Emir. J. Food Agric. 2014. 26 (11): 987-999
doi: 10.9755/ejfa.v26i11.18986
http://www.ejfa.info/

Cultivation

REVIEW ARTICLE

Date palm cultivation in India: An overview of activities

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Abstract

The ancestry of date palm is reviewed with reference to the complex relationship existing between date palm (*Phoenix dactylifera*) and sugar date palm (*P. sylvestris*) during early introduction of the date palm into India, especially in Kutch, Gujarat. The cultivation practices of growing the date palm in important regions of India are described. Because of climatic limitations, it is impossible to fully ripen fruits on the trees; therefore, harvest is done at khalal stage with subsequent artificial ripening. The common varieties preferred for cultivation and their performance are reviewed. The institutions involved in activities of introducing imported cultivars and developing tissue culture plants from local varieties are detailed. Introductions of elite foreign cultivars have been successful, especially with respect of Barheecv. Studies are underway to assess the germplasm value of seedling date palms, and to establish tissue culture laboratories to propagate local varieties and imported cultivars. Because India is the world's largest importer of dates, local production has strong potential to supply domestic markets and to create jobs in the dry areas of the northwest. Problems facing the cultivation of date palm in India are pointed out.

Key words: Ancestry, Cultivation practices, Date palm, India, Introduction, Kutch, Tissue culture

1. Introduction

The date palm (*Phoenix dactylifera*) is one of the oldest cultivated fruit trees on earth. The closely-related, sugar date palm (*P. sylvestris*) is also very old. As far as India is concerned, *P. sylvestris* appears to be older than the date palm. The Indus valley people cultivated wheat, barley, millets, dates etc. (Tiwari, 2003). Sangam literature also mentions date palm along with jack fruit, coconut, areca nut, plantain and tamarind. But in South Asia the date palm did not achieve the religious or social status it attained in Jewish, Christian and Islamic societies.

The cultivation of date palm is fairly widespread in the Arabic countries, Africa and Israel. Typically, India is not included in this list. Date fruits are eaten at *doka* or khalal stage, soft or ripened stage (*pind* or tamar) and at dry stage (*chuhhara*).

India produces and markets dates at the khalal stage because climatic conditions do not favor full ripening on the tree to produce tamar dates. India imports over 250,000 mt of dates per year.

Dates are highly nutritious and relished by Indians. They have been used in various ways and at religious and social festivities they find their proper place. Even dry dates have various uses and certain Hindu religious ceremonies always require their presence.

1.1. Ancestry

The sugar date palm is widely distributed in and native to India, growing in forests, fields and sometimes in open places. There are published references to a date palm from the Veda and Ramayan eras. Sangam literature (600 BC to 300 AD) also mentions date palm. A most interesting question is whether the references refer to *P. sylvestris* or *P. dactylifera*.

Vaidya (1953) authored a book in Gujarati which documented the plants mentioned in Sanskrit literature, drawing upon his expertise as a plant scientist and Sanskrit scholar. The following references about *P. sylvestris* in the Sanskrit literature are provided by Vaidya. In Raghuvans Section, 4-51, written in the fourth century AD by

Received 11 June 2014; Revised 02 August 2014; Accepted 19 August 2014; Published Online 15 October 2014

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the poet Kalidas, it is mentioned that "elephants were tied to the tree of *kharjuri* (*P. sylvestris*). In Shakuntal (a famous Sanskrit drama by Kalidas), there is reference to a man fully satisfied after eating *pindakharjura* (Act 2 Page 70). Here the word refers to the fruit of *P. sylvestris*, according to Vaidya; it also means the best quality of the fruit.

In the Nighantu Dictionary of Ayurvedic Plants two types of the best sugar date palm fruits are mentioned: *rajapinda* and *nripapriya* (Vaidya, 1953), the difference between the two being one of personal preference. In Kadambari, a novel by Bhavbhuti (seventh century AD, early Para 132), it is mentioned that *pindakharjura* is very sweet and birds break the fruits with their beaks. According to Vaidya all these references relate to *P. sylvestris*; he does not mention *P. dactylifera* in his account of the sugar date palm fruits. In a recent article by Ahmad et al. (2013), *pindkharjura* is referred as *P. dactylifera* which conflicts with Vaidya's interpretation.

1.2. Enigmatic Origin

The exact geographic origin of the date palm has not yet been established. It has been cultivated since at least 4,000 BC in Mesopotamia. Various opinions are expressed about date palm origins. These will be examined with specific reference to India with certain observations which have not been considered adequately. In Sanskrit literature, the wide prevalence of *P. sylvestris* in the Indian subcontinent and absence of *P. dactylifera* have been pointed out.

According to Zaid and de Wet (2002), the date palm (*P. dactylifera*) evolved from *P. reclinata* native to Tropical Africa or *P. sylvestris* in India, or a hybrid between the latter two species. Sanderson (2001) states that the date palm is recorded in ancient history as extending over an area from the Indus valley (now Pakistan) to Mesopotamia (now Iraq), the Nile valley, Southern Persia, the Eastern Mediterranean and the Horn of Africa. He postulates that such a wide distribution implies its evolution in a more limited geographic place from where it was spread by human agency to regions with varied but favorable geographic, soil and climatic conditions. Sanderson supports the theory of the date palm origin in the Indus Valley; *P. dactylifera* occurring wild as a natural hybrid with *P. sylvestris* which was growing wild from at least the 6th millennia BC.

According to (Barreveld, 1993) the earliest evidence of date palms has been found in Ancient Egypt; the earliest form of cultivation coincided with the oldest civilization and originated in Northeast Africa.

It is interesting to consider some observations made by Jaykrishna Thakar, a self-trained and brilliant taxonomist born in the Kutch in 1849 (Shah, 1999). Thakar was a curator of forests and gardens in Porbandar State (now in Gujarat) 1886-1904 and studied the flora of the Barda Hills and wrote a voluminous flora on the subject (Thakar, 1910). In it, only *P. sylvestris* is included, described as a tree mostly without offshoots, flower clusters of 2.54-3.76 cm, fruits yellow or orange colored. Thacker noted that Egyptian date palms were cultivated, and in a footnote states that in the Kutch-Bhuj and Abadasa regions, date palms known as *kharekadi* or *khalela* (*P. sylvestris)* produced yellow and red, very sweet and tasty fruits (could these be a hybrid with *P. dactylifera* ?). In a later book Thakar (1926), *P. sylvestris* is mentioned as only growing wild and cultivated in Kutch-Bhuj while it is also noted that *P. dactylifera* (*khajuriarabi*) was observed in the Bhuj King's Sarad garden. Fruits obtained from *P. sylvestris* growing in and around the Bhuj and Abadasa region were famous.

Introduction of Arabian date palms into India perhaps began at the time of the first Mohammadan invasion of the Sind (in undivided India) in the early eighth century when the date was believed to have been brought in for cultivation in Western India (Blatter, 1926). The presence of *P. dactylifera* in the Indus valley is attributed to the army of Alexander the Great (fourth century BC) or to Arab conquerors (seventh century) or to pilgrims from Mecca (Makkah) (Newton et al., 2013). Hooker (1894) in the *Flora of British India*, mentions *P. sylvestris* as wild and cultivated throughout the plains of India, Burma and wild in the Indus Basin and *P. dactylifera* as introduced into Sindh and Northwest India. Cooke (1908), in the *Flora of Bombay Presidency*, mentions only *P. sylvestris*. Basu and Chakraverty (1994) reported that *P. dactylifera* was cultivated in the Indian Botanical Garden in the early nineteenth century.

1.3. Recent Investigations

Newton et al. (2013) studied the complex relationship between *P. dactylifera* and *P. sylvestris* in India. The authors traveled in Kutch, Saurashtra (Kathiawad), and the Aravalli Hills and observed *P. dactylifera* in Kutch and on the northeast part of the Kathiawar Peninsula, along the Gulf of Kutch. In Kutch, *P. dactylifera* was the only *Phoenix* species exclusively under cultivation and was not observed in the wild. On the other hand, *P. sylvestris* was

found in the Kathiawar Region as both a wild and cultivated palm. From their collections and subsequent genetic analysis they identified a cluster of both species, not easily differentiated and in sympatry near Jamnagar. Interestingly, Thaker (1926) reported that *P. sylvestris* was only present in Kutch, and *P. dactylifera* was growing in a private royal garden; however, the recent investigation by Newton et al., (2013) reported no occurrence of *P. sylvestris* in Kutch.

Gros-Balthazard (2013), on the basis of phylogenetic analysis of *Phoenix* made from chloroplast sequences, analysis of genetic diversity and structure, identified closely-related populations of wild date palms for the first time. Studying the hybridization process in *Phoenix*, the author discussed the difficulties of identifying species within the genus. On the basis of experimental data it was pointed out that *P. sylvestris* is not the progenitor of *P. dactylifera.*

If Thakar's observation (1926) is accepted, then *P. sylvestris* was most common in Kutch and *P. dactylifera* only cultivated in a few locations. As years passed, date palm cultivation increased and the sugar date palm decreased as more and more land was utilized to cultivate date palm. Over a long period of sympatry between the two species and cultivation by seed as a normal practice, a continuous hybridization process could have resulted in a number of distinctive *P. dactylifera* types. That may be why, at present, some of the local elite cultivars of the date palm in Kutch are far superior to the imported tissue-culture types. At present with 2 million date palms of varying cultivated types (seed, offshoots and tissue culture) growing in Kutch and uninformed farmers pollinating the female plants at random, a wide range of khalaldate fruits occur. These fruits are marketed for INR 40 (USD 0.67) per kg to INR 500 (USD 8.37) and as I was informed INR 1,000 (USD 16.75) per kg for the best elite dates

2. Cultivation of Date Palm in India

According to FAO statistics, in 2011 India was the largest world importer of dates (256,295 mt) and its neighbor Pakistan, in 2012, was the world's sixth largest producer (600,000 mt). The major date palm growing areas in India are Kutch (Gujarat), Rajasthan, and certain parts of the Punjab, as well as Tamilnadu State to some extent. In Kutch there are more than 2 million date palms, the majority of them grown from seeds and offshoots, providing a huge biodiversity for experimentation and improvement of products. The fruits produced (*doka* or khalal) have a market price range of INR 10-400 (USD 0.17-6.80) or more per kg. Efforts by the Indian government in the last decade have resulted in an increase of date palm cultivation from 8,973 to 16,000 ha and establishment of a prominent effort in Rajasthan. A great deal more is required to improve cultivars, the use of hybridizing techniques, screening of local varieties, training of farmers, establishment of regional norms of date palm cultivation, grading, marketing and increasing fruit shelf life (Abbas, 2014a,b).

2.1. Date Palm Cultivation in Punjab

In undivided India, the Punjab was a very important region, along with Kutch in Gujarat for date palm cultivation. Its importance is reflected in the publication of an early and very informative book by Milne (1918). Some of the important observations on cultivation given by Milne are as follows:

The very best dates known can be grown at Montgomery, Multan, Khushab, Sirsa and Lahore (now in Pakistan) and Ludhiana (in India), but that Delhi and Amballa (India) fall somewhat short of the required climatic standards. Milne stated that minimum and maximum temperatures are suitable for the fruiting season at all stations, he observed that if first class dates ripen under 3,277 heat units then the finest dates should ripen in Punjab. In the fruiting season, excess rainfall and normal high humidity cause the most damage during the ripening period. For offshoot propagation, if the fruits are ripe on the mother tree, at that time the offshoot is cut, there can be no doubt of the type of fruits that the offshoots will bear. Before being removed, offshoots should be pruned of mature leaves, preserving the tender young opened leaves in the central bud. To prevent excessive water loss from transpiration, offshoots should weigh at least 2.7 kg; those of lesser weight will likely die. Trimmed offshoots ready to be planted should weigh 5.4-6.8 kg and be 3-4 yr old. Some 6-12 mo before the offshoot is to be removed, earth should be heaped around the base of the mother palm and kept moist to stimulate root growth. When planting the offshoot, a cleared circular area 5-6 m in diameter around each tree is recommended. Adjacent rows should alternate and not be opposite.

Offshoot water needs must be carefully considered. The date palm produces its best crops only with proper drainage and soil aeration. Its roots descend into loamy soils to a depth of 2-3 m; therefore, proper soil aeration to this depth is to be maintained. Even if irrigation is present, the permanent water table level should be at 2.7-4.9 m. No manure, according to Milne, should be placed in

the planting hole with the offshoots as they have few roots. Manure should be applied after growth begins. In Punjab, coal ashes appear to be the best for spreading around the plant as they form a good mulch and prevent termite attack.

Intercropping can be practiced during the early years; legumes or other fruits such as pomegranates or figs are suggested. The soil should be kept moist for the first month after date palm planting and until they are fully established. Offshoots in well-drained medium loamy soil in early September will require daily watering for the first 40 d, every-other-day watering for the next 40 d and thereafter watering every 6 d until growth begins. In spring, watering should be every 4 or 5 d until the rains commence. An annual application of 23 kg of well-seasoned manure per adult plant is needed.

The timing of hand pollination varies; if the winter is warmer, flowering is earlier. Pollination is appropriate when the female spathe bursts and the stigma is receptive. The male flower cluster with its enclosing spathe is cut when it is about to open. Waxy scales cover the stamens. One or two small branches are cut from the male cluster and placed among the small branches of the female cluster. One male tree may suffice to pollinate 100 female trees; however, it is safer to have 2-3 male palms per 100 females. Netting to protect the ripening fruits is necessary to protect against bird damage.

The performance of the various cultivars was monitored in the Abohar area of Punjab to assess their performance (Vij et al., 2005). Among the fruit characters noted were maximum number of fruits (15-21) per strand recorded for cv. Deglet Noor; maximum fruit weight (23-68 g) and seed weight (2-35 g) in cv. Medjool. Total soluble solids recorded maximum (27.6%) in cv. Halawy. Halaway and Barhee fruits were good for fresh eating at *doka* stage and cv. Medjool was best for *chuhhara* (dry date) making, whereas cv. Zahidifruits were good for processing as soft dates.

2.2. Date Palm Cultivation in Gujarat

Along the western border of Gujarat, Kutch, Saurashtra and North Gujarat are considered the best regions for date palm cultivation. As stated previously, Thaker (1926) observed the Arabian date palm in the private garden of the King of Kutch. Old records show that date palm groves on the northwestern border of India were developed from seeds discarded by army encampments and in part from the seeds and offshoots planted by settlers, returning from the Haj pilgrimage. It is said that 400 years ago Mundra in Kutch was the only sea route through which pilgrims from India went for Haj and on return brought the dates (personal communication with N.N. Sodagar, Retired Senior research Officer, Mundra Research Station, Mundra, Kutch, April 2014). In the course of time, date plantations increased. Previously Kutch, the largest district of Gujarat, was almost isolated from the mainland. Only after 1947 with the improvement of road and railroad connections were the trade channels opened and the marketing of dates improved. There was considerable increase in date palm plantations; in 2004-2005 the total area increased from 8,973 ha to 16,000 ha during last decade (Abbas, 2014a). Under a National Horticulture Mission of the Government of India, Gujarat has received grants to promote date palm cultivation and research.Date cultivation suffered heavy losses in 1998 from a major hurricane and hundreds of plants were destroyed.

2.2.1. Suggested Cultivation Practices for Date Palm

The Date Palm Research Station, Mundra (1959/1972) has recommended the following cultivation practices for Gujarat:

Soil: There are no specific soil requirements but for higher production sandy loams with good moisture retaining capacity, proper drainage and aeration are recommended. Date palm is tolerant to soil salinity of up to 4dsm-l.

Climate: For the best growth, flowering and fruiting, a long summer with long days as well as high temperature, a mild winter without frost and the absence of rain during flowering and fruit setting with low relative humidity and plenty of sunshine are required.

Varieties: Most of palms grown in Kutch are from seed and hence exhibit great variations in fruit size, color, taste and other qualities. Each seedling date palm has its own genetic identity. Experimental data of the station suggest that cvs. Barhee and Halawy are suitable for cultivation in Kutch.

Propagation: Propagation by seed is impractical as both male and female palms result and are only distinguishable by farmers at flowering. Moreover, there will be many variations in flowering and fruit qualities. Seed selected from elite cultivars may be planted in plastic bags in the nursery. During the monsoon, seedlings should be transplanted to the field at a spacing of 7-8 m between rows and 1 m between plants. Adjacent rows should have alternate sowings. At sexual maturity, male plants are moved, maintaining 3-5% males. The best fruiting females should be selected. This method of

propagation involves a high cost in terms of time, manpower and money.

Propagation by offshoots is a better method, saving labor, manpower and cost, and yields true-to-type fruits. Offshoots are borne in the early adult life of the plant, normally after the fourth or fifth year. Depending on adequate fertilization and irrigation at least two offshoots can be cut per tree per year and the tree used for a period of 10 yrs. Maximum care must be exercised to remove the older leaves, protecting the terminal bud; ideal weight of an offshoot is 15-20 kg.

Six months or a year before the offshoot removal, a mixture of earth, sand, farm yard manure (FYM) and sawdust should be mounded up around the base of the offshoot and kept moist. Before separating the offshoot, the mother plant should be kept watered. Before separation, the earth at the base of the offshoot union with the mother palm should be cleared and large leaves tied up or removed. A single cut should separate the offshoot. The shoot base should be treated with IBA 1000 ppm to stimulate rooting. The exposed region of the mother plant stem and the shoot should be treated with a copper fungicide. The offshoot should be transplanted into the field at a spacing of 7 x 7 to 10 x 10 m in a prepared hole of 1 x 1 x 1 m and filled with a mixture of 20 kg FYM, 2 kg castor cake, sawdust, sand and methyl parathion 2% dust. After transplanting the offshoot should be protected from heat and cold. Initial mild daily watering is needed for 5-6 weeks and later on alternating days. During summer irrigation should be at 3-4 d intervals and during winter at an interval of 7-10 d.

Irrigation: Adult palms need to be irrigated every 15 d during winter and every 7d in summer.

Pruning: This consists of pruning of diseased and old leaves, removal of spines, cutting of undesirable inflorescences and thinning of clusters/strands or fruits. Generally the number of leaves on the tree determines the number of retained inflorescences. An insufficient number of leaves affects the fruit quality and reduces the number of mature fruits.

Pollination: Hand pollination is preferable because individual date palms are either male or female. The usual method is to place strands of male flowers ready to shower pollen grains on the stigmas of the carpels of the female flowers. Determining when the female flower is open and ready to receiving pollen is a skilled art. Normally 3-5 male plants are sufficient to pollinate 100 female plants.

Fruit Thinning: To improve fruit quality and to ensure their proper nutrition and development on the bunch, thinning, is necessary. There are three methods of fruit thinning: (i) cutting the strands to reduce their length; (ii) removing some strands from the center of the bunch or (iii) reducing the number of fruits on each strand. Experiments showed that removal of one-third of the strand from the center in all bunches improved fruit qualities and ripening in Barheecv.

Yield: With proper care, the date palm will produce fruits from the fourth year onwards and yield economically satisfying amounts after 7-8 yr, continuing as an adult tree of 60-70 yr. Annually, an average adult palm will yield 100 kg of khalal stage fruits and an elite cv. up to 200-300 kg.

Sardarkrushinagar Dantiwada Agricultural University (SDAU, 2010) made the following observations about date growing in Gujarat:

(a) Khalal stage of Halawy cv. is the best quality for making *chuhhara*, prepared by immersing fruits in boiling water for 20 min and subsequent drying on trays in an air circulation oven at 45° C for 60-65 hr.
(b) Barhee cv. is the best for making *pindkhajoor*.
(c) Medium quality fruits are useful for preparing good quality beverages. The Local Red variety is good for making jam.
(d) Cultivars Medjool, Hatemi, Ruzaiz, Selection-3 and Tayar are resistant to white scale, *Parlatoria blanchardi*.
(e) Use of 600 gauge low density polythene at color break stage of the fruit (ICBR of 1.1.73) protects against rain damage in late maturing cvs.

2.2.2. Date Palm Technologies in Gujarat

In Gujarat, about 2 million date palm trees are cultivated. Most are propagated from seed and therefore the genetic variability is immense with some fruit suitable to be eaten fresh with little or no astringency. Irrigation is mostly by drip systems. The involvement of a fertigation expert could assist in optimizing performance (MOAG, nd).

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http://www.ejfa.info/

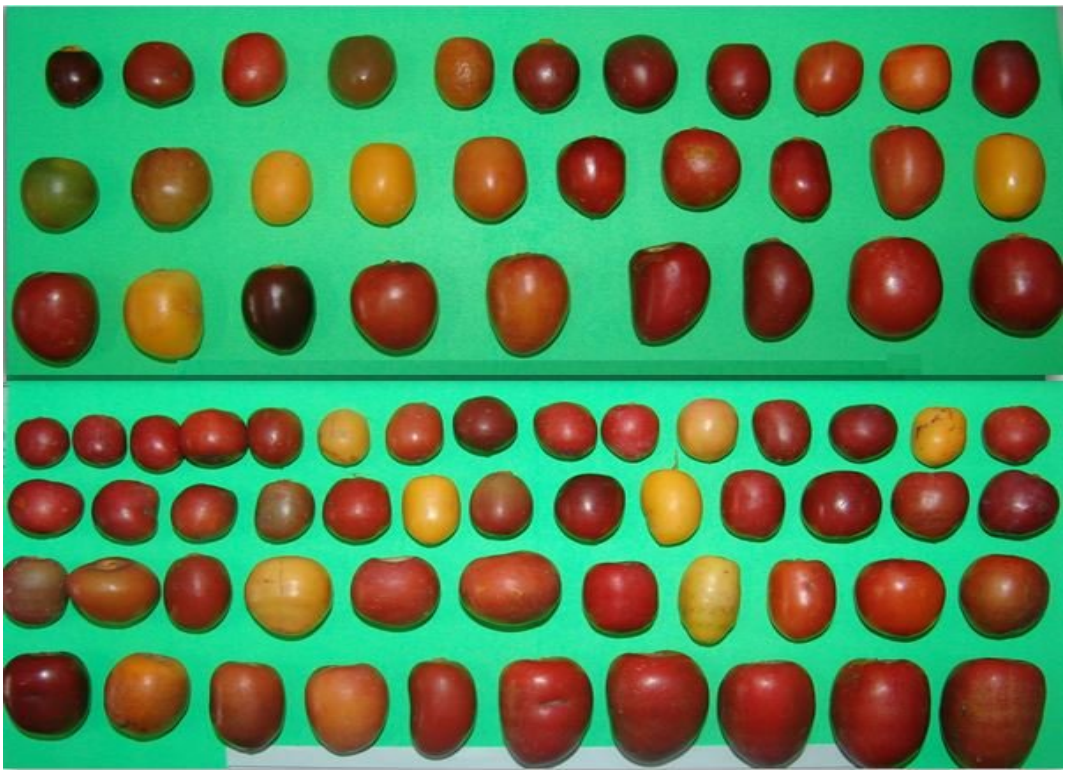

Figure 1.Variation of color, shape, size and weight of khalal fruits of seedling date palm populations of Kutch.

Figure 2. Tissue-cultured elite local date palm cultivars from Kutch. Barhee date palms- 1st row 1st and 2nd pictures only from left.
Courtesy Kutch Crop Services.

The main gaps in technology include the lack of storage technology and facilities, problems in multiplication of outstanding local cultivars (e.g. tissue culture technology) and the presence of red palm weevil. The latter is considered a major threat to production and its control should be given priority. Protocols for monitoring and combating the red palm weevil are present.

Another problem is the high level of infection with *Graphiola*, a leaf fungus. Storage technology could be supplied from Israel and likewise tissue culture technology. It may also be desirable to chemically treat *Graphiola*.

2.3. Performance of Date Palm Cultivars in Kutch

Some 70-80% of date palm cultivation in the coastal belt of Kutch (Figure 1) from Anjar to Mandvi, originates from seed and the majority of fruits are of inferior quality (Ramdevputra et al., 2009). As a result, offshoots of date palm cultivars were obtained from different date-growing countries through the United Nations Development Program (UNDP) and their evaluation was undertaken in Kutch. Five introduced date palm cvs. Zahidi, Halawy, Barhee (Figure 2), Khadrawy andSayar, and one Local Red variety as control were evaluated in 1999-2001 at the Date Palm Research Station, Mundra, Kutch. During 2000/2001 Barhee cv. gave maximum yield of 66.17 kg/palm over three years. Sayar and Khadrawy cvs. recorded the lowest yield. The maximum numbers of strands (62.08) and length of strand (44.92 cm) were recorded in cv. Barhee, but Halawy was also statistically on a par with Barhee. The maximum fruit weight was in Halawy in 1999; in years 2000 and 2001, Barhee cv. had the maximum average fruit weight i.e. 15.40, 12.63 and 12.74 g**,** respectively. Fruits of Barhee, Zahidi, Khadrawy and Sayar cvs. had poor taste quality and were astringent at khalal stage, whereas Halawy, Barhee cvs. and Local Red var. were superior with a market price of INR 15/kg.Barhee gave the maximum return of INR 992.70 per palm per year for its sweet taste and softness in khalal stage (Ramdevputra et al., 2009).

2.3.1. Kutch Date Development Consortium (KDDC)

The entrepreneur Rahul Gala Shah founded KDDC in 2006 to teach farmer members about technology and date palm farming. KDDC is an association of farmers registered under a society act (1960) based in Bhuj, Gujarat and is the largest organization of Barhee date palm growers in India. There are 223 ha under date cultivation. Kutch provides suitable factors like a well-drained, deep, sandy type of soil having adequate aeration (12%) with a bulk density of 1-1.5 g/cm^3 and water-holding capacity of at least 15%.

The organization looks after all the needs of the members ranging from import of date palms, Post Entry Quarantine (PEQ) facilities, fertilizers, manure, pesticides, technical knowledge, and for development of marketing channels and buyback guarantees. A total of 25,000 offshoots and tissue-cultured plants were procured from Israel, Jordan and the United Arab Emirates (UAE). The society expected to harvest 6,000-8,000 mt of dates in 2010-2012; it exports dates under the brand name Golden Dates, as well as other fruits. The annual turnover is IND 10.5 million (KDDC, 2009).

2.4. Date Palm in Rajasthan

The northern arid regions in India consist largely of the Rajasthan Desert, the Rann of Kutch and semiarid regions of Punjab and Gujarat. Rajasthan occupies almost 60% of the total of these regions. The region has sandy saline soil of 8-10 pH, with very low rainfall, cold winters and very hot summers. Furthermore, it has salty ground water, strong winds and low soil fertility. The Rajasthan canal system represents the major irrigation scheme. With construction of the Indira Gandhi Canal, Jaisalmer District has an area of 677,000 ha and Barmur District 3,100 ha of irrigation facilities. This facility has led to making this region a garden of date palms as it grows well under extreme temperatures and saline soil, although requiring a proper water supply.

Atul Ltd., a prominent industrial chemical company located in South Gujarat, has undertaken a massive effort to make the Rajasthan Desert green with date palms. The company and the Rajasthan Government have formed a joint venture company, Atul Rajasthan Date Palm Ltd. (ARDP), a public-private-cooperative venture. A memorandum of understanding was signed between UAE University, Al-Ain and Atul to transfer tissue culture technology of date palm to Atul. Atul in 2011 acquired a majority holding in DPD Ltd., London, which produces tissue culture date palm plantlets for distribution worldwide.

The Atul date palm project is very ambitious and when fully implemented will represent an outstanding private/public program effort for date palm cultivation and create in Rajasthan a forest of dates. However; there are many scientific, social,

climatic conditions to overcome. The following steps are being taken to implement the program (Rajmohan et al., 2010) in two phases: first, import of secondary hardened plantlets and establishment of demonstration farms and second, the establishment of nurseries and import of primary hardened plants with secondary hardening in India. Activities included: (a) About 47,000 primary tissue culture palms of Barhee, Khalas, Khunezi and Medjool cvs. (female and male) were imported from Arab nations and secondary hardening is in process at a new nursery at Jodhpur, Rajasthan. After 1 yr plants showed satisfactory growth; (b) In an area of 104 ha at Jaisalmer, Rajasthan, tissue culture female palms of cvs. Barhee, Medjool, Saggai and Zamli have been planted along with male Madsari and Ghannami cvs. for pollination. Details of irrigation, manure, planting methods, soil and age of plants planted have not been mentioned. Growth of all cultivars after 1 yr of planting has been considered excellent with Barhee cv. palm showing collar girth of 17.3 cm, the number of leaves 8.2, number of pinnae per leaf 22.0 and length of the longest leaf 63.8 cm. The activities mentioned above will continue for a further 3-4 yr until phase three of this project of establishing a state-of-the-art tissue culture laboratory is complete.

In summary, the new Rajasthan date palm project is supported by the state government. A 4-year-old plantation (104 ha) was established with tissue-cultured plants of several cultivars. Drip irrigation is practiced but maintenance of the system is inadequate. Upgrading the system to a full fertigation level along with periodic maintenance is desirable. A large number of the plants exhibit a phenotype that is not typical of the cultivar. Problems during production in the laboratory stage may be the cause for this presumed somaclonal variation.

These plants should be followed for their fruit characteristics and overall yield, such as Barheecv. In some cases replacement of plants is recommended. Symptoms of trunk rot resembling those caused by the *Thielaviopsis paradoxa* pathogen are present on a few trees. The presence of this pathogen is difficult to determine but laboratory tests should be repeated. It is suggested involvement of experts in the following disciplines: fertilization, pest and disease control and horticulture (MOAG, nd). Over the first 5 years, cultivation of 2,000 ha of date palms is the project goal.

Pundir and Porwal (1998) investigated the performance of different date cultivars under hyper arid supplementary irrigation in the western plains of Rajasthan. The average fruit yield per palm at full *doka* stage was, in Barhee (66.0 kg), Halawy (59.7 kg), Khalas (43.7 kg) and Medjool (35.0 kg). Medjool is good for preparing dry dates (*chuhhara)*; Halawy, Barhee, Khalas and Sewicvs. are best for dessert purposes.

2.5. Date Palm in Tamilnadu

Tamilnadu is an important state in southern India where climate, soil and irrigation facilities in certain coastal regions such as Tirunelveli, Tuticorin and Ramanathpuram districts favor date palm cultivation (The Hindu, 2006). About 809 ha in Tamilnadu are cultivated with Arabian dates. The first plantlets for commercial growth were procured over 15 years ago at a cost of INR 3,250. (USD 54)/palm from Saudi Arabia (India News, 2010). Mr. Nizamuddin is the first and foremost person of date palm cultivation in South India. He brought from Saudi Arabia cultivars like Aguah, Makthumii, Sukkary, Katima and Muscat and planted them in Dharmapuri District. Out of 100 seedlings only 7 survived including 2 males. After 14 yr, an average yield of 150 kg of dates per palm per year is obtained (Dates India, 2011a).

2.5.1. Cultivation Practices

Saliah nursery (Dates India, 2011b) in Tamilnadu imports tissue culture plants of cvs. Meznaz, Chayar, Jagulal, Barhee, Jagidar, Kathravi and Kalas. According to Mr. S. Nizamudeen, these plants have grown to 1.5-3 m tall. They are all female trees and bear fruits from the second year of planting. Recommended practices are as follows:

(a) Planting and irrigation: planting in a pit 60 x 60 x 60 cm. Biofertilizers like earthworm manure, sheep manure or farm yard manure (any one of them) can be used with plant spacing of 6 x 6 m. Irrigation of 30 l per tree once a week up to 1 yr. For the next 2 yr, 50 l per tree once a fortnight. For the subsequent 2 yr, 100 l per tree once a month under drip irrigation, then the drip system should be converted into basins.

(b) Intercropping: during the early years intercropping can be done to generate additional income and to provide protection to young palm trees against heat. Plants like *amla* (Indian gooseberry), fig, *bathal* (monkey fruit, lakoocha), *seethaphal* (custard apple), red gram, green gram, horse gram, *till* (sesame), sunflower, maize, *juwar* (sorghum) and *ragi* (finger millet) can be grown. For

such plantings additional irrigation must be provided.

(c) Pollination is by hand: for better pollination honey bee rearing should be introduced.

Date-palm flowering is during January to February. Fruit harvest is in June or July. After 5 yr of planting the fruit is collected at three stages. The fruiting begins from the fifth year of planting. Under drip irrigation the yield in year 5 is 50 kg, year6 is 60 kg, years 7 and 8 is 100 kg and in year 9 reaches150 kg. The average of 150 kg date palm fruits per year for a tree assumes that it is healthy. The date palms yield well for up to 50 yrbut for following 50 yr the yields decrease. For better pollination and fruit yield 10 males are necessary for 100 female plants (Dates India, 2011b).

2.5.2. Organic Farming of Date Palm in Tamilnadu

According to The Hindu (2012), Mr. K. G. Murugavel is one of the first in southern India to successfully cultivate organic Barhee dates. About 30 km from Coimbatore, he has a 1 ha farm in Vanjipalayam where he has 3.1 m tall palms of Barhee. A total of 200 plants grow in neat rows; each boxed in by thin sprinkler pipes and 8 m apart. Each tree was laden with 50-80 kg of shiny yellow dates, nicknamed *honeyballs*. They are crunchy and sweet. In Feb. 2009 he imported 200 plantlets from the UAE and planted them on his farm. Holes were filled with organic manure, ash and sand, 148 plants per ha, watered every 3 d. Neem cake and organic manures are applied once every 3 mo. He harvested fruit within 28 mo, a very fast time period for Barhee.

In the first year the plant height was 2.4 m tall with 20 kg of fruit and in the second year 40 kg per plant. When in full maturity each tree will be 20 m tall and estimated to yield 200-300 kg of organic dates which are harvested annually in July and September. This year each kilogram of dates fetched IRN 300. The dates do not require any processing and are plucked at three stages.

3. Tissue Culture of Date Palm in India

Given the complex biological relationship between the date palm and sugar date palm and ancient historical presence of the latter and the subsequent introduction of the former in India, especially in the Kutch Region, this situation raises some questions regarding the origin and the present status of date palm in India.

With a survey of date palm cultivation in Punjab, Kutch and Tamilnadu and recent attempts of covering vast arid and semiarid regions of Rajasthan and its adjacent regions with date palm presents great challenges to improve cultivating practices, find local elite cultivars and import cultivars for better uniform acceptability and improved better date products. Over decades of cultivation practices followed in different regions, regenerating dates either by seeds or offshoots and trying different imported cultivars, there are present date fruits of great variations in size, shape, color, weight, taste and astringency. The failure to control diseases of date palm using methods which do not pollute soil, plant and products is evident.

The only solution was obviously to produce date palms by tissue culture technology. One way was to import tissue culture plants from abroad where such technologies have been developed. But it was necessary to develop such technologies in India using either the local elite cultivars and/or develop select cultivars from abroad found suitable for the conditions of India's different regions. Such an attempt was made for the first time in India by Kutch Crop Services Ltd. (KCSL). Following is a short profile of KCSL and its growth, activity, social contribution and scientific pursuits made without any government help (KCSL, 2014)

3.1. Genesis of Kutch Crop Services Ltd. (KCSL)

For more than three decades all the promoters of KCSL have been involved in activities related to the socioeconomic development of Kutch. The need for evaluating date palm as a source of income for the farmers of Kutch was established at Shri Vivekananda Research and Training Institute (VRTI) in 1994; in 1995 a study was initiated in consultation with Israeli scientists to identify elite date palm cultivars. A report was prepared on about 200 cultivars grown in Kutch.

In 1998 a devastating cyclone uprooted large numbers of date palms, depriving many farmers of their source of income. This induced Mr. Sumati Chandra Mehta to search for a solution that could help a large number of farmers to substantially increase their incomes and improve their standard of living. He consulted many scientists and in 2000 decided to establish a tissue culture laboratory for date palm. In 2001 he sponsored the Rural Agricultural Research and Development Society (RARDS) to set up a date palm tissue culture lab in Mundra, Kutch.

In 2007 RARDS approached KCSL promoters to consider the possibility of supporting RARDS to market their date palm plants and an MOU was signed to that effect. In 2008 RARDS decided to sell the complete plant, machinery and apparatus of

the laboratory to KCSL and transfer all the employees to the KCSL payroll.

With the scientific and business acumen of the promoters, KCSL has succeeded in motivating the entire team to establish the protocol for about 16 elite cultivars of Kutch date palms and today the laboratory is producing about 5,000 sellable plants, and recently has expanded the capacity to about 10,000 plants per year at the same premises.

KCSL has also been importing tissue culture plants of Barhee cv. from the Middle East. In the last six years KCSL has supplied more than 40,000 Barhee plantlets to farmers across the nation. The company proposes to set up a laboratory in Kutch to produce 105,000 sellable date palm plants per annum.

3.1.1. Mission of KCSL

The following activities constitute the mission of KCSL: (a) improve the socioeconomic conditions of local farmers in Kutch and other regions; (b) provide knowledge about scientific cultivation practices in a cost effective manner; (c) provide quality planting material at an affordable cost and (d) conserve the natural heritage of elite date palm from Kutch and promote them internationally.

3.1.2. R & D Roadmap of KSCL

KSCL has ongoing activities on: (a) initiation of new offshoots using multiple auxins and cytokinins; (b) initiation of inflorescences; (c) initiation of leaf explants from in vitro and field plants; and (d) callus multiplication in new media by using different auxins/cytokinins ratios.

They are also developing micropropagation protocols for date palm through: (a) inflorescences; investigators have standardized initiation of sterile cultures that regenerated into shoots from inflorescence explants from this specific elite plant; however, sustained growth leading to multiplication of regenerated shoots was not achieved; (b) leaf sheaths, the critical variable in the establishment of a growing culture is the explants; since leaf sheaths and immature inflorescences are the only explants available for the elite material, the date palm multiplication technology will be standardized from such explants.

Regarding genetic research and development, KSCL is pursuing:(a) development of genomic tools for germplasm characterization in date palm; (b) assessment of genetic abnormalities found in the tissue culture derived dates; (c) fingerprinting of date palms; (d) construction of a genetic map of date palms; (e) a breeding and selection program for date palm improvement; (f) development of new date palm clones tolerant of saline conditions and (g) characterization of date palm cultivars.

KSCL has additional goals: (a) improve the shelf life of fruits; (b) study likely climatic changes in Kutch Region and develop in advance appropriate cultivating practices and (c) attempt to develop or obtain technologies to control important pests and diseases without polluting the soil, plant and products.

3.2. Tissue Culture Technology by Anand Agricultural University (AAU)

The AAU Plant Tissue Culture Laboratory claims to have developed, for the first time in India, a protocol of micropropagation of indigenous genotypes of date palm. Field evaluations of tissue culture grown plants at Anand and Dantiwada (university fields) have shown total field establishment (no mortality), early flowering and profuse suckering. On flowering they were true to type DNA based molecular markers (viz. Random Amplified Polymorphic DNA (RAPD), Inter-simple Sequence Repeat (ISSR) and Simple Sequence Repeat (SSR) have been employed to verify variant plants and proved their superiority and clonal fidelity. According to Dr. Subash, responsible for developing this technology, around 1,500 plants are under hardening process in different stages. The fruits from local genotypes and elite varieties have huge potential to capture local and global markets. The technology involves raising shoot apices (apical and axillary buds) of selected offshoots of elite cultivars. The stages involved are callus initiation, somatic embryo induction, development, maturation, germination and finally in vitro plantlet development. Until now the tissue culture plants have not come on the market for sale (AAU, 2011).

4. Harvesting, Post Harvesting and Marketing of Dates

In addition to their cultivation, harvesting, post harvesting and marketing of dates form an important set of neglected agriculture practices in Kutch region (Kadar and Hussein, 2009). Kutch produces only khalal dates; rutab and tamar stage of dates are not produced because of unfavorable climatic conditions in June-July which are the months for further ripening of the dates. Kutch produces the largest share of dates in India. With about 2 million cultivated plants, mostly from seed, offshoots and about 120,000 from tissue culture plants, this scenario of cultivation has raised difficult problems which are as important as cultivating practices.

Dates produced from these three major sources in Kutch also have sub cultivars (varieties) developed from many years of cultivations, long life of trees and possibility of random, natural or human (inter varietal) pollination resulting in a complex heterogeneous population of genetic diversity producing mostly poor quality dates and a few elite ones. Problems associated with harvesting and grading of fruits are not scientifically resolved or taken care of with appropriate awareness of the farmers. Hence date cultivars undergo monetary loss and frustration.

In Kutch there are local varieties, tissue cultured selected local varieties and imported Barhee cv. Pre-harvest practices that determine fruit quality and appropriate covering of fruit bunches and thinning fruit strands or bunches require standardization. Postharvest grading of fruits depends on size, color, flavor, weight, shape, sweetness and astringency at khalal stage. Marketing involves establishing prices based on grading by an organized independent agency to avoid middle man interference. In Anjar (Kutch) there is a sort of an open market where farmers bring their dates to sell; but in the absence of a grading and price setting agency it is unorganized and date growers depend upon the middleman who decides the quality and price.

5. Date Palm Protection in India

The executive summary of the report of the committee which visited Gujarat and Rajasthan states (MOAG, nd) stated that in Rajasthan symptoms resembling those of trunk rot (*Thielaviopsisparadoxa*)pathogen are present on a few trees. The presence of this pathogen is difficult to determine and laboratory tests should be repeated.

In Gujarat, among the main problems, is the presence of red palm weevil (RPW), which is considered to be a major threat to production and should be given priority. Another problem is the high levels of infection with *Graphiola*, a leaf fungus. Protocols for monitoring the red palm weevil are also present.

It may be desirable to treat *Graphiola* chemically; control measures consist of: (a) leaf pruning, coupled with treatment with any wide spectrum fungicide and (b) planting of resistant cultivars. Control measure for red palm weevil involve: (a) pheromone based RPW-IPM strategy; (b) set monitoring traps; (c) check palms around traps and (d) treat infested plants.

6. Conclusions and Prospects

The Kutch Region of Gujarat produces the highest quantity of dates (khalal stage) in India and has about 2 million date palms growing. Kutch has an ancient history of introduction and cultivation of date palms. Not only is there a record by Thakar (1926) in Gujarat but also by others earlier on such as Cooke and Hooker that *P. sylvestris* was present in a wild state in Kutch and that *P. dactylifera* was introduced. Today the sugar date palm has practically disappeared in Kutch, although nearby Saurashtra region of Gujarat still has *P. sylvestris* and it is present throughout India. This complicated biological relationship is to be explored and Kutch is a fertile ground for an investigation.

Kutch has a high genetic diversity in date palms; not only due to the complex relationship of natural hybridization with sugar date palm but the present populations of date palms consist of a majority grown from seed, offshoots and more recently from tissue culture. A few recent attempts (Srivastav et al., 2013, 2014) at molecular characterization to find the best genotypes and identify sexual differentiation have been made for date palms in Kutch. But more systematic and concentrated investigations are required to identify genetic markers for the best cultivar identification and characterization of fruit qualities, such as shape, weight, color, taste and sweetness.

Outside India, the achievement of mapping the genomes of 60 cultivars of date palms from North Africa in less than a year-and-a half with a goal of doing similar mapping for 1,000 cultivars is a great step towards improving the date palm cultivars and throwing light on the origin and domestication of the date palm. Similarly the achievement of Saudi-Sino date palm project under which about 450 cultivars of genome mapping has been done is a noteworthy service to date palm biotechnology (KACST, 2013; NYURD, 2014).

For the date palms in Kutch it is necessary to have morphometric and cellular markings for different cultivars and especially of elite cultivars with superior date qualities recognized for global market.

India has main four regions of date palm cultivation, Punjab, Gujarat, Rajasthan and the southeastern coastal region (mostly Andhra Pradesh and Tamilnadu); with advancing climatic changes and preference for date palm cultivars, the best cultivation practices and disease preventive measures should be standardized.

Kutch has a huge population of date palms. The pollination is a skilled practice apart from selecting

appropriate varieties having metaxenic pollen effects. If a pollen bank were established on a cooperative basis having necessary storing facilities and appropriate grading of varieties, it would be a boon to farmers.

Given the frequency of earthquakes and hurricanes, it is urgent that germplasm of elite cultivars of Kutch be preserved and appropriately stored for the future. The present tissue culture technology developed in India to produce date palm plantlets requires fine tuning and appropriate changes to produce true-to-type plants. At present tissue cultured palms pose some problems of somatic clonal variations. Moreover it is necessary to have tissue culture plantlets of elite cultivars suitable to different regions and satisfying local tastes and demand as well as export requirements.

The development of various technologies and the requirement for date-palm research in India are focused on Kutch at present with its huge genetic diversity and capacity for producing major quantities of dates for the country. It is necessary to have a modern center of date palm biotechnology to satisfy future requirements of all date palm growing regions. Mundra (Kutch) Date Palm Research Centre is the appropriate choice for elevation to this status.

The date palm has its own unique place in agroforestry. Its usefulness in many ways and means and ability to endure unfavorable climate with long life satisfy the objectives of agroforestry development in arid and semiarid regions for the benefit of the inhabitants.

The useful varied products obtained from date fruits have an economic and social benefit of creating jobs. As well, to create a garden of date palms in the vast arid and semiarid regions of India would be an ecological asset.

Acknowledgement

I am thankful to Kutch Crop Services Ltd. for giving me their useful information and photographs. I thank Mr. N. N. Sodagar, Retired Senior Research Officer, Mundra Research Station, Kutch and Dr. Murlidharan, Director, Mundra Research Station, Kutch for information on date palms in Kutch. Special thanks are due to Dr. Susy Albert, Associate Professor of Botany, M.S. University, Vadodara for technical assistance.

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