European Journal of Scientific Research
Revue Européenne de la Recherche Scientifique

Modeling of the date palm (*Phoenix dactylifera* L.) inflorescence architecture, example of three Tunisian cultivars

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Abstract

The present study was carried to characterize the female inflorescence architecture of the date palm through the valuation of numerous structural and geometric parameters. The vegetal material was composed of three Tunisians varieties of Phoenix dactylifera L., 'kenta', 'Rochdi' and 'Barhi'. The observations are taken place in the littoral oasis of Gabes. Analysis confirms that the length of the inflorescences decreases when we are moving towards the crown periphery. We notice that the width and height of the peduncle are constant throughout its length, irrespective of the inflorescence position in the crown. Analyses show that the spikelets lengths are linked to their relative position on the rachis. Results obtained from analyzing the morphological and architectural characters show some differences between the two varieties. The study of the spikelets organization on the rachis and the dates on the spikelets allow implementing a new measurement protocol for computing and simulating realistic 3 D models.

Key words: *Phoenix dactylifera* L., female, inflorescence, architecture, models.

1. Introduction

Date palm (*Phoenix dactylifera* L.) represents a focal point in crop production within the oasis system. Date palm constitutes the principal basis of social, environmental and economic stability in south Tunisia. About 250 cultivars of date palm are identified in Tunisia (Rhouma, 1994). The *Arecaceae* or palm family is large and its members are morphogically diverse (Moore, 1973) *Phoenix* is distinguished from other palm groups by the morphology of the leaf and leaflets (Tomlinson1961). Classified in the model of Corner according to the botanists (Halle and Oldeman, 1970) the date palm is generally characterized by only one vegetative axis with apical and continues growth on which the inflorescences are produced laterally to the palm bases. The date palm is dioecious specie, where the male and female flowers are

beard by separated individuals. 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 (Zaid and de Wet, 2002). The flower stalks of the date are produced from the axils of the leaves in similar positions to those in which the offshoots are produced (Mason, 1915). Within the study present framework, the main purpose is to understand the architecture and the geometry of the female inflorescences .Plant architecture is defined like the whole of the structural forms which the plant presents throughout its existence; topology is the way in which its organs are laid out the ones linked to the others, while the geometry describes the size and arrangement in the space of these organs (Barthelemy and Caraglio, 2007). The knowledge of these parameters on the level of the inflorescence will be used to evaluate the morphological characteristics of the three studied varieties.

2. Material and methods

2.1. Plant material

The mature measured inflorescences of the three cultivars ‘kenta’, ‘Rochdi’ and ‘Barhi’ were taken in the palm plantation of Nahal Gabes in south Tunisia and in total 64 mature 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.

2.2. Metric measurement

Metric measurements relate to the length of the stalk which is the distance from its insertion on the stem until the end of the inflorescence axis measured with one tape meter and the width and height measured by means of a digital caliper at different check-points. 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 (Fig. 1).

For the spikelet we measured the total length, which is the length from the insertion point on the rachis axis until the end of the spikelet, the sterile length from the insertion point to the insertion of the first flower. The diameter was measured at the base of the spikelets and then every 10 cm until the end. For the fruit the length, width and weight were measured.

3. Results

3.1. The spathe development

The spathes 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 spathes ripeness gradient confirms that there are three successive periods of spathe opening

within the same palm tree crown for the three cultivars ‘Barhi’ and ‘Rochdi’ and ‘kenta’. The inflorescences of the summit open in the first followed by the median and peripheral inflorescences of the crown.

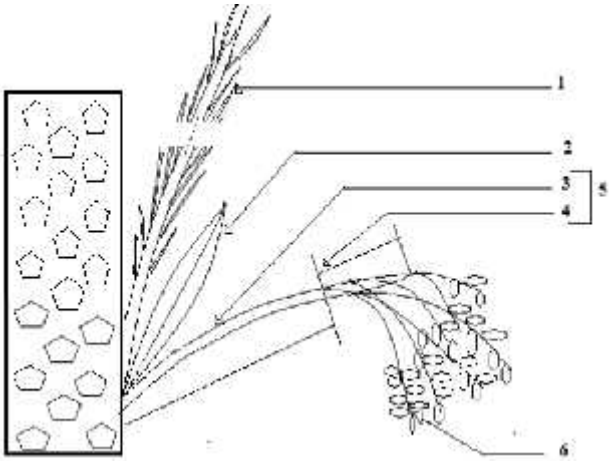

Figure 1: Date palm inflorescence.
1-Palm; 2- Spathe; 3- Peduncle; 4-Rachis; 5-Stalk; 6-Spikelet

3.2. The stalk and rachis length

The average length of the stalk of the variety ‘kenta’, ‘Rochdi’ and ‘Barhi’ is successively equal to 107 cm, 121 cm and 160 cm. It is found that there is significant correlation between the stalk length and the position of the inflorescence in the crown for the three varieties ‘kenta’ $R^2 = 0.53$, ‘Rochdi’ $R^2 = 0.85$ and ‘Barhi’ $R^2 = 0.87$ (Fig. 2 (A)). The observation confirms that the length of the inflorescences decreases when we are moving towards the crown periphery. For variety ‘kenta’ we note the existence of a strong correlation between the rachis length and the position of the inflorescence in the crown $R^2 = 0.71$, for ‘Rochdi’ $R^2 = 0.41$ and ‘Barhi’ $R^2 = 0.31$ (Fig. 2 (B)).

3.3. Width and height of the stalk

The stalks width of the variety ‘Barhi’, ‘Rochdi’ and ‘Kenta’ depending on the relative position of the control points shows considerable correlation, the corresponded scored correlation are $R^2 = 0.47$, $R^2 = 0.4$ and $R^2 = 0.5$ respectively (Fig. 3 (A)), the correlation is negligible for the peduncle $R^2 = 0.08$, $R^2 = 0.13$ and $R^2 = 0.01$ (Table 1) but it becomes very important in the rachis $R^2 = 0.93$, $R^2 = 0.69$ and $R^2 = 0.84$ (Table 1).

We also note the strong correlation of the stalks height as a function of the relative position of the control points for the three cultivars ‘Barhi’, ‘Rochdi’ and ‘Kenta’ (Fig. 3 (B)) $R^2 = 0.69$, $R^2 = 0.35$ and $R^2 = 0.52$, this value is higher in the rachis $R^2 = 0.82$, $R^2 = 0.92$ and $R^2 = 0.73$ (Table 1) relative to the peduncle $R^2 = 0.43$, $R^2 = 0.25$ and $R^2 = 0.06$ (Table 1).

We notice that the width and peduncle height are constant throughout its length, irrespective of the position of the inflorescence in the crown and cultivar studied but with very low correlations relative to the fertile part. The low correlation of height and width as a function of the control points at the sterile part of the stalk or peduncle confirm the existence of an intra-varietal variability (Table 1). Along the fertile part of the stalk or rachis is found that the width and height gradually decreases from the base to the tip, irrespective of the inflorescence

order and the observed variety. Peduncles of the cultivar 'Kenta' are larger with an average of 5 cm than those of the variety" Barhi "mean = 4.7 cm" Rochdi "mean = 3.51 cm.

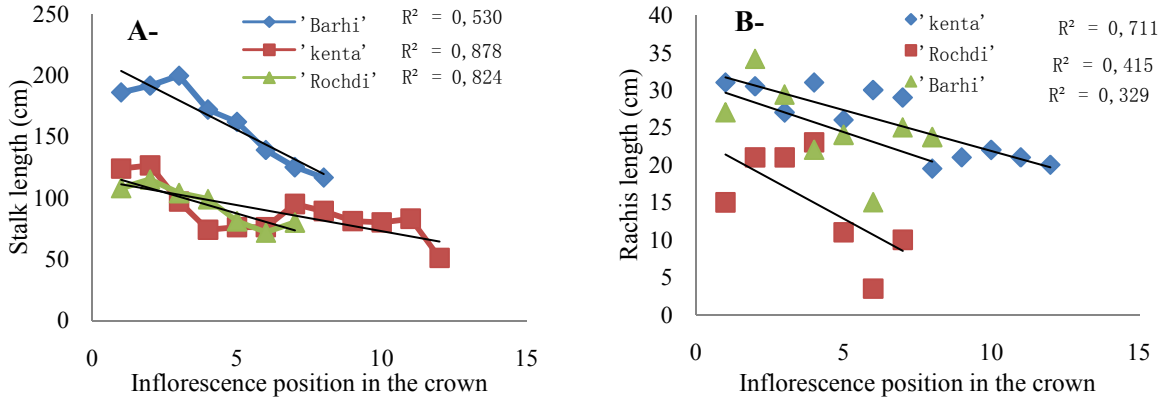

Figure 2: Inflorescence dimensions of 'Barhi', 'kenta' and 'Rochdi' (A) Stalk length; (B) Rachis length.

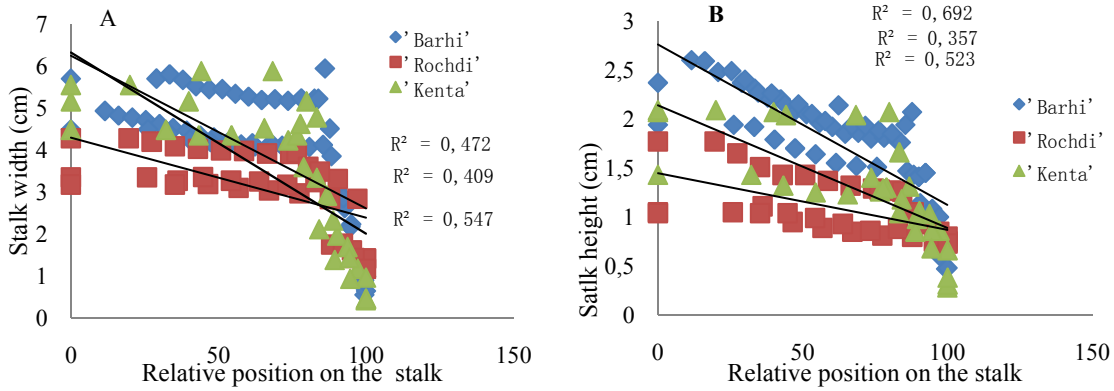

Figure 3: Stalk dimensions of 'Barhi', 'Rochdi' and 'Kenta' cultivars; (A) Stalk width; (B) Stalk height

3.4. Metric measurements on spikelets

The total length of spikelets (Fig. 4 (A), (B)) and the diameter along the spikelet of the three observed cultivars 'kenta' 'Rochdi' and 'Barhi' decrease from the base of the rachis towards its end, irrespective of the inflorescence position in the crown. The spikelets of the variety 'kenta' are the longest with an average of 52 cm, 'Barhi' 49 cm and "Rochdi." 37 cm. Varieties "Bahri" and 'kenta' are characterized by a similar number of spikelets in average 71 per inflorescence with neighboring fertile and sterile lengths, the number of flowers of the variety kenta is higher compared to 'Barhi' but the number of fruits produced by the cultivar 'Barhi' is much higher (Table 2).

3.5. Development of the fruits

The monitoring of fruit growth for the three varieties 'Barhi', 'Rochdi' and 'kenta' at different stages of development: the diameter, length and weight (Fig. 5 (A), (B), (C)) shows that the fruits growth of the variety 'Rochdi' is the earliest and the most important point of view

characteristic dimensions of fruit, we found the diameter D = 2.7cm and length L = 4.4 cm in comparison to ‘kenta’ D = 2.5 cm, L = 4.4 cm and ‘Barhi’ D = 2.7, L = 3.2.

Table 1: Stalk dimensions.

	Peduncle		Rachis	
	Width R²	Height R²	Width R²	Height R²
« Barhi »	0.08	0.43	0.93	0.82
« Rochdi »	0.13	0.25	0.69	0.92
« Kenta »	0.01	0.06	0.84	0.73

Table 2: Morphometric characteristic of each variety spikelets.

	Rachis length (cm)	Spikelets number	Spikelets length (cm)	Sterile length (cm)	Fertile length (cm)	Flowers number	Fruits number
‘Kenta’	24.84	72.26	51.62	24	27.62	2741	238
‘Barhi’	25.21	71.5	49	23.82	25.18	2384	1182
‘Rochdi’	18.28	48.28	37.51	21.3	16.21	1413	351

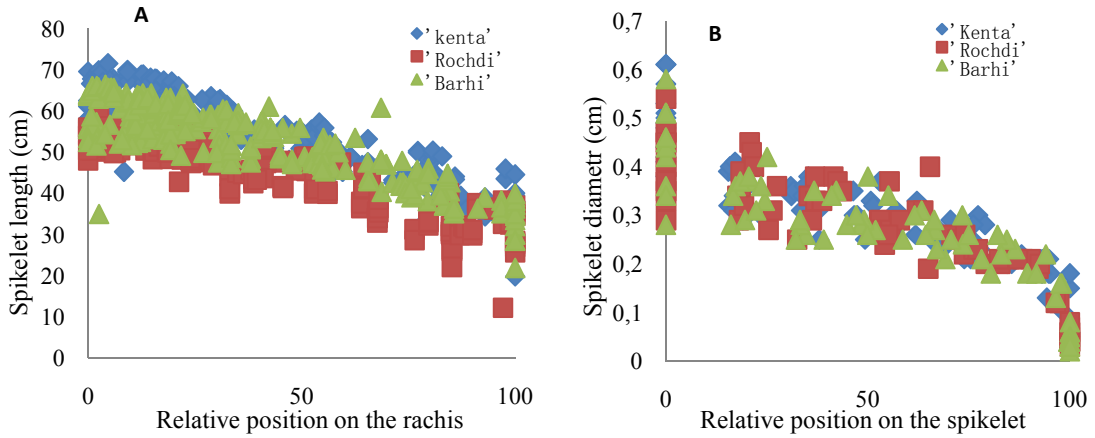

Figure 4: Spikelet dimensions of ‘Kenta’,’Rochdi’ and ‘Barhi’ cultivars; (A) spikelet length; (B) spikelet diameter.

3.6. Modeling of the fruiting architecture

The set of metrics and geometrical measurements on the different characteristic parameters of the date palm architecture have led to the modeling of the three varieties at different ages. The software "Explo" also allows individualizing separately aerial vegetative organs and reproductive systems in different topological level; it extracts the palms, pinnae, bunchs and spikelets distinctly which facilitates the comparison of the characteristics of different cultivars later.

Modeling bunches allowed to directly observing the difference in fruiting rate among the three cultivars; cultivar ‘Bahri’ is characterized by the most filled bunches where 100% of flowers produce fruits, for ‘Rochdi’ only 30% and ‘kenta’ 32% (Fig. 6 (A), (B), (C)). This variability in the density of the fruit is clearer on spikelets where one notices the homogeneous distribution of the fruit throughout the fertile part in ‘Barhi’ while the spikelets

of ‘kenta’ and ‘Rochdi’ are very lightly loaded by fruits (Fig. 7 (A), (B), (C)), knowing that the three varieties are grown in the same conditions, however the variety 'Barhi’ shows much adaptation and resistance to the culture conditions which explains the great productive output.

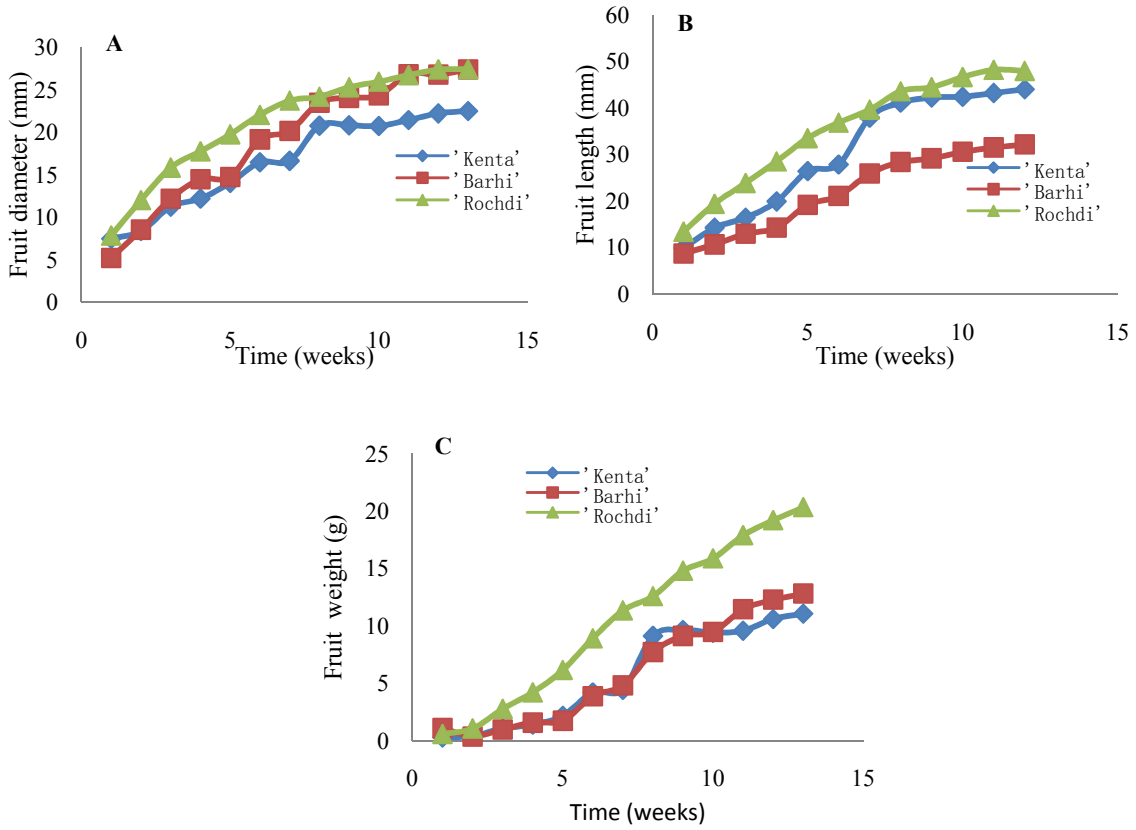

Figure 5: Fruit dimensions of ‘Kenta’,’Barhi’ and ‘Rochdi’ cultivars; (A) Fruit diameter; (B) Fruit length; (C) Fruit weight.

4. Discussion

The spathes development is acrotone. The highest spathes are the earliest and the most developed, while the lower ones are the latest and the weakest. The spathes ripeness gradient shows that there are three successive periods of spathe opening within the same palm tree crown. The observation confirms that the length of the inflorescences decreases when we are moving towards the crown periphery .These results are in accordance with those reported by Pintaud (2008-2011) and Bouguedoura (1979).

We note the existence of a strong correlation between the rachis length and the position of the inflorescence in the crown.

The width and peduncle height are constant throughout its length but with very low correlations relative to the fertile part which confirms the existence of an intra-varietal variability .These data are in line with those of Zango et al (2011). The total length of spikelets and the diameter along the spikelet of the three observed cultivars ‘kenta’ ‘Rochdi’ and ‘Barhi’ decrease from the base of the rachis towards its end.

The monitoring of fruit growth for the three varieties ‘Barhi’, ‘Rochdi’ and ‘kenta’ at different stages of development: the diameter, length and weight shows that the fruits growth of the

variety ‘Rochdi’ is the earliest and the most important point of view characteristic dimensions of fruit.

5. Conclusion

The set of metrics and geometrical measurements on the different characteristic parameters of the date palm architecture have led to the modeling of the three varieties at different ages. Modeling bunches allowed to directly observing the difference in fruiting rate among the three cultivars; cultivar ‘Barhi’ is characterized by the most filled bunches where 100% of flowers produce fruits. Knowing that the three varieties are grown in the same conditions, however the variety 'Barhi "shows much adaptation and resistance to the culture conditions which explains the great productive output.

Figure 6: Modeling of the bunches; (A) ‘Barhi’ bunch; (B) ‘Kenta’ bunch; (C) ‘Rochdi’ bunch

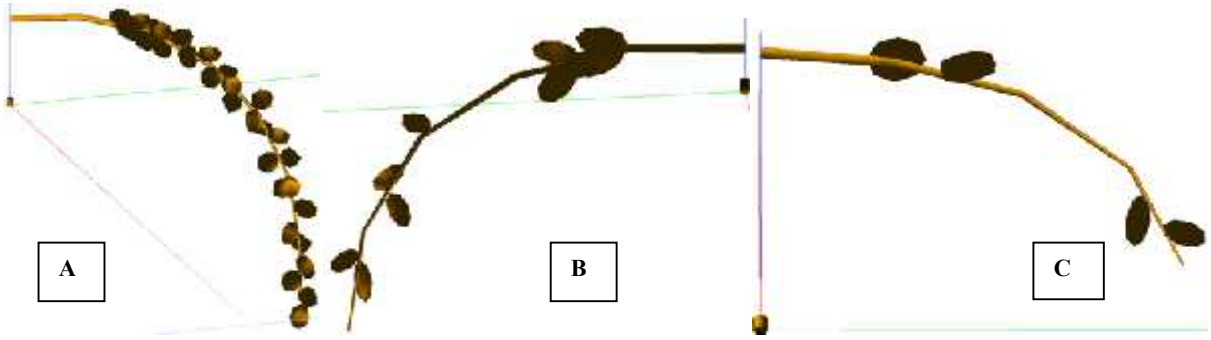

Figure 7: Modeling of the spikelts; (A) ‘Barhi’ spikelet; (B) ‘Kenta’ spikelet; (C) ‘Rochdi’ spikelet.

Acknowledgment

The network which allowed these works is supported by a ‘Euro-Mediterranean 3+3’ consortium, reinforced by PhD students who benefit from a mobility support as part of a PHC-Maghreb program from Campus France. We thanks all the members of these networks

and, particularly M. A. El Houmaizi, N. Bouguedoura, M. Bennaceur, , C. Littardi, R. Lecoustre and all the other Ph.D. students involved in these programs and particularly, O. Zango.

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