

Phenological and Architectural Study of the Date Palm (*Phoenix dactylifera* L.) Female Inflorescence

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Abstract: The date palm (*Phoenix dactylifera* L.) is the main element upon which the sustainable biophysical and socio-economic organizations of the oasis ecosystem are based. The present study was carried to understand the phenology and the architecture of the date palm female inflorescence. The vegetal material was composed of two Tunisians cultivars of *Phoenix dactylifera* L. 'Kenta' and 'Rochdi'. The observations are taken place in Gabes. Generally the inflorescence development is acrotone. The opening of date palm spathes follows a 4-steps gradient during 3 to 6 weeks after the beginning of his emergence. The inflorescence rachis is bilateralized with one ramification order corresponding to the spikelets which are organized in pseudo-verticils. The measurement of the descriptive parameters shows some differences between the two varieties and allows executing realistic models.

Key words: *Phoenix dactylifera* L. • Cultivar • Inflorescence • Architecture • Models

INTRODUCTION

Date palm, *Phoenix dactylifera* L. (*Arecaceae*), is a dioecious monocotyledon; its vegetative propagation through shoot cuttings is widely practiced. Belonging to the *Phoenixaceae* tribe [1] classified in the model of Corner [2], the date palm is built with one vegetative axis with apical continues growth and a massive crown of leaves with thorny base, the inflorescence are produced laterally to the palm leaves. It is widely planted for its numerous uses and its ecosystem services, particularly for its edible fruits of which thousands of varieties were selected [3]. In Tunisia, there are over 250 cultivars that are considerably differed in their vegetative growth and yield characteristics. The unisexual flowers are borne in a big cluster (inflorescence) called spadix or spike, which consists of central stem called rachis and several strands or spikelets (usually 50-150 lateral branches). 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 flower mature exposing the entire inflorescence for pollination purposes [4]. Within the study present framework, the main purpose is to

understand the phenology and the architecture of the date palm female inflorescence. The knowledge of these parameters on the level of the reproductive organs will be used to compare and model the morphological characteristics of the two studied cultivars 'Rochdi' and 'Kenta'.

MATERIALS AND METHODS

Vegetal Material: The mature measured inflorescences of the two cultivars 'Rochdi' and 'Kenta' were taken in the date palm plantation of Nahal Gabes in south Tunisia and in total 64 inflorescences were used for this study. The work began with the identification of the date palm trees and their phyllotaxy using the parastichies 8 and 5. Locate the spire (the first incompletely deployed palm) considered No. 1, then numbering the palms to the base of the crown and each inflorescence took the rank of the palm which axile (Fig. 1 (a)).

Metric measurements: Metric measurement relate to the length of the spathe and the stalk measured with one tape meter and the height and width measured by means of a digital caliper at different check-points (Fig. 1 (b)).

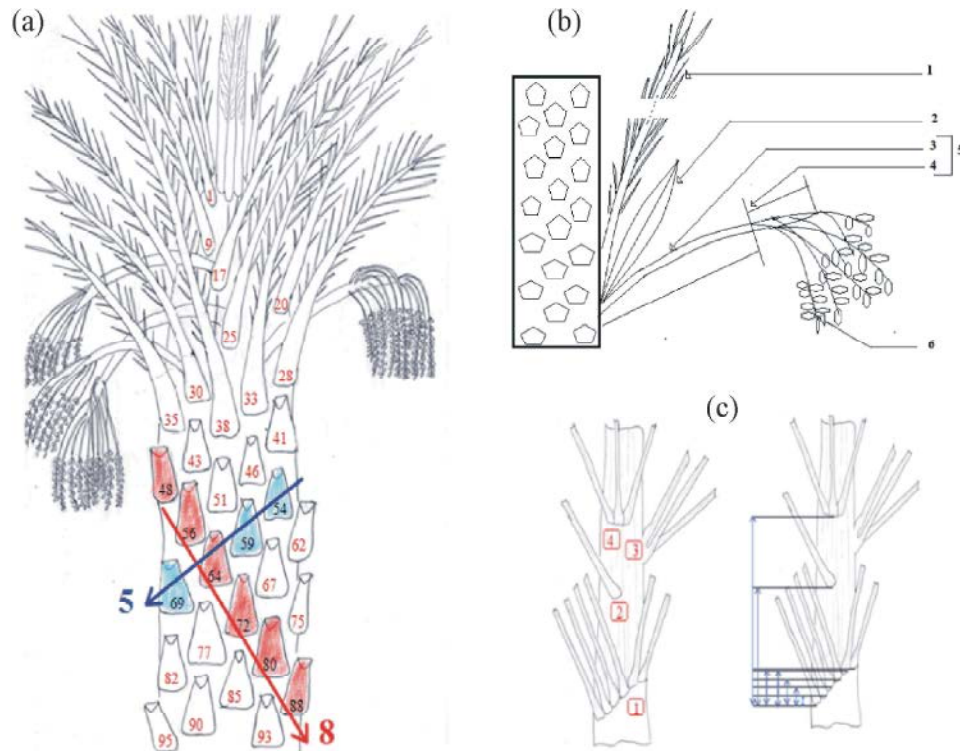


Fig. 1: Morphometric measurement on the inflorescences. (a) Numbering of the palms; (b) Palm tree inflorescence: 1-Palm; 2- Spathe; 3- Peduncle; 4-Rachis; 5-Stalk; 6-Spikelet; (c) identification of the spikelets groups and metric position

The length of the rachis which is the distance from the insertion of the first spikelet to the end of the inflorescence axis as for the width and height of the rachis are measured every five centimeters. For the spikelet we measured the total length, the sterile length from the insertion point on the rachis to the insertion of the first flower. The diameter was measured at the base of the spikelets and every 10 cm until the end. The number of each pseudo-vercical (spikelets group) is noted on the rachis, starting with the most basal pseudo-vercical (Fig. 1 (c)). Within a same pseudo-vercical, the spikelets positions are measured. For the fruit the length, width, weight and metric position were measured.

RESULTS

Spathe Development: The spathe requires an average of 4 weeks to reach its final size for the cultivar "Kenta" and 3 weeks for 'Rochdi', It is observed that the width of the spathe is usually somewhat variable and shall take a steady value within the first weeks of the inflorescence appearance, it is about 11 cm for "Kenta" and 7 cm for "Rochdi", the first two weeks are characterized by rapid growth with an average of 10 cm for 'Kenta' (Fig. 2)

and 7 cm 'Rochdi', these data are in line with those of Pintaud [5].

The spathes of the summit mayevolve of 20 cm in the first weeks for the cultivar 'Kenta' and 14 cm for 'Rochdi' knowing that they take a longer time to reach their final size compared to other lower inflorescences in the crown. The observation show that the width of the spathes is usually a little variable and shall take a steady value within the first weeks of theinflorescences appearance, it is about 11 cm for "Kenta" and 7 cm for "Rochdi"(Fig. 2).

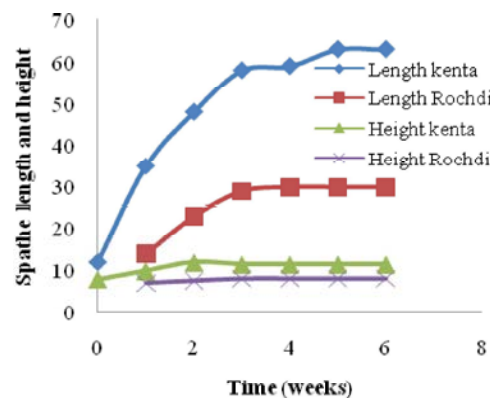


Fig. 2: Spathe length and height of the two cultivars 'Kenta' and 'Rochdi'.

Spathe Opening: The spathe development is acrotone. The highest spathes are the earliest and with the largest development, whereas the lower ones are the latest and the weakest. The observation of the spathe ripeness gradient confirms that there are three successive periods of spathe opening within the same palm tree crown for the two cultivars 'Kenta' and 'Rochdi'. The inflorescences of the summit open in the first followed by the median and peripheral inflorescences of the crown.

The observations confirm that when the spathe reached its final size it exists four stages before the full opening, the first step is the apparition of a torn at the extremity of the spathe, after a week the inflorescence summit emerges with white spikelets, during the third week the rachis emerged with yellowish and gathered spikelets and in the course of the fourth week the inflorescence is completely released and the spikelets are separated with green fruits, similar observations have been mentionned by Zaid *et al.*[4](Fig. 3).

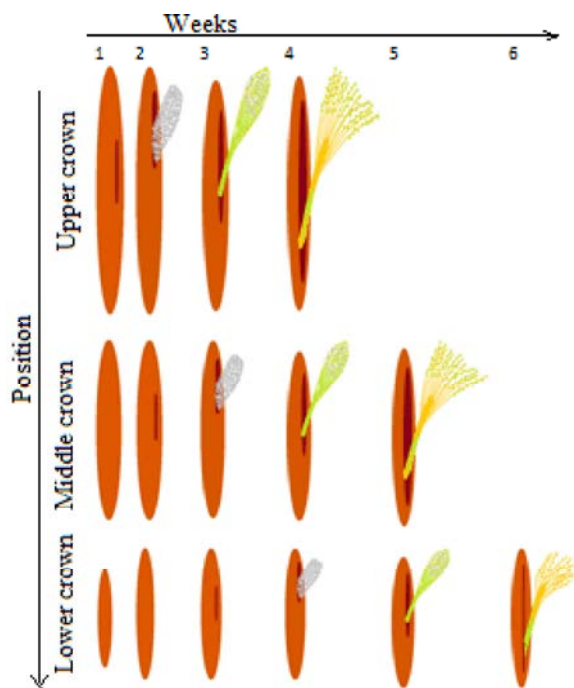


Fig. 3: The spathe opening gradient.

The Stalk Length: The stalk of the cultivar 'Kenta' is longer than the cultivar 'Rochdi'; the average scored values are 121 cm and 107 cm respectively. The observation confirms that the length of the inflorescences decreases when we are moving towards the crown periphery (Fig. 4).

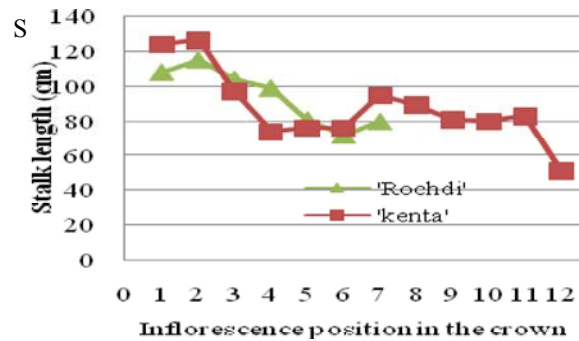


Fig. 4: Stalk length of the two cultivars 'Kenta' and 'Rochdi'.

Width and Height of the Stalk: Measurements show that along the peduncle the width and the height are constant and gradually decreases from the base to the tip of the rachis and this regardless of the inflorescence order and the observed cultivar (Fig. 5), similar results were found by Zango *et al.* [6]. The stalk of the cultivar 'Kenta' are larger with an average of 5 cm than those of the cultivar 'Rochdi' 3.51 cm (Table 1).

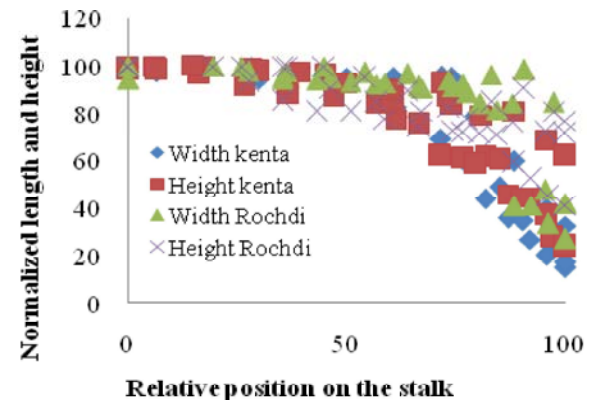


Fig. 5: Normalized length and height of the cultivars 'Kenta' and 'Rochdi'.

Metric Measurements on the Spikelets: The spikelets of the cultivar 'Kenta' are the longest with an average of 52 cm compared to 'Rochdi' 37 cm. The cultivar 'Kenta' is characterized by a large number of spikelets and fruits with an average of 71 spikelets and 2741 fruits per inflorescence (Table 2).

Inflorescence Classification: The different observations allow the classification of the 'Rochdi' inflorescences into three types: -Inflorescences type 1: belonging to the upper crown and are characterized by an average spikelets number of 64, rachis length of 31.23 cm, total spikelets length of 43.57 cm and flower number equal to 2363.

Table 1: Stalk characteristics of the two Tunisians cultivars.

Cultivar	Peduncle		Rachis	
	Mean width (cm)	Mean height (cm)	Mean width (cm)	Mean height (cm)
'Rochdi'	3.51	1.15	2.31	0.95
'Kenta'	5	1.72	2.15	0.95

Table 2: morphometric characteristics of eachcultivarspikelets.

Cultivar	Mean spikelets number	Mean spikelets length	Mean sterile length	Mean fertile length	Mean flowers number
'Kenta'	72.26	51.62	24	27.62	2741
'Rochdi'	48.28	37.51	21.3	16.21	1413

Table 3: Inflorescence types of the cultivar 'Rochdi'.

Cultivar	Mean rachis length (cm)	Mean spikelets number	Mean spikelets total length (cm)	Mean spikelets fertile length (cm)	Mean spikelets sterile length (cm)	Mean flowers number	Mean fruits number
Rochdi T1	31.23	64	43.57	20.12	23.44	2363	497
Rochdi T2	24.22	56	46	20.92	25	1893	496
Rochdi T3	5.7	32	27.82	10.44	17.37	460	156

Table 4: Inflorescence types of the cultivar 'kenta'.

Cultivar	Mean rachis length (cm)	Mean spikelets number	Mean spikelets total length (cm)	Mean spikelets fertile length (cm)	Mean spikelets sterile length (cm)	Mean flowers number	Mean fruits number
Kenta T1	26.55	78	55.6	30.7	25	3636	135
Kenta T2	18.31	53	41	18.86	22	1239	152

- Inflorescences type 2: this type of inflorescence may be encountered in the middle or upper crown.
- Inflorescence type 3: they belong to the lower crown and are generally less productive compared to other (Table 3).

The observations allowed the classification of the cultivar 'Kenta' inflorescences into two categories:

- Inflorescences type 1: belonging to the inner part of the crown and are characterized by an average spikelets number of 78, rachis length of 26.55 cm and a flower number equal to 3636.
- Inflorescence Type 2, they belong to the lower part of the crown and are often less productive compared to the other inflorescences types (Table 4).

The Pseudo-Verticils Phyllotaxy: The observation of the spikelets distribution shows the importance of comparing the ventral and dorsal sides of the rachis in the horizontal plane.

The Rachis Phyllotaxy of the Cultivar 'kenta': *Ventral side: The observations of the rachis base from 0 to 20%

confirm the presence of two dense pseudo-verticils stacked in two parallel series with spikelets group of 5 to 12 spikelets and from 20 to 100% there is a progressive decrease of spikelets number with the presence of some spikelets group of 2 and 3.

***Dorsal Side:** commonly there is one dense pseudo-verticil between 0 and 20% of the rachis length.

Half of the cultivar 'Kenta' spikelets are found in 15% of the rachis length for the upper inflorescences and 24% of the rachis length for the inflorescences of the crown periphery (Fig. 6 (a),(b)).

The Rachis Phyllotaxy of the Cultivar 'Rochdi': Ventral side: The observations of the rachis base from 0 to 40% of the total length confirm the existence of some single spikelets and usually one dense pseudo-verticil. The part between 50 and 60% of the rachis length is commonly characterized by the absence of spikelets, while the last portion is distinguished by the presence of some spikelets groups looped around the rachis.

Dorsal Side: Characterized by the existence of some parallel pseudo-verticils along the rachis(Fig.6 (c),(d)).

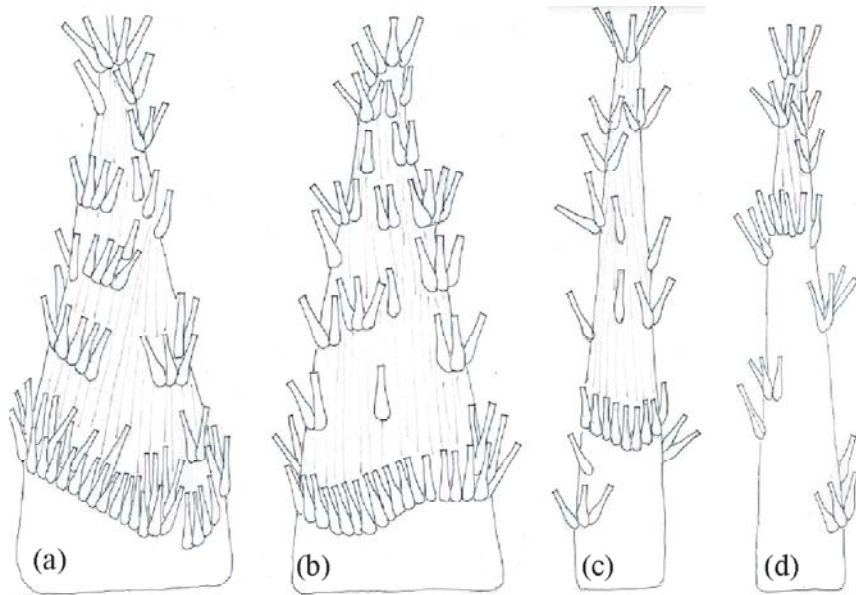


Fig. 6: The rachis phyllotaxy of the two cultivars 'Kenta' and 'Rochdi'. (a) 'Kenta' ventral side; (b) 'Kenta' dorsal side; (c) 'Rochdi' ventral side; (d) 'Rochdi' dorsal side.

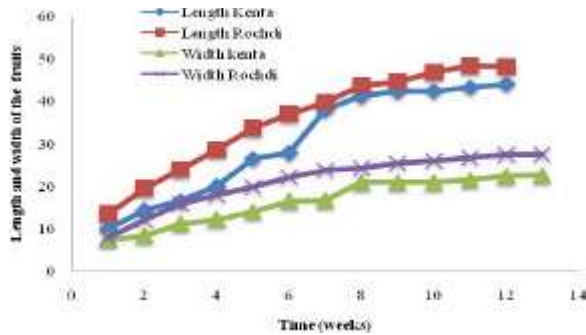


Fig. 7: Length and width of the two cultivars 'Kenta' and 'Rochdi' fruits.

Growth Cycle of the Date Palm in the Littoral Oasis of Tunisia:

Monitoring of the fruit growth in both 'Rochdi' and 'Kenta' cultivars at different stages shows that of the fruits growth of the cultivar 'Rochdi' is the earliest and the most important point of view characteristic dimensions with an average of fruit width of 2.7cm and length of 4.4 cm in comparison to 'Kenta' Width = 2.5 cm and length = 4.4cm (Fig. 7). The observation of inflorescence development and ripeness has allowed the deducing of the date palm vegetative cycle (Table 20) in the climatic and cultural conditions of the coastal oasis in south Tunisia, although there is usually slight differences between the two varieties, for example the

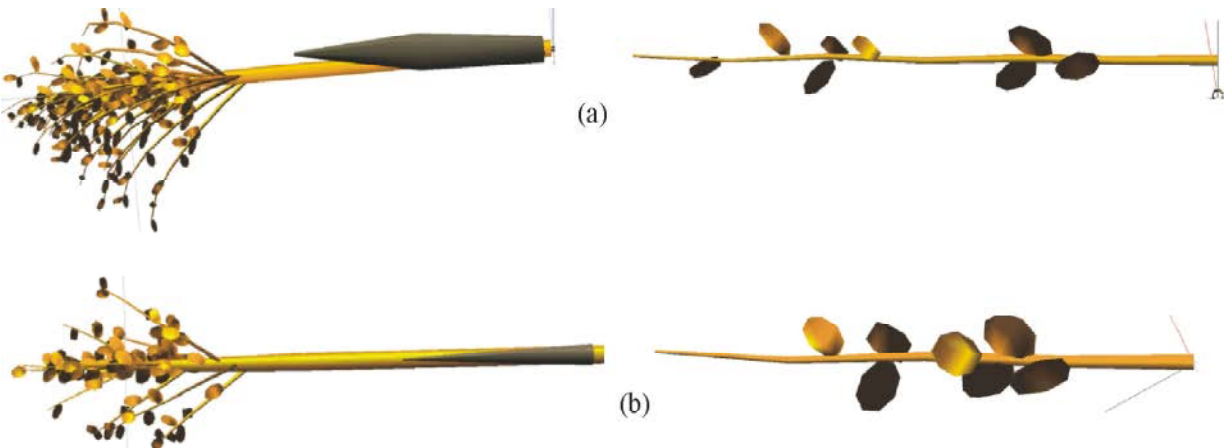


Fig. 8: Modeling of the date palm bunches; (a) 'kenta' bunch and spikelet; (b) 'Rochdi' bunch and spikelet.

Table 5: Growth cycle of the date palm in the littoral oasis of Tunisia.

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering -pollination												
Fruit set												
Fruit growth												
Fruit ripening												

spathes of the cultivar 'Kenta' are the earliest but the cultivar 'Rochdi' is characterized by a much faster fruit set and ripeness, the results obtained in this study are in agreement with those obtained by El Houmaizi [7] (Table 5).

Modeling of the Fruiting Architecture: The set of morphometric measurements on the characteristic parameters of the date palm female inflorescence architecture have led to the modeling of the two Tunisian cultivars 'Rochdi' and 'Kenta'. The software "Explo" designed by CIRAD agronomist allows individualizing separately aerial vegetative organs and reproductive systems in different topological level; it extracts the palms, pinnae, bunches and spikelets distinctly which facilitates the comparison of the two cultivars later (Fig. 8 (a),(b)).

Conclusion and Perspectives: *Phoenix dactylifera* L. is widely distributed and performs an important socio-economic role in the south of Tunisia. For instance, more than 10% of Tunisian population depends on date palm's culture where more than 250 cultivars have been inspected [8]. In this study we have measured numerous architectural and phenological parameters of the date palm female inflorescence. Generally the inflorescence development is acrotone. The opening of date palm spathes follows a 4-steps gradient during 3 to 6 weeks after the beginning of his emergence. The inflorescence rachis is bilateralized with one ramification order corresponding to the spikelets which are organized in pseudo-vercils. The measurement of the architectural parameters allows executing realistic models. The next step will be the study of the relation between aerial and reproductive architecture of other date palm cultivars. A significant work remains to be made to describe precisely the spikelets architecture.

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