

The Date Palm Grove of Elche, Spain: Research for the Sustainable Preservation of a World Heritage Site

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1. The palm grove at Elche, Spain with the original Arab castle in the background.



The date palm (*Phoenix dactylifera*) grove (Fig. 1) of Elche, Spain, is unique. Its creation at a northern latitude, very marginal for date palm culture, and its maintenance to the present represent a living testament to the historical Arabic Berber presence in Spain from the 8th to 17th Centuries. Because of the cultural and historical value of this legacy, the Elche palm grove was declared a World Heritage Site by UNESCO in December 2000.

One of the proposals to maintain this heritage in a sustainable way is to renew the interest in date fruit production in Elche. To this end, a research station has been established named Estación Phoenix (representing a collaboration between Spain and France, for the Spanish side the Municipality of Elche, the Government of Valencia and the Universities of Elche and Alicante, and, for the French side, the National Institute of Agronomic Research and the Centre of International Co-operation of Agronomic Research for Development). To fulfil its applied objective, the research station is carrying out original research on the very peculiar characteristics of date palm culture in Elche – characteristics related to the northern latitude, the peculiar traditional agricultural practices, specific pests and date palm uses, original legal status and a unique socio-economic context.

Background

Date palm cultivation is considered typical of a hot and arid climate. However, as an ornamental tree, it is grown in many other locations where winter conditions are not too severe. In southern Europe, the date palm is also cultivated for its fruits and leaves. The palm grove of Elche, Spain is the largest and best known. There also exist some small plantations elsewhere in Spain (Ferry 1994) as well as in Italy and in Turkmenistan (Munier 1973). The climate of Elche, located at 38°N latitude, is marginal for date growing.

The palm grove of Elche is made up of about 180,000 adult date palms, in a total planted area that does not exceed 400 ha. The total date fruit production in Elche is estimated to be 5,000 tons per year, of which only about 100 tons are sold for human consumption (Ferry et al. 1997). The Elche palm grove exhibits many peculiarities wherein specific problems persist and threaten the survival and development of the agricultural system (Ferry 1999). This article presents the major original characteristics of the Elche palm grove, the problems related to the development of this relict date cultivation system and the different lines of research that are being pursued to try to resolve these problems and to preserve the historical character of the landscape that has led to its designation as a World Heritage Site by UNESCO.

Climatic limitations and research on date technology

During the critical period for ideal date cultivation, the months of fruit maturation, temperatures are below the optimal level in Elche. This lack of heat can be expressed by the heat fructification index. Heat units are calculated by subtracting 18 from

the mean temperature during the fruiting season and then multiplying by the number of days from pollination to harvest. Elche has 792 heat units as compared with 1,854 for Touggourt, Algeria, a typical date growing location (Munier 1973).

Fruit maturation

The temperature deficiency in Elche has some general consequences with regard to date fruit maturation.

A portion of the fruit produced never reaches maturity or matures imperfectly so that it is unsuitable for human consumption.

There is a high degree of heterogeneity of fruit maturation (Fig. 2) on the same tree and within the same fruit bunch. It is common to find in the same bunch, fruits at the *kimri* (green, hard) stage as well as the *kalal* (red or yellow, hard) and *rutab* (soft) stages. As a consequence, date fruits are generally harvested one by one. Date harvesting in Elche requires that an individual tree be climbed twelve to fifteen times to gather all the ripe dates. This increased labor cost is an important negative factor as far as profitability is concerned. Traditionally, an artificial technique is used to ripen the immature fruits when entire bunches are harvested at the same time. The immature dates are moistened with vinegar and kept in a closed environment for two days.

The majority of the date palms grown in Elche are of the soft type when the fruit is ripe. The dates have to be picked at the appropriate time because they deteriorate rapidly and must be sold and consumed quickly since their shelf life is only two to five days.

Research on date technology

Some rare date palms in Elche produce fruits that possess appealing commercial potential, such as attractive size and color, good taste and distinctive quality as a soft date. There are inherent problems of soft dates with respect to harvesting and shelf life as described. Nevertheless, if appropriate technologies are developed, it is possible to take commercial advantage by offering a new type of date fruit, very different from the common imported varieties such as 'Deglet Nour' and 'Medjool.' Because of the high production costs it is to Elche's advantage not to attempt to compete with producers of the more common varieties. Moreover, the soft dates grown in Elche fit into current consumption tendencies where freshness, natural production and lower caloric content are attractive.

Consequently, research undertaken by the Phoenix Station has focused on two associated issues –

controlled maturation and processing/preserving to offer the market "fresh" soft dates (Vilella 1996) (Fig. 3). To create these technologies, the physiological and biochemical mechanisms of development and maturation are being investigated (Ros 1996, Vilella et al. 1999). Indeed, although a significant number of papers on the chemical composition of dates have been published, little is known about the mechanisms functioning during date fruit development and maturation. An efficient new technique has been devised to ripen dates and to keep them "fresh" without resorting to freezing. Because of the industrial interest and potential, the technique is in the process of being patented.

In Elche, the rare and interesting date palms for commercial fruit production represent uniquely different genotypes. Therefore research on date fruit technology makes sense because it parallels research on the propagation of these unique genotypes, as well as on the agricultural and farming systems that will make profitable the establishment of new date palm plantations.

Propagation research

Traditional seed propagation: an historical farming system based explanation

Surprisingly, date palms in Elche are propagated only by seed (Fig. 4), and as a consequence, the palm grove consists of a population of hybrids. Curiously, although the date palm has been propagated by seed for centuries, and probably since its introduction, the grove presents very high phenotypic diversity.

Why vegetative propagation by offshoots has never been used in Elche is interesting. Date palms were present in this and various other locations on the Spanish coast before the arrival of the Arabs (Pliny the Elder 77, translation from Ernout 1956). However, the date grove of Elche and the associated agricultural system, were created by Moslem conquerors, perhaps, much later, contrary to what was stated in an earlier publication (Ferry 1997). In the few extant documents concerning Elche during the Moslem domination, no reference is made to the date grove. As emphasized by Jaén (1994), and contrary to what is often claimed in publications about Elche, nothing is recorded about Elche date palms in the chronicle of James I of 1267, when the Christians regained control of this region of Spain. In fact, the founding of Elche itself and the Islamic conquest of the area were relatively late, perhaps in the 10th or 11th Century (Ramos 1994). Furthermore, Islamic conquest does not mean that the area was

occupied by Arab people or by people with knowledge of date palm cultivation.

However, even in the many other locations in Spain, where agro-ecological conditions were similar to or better than at Elche, and where Arabs or Berbers remained for several centuries, date palm cultivation was not developed. We believe that, if this type of cultivation was not developed widely in Spain, even during the Islamic domination when there would have been high demand for date fruit among Moslems, it is because of the problem of date quality at this northern latitude. As already stated, because of the lack of heat, dates do not generally ripen well and, above all, they cannot be stored for more than a few days. Already in the 1st Century, Pliny mentioned the absence of a sweet taste in Spanish dates.

In Elche, the development of date cultivation reached, probably little by little, modest importance but it has always been very limited. As emphasized by Jaén (1994), the number of date palms probably never exceeded 70,000–80,000 before the 20th Century (again contrary to what is usually claimed).

Date palms have been grown in Elche as a secondary crop, at a high density, on the periphery of plots of major crops (Fig. 5). As in many other date groves in the world, they have been grown for their multiple uses – handicrafts, construction, fuel-wood, forage or landscaping. Furthermore, in Elche, the ancient (15th Century) and continued production of white leaves has probably contributed to a heightened interest in date palm growing. We consider that the white leaf production has played an essential role in the conservation of the palm grove to the present day.

As Elche's dates were cultivated for various uses other than just for fruit production, there was no need to select and propagate date palms by offshoots. Propagation of the date palms by seeds is a simple and quite satisfactory technique. This situation explains well why, in Elche, vegetative propagation and the creation of varieties have not occurred.

In vitro propagation

There are no true date varieties to be found in Elche; moreover, because the offshoots are not used for propagation, they are pruned to facilitate the work at the base of the date palms and to promote the growth of the parent tree. The only offshoots that are not eliminated are those that develop above ground level in a small number of palm trunks. These offshoots are sustained by metal supports to avoid their breaking off. These



2. Uneven ripening of date fruit.

“branched” palm trees constitute remarkable ornamental specimens. The most spectacular and famous is the Imperial date palm of the Huerto del Cura garden, in Elche. It has seven branches at the same level around the main stem.

Besides the absence of varieties and the traditional practice to eliminate offshoots, the majority of the adult date palms in Elche are old – more than fifty years of age. Over the past decade, numerous date palm nurseries for ornamental purposes have been established, but these date palms are still too young to evaluate with regard to the quality of their fruit production. The rare genotypes of interest for their commercial date quality are thus all old trees.

The only efficient way to propagate these promising date palms is by tissue culture. However, knowledge of the use of adult palm trees for tissue culture is rare. Consequently, the initial work of the Phoenix Station has been to study the structural biology of the adult date palms and, particularly, of the shoot tip and of the production of axillary buds. It has been established that it is possible to extract a large number of undifferentiated axillary buds from the shoot tip (Ferry 1996, Ruiperez 1996).

As a result, research on *in vitro* propagation by organogenesis has been carried out. A very high percentage of reactive explants of this type has been obtained by culturing them in liquid media (Ruipez et al. 1995). Vegetative plantlets have been obtained *in vitro*, but in the majority of them, the development of the explants has been floral (Ferry 1994, Ferry et al. 1999). Research is

continuing to find a way to eliminate the floral signal.

In a parallel way, research on the propagation from other initial explants (young spikelets, small leaves) is on-going. *In vitro* plants have been obtained either by indirect (Navarro et al.1996, Navarro et al. 1999) or direct somatic embryogenesis, or by adventitious organogenesis (Ferry et al. 2000). In any case, the proliferation



3. Date processing research.

4. Plantation at high density and traditional propagation by seedlings.



5. Date palms within a complex agrosystem.



stage is obtained and maintained without callus. Research has also been carried on to study the behavior of exotic varieties under Elche conditions. *In vitro* plants of eleven varieties produced by the GRFP (Groupement de Recherche Français sur le Palmier Dattier) by means of organogenesis techniques were planted in Elche in 1989–1990. The study of the harvest in recent years has demonstrated that the *Medjool* variety produces dates that reach maturity in Elche.

Besides research work, the Phoenix Station also is carrying out tissue culture date palm production

activity. Two genotypes selected for their high economic potential are being propagated by tissue culture in response to local demand. They are *Medjool* and *Confitera* (a local genotype very similar to *Medjool*). The first out-plantings were scheduled for the spring of 2001.

White leaf production and insect pest problems

The production of white leaves

There is also in the palm grove of Elche a use of the palm leaves that is very old and nearly unique in the world – the commercial production of white

leaves (Gomez et al. 1999a). In Bordighera (Italy), a small date grove was created probably in the 15th century for the production of leaves for Palm Sunday and for the Jewish Soukhot religious feast (Castellana, pers. comm.). The process of the production of white leaves in Elche has been described in a previous paper (Gomez et al. 1999b). It constitutes a very elaborate and impressive technique transmitted from generation to generation. The oldest written document found that mentions white leaf production dates to 1429 (Castaño 1992). For more than five hundred years, white leaves have been sold for religious purposes. Each Palm Sunday, processions take place in Elche and in other Spanish cities in which people walk in processions carrying a white leaf to commemorate the reception given Jesus Christ when he arrived in Jerusalem.

Red date scale and other new insect pests

During the winter of 1992/1993, a new exotic pest appeared in Elche. The red date scale insect (*Phoenicococcus marlatti* Cockll.), considered in the other palm groves of the world to be of minor or no importance, developed here in a very explosive way (Gomez et al. 1995). Within a few years, all the date palms of the area have become infected.

Very likely, the red date scale was introduced with the large number of adult date palms imported from Egypt. During the last fifteen years, a high demand for adult palm trees has developed in Spain for planting in municipal gardens and parks, as well as for landscaping associated with events such as the Olympic Games in Barcelona. The successful adaptation of the exotic red date scale to Spanish ecological conditions, along with the absence of effective local natural controls, explains its explosive development.

In Elche, the introduction of red date scale has taken on great importance because of its impact on white leaf production. The red date scale insect sucks sap from the leaflets or the rachis. Around the opening they cause tissue necrosis or a fungus spreads out to create a brown stain. To be sold, the leaves must be perfectly white; therefore damaged leaves must be discarded. Furthermore, the microclimate created within the cone and cowl for white leaf production is very favorable to the development of red date scale.

Research has been carried out to control this pest. Red date scale is mainly present hidden deep in the leaf bases. However, characteristic external symptoms of its presence have been well-established – brown spots at the base of the leaflets and terminal part of some of the central leaves totally white. Knowledge of these characteristics

is very useful to establish the presence of the red date scale in date groves where it has not yet been reported.

No specific pesticide is known to be effective against the red date scale. To reach the hidden insect colonies efficiently, chemical treatments would be difficult to apply, and they would more probably kill a large proportion of the fauna present in the date palm crown without eliminating the red date scale. For these reasons and also for human health considerations, where a large proportion of the date palms are located within the city, research on biological control of the red date scale has been pursued (Gomez 1996a).

Two local predators of red date scale have been identified, *Rhyzobius lophantae* and *Chilocorus bipustulatus* (Gomez 1996b). Thousands of these two predatory insects have been raised and released in the urban part of the palm grove over the last two years. It is believed that more than 50% of the palm grove is now protected by biological control against the red date scale.

In addition to the red date scale, at least two other exotic pests have been introduced into Spain, probably also arriving with the imported date palms (Gomez et al. 1999a). The insect *Arenipses sabella* Hmps was reported for the first time in 1996 (Gomes 1997). The very serious insect pest, *Rhynchophorus ferrugineus*, was recorded in coastal Grenada Province in 1994 (Barranco 1996); it has not yet been observed in the palm grove of Elche.

Socio-economic factors

Disappearing traditional agricultural system

As stated previously, the date palm has probably always been cultivated in Elche as a multipurpose tree in association with other fruits trees and annual crops. In addition, date palm cultivation was initiated when irrigation systems had already been present for centuries, at least since Roman times. This circumstance explains quite well the peculiar organization of the date plantings in Elche. The trees are planted, in one or two rows, around cultivated and irrigated plots that are generally rectangular in shape and about 1,000 m² in area. This division into small cultivated parcels existed for centuries and was probably adopted with the installation of the irrigation works and was compatible with the irrigation management constraints of the farmers.

Another reason may explain the planting of date palms around the plots. Compared with typical date-growing regions, Elche suffers from insufficient sun and heat and has relatively high

humidity; these conditions are not favorable to a system where the associated crops are shaded by date palms. As a consequence, the date palms cannot be planted over the entire cultivated area but only along the edges. This particular planting pattern exists in other locations, such as in Gabes, Tunisia.

The major crops formerly cultivated in plots in Elche were cereals, alfalfa, cotton and fruit trees such as citrus or pomegranate. Animal husbandry with small livestock completed the system (Fig. 6). Nowadays, this complex agricultural system has virtually disappeared because date palm growing has practically lost all its original economic value and interest in the multiplicity of its uses. There is no market for most of the date fruits produced because of the higher quality demands of consumers that cannot be met. Very little use is made of immature, culled or bad quality dates for animal consumption because of the virtual abandonment of local animal husbandry; moreover, nearly no use is made of the leaves (apart from white leaves) and the trunk because of alternative raw material substitutes (Ferry 1999).

A new interest has appeared over the past 30 years; date palms with 2 m or more of trunk are being used for ornamental purposes. Although it is illegal to remove date palms, some exploitation does occur. Since the mid 1980s, many date palm nurseries have also been created inside the plots surrounded by the protected date palms. The new system superficially resembles the traditional agricultural system, but it is not fully functional as compared to the traditional system.

It is pertinent to pose the question as to whether it would be beneficial to enact new regulations to allow exploitation, for ornamental purposes, of a portion of the larger protected date palms, providing that they are replaced. Such a measure would act as a stimulant to the traditional agricultural system, or at least to the traditional plantation structure. An added advantage would be to promote a gradual replacement of the protected date palms and assure future maintenance of the traditional structure.

Because of the sharp decline of economic interest in the date palms for fruit production, replacement of senescent palms has not been realized. Date palm maintenance has been reduced or abandoned altogether; consequently, a high proportion of Elche's date palms, particularly within the city, are old and in danger of dying.

An important tradition of work on date palm

The ancient tradition of date palm cultivation in Elche has resulted in an original and very effective

knowledge of certain date palm cultivation practices that has been transmitted over the generations to the present day. These practices are concerned mainly with leaf pruning techniques and the production of white leaves.

Formerly, the individuals who climbed the palms for leaf pruning and fruit harvesting, utilized a climbing rope made from fiber derived from the date palm leaves. This previously-used traditional rope is very similar to the ones used in many other date groves in the world. Nowadays, the climbing rope is made of six-nylon strands. To each strand has been added a metallic cable located in its center. This improved rope is rather rigid. This characteristic constitutes an important improvement over the traditional one because the rigidity greatly facilitates the ascent of the date palm. An improvement of this climbing system was realized in 1997 to assure more safety and to offer new advantages to this system (Vilella et al. 1997).

Apart from the rope, the date palm farmers of Elche have created various original and specific manual tools. Examples of two of these tools are the *corbillote* – a heavy cutting tool that facilitates removal of dead leaves – and the *gumia* – a cutting tool that has a long handle and with which it is very easy to cut the green leaves. We consider that these two tools are quite superior to those used for date palm maintenance elsewhere. These tools could be very profitably adopted for use in other palm groves of the world. We will not elaborate further on the work, know-how and special tools concerning the production of white leaves. They are very specific to Elche and represent an impressive level of proficiency in working at the top of the date palm and in managing the crown of leaves. In contrast to the sophisticated crown maintenance techniques for white palm production, management practices for date production are not so well developed. The exception is the traditional artificial maturation of the dates with vinegar. There is little or no knowledge concerning offshoot cutting. Leaf pruning practices are hard to understand. Pruning is very severe and in Elche, a well-cared date palm never bears more than 50 to 60 leaves. Leaves are often mistakenly considered as competing with trunk growth and even fruit production.

These misconceptions also explain why the traditional producers of white leaves cut off the green external leaves instead of keeping them to help the tree to recover. A campaign has been initiated by the Phoenix Station to induce producers to maintain as many green leaves as possible and some of producers are now following



6. Livestock associated with date palm culture.

this advice. In fact, the technical deficiencies in the cultural practices of Elche's date palm grove can be explained by the traditional multipurpose role attributed to the palm. The trees are cultivated at a very high density, reaching an average 400 trees per ha (if the density is calculated based on the trees distributed over the entire surface). However, in fact it is even higher because the trees are planted close together at the periphery of the plot. This external position of the plantation is associated with reduced care for the date palms; fertilizer and irrigation is used for the main crops. The force of this tradition is so strong that, nowadays, even though there are no associated crops, irrigation water is usually still applied to the entire surface of the plot!

Research to maintain the date palm heritage

The date palm grove is part of the patrimony of Elche and now of the patrimony of the world. Its maintenance represents a collective obligation. Various solutions are proposed. Two research avenues are currently being pursued.

Reestablish economic interest in date fruit production

One proposed solution to maintain the date palm patrimony is to rekindle economic interest in fruit production. This research constitutes the main applied local objective of the date palm research center of Elche. The realization of this objective means the future creation of new plantations of date palms that are economically profitable. Research is being carried out to establish the technical and economic conditions necessary to assure profitability.

Studies on the very competitive date market and on date demand are being realized to define better

the quality, prices and quantity of date fruits, and how to satisfy market requirements (Greiner 1996a, 1996b). Parameters of the production costs in Elche have been studied to simulate the various possible profitable production systems (Greiner 1996d). Labor cost and the need for specialized work time per tree and per year will limit significantly the number of possible solutions. The need for irrigation water is high in the area. Potential evapo-transpiration is about 1,000 mm whereas average annual rainfall is about 250 mm. This represents another limitation to different possible solutions because irrigation water is costly and/or not available and/or of bad quality. In reference to this aspect, the areas of El Hondo and Las Saladares, where there is a water table close to the surface, seem to be the more appropriate locations for future date plantations in Elche. The higher humidity of these areas that affects date fruit maturation should not be a problem because the objectives of the research on date technology assume harvesting date fruits before maturation, at the *kalal* stage.

Development of the rural and urban date palm landscape

Research has begun to ascertain the expectations of residents and tourists concerning the date palm grove of Elche. This research is concerned specifically with the landscape of the city and its environs (De Los Rios 1998). Results will determine whether the present policy to maintain the traditions of the date palm grove is responsive to the landscape desires of local people and visitors and how, eventually, policies could be improved. Current policies, including the legal protection of

the date palms, promote the maintenance of the traditional plantation structure. However, the essence of the structure derives from the overall agricultural system of which it was an original part. Without the associated crops, as is very often the case nowadays, this plantation structure has lost a key component and, perhaps as a consequence, its landscape value (Ferry 1996).

The question may be asked: is it possible to find a new *raison d'être* for this traditional agricultural structure and, at the same time, to produce a compatible urban landscape of value? Research has begun to study, through computer image simulations, the various types of urban and rural landscapes possible based on the date palm. This work will also permit simulation of the urban date plantations in the future, assuming the natural death of the tallest and oldest trees.

Conclusions

The existence for centuries of a tradition of date palm cultivation in a location quite different from classical date palm areas, has created certain unique characteristics. These characteristics concern the date palm itself being grown under marginal conditions, and also the farming practices and systems that local people have devised and adopted.

The study of these characteristics is necessary to find solutions to maintain this original agricultural system, currently at the point of disappearance. Research has to be conducted in a variety of complementary disciplines.

Farming systems based on the date palm are threatened with disappearance in Elche and are also declining (apart from mono-cultural plantations) elsewhere in the world (Ferry 1995). Research being carried on in Elche is also underway in most of the other research centers concerned with the date palm.

Comparison of the situations, approaches and of the research and development efforts among palm grove and date palm centers located within such different contexts, presents, without doubt, an opportunity of great potential benefit. Research must be conducted in such a way as to promote exchange and co-operative projects. This is the reason why part of the activities of the Phoenix research station is devoted to international research/development cooperation projects. One of these ones concerns the development of oasis agriculture in the Sahel.

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