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CHAPTER I: BOTANICAL AND SYSTEMATIC DESCRIPTION OF THE DATE PALM

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1. Introduction

The botanical name of the date palm, *Phoenix dactylifera L.*, is presumably derived from a Phoenician name "phoenix", which means date palm, and "dactylifera" derived from a Greek word "daktulos" meaning a finger, illustrating the fruit's form (Linné, 1734).

Another source refers this botanical name to the legendary Egyptian bird, "Phoenix", which lived to be 500 years old, and cast itself into a fire from which it rose with renewed growth (Pliny, 1489; Van Zyl, 1983). This resemblance to the date palm, which can also re-grow after fire damage, makes the bird and the date palm share this name, while "dactylifera" originates from the Hebrew word "dachel" which describes the fruit's shape (Popenoe, 1938).

2. Systematic distribution

Belonging to the Angiosperms-Monocotyledones, *Palmaceae* is a family of about 200 genera and 1, 500 species (Dowson, 1982). Phoenix (*Coryphoideae Phoeniceae*) is one of the genera which contains a dozen species, all native to the tropical or subtropical regions of Africa or Southern Asia, including *Phoenix dactylifera L.* (Munier, 1973). According to Dransfield and Uhl, (1986) date palm is classified as follows:

- Group: Spadiciflora
- Order: Palmea
- Family: Palmaceae
- Sub-family: Coryphyoideae
- Tribe: Phoeniceae
- Genus: Phoenix
- Species: *Dactylifera L.*

Twelve species of the genus "Phoenix", along with their geographical distribution, were first listed by Chevalier (1952):

Species	**Common Name**	**Distribution**
Phoenix dactylifera L.	Date Palm	Mediterranean countries, Africa and part of Asia; introduced in North America and Australia
P. atlantica A. Chev.		Occidental Africa and Canary Islands
P. canariensis chabeaud.	Canary Palm	Canary Islands and Cape Verde
P. reclinata Jacq.	Dwarf Palm	Tropical Africa (Senegal and Uganda) and Yemen (Asia)
P. sylvestris Roxb.	Wild Date Palm or	India and Pakistan

	Sugar Palm	
P. humilis Royle.		India, Burma, and China
P. hanceana Naudin.		Meridional China and Thailand
P. robelinic O'Brein.		Sri Lanka, Toukin, Annam, Laos and Thailand
P. farinifera Roxb.	Pigmy Palm	India, Ceylon and Annam
P. rupicola T. Anders.	Rocky Date Palm	India
P. acaulis Roxb.	Dwarf Palm	Bengaladesh and India
P. paludosa Roxb.	Hental or Juliana Palm	Bengaladesh, Tenasherim, Andaman, Nikobaren and Thailand

Besides date palm, five of the above species bear edible fruit (*P. atlantica* chev., *P. reclinata* Jacq., *P. farinifera* Roxb., *P. humilis* Royle., and *P. acaulis* Roxb.).

Most of the 12 *Phoenix* species are well known as ornamentals, the most highly valued is *P. canariensis* Chabeaud, commonly called the Canary Island Palm. *P. sylvestris* Roxb. is widely used in India as a source of sugar. *P. dactylifera* L. is distinguished from the above two species by several characteristics which could be summarised as follows:

- production of offshoots;

- tall, columnar and relatively thick trunk. If the crown of fronds is included, the date palm could reach a height of over 20 m (Blatter, 1926); and

- dark green leaves, (instead of the shiny green colour of the two other species).

Close relationship among the 12 species is illustrated by the ease of hybridisation and cross-pollination (Moore, 1963; Munier, 1973). Several natural hybrids were hence obtained: *P. dactylifera* X. *P. sylvestris* (India); *P. dactylifera* × *P. canariensis* (Morocco, Algeria and Israel); *P. dactylifera* × *P. reclinata* (Senegal).

Phoenix dactylifera L. has 36 chromosomes (n = 18; 2n = 36) (Beal, 1937), but polyploidy cases were reported by Al- Salih and Al Najjar (1987) with Iraqui date varieties (2n = 64). The same authors reported differences between varieties: Sayer as an early variety (2n = 32) and Khasab, a late variety (2n=36). Furthermore, in both varieties, aneuploidy and euploidy were observed: (Sayer: 32, 34, 36 and 64 and Khasab: 32 and 36).

3. Botanical description

3.1 Vegetative organs

3.1.1 Root system

Being a monocotyledon, date palm has no tap root. Its root system is fasciculated and roots are fibrous, similar to a maize plant. Secondary roots appear on the primary root which develop directly from the seed. These secondary roots produce lateral roots (tertiary roots and so on) of the same type with approximately the same diameter throughout their length.

The date palm root morphology and distribution are illustrated in Table 1.

TABLE 1
Date palm root morphology and distribution

Roots Order	Origin	Form	Average length (m)	Average diameter (mm)	Characteristics
Primary	Trunk base	Cylinder	4 (up to 10)	9.5 (7-12.5)	- vertical - adventitious - no root hair - conic tip - called auxirhyzes and also main roots
Secondary	Primary roots	Similar to primary roots	0.20 - 0.25	3.5	- called mesorhyzes
Tertiary	Secondary roots	Similar to secondary roots but thin	0.02-0.1	0.3 - 1.5	- Low growth - short and - abundant called brachyrhizes

All date palm roots present pneumatics, which are respiratory organs. Roots are found as far as 25 m from the palm and deeper than 6 m, but 85 percent of the roots are distributed in the zone of 2 m deep and 2 m on both lateral sides in a deep loamy soil (Munier, 1973). It is worth mentioning that date roots can withstand wet soil for many months, but if such conditions spread over longer periods, they become harmful to the health of the roots and to fruit production. Figure 1 diagrammatically shows a date palm's construction with its root system.

From Figure 1, it is clear that the date palm root system is divided into four zones (Oihabi, 1991):

- *Zone I, called respiratory zone:* It is localised at the palm base's surrounding area with no more than 25 cm depth and a lateral distribution of a maximum of 0.5 m away from the stipe. Found in this zone are mainly roots of primary and secondary nature. Most of these roots have a negative geotropism and play a respiratory role.

- *Zone II, called nutritional zone:* It is a large zone and contains the highest proportion of primary and secondary roots. It could contain 1000 roots per m² and more than 1.60 gm of roots/100 gm soil (Oihabi, 1991). They develop between 0.90 and 1.50 m depth and could laterally be found outside of the projection of the tree's canopy. In the case of Deglet Nour variety, lateral roots were found up to 10.5 m from the trunk (Bliss, 1944). Recently planted offshoots develop their roots at zone II then at zone III. At one year old, they could reach 1 m, while 3 m depth is easily reached at the second year.

- *Zone III, called absorbing zone:* The importance of this zone is dependent on the type of culture and on the depth of underground water. It is usually found at a depth of 1.5 to 1.8 m. Mostly primary roots with a decreasing density from top to bottom are found here. The density of this zone is lower than in zone II - only about 200 roots are found per m².

- *Zone IV:* The largest portion of this zone is dependent on underground water. At a shallower depth, it becomes difficult to distinguish between Zone III and Zone IV as both types of roots are found here. When the underground water is deep, roots of this zone could reach a greater depth. They usually are presented as vaissels with a positive geotropism.

In conclusion, the root type and distribution illustrate the role of the date palm. The lack of roots in the top soil allows other cultures such as wheat, lucerne and vegetables to be inter-cropped. While, the high concentration and deep presence of primary roots allows the date palm to benefit from underground moisture and consequently, unlike most fruit palms, resist water stress and drought conditions.

Date palm root development and distribution depends on soil characteristics, type of culture, depth of the underground water and variety.

3.1.2 Trunk

The date palm trunk, also called stem or stipe is vertical, cylindrical and columnar of the same girth all the way up. The girth does not increase once the canopy of fronds has fully developed. It is brown in colour, lignified and without any ramification (Figure 1). Its average circumference is about 1 to 1.10 m.

The trunk is composed of tough, fibrous vascular bundles cemented together in a matrix of cellular tissue which is much lignified near the outer part of the trunk. Being a monocotyledon, date palm does not have a cambium layer.

The trunk is covered for several years with the bases of the old dry fronds, making it rough, but with age these bases weather and the trunk becomes smoother with visible cicatrices of these bases. Vertical growth of date palm is ensured by its terminal bud, called phyllophor, and its height could reach 20 metres.

Horizontal or lateral growth is ensured by an extra fascicular cambium which soon disappears, and which results in a constant and uniform trunk width during the palm's entire life. However, the terminal bud could experience an abnormal growth caused by a nutritional deficiency, which leads to shrinkage of the trunk. This stage is mainly caused by drought conditions.

Sometimes date palms show a branching phenomenon (Figure 2) which was studied by Zaid (1987) and found to be attributed to several causes. The author's findings are summarised as follows:

- Branching in date palm is a result of either dichotomy, axillary bud development, polyembryony or attack by a disease.

- Branched date palms are fertile and can produce as much fruit as a single headed palm.

- There is a need of an analysis of the vascular system of branched date palm by cinematographic techniques. This anatomical study is necessary to show the continuity of growth from the single to the divided state of the shoot.

- It is necessary to study *in vitro* the regenerating capacity of divided portions of the apical meristem and axillary buds of these specimens in the hope of establishing a rapid mass propagation technique for date palm.

3.1.3 Leaves

Depending on variety, age of a palm and environmental conditions, leaves of a date palm are 3 to 6 m long (4 m average) and have a normal life of 3 to 7 years. The greatest width of the frond midrib attains 0.5 m, but elsewhere it is only half this size and rapidly narrows from the base upwards. The frond midrib or petiole is relatively triangular in cross section with two lateral angles and one dorsal.

It is bare of spines for a short distance but full of spines on both sides thereafter. (Figures 3, 10 and 14). Intermediate zones have spine-like leaflets, also called leaflet-like spines.

At the tip of the leaf, there may be a single terminal leaflet or two leaflets forming a V (Figure 3). Leaf structure is variety and environment dependent, but usually the whole length of a frond has the following proportions:

- The distance from the fibre at the base of the frond to the base of the spine-leaflets is about 28 % of the whole frond;

- The spine-leaflets occupy about 4 %;

- The leaflets occupy about 62 %; and

- The terminal leaflets occupy about 6 %.

All these characteristics coupled with others, are used as a taxonomical index to differentiate between varieties. Unlike other fruit trees, dead or old leaves are not shed and do not drop on their own, but are removed under cultivation.

An adult date palm has approximately 100 to 125 green leaves with an annual formation of 10 to 26 new leaves. The functional value of the leaf to the palm declines with age and no two leaves are the same age. Furthermore, leaves which are four years old are only about 65 percent as efficient in photosynthesis per unit area, compared to leaves of one year old (Nixon and Wedding, 1956). Under good cultural conditions a leaf can support the production of 1 to 1.5 kg of dates.

Depending on their position in the palm's canopy, leaves could be divided into 3 categories:

- On the outside, leaves are green and photosynthically active;
- At the centre, fast growing green leaves;
- On the inside, at the palm's heart, juvenile leaves, not yet photosynthetic with a white colour.

On average, there are 40 % of juvenile leaves, 10 % fast growing leaves and 50 % photosynthetic leaves.

Leaves are grouped in 13 nearly vertical columns, spiralling slightly to the left on some palms and to the right on others. The grower must only count the number of leaves in one of these columns and multiply it by 13 (Figure 4). According to Nixon and Carpenter (1978) and in order to allow for uneven pruning at the base, counts could be made on opposite sides and divided by two. This technique will allow the grower to calculate the total number of leaves on the palm. A ratio of 8 leaves per fruit bunch will indicate how many bunches to leave on that palm.

Leaves of seedling date plants are characterised by a slightly developed petiole and a juvenile leaf which develops during the first three years after seed germination (Figure 5). These leaves are also called primordia, non-pinnae or entire leaves. Adult leaves are pinnate and arise, in a flattish ascending spiral, from buds produced by the apical growing point.

At the base of each leaf, there is an axillary bud which could yield an inflorescence at the palm's top level or an offshoot at its base. According to Bouguedoura (1982), there are three distinct development phases:

- Juvenile phase which is sterile and leads the palm to produce more inflorescence buds than vegetative ones, which will abort very soon.

- Second phase called vegetative, where vegetative and flowering buds are produced in equal numbers; however, vegetative buds are the ones which develop.

- Third phase, usually after the palm is more than 10 years old, where most of the buds produced are flowering ones.

3.1.4 Fibre, spines and leaflets

As well described by Dowson (1982), the base of the frond is a sheath encircling the palm. This sheath consists of white connective tissue ramified by vascular bundles. As the frond grows upwards, the connective tissue largely disappears leaving the dried, and now brown, vascular bundles as a band of tough, rough fibre attached to the lateral edges of the lower part of the midribs of the fronds and ensheathing the trunk. Varieties differ in the height to which the fibre grows up the central column of unopened fronds, and in the texture of the fibre and also somewhat in colour.

Spines, also called thorns, vary from a few cm to 24 cm in length and from a few mm to 1 cm in thickness. They are differentially arranged on the two outer edges of the fronds while their number varies from 10 to about 60. Spines can be single, in groups of two, or in groups of three.

Leaflets or pinnae are between 120 to 240 per frond, entirely lanceolate, folded longitudinally and oblically attached to the petiole. Their length ranges from 15 to over 100 cm and in width from 1 to 6.3 cm. Their arrangement depends on variety and could be in groups of 1, 2, 3, 4, or 5 pinnae (Figure 14).

3.2 Reproductive organs

Date palm is a dioecious species with male and female flowers being produced in clusters on separate palms. These flowering clusters are produced with axils of leaves of the previous year's growth. In rare cases both pistillate and staminate flowers are produced on the same spike while the presence of hermaphrodite flowers in the inflorescence has also been reported (Mason, 1915; Milne, 1918). Palms which carry both unisexual and hermaphrodite flowers are known as polygamous.

The unisexual flowers are pistillate (female) and staminate (male) in character; they are borne in a big cluster (inflorescence) called spadix or spike, which consists of a central stem called rachis and several strands or spikelets (usually 50 - 150 lateral branches); (Figures 6a, b and 7a, b).

3.2.1 Inflorescences/Flowers

The inflorescence, also called flower cluster, in its early stages is enclosed in a hard covering/envelope known as spathe which splits open as the flowers mature exposing the entire inflorescence for pollination purposes (Figure 8). The spathe protects the delicate flowers from being shrivelled up by the intense heat until these are mature and ready to perform their function. The spathe at the beginning is greenish, becoming brown when near splitting - splitting is longitudinal. The male spathes are shorter and wider than the female ones. Each spikelet carries a large number of tiny flowers as many as 8,000 to 10,000 in female and more in male inflorescence (Chandler, 1958). The annual number of spathes born by a palm varies from none to about 25 in females and to even more in males, but the average is a dozen for females and more for males.

The male inflorescence is crowded at the end of the rachis, while branches of the inflorescence of the female cluster are less densely crowded at the end of the rachis. These characteristics allow the recognition of the inflorescence's sex before its opening (Figure 8). The male flower is sweet-scented and normally has six stamens, surrounded by waxy scale-like petals and sepals (3 each). Each stamen is composed of two little yellowish pollen sacs.

The female flower has a diameter of about 3 to 4 mm and has rudimentary stamens and three carpels closely pressed together and the ovary is superior (hypogynous). The three sepals and three petals are united together so that only tips diverge. On opening the female flowers show more yellow colour while the male ones show white colour dust, produced on shaking. The pollen sacs usually open within an hour or two after the bursting of the spathe.

Only one ovule per flower is fertilised, leading to the development of one carpel which in turn gives a fruit called a date; the other ovules aborted. The aborted carpels persist as two brown spots in the calyx of ripe fruits.

3.2.2 Fruit

Depending on the variety, environmental conditions and the technical care given (fertilisation, pollination, thinning,...), fruit characteristics vary tremendously. Table 2 illustrates this variation:

TABLE 2
Variation of date palm fruit characteristics

Fruit characteristics	Weight (g)	Length (mm)	Width (mm)	Colour	Taste	Consistency
Range of variation	2 to 60	18 to 110	8 to 32	Large variation (yellow to black)	Large variation	Soft to dry

The date fruit is a single, oblong, terette, one-seeded berry, with a terminal stigma, a fleshy pericarp and a membranous endocarp (between the seed and the flesh) (Figure 9).

3.2.3 Seed

As with the fruit, seed characteristics vary according to variety, environmental and growing conditions. A seed's weight could range from less than 0.5 g to about 4 g, in length from about 12 to 36 mm and in breadth from 6 to 13 mm. (Figure 9). The seed is usually oblong, ventrally grooved, with a small embryo, and with a hard endosperm made of a cellulose deposit on the inside of the cell walls.

3.2.4 Variety description

Date varieties have been developed by thousands of years of selection of seedlings and only those possessing desirable characteristics have been propagated. Date palm counts for more than 3,000 varieties all around the world. There are about 400 in Iran, 370 in Iraq, 250 in Tunisia, 244 in Morocco, as well as many additional varieties in the other major date growing countries.

Several date specialists attempted to list and to botanically describe the varieties grown in their respective countries. Table 3 illustrates this effort in botanical description of date palm varieties.

TABLE 3
Number of date varieties described per country

	Number of varieties described	Author/Reference
Egypt	26	Brown, 1924
Egypt and Sudan	22	Mason, 1925
Iran	400	FAO, 1996
Iraq	370	Dowson, 1923
Morocco	244	Saaidi, 1974
Tunisia	250	Kearney, 1906
USA	196	Nixon, 1950

In the present document, the authors decided to include an updated variety description of the two renowned varieties, Medjool and Barhee, which have a high marketing potential.

The aim of this description is to present these two varieties in such a way that the date grower will become fully familiarised with their main characteristics. The study was based on 20 random date fruits of each variety.

Medjool variety

Synonyms: Mejhool, Medjoul, Majhoul, Majul, Medjhool, Medjehuel, Majhol and Me-jool.

Meaning: (Arabic); referring to its origin: Unknown

History: Originally from Morocco (Tafilalet area) where it was the principal export date since the 17th century and was sold in a fancy gift box for Christmas in Paris, Madrid and London, but largely introduced into the new world of date culture: USA (1927) and Israel (1934).

Distinguishing characteristics: Medium size trunk, short to medium leaves which are organised with little curvature. Has a high fruit quality (large size and attractive). It outshines all other varieties with regard to fruit quality and size. It is of high commercial value and is considered date No. 1 for export market.

Description

Palm: Leaves are short to medium (3.5-3.8m), about 1m shorter than Deglet Nour and Barhee with a slight curvature. Dark green at early age then change to yellow with brown strips at the middle.

Trunk: Narrow to medium diameter.

Leaf bases: Average in size with light and inconspicuous scurf on edges.

Spines: 30 to 35 in number, thick and significantly developed at the base, 1/4 of the leaf's length; usually in 2's and sometimes in 3's (Figure 10). Lower spine's length from 5 to 10 cm and the upper ones from 15 to 20 cm.

Pinnae: Straight but could be found curved to the middle; a taller pinnae (70 to 80 cm × 2.5 to 4 cm); width (36 to 54 × 4.5 to 5.0 cm). On the outer centre side of the leaf they are open fl at to 160° - 180°, and on the inner side to 50° to 90°. At the end of the leaf, the pinnae are at 45° on both inner and outer

sides. At the base of the leaf, the pinnae start at 50° opening to 90°. Along the length of the leaf, pinnae protrude at various angles (45° to 180°), in a unique formation, specific to Medjool.

Inflorescence: Short orange base with a large number of spikelets each with 50 to 60 flowers.

Fruitstalk: Orange-yellow in colour; short to medium size but thick; a wax cover is usually found at its lower half. The fruitstalk with its short length, if not properly supported, could be broken when bearing heavily.

Fruit: Very large (20 to 40 gram) and elongated - broadly oblong oval to somewhat ovate (5cm long by 3.2cm in diameter). Irregularities in shape are common and are associated with ridges on the seed. Yellow-orange with clear dark red strips at Khalal stage. Amber at Rutab and transparent dark brown to black at Tamar (ripe) (Figure 11). Mature fruit colour is related to the climate and growing conditions. Covered with a waxy structure.

The skin is irregularly wrinkled, shiny at the peak and dull at the lower part. Skin is medium thick and tender, tied to the flesh, but at tamar stage it shrinks; thickness of the flesh: ± 5 to 7 mm with little fibre. Flesh is firm, meaty and thick, brownish amber, translucent with practically no fibre around the seed. Taste is excellent, sweet, but not concentrated.

Seed: Walnut - Brown shiny colour darker at the end, 1.5 gram. Seedling canal is closed approximately 50 % of the seed diameter with small wrinkles. On each side of the seed there is a protrusion forming a "wing shape" that is typical of Medjool and different from all other varieties.

Fruit defects: Two main non- pathogenic defects are typical to Medjool:

a) Loose skin: During drying, on the palm and after picking, as the flesh looses water, the skin tends to separate from the flesh. Loose skin is mainly the result of growing and habitat conditions. It is not affected much by the naturally or artificially drying process. Loose skin is an aesthetic defect rather than a taste defect and fruit with more than 20 to 25 % loose skin are graded as Class II.

b) Sugar crystallising: A common problem with loose skin fruit, mainly where the skin is broken, is that aromatic sugar crystals are formed on the flesh and under loose skin. Sugar crystallising is more common in fruit with high moisture content at harvest. Again this is an aesthetic defect that will categorise the fruit as Class II.

Pests and Fungi: During drying, many fruits fall from the bunch without the calyx, leaving a hole at the base of the fruit before drying is completed. Through this hole, fermenting beetles and fungi enter the fruit and that causes the fruit to sour. A slow drying process results in a higher level of fruit spoiling.

Special treatment in Medjool

Fruit size

To achieve large and jumbo sizes, the number of fruits per spikelet and bunch and the yield per palm must be monitored by the grower. Depending on the overall growing conditions the following is suggested:

Yield per palm: 80 - 120 kg
Number of spikelets per bunch: 25 - 35
Number of fruits per spikelet: 5 - 10

Reducing the number of fruits per spikelet could be achieved by:

1. Non- effective pollination.

2. Decreasing the number of fruit setting from flowers by chemical spraying (not advised).

3. Hand thinning. The best results are still by hand thinning when the fruit is at 1 to 1.5 cm in size.

Comments

- It is estimated that in 1996 100,000 Medjool palms, half in USA and half in Israel, supplied the world market with 1,000 tons of Medjool fruit.

- All the Medjool palms in the world, have originated from one palm in Bou Denib (Morocco).

- Medjool is an early ripening variety.

- Although classified as a soft date, Medjool is firmer than varieties like Barhee and Khadrawy.

- Very little damage from rain. Fruit quality however, is very sensitive to temperature and humidity. Both low and high extremes are not suitable for achieving high quality fruits.

- Extra heavy thinning is required to obtain a high value commercial fruit.

- Easily produces 20 to 25 offshoots per palm.

- In Israel Namibia RSA and USA the Medjool and Barhee superficies are increasing annually (Figures 12 and 13).

Barhee variety

Synonyms: Barhi, Berhi, Birhi.

Meaning: Uncertain (Arabic)

History: Barhee originates from Basrash Iiraq). Inroduced into the USA by Popenoe (1913); also found in Egypt and Israel.

Distinguishing Characteristics: Heavy trunk of a medium height, moderately curved green leaves, slightly drooping pinnae. The palm has a dusty greenish colour and looks dense and spherical. The fruit is broadly ovate round with relatively no astringency or objectionable tannin flavour at Khalal stage.

Description

Palm: Leaves light elm green with a heavy whitish bloom: Sometimes the trunk has a slight curvature near the apex caused by the weight of a heavy crop. Leaf is long and wide. Blade length about 380 to 415 cm. Maximum leaf width reaches 70 cm. Leaf stalk is wide and strong.

Leaf bases: Broad, green leaves with old ones slightly narrow on edges. Sparse scurf on edges, extending along rachis into lower blade.

Spines: 28 to 36 in number and cover approximately 1/5 of the leaf. Are short and thin; length from 2 to 4 cm; below to 8 or 12 cm; above slender to medium heavy; rachis angle about 15° to 40° (Figure 14). 3/4 of spines are by pair but also found arranged in a group of 3 - 5 on each side of the stalk. Above these, there are 5 - 6 separated spines on each side, which are longer and thicker than the first.

Pinnae: Are relatively wide and crowded. Rather stiff with occasional slight to moderate drooping. Length: 60 to 72. Width: 4.5 to 5.2 cm. Grouping usually in 2's in lower blade with a few in 3's near midblade and above, very distinct near the apex.

Fruitstalk: Wide, long and heavy. It is deep green at bloom and becomes greenish yellow to orange yellow at the Khalal stage Slight to moderate scurf on lower portion. Fruitstalk length ± 150 cm, breadth and thickness immediately below fruiting head 64 × 26 mm. Length of fruiting head ± 55 cm. Strands are mid size and have the same colour as the fruitstalk. Number of strands differs from 90 to 140. Longest strand: ± 75 to 80 cm; breadth and thickness 3.7 × 3.0 mm; fruiting area ± 42 cm; number of flowers ± 45. Shortest strand: ± 35 cm; breadth and thickness 3.9 × 2.7 mm; fruiting area ± 26 cm; number of flowers ± 42.

Bunches: Wide, mid length and heavy with a lot of strands (up to 140 per bunch).

Fruit: Khalal colour is opaque yellow (± apricot yellow to near antimony yellow) internal colour of the bunch is pale; while rutab is amber (raw sienna to amber brown) and becomes very soft and can be easily separated from the skin. Develops into a golden brown colour in the early tamar stage (ripe). The fruit is medium sized. Shape broadly ovate to somewhat rounded (egg-shaped), commonly with a wedge shaped taper from middle to bluntly pointed apex. Calyx flattened and a little submerged, rounded-triangular, usually with 1 to 3 slight breaks in margin. Small fruit length (± 32.5 mm) with a big diameter (± 25.4 mm); size ± 32 to 37 × 23 to 30 mm. Fruit of thinned bunches may be about 31 mm long and 27 mm wide (length to width ratio is about 1:15). Medium weight (± 15 - 20g). Flavour rich and delicate with a low total soluble solids (± 30 %); Flesh is thick and juicy. At rutab stage, the fruit is very sweet. At tamar stage skin is completely separated from the flesh, except around the calyx. The skin is greyish yellow and the flesh loses its transparency and turns into bright to dark brown (Figure 15).

Seed: The seed fills the whole volume of the seed cavity. Light brown to wood brown; oblong, slightly wider above middle, somewhat tapering to the blunt apex. It is short and wide, (18 to 23 × 8.4 to 10.5 mm). Germ pore central or nearly so and can be clearly seen at the centre of seed's dorsal side. Furrow commonly medium in width and depth. Light seed weight (± 0.88g) and a high pulp: seed ratio (± 12.75) (Figure 15).

Comments:

- Barhee is a medium to late fruit ripening variety.

- Yield of Barhee variety is high, reaching up to 500 kg per palm (in Israel) with an average of 200 kg per palm.

- The fruit at Khalal stage has an excellent flavour, with little astringency, distinguishing it from all other date varieties.

- The fruit is more subject to checking and splitting than that of other varieties.

- Checking is mostly longitudinal lines from middle to apex. The skin could be a little tough and this texture is accentuated by over thinning.

- At the tamar stage, ripe fruits are so soft and the bunches so dense that it is heavily damaged by rain.

- Offshoots production is low (usually only 3 - 5 per palm) but offshoots are large and vigorous for their age. Palms originated from tissue culture bear many more offshoots (up to 10 or even more).

- Barhee palm and offshoots are sensitive to frost (Barhee palms were severely damaged by the 1937 frost in the USA).

- In Iraq, Israel, as well as in international commerce, Barhee is marketed and consumed only as fresh fruit on strands, at the Khalal stage.

3.2.5 Growth and development stages of date palm fruit

The growth and development of date palm fruit involves several external and internal changes. These changes are often classified on the basis of change in colour and chemical composition of the fruit, as five (5) distinct stages of fruit development, known as Hababouk, Kimri, Khalal, Rutab and Tamar.

These terms are Arabic and have been internationally used by various authors including American and Israeli date growers. There are no equivalent English words.

a) *HABABOUK STAGE*

Synonyms: Habbabok, Hababauk.

Starts soon after fertilisation and continues until the beginning of the kimri stage. It usually takes four to five weeks to complete and is characterised by the loss of two unfertilised carpels; a very slow growth rate is another characteristic. Fruit at this stage is immature and is completely covered by the calyx and only the sharp end of the ovary is visible. Its average weight is one gram and the size is about that of a pea.

b) *KIMRI STAGE*

Synonyms: Khimri, Jimri, also called green stage.

At this stage the fruit is quite hard, the colour is apple green and it is not suitable for eating. This stage lasts from a small green berry to an almost full sized green date (Figure 16). It is the longest stage of growth and development of dates and lasts a total of nine to fourteen weeks, depending on varieties.

During the first 4 to 5 weeks, there is an average relative weekly growth of 90 %, while during the second period of kimri stage there is only about 22 % growth.

The first phase is characterised by a rapid increase in weight and volume, rapid accumulation of reducing sugars, low but increasing rate of accumulation of total sugars and total solids, highest active acidity, high moisture content though slightly less than that of the second phase.

c) *KHALAL STAGE*

Synonyms: Khalaal, called also colour stage.

The fruit is physiologically mature, hard ripe and the colour changes completely from green to greenish yellow, yellow, pink, red or scarlet depending on the variety. It lasts three to five weeks depending on varieties, with a low average relative weekly increase in fruit weight (3 to 4 %). At the end of this stage, date fruit reaches its maximum weight and size, but sugar concentration

(saccharose), total sugar and active acidity have a rapid increase associated with a decrease in water content (around 50-85 % moisture content). It is to be noted that date fruit accumulate most of their sugar, both the sucrose type and the reducing sugar type, as sucrose during the Khalal stage (Table 4). At this stage colour of the seed changes at the end from white to brown.

Some varieties such as Barhee, Hallawi, Hayani and Zaghloul are consumed in this stage, as they are very sweet, juicy and fibrous but not sour. However, Khalal dates must be eaten immediately after harvesting as they will keep for only a few days without cold storage (7°C for one week or 0-1 °C for longer periods) due to their high sugar and water content which cause fermentation during hot weather. If supply and demand are in equilibrium, the Khalal season will last for a couple of weeks.

Varieties harvested and marketed at Khalal stage present the following advantages: minimum infestation, possibility of cutting the whole bunch, easy handling and packing, high yield and consequently high income.

d) *RUTAB STAGE*

Synonyms: Routab; meaning wet. Also called soft ripe stage.

At this stage the tip at the apex starts ripening, changes in colour to brown or black and becomes soft. It begins to lose its astringency and starts acquiring a darker and less attractive colour from the previous stage. However, some varieties such as Khadraoui (Iraq) and Bousekri (Morocco) turn green at this stage.

At this stage, which in total lasts for 2 to 4 weeks, there is a continuous decrease in fresh fruit weight mainly due to loss of moisture (Table 5). The average weekly decrease in fresh fruit weight is 10 % during the last week of the rutab stage.

An increase in reducing sugar, a rapidly increasing rate of conversion of sucrose, a gain of total sugars and total solids also characterise this stage. It has already been observed in respect of the reducing sugar type date, i.e. Barhee, that all the sucrose accumulated during the previous, Khalal stage, inverts and there is a continuous decrease in active acidity and decrease also in moisture content (average 30 - 45 %). With softening, the last of the tannin under the skin is precipitated in an insoluble form, so that the fruit loses any astringency that may have remained in the Khalal stage from the Kimri stage.

It is a very good stage for consumption as a hard ripe date. With the exception of a few varieties, fruit at this stage is very sweet. It is, however, very important to harvest and market the fruit at this stage. Unless they are cold stored, the fruits quickly turn sour and become of no commercial value. For dessert purposes, most people prefer dates after they have passed the Rutab stage.

e) *TAMAR STAGE*

Synonyms: Tamer, Tamr, also called full ripe stage or final stage in the ripening.

This is the stage when the dates are fully ripe, and they completely change the colour from yellow to dull brown or almost black. The texture of the flesh is soft. The skin in most varieties adheres to the flesh, and wrinkles as the flesh shrinks. The colour of the skin and of the underlying flesh darkens with time.

At this stage, the date contains the maximum total solids and has lost most of its water to such an extent (below 25 % down to 10 % and less) that it makes the sugar water proportion sufficiently high to prevent fermentation. This is the best condition for storage. The average relative decrease in fruit

weight during this stage is 35 %. The loss in fruit weight continues if fruits are left on the palm. This stage is equivalent to that of the raisin in the grape and the dried prune in the prune type of plum.

At the Tamar stage, the fruits on a bunch do not all ripen simultaneously, but over almost a month. Hence, three to four harvest times are necessary.

Comments

- Dates in all the above stages except the Tamar are perishable, due to their high water content.

- Whole dates are harvested and marketed at three stages of their development (Khalal, Rutab and Tamar) depending on variety, climatic conditions and market demand.

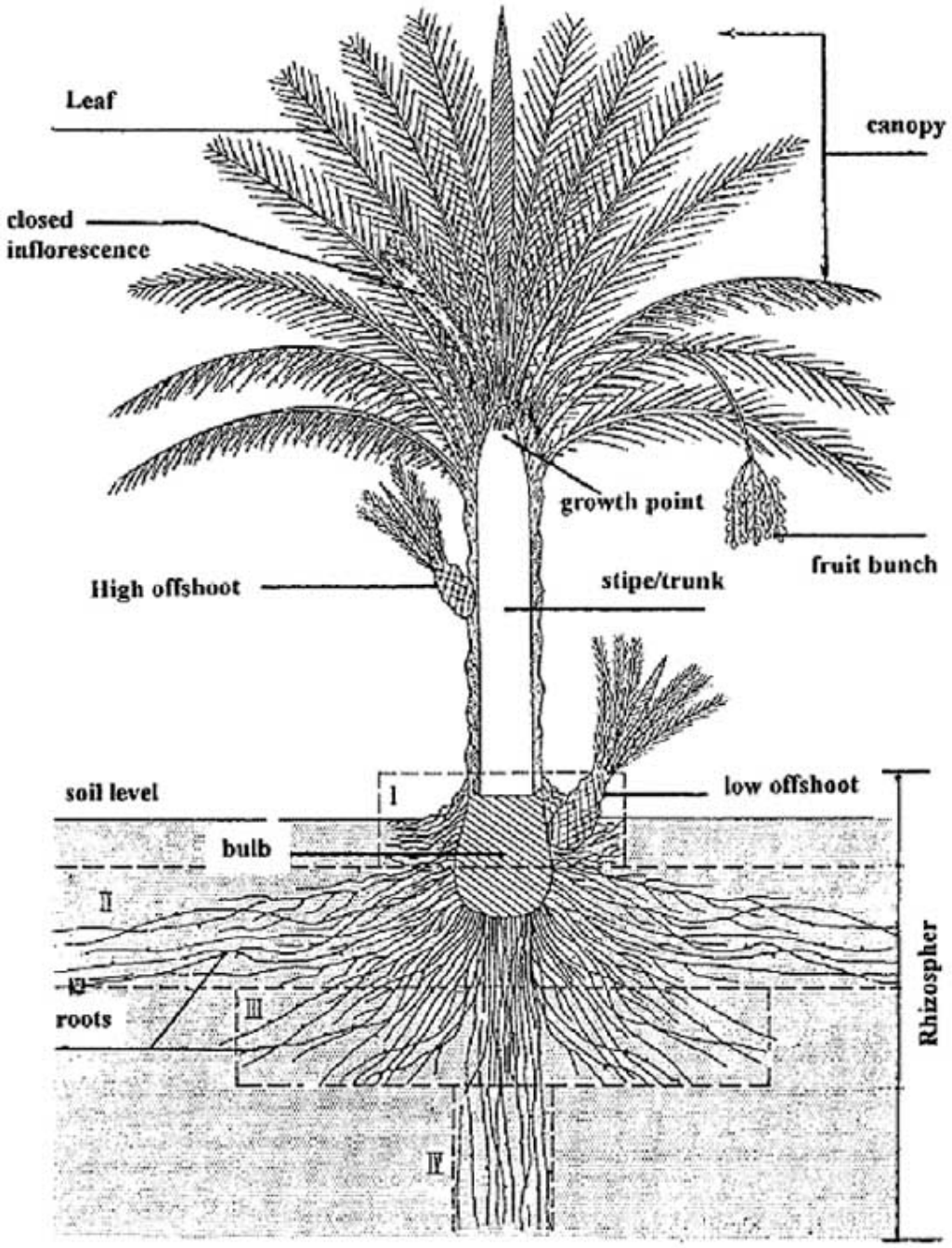
TABLE 4
Main changes in the composition of the Californian Barhee during development

Day of sampling	Stage of ripening	Fresh weight of fruit in grams	Percentage			
			of fresh weight	of dry weight	water	reducing sugars
23.5.39	Kimri	0.5	81	17	5	22
21.6	Kimri	5	86	43	5	48
2.8	Kimri	14	85	45	14	59
2.9	Khalal	16	64	17	62	79
11.9	Tree-ripe (rutab)	14	39	79	0.25	79

TABLE 5
Water content of a date fruit during its maturation from Khalal to Tamar stage

Stage	Water content (%)
Kimri and Early Khalal	85
Late Khalal	50
Early Rutab (tip browning)	45
50% Rutab	40
100% Rutab	30
Tamar	24 and less

Figure 1. Diagrammatic construction of a date palm with its root system



(Source: Munier, 1973 and Oihabi, 1991)

Figure 2. A young dichotomously branched date palm (*Phoenix dactylifera* L.) at Afechtal grove (Marrakesh, Morocco).

Figure 3. Date palm leaf characteristics.

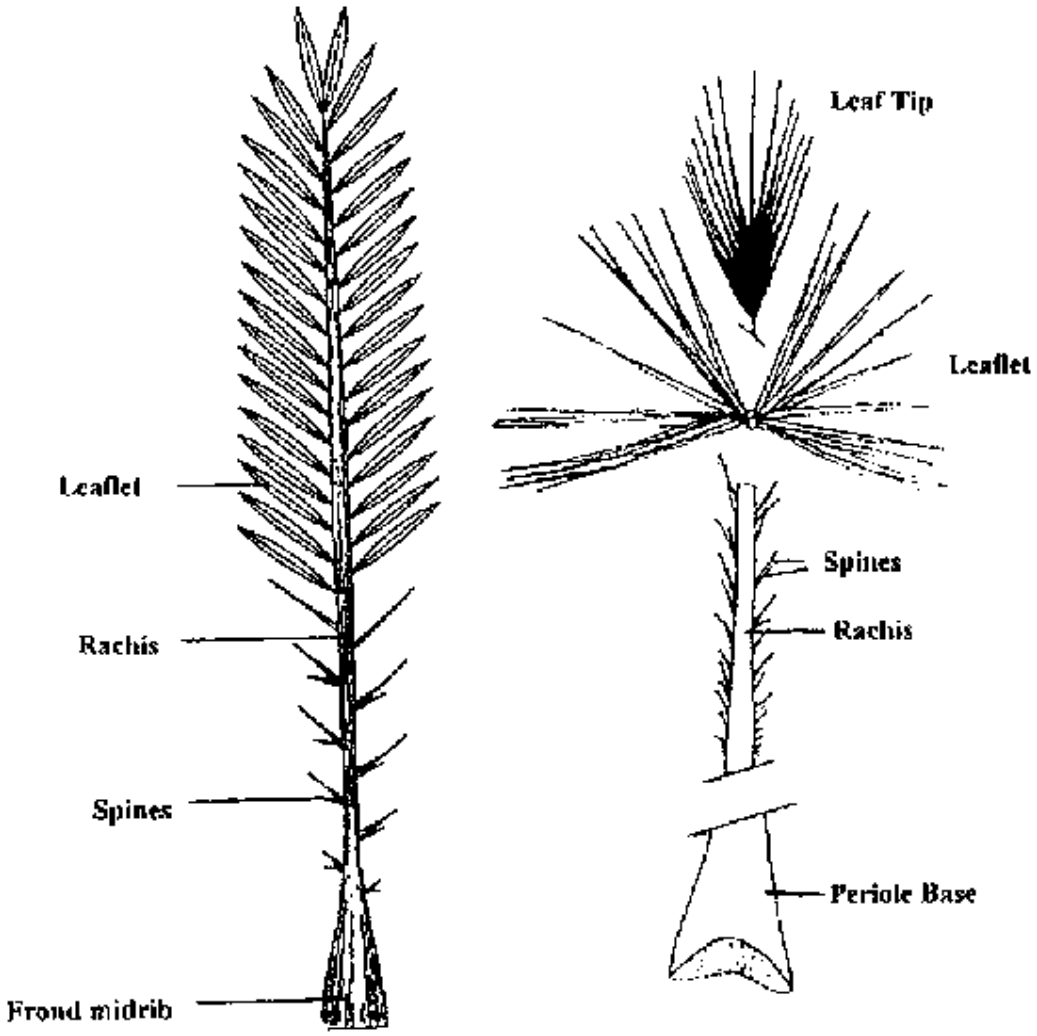
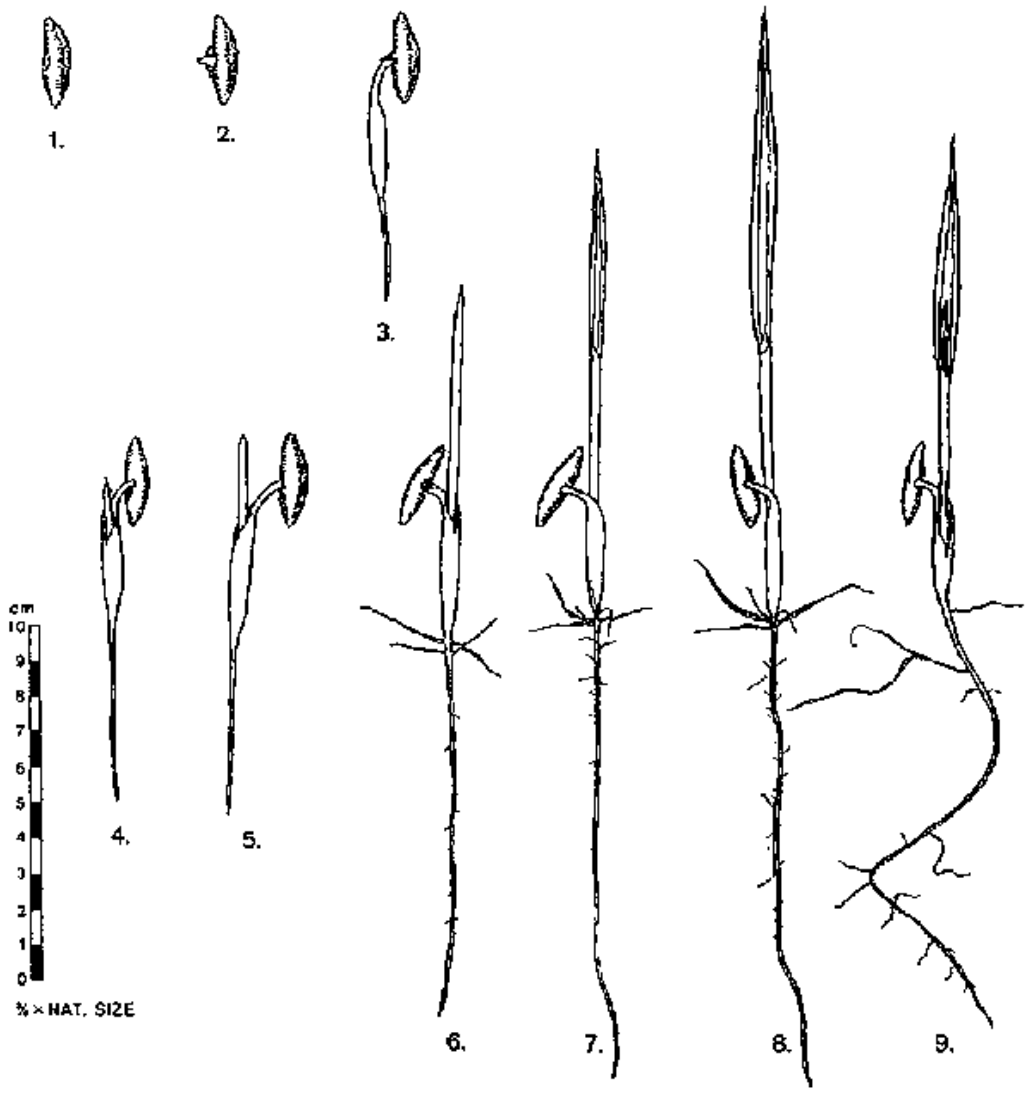


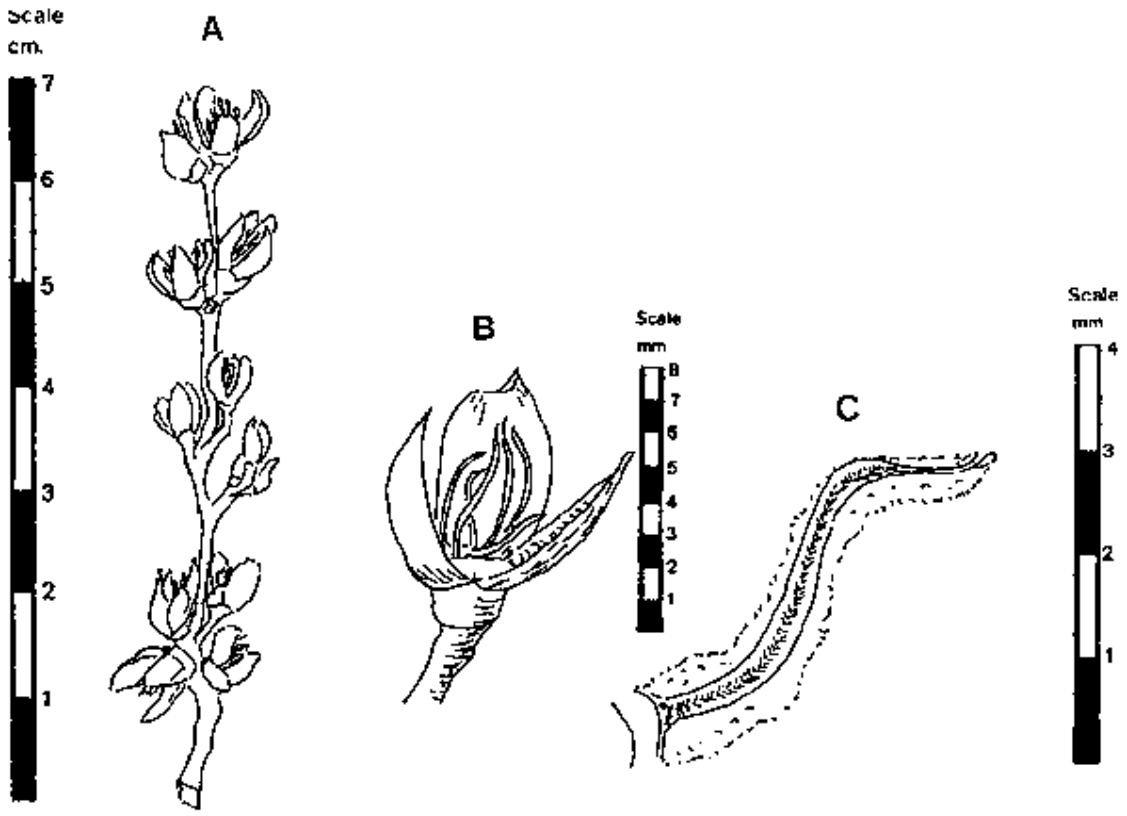
Figure 4. Date palm leaves grouped in 13 columns, spiralling to the right or to the left.

Figure 5. Various development stages of a date palm seedling of Deglet Nour variety.



(Source: Dowson, 1982)

Figure 6a. Date palm male flowers (Source: Dowson, 1982).



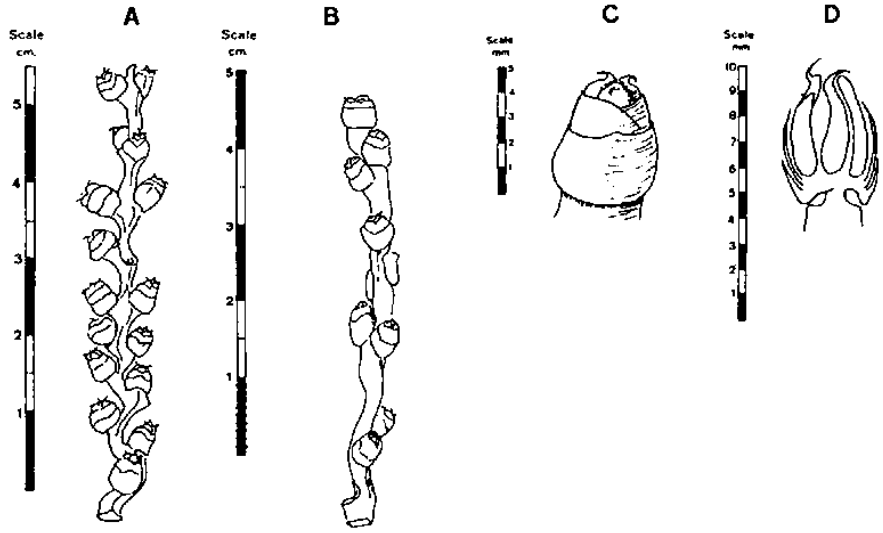
A. Spikelet

B. Flower: 6 stamens, 3 petals, and three-toothed calyx. Most of the flowers have 3 petals but a few have 4.

C. Stamen: Length about 4 mm.

Figure 6b. Date palm male inflorescence 4 days after opening.

Figure 7a. Date palm female flowers (Source: Dowson, 1982).



A.& B Two (short) spikes
From different palms of the Burunsi variety

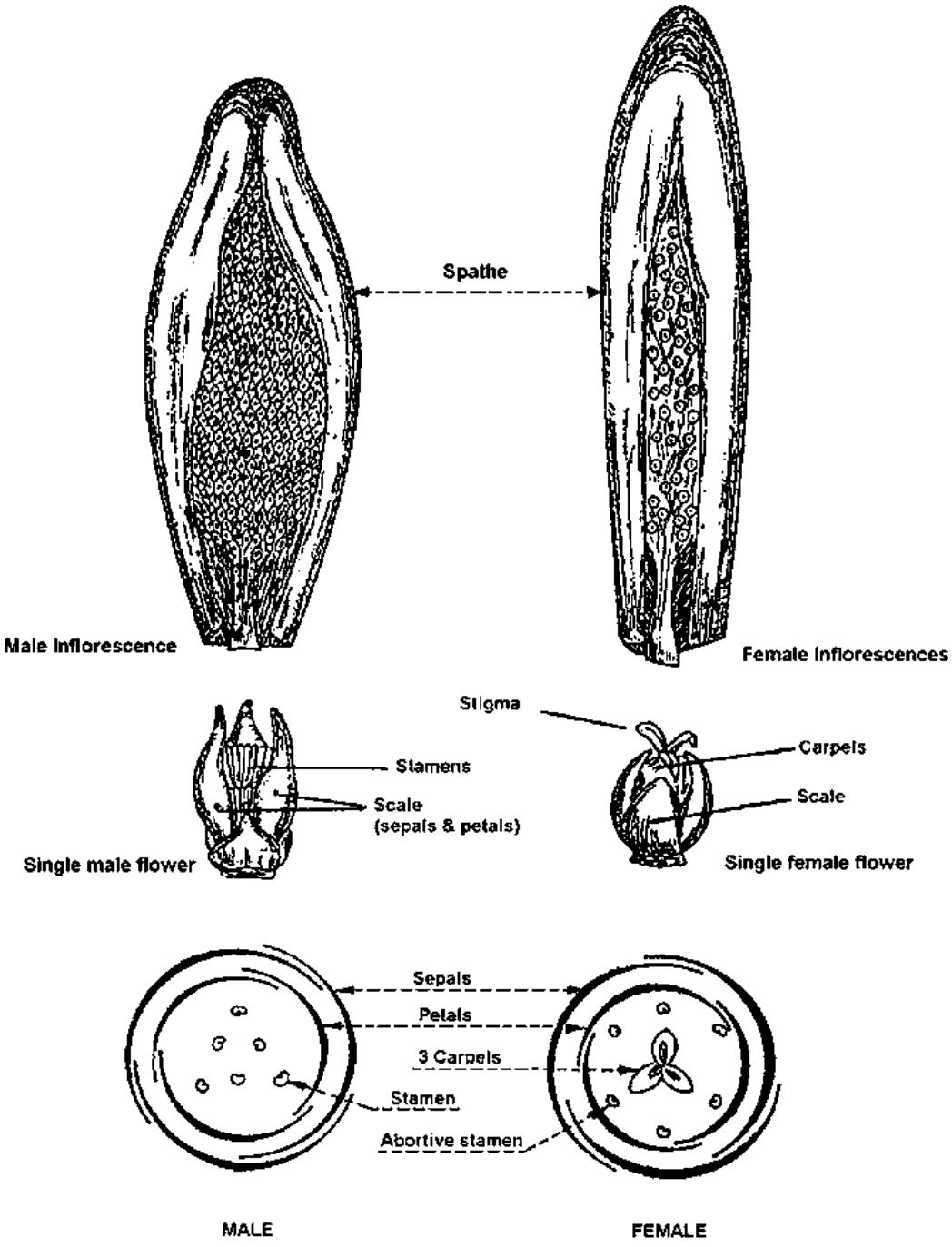
B. Four days after emergence from spathe

C. Unpollinated flower showing two of the three petals, the three-toothed calyx, and three unfertilized carpels.

D. Unpollinated flower: Vertical section six days after emergence from spathe.

Figure 7b. Female inflorescence of a seeding date palm 3 days after opening.

Figure 8. Date palm male and female inflorescences and flowers.



(Source: Munier, 1973)

Figure 9. Morphology and anatomy of date palm fruit and seed.

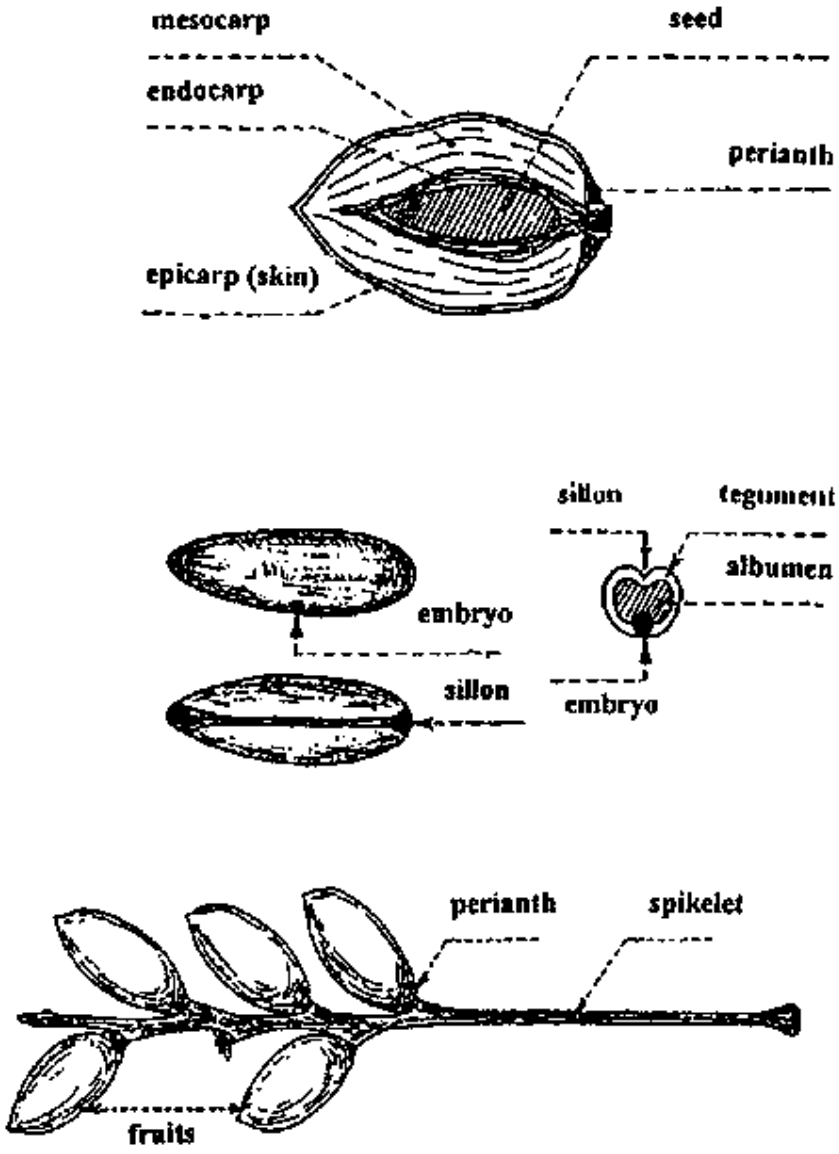


Figure 10. Lower section of a Medjool leaf showing spines and leaflets characteristics and distribution

Figure 11. Medjool samples showing fruit and seed characteristics

Figure 12. Commercial plantation of Medjool in Namibia (Naute Dam, March 1997)

Figure 13. First Barhee dates produced in Namibia (April, 1997)

Figure 14. Lower section of leaves showing spine characteristics of five commercial date varieties: A - Barhee; **B -** Dayri**; C -** Deglet Nour; **E -** Halawy

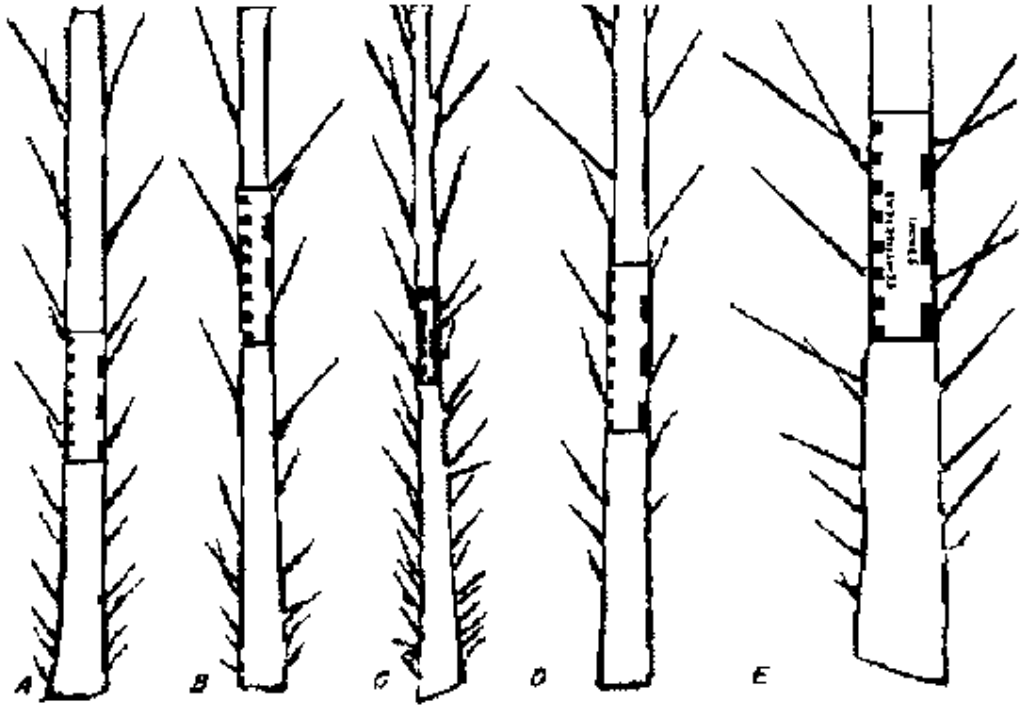


Figure 15. Barhee samples (Khalal stage) showing fruit and seed characteristics

Figure 16. Fruit Kimri stage of Barhee variety

http://www.fao.org/DOCREP/006/Y4360E/y4360e05.htm#bm05.3