable for breeding (Carpenter 1979)
Blonde Beauty	Believed from cv. Deglet Noor seedling	Khalal yellow; rutab amber; tamar reddish brown. 45-50 x 20-24 mm. Flesh soft and melting, flavor pleasing.	Midseason ripening. Palm resembles cv. Deglet Noor. Exclusive cv. of single grower, Indio CA.
Brunette Beauty	Believed from cv. Deglet Noor seedling	Khalal medium red; rutab and tamar nearly black. 42-47 x 20-23 mm. Flesh soft with good flavor.	Late ripening. Exclusive cultivar of a single grower, Indio CA.
Empress	cv. Thoory seedling	Khalal yellow; rutab amber; tamar reddish brown. 46-54 x 21-24 mm. Flesh soft with pleasing flavor.	Midseason ripening. Has characters desirable for breeding (Carpenter 1979)
Honey	cv. Deglet Noor seedling	Khalal yellow; rutab amber; tamar reddish brown. 40-47 x 21-23 mm. Flesh soft and melting with pleasing mild flavor.	Midseason extending to late ripening.
McGill's No. 1	Uncertain, palm somewhat resembles cv. Kustawy	Khalal yellow; rutab amber; tamar reddish brown. Flesh soft and caramel-like, rich flavor.	Fruit size and fruiting season unknown.
Sphinx or Black Sphinx	Uncertain, possibly a cv. Hayany seedling	Khalal medium red; rutab and tamar dark brown to black. 41-48 x 26-28 mm. Flesh soft with good flavor. Fruit subject to severe checking.	Late ripening. Prolific offshoot producer.
Tabarzal	Uncertain, probably from imported offshoots	Khalal light yellow; rutab light amber brown; tamar reddish brown. 46-54 x 27-29 mm. Flesh thick, soft with mild flavor. Fruits subject to slight checking.	Early ripening.
T-R or Triumph	cv. Thoory seedling	Khalal pale yellow; rutab amber; tamar reddish brown. 43-52 x 19-22 mm. Flesh soft and melting, pleasing flavor.	Early ripening.

Source: Nixon, 1955.

\* Specimens of all these American cultivars are in formal field germplasm collections in California and Arizona, USA.

In an unpublished manuscript, Nixon (1955) described the 40 major American cultivars found in the course of extensive field work in California and Arizona, all believed to have originated from seed of the imported cultivars. The nine American cultivars grown on a limited commercial scale in the two states are listed in Table 4. The cv. Empress date palm and its fruit are shown in Figures 9 and 10. The fruit quality of the American cultivars is on a par with the imported cultivar dates grown in the USA.

The most fascinating account of American cultivars concerns the Sphinx (or Black Sphinx). It was discovered near Phoenix, Arizona in 1928, gave rise to the establishment of stands of the palm, facilitated because Sphinx is a prolific offshoot producer. The land of the largest grove of Sphinx palms was sold for a housing development in the 1950s. Many of the Sphinx palms were left in place (Figure 11) as attractive ornamental trees for the housing tract (Johnson et al., 2002).

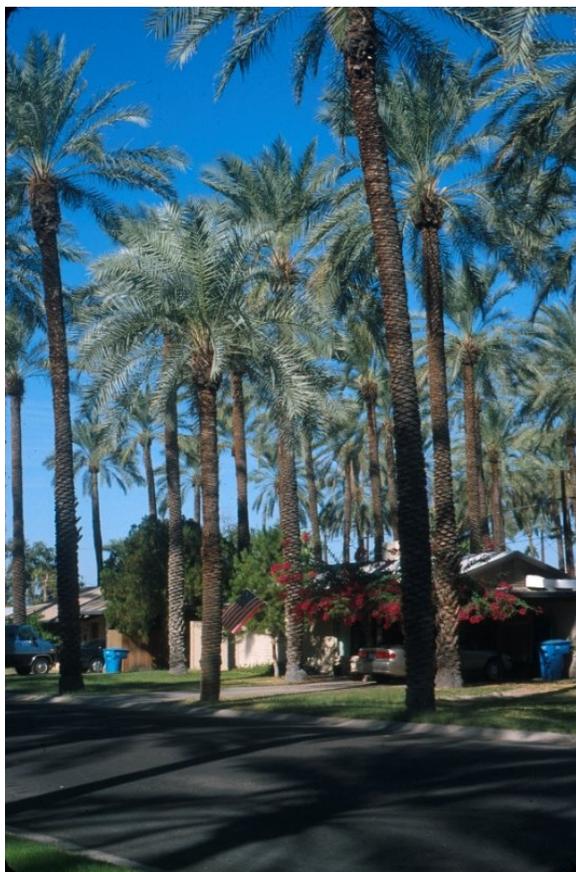


Figure 11. American date palm cv. Black Sphinx,  
Phoenix, Arizona.  
Photo: D. Johnson.

A few American male cultivars have also been established in California as pollen sources; Zaid (2002) names six cvs. - Mosque, Mejhool BC3, Deglet Nour BC4, Fard No. 4\*, Jarvis No. 1\* and Boyer No. 11\*. Three more cvs. are known: Crane\*, Barhee A-19\* and Tazizoot BC#3\*. An asterisk indicates the cultivar is accessioned in one or more of the official government or university date palm field germplasm collections in California and Arizona (Hodel and Johnson, 2007).

Most if not all of the other American female cultivars Nixon described have been lost to cultivation, because they apparently were unpromising based upon early assessments and hence are no longer grown on research stations or by farmers, or through changing agriculture land use which eliminated the palms. Unfortunately they were lost before they could be studied fully to assess their germplasm potential.

#### Research priorities

A research program focused on the potential genetic value of seedling date palms is recommended and should consider two broad factors. One, there are large stands of seedling date palms which have persisted for hundreds of years. These stands, reproducing naturally within a restricted population, will have produced a wide range of different genotypes for evaluation. Second, seedling date palm stands occur under different conditions of latitude, elevation and climate, as compared to the traditional date growing areas of the Middle East and North Africa. Over time, palms growing under a different set of environmental conditions may, through sexual reproduction, develop traits to cope with such factors as abiotic stress.

It is suggested that research on seedling date palms be directed toward the following purposes:

1. Examine genetic fidelity among seedlings with respect to the mother tree.
2. Evaluate behavior of seedling growth, with respect to chemical and physiological parameters.
3. Determine yield quantity and fruit characteristics of adult seedling date palms.
4. Evaluate behavior of adult palm growth, with respect to chemical and physiological parameters.
5. Examine the resistance of adult seedling date palms to common biotic and abiotic stresses.
6. Explore modern technologies like mutagenesis and genetic engineering for the purpose of genetic improvement.

7. Establish and maintain a germplasm collection of seedling date palms (living or by cryopreservation) with desirable traits. Engelmann (2010) provides a review of the methods of conserving date palm germplasm.
8. Establish a date palm germplasm website.

### Conclusion

As the original source of all cultivar dates, seedling dates continue to be present, to varying degrees, in all date-growing areas. As many as 500,000 producing seedling date palms may be growing in Spain, Peru and Mexico, with countless others in North Africa and the Middle East. Seedling date palms represent unevaluated germplasm resources that could hold new forms with superior fruit characteristics, hardiness and tolerance of saline soils as well as resistance to drought, diseases and pests.

Molecular breeding and the engineering of genetically modified date palm cultivars holds significant promise, but investigations should not be limited to the genetic materials in cultivar date palms. Inclusion of seedling date palms in the search for desirable traits will increase the likelihood of discovering superior genetic material to sustain and improve this ancient domesticated tree, and to transform it into a more highly productive genetically modified plant.

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