Phyllotactic variability of some Algerian date palm varieties

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ABSTRACT

The phyllotaxis phenomenon for certain date-palm (Phœnix dactylifera L.) was not deeply and thoroughly studied. Indeed, our purpose aims to confirm some phyllotaxis hypothesis for seven Algerian date-palm varieties. Using an empirical method, we have studied the phyllotactic variability based on biometrical measures of date-palm trunk. The study shows that for the divergence angle, orthostical distance and parastichy's slope in each contact parastichy matters in their phyllotactic modeling. The results confirm an intravarietal difference in the phyllotaxis of the seven studied varieties. The particular concluded remark is that the thirteenth parastichy of Itima variety become orthostic, which give the specific aspect (overlaid leaves) on the corona.

Keywords: Phyllotaxis, Contact Parastichy, *Phoenix dactylifera*, Algerian date-palm.

INTRODUCTION

The date palm's phyllotactic systems did not receive enough attention for in-depth study of *Phœnix Dactylifera L.*, There are few studies treating this subject, especially for the local varieties in Arab countries. Our study comes to check some hypotheses about the determinants of the phyllotactic systems for seven varieties of Algerian date palms.

With an empirical method, we aim to show the variability in phyllotactic systems, relying on a biometric measurements on the trunk of the palm, considering so that the divergence angle, the distance between orthostics, and the parastichy's slope in each contact parastichy which matters in modeling phyllotactic systems. The results confirm an intervarietal difference in the phyllotatic structure of the studied varieties. The particular concluded remark is that the 13th parastichy of Itima variety become orthostic, which give the specific aspect on the corona.

Our research paper is structured as following. First, a brief look at the conception evolution in the theoretical research of phyllotaxis. We focus after that on the phyllotactic systems of the palm, particularly, of the date palm. At second, we explain the methodology as well as experimental and modeling method used. Finally, we present and discuss the most important results obtained.

An Overview of Theoretical Framework of the Phyllotactic Systems

The phyllotaxis is currently considered as a multi-disciplinary with different methodologies. Guerreiro (1995) deduced its applications as a physical system and mathematical framework used in modern theoretical studies of phyllotaxis. The origins of the theoretical studies are relates to the work of Arthur Church (1904) who framed and theorized the phyllotaxis with mathematical approach. He has relied on the previous famous works of Bravais brothers with their descriptive approach. Every research had treated the simplest pattern of phyllotaxis.

The beginning of the in-depth studies coincide with the studies of the apical meristems structure where with studying the activity of this latter, we can understand the leaves' positions on the stem. The Plantefol theory (1947) has given a comprehensive approach of the apical meristem activity.

In modern approaches, Roger Jean's works are considered as the leading thesis in the modern theory. He presented several mathematical models in the last half century, and in-depth studies in apical activity (Jean, 1983), methodological studies

used for plant biology and phyllotaxis (Jean, 1986) and some surveys in this area (Jean, 1995), and provided with Irvin Adler (Adler *et al.,* 1997) a historical study in phyllotaxis.

Modeling Systems for the Phyllotaxis of Date Palm

The first studies had focused on oil palm phyllotaxis, relying on the above-mentioned works. Among these studies, was the study of Henry (1955), using the Plantefol's model for his descriptive study of oil palm phyllotaxis (Elais geinesis) considering the unique helix hypothesis. Rees (1964) present an in-depth study on the role of organizing apical meristem on phyllotaxis formations for Elais geinesis. Thomas et al. (1969) and on the same species, propose the equivalent phyllotaxis index (EPI) to explain fronds position on oil palm's trunk.

The study of Ferry (1998) comes to highlight the date palm phyllotaxis (*Phoenix dactylifera* L.) and is considered as the first study of the impact of the leaves shape characteristics on its phyllotaxis system where it has concluded that there are several models of the date palm using various methods. In contrast, Elhoumaizi et al. (2002) present a geometrical study of phyllotaxis, defining the divergence angle between fronds and its role in phyllotaxis systems and the phyllotactic variability. Moreover, Dror and Shimshoni (2009) suggest a study of the reconstruction of three-dimensional phyllotactic system for the date palm using modern techniques of simulation.

METHODOLOGY

In this study, we have adopted a biometric approach and we have acquired 5 895 measures on seven (07) date palm varieties located in the region of Biskra (Ziban oasis) which is considered as the most important region of the palm in Algeria. Three palm trees were chosen for each variety. In each palm tree, we have relied on four different measurements on the trunk that reflect the fronds positioning relative to each other.

Our study tries to find the possible relationships to consider a conceptual phyllotactic structure proving the following two hypotheses:

Hypothesis 1: The phyllotactic structures of date palm varieties differ according to their measurements.

All measurements (described later) differ in the selected seven varieties in our experience, which confirms the variability in the phyllotactic structure of the date palm trunk.

Hypothesis 2: The Itima represents a special case according to the parastichy slope.

We have note in the studied phenomenon that the contact parastichy differs in its parastichy slope from one to another (from 13, 8, 5 and 3). Furthermore, only the 13th parastichy in the case of Itima turns into an orthostic.

Variables

The studied phenomenon depends on the variable of diversity of phyllotactic forms as the dependent variable describing our phenomenon. The numeric values for this variable reflect the order of studied varieties as follows:

1. Deglet-Nour
2. Ghars
3. Mech-Degla
4. Itima
5. Safraye
6. Zogar-Mogar
7. Tati-Bent-Nouh

While four parameters (measurements) taken as variables explains the diversity of phyllotactic forms. These parameters (measurements) are regrouped in two kinds of measures. The direct one including the distance between the orthostics and the helix height, and the indirect one which include the divergence angle and helix slope.

The distance between the orthostics (A): It is the vertical distance between the two fronds in a same parastichy (cm).

The helix height (B): Is the height of helical unit (cm).

The slope helix: Calculated by the distance between the orthostics (A) and the distance between the two fronds in same parastichy (F) expressing the relationship as following:

$$\alpha = \cos^{-1}(A/F)$$

The divergence angle: Calculated by the twice distance between the orthostics (A) and the radius (r) expressed as following:

$$\theta = A/r$$

The figure 1 shows the various measurements in our experience.

The Model

The nature of the dependent variable in this phenomenon (diversity of phyllotactic forms) is a qualitative and taken seven value reflect the seven varieties studied. We use for that the probabilistic modeling (the Logit Model) which as appropriate modeling kind for our variables case, presented by the following formula:

$$\Pr[E(Y = k|X_i)] = \alpha_i X_i + \epsilon$$

Where Xi indicates the above measurements, relying on two statistical tests, the adjusted correlation coefficient and of course using the null hypothesis test p-value.

RESULTS AND DISCUSSION

The experiment confirms null-hypothesis test where the model is represented in the following formula:

$$Y = \underset{(.001)}{-.038}\ \alpha - \underset{(.001)}{.028}\ \theta - \underset{(.005)}{.093}\ A - \underset{(.002)}{.005}\ B$$

; R2=0.97P<0.0001

This model is significant, with a strong correlation between the different variables (Xi) and diversity variable, and each variable separately has a very significant effect with lower p-value, which confirms the null-hypothesis for each variable (see Table 1).

The two first graphs (see Figures) show an inverse relationship between the divergence angle and slope helix (Figure 2) and as well as the distance between the orthostics and the slope helix (Figure 3).

The latter shows clearly the inverse relationship of the various helixes. We can even notice the discrepancy between the various helixes. As Figure 2 shows an exceptional gathering where the divergence angle and slope helix is a large, specific to Deglet-Nour variety where 8th parastichy have a great divergence angle and slope helix. To prove our first hypothesis that relies on the variability of the phyllotactic structures of date palm and from their significance of results, we suggest the graphics (Figure 4 and 5).

Based on the three basic parameters, we have a clear contrast between the various phyllotactic systems of studied varieties, which clearly illustrate the seven gatherings. Figure 4 shows the relationship between the divergence angle and the helix height. Three mixed overlapping gatherings are illustrated and the same for Figure 5, which shows the relationship between the orthostic distance and the helix height.

We can denote also in Figure 6, that shows the divergence angles by varieties, a relative variation for each variety. We can confirm the difference between phyllotactic structures in the studied varieties.

The Figure 7 comes to confirm our second hypothesis showing the slope helix for the studied varieties, and indicates that the fourth variety (Itima) is characterized by the presence of a vertical parastichy (90°), which represents the 13th parastichy in contrast of the rest.

This feature could be observed clearly in this variety where the 13th parastichy represent an orthostic on the trunk as well as on the corona, which make it distinct variety among others with regular spaces between parastichies on the corona that resulted from the vertical overlaying of fronds.

CONCLUSION

As result of this study, we can conclude that the phyllotactic systems of the date palm (*Phoenix dactylifera* L.) vary among varieties. The experience was conducted on seven Algerian date palm varieties. Through some biometric measurements of the phyllotaxis, the modeling has allowed us to show the variability in phyllotactic structures. While, this study calls for several perspectives including more varieties, relying on the palm corona, and focusing on the physiological aspects of apical meristem activity.

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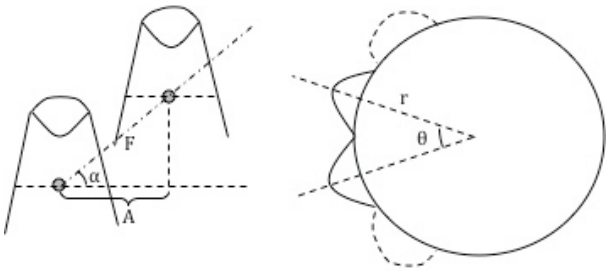


Figure 1. Representation of the used parameters

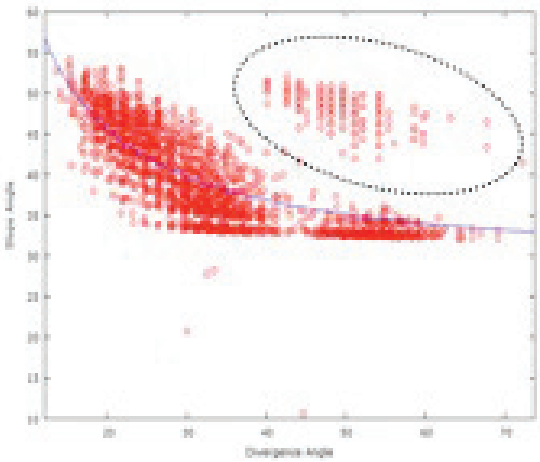
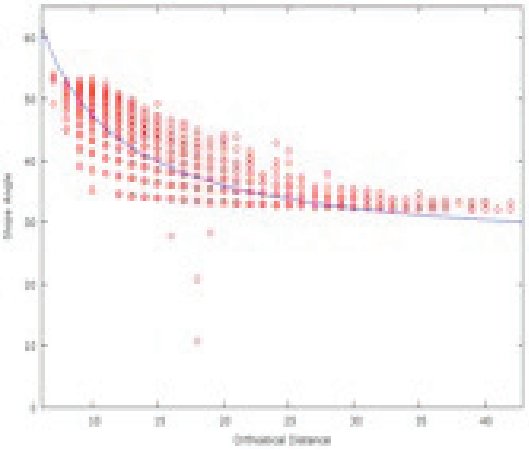


Figure 2.



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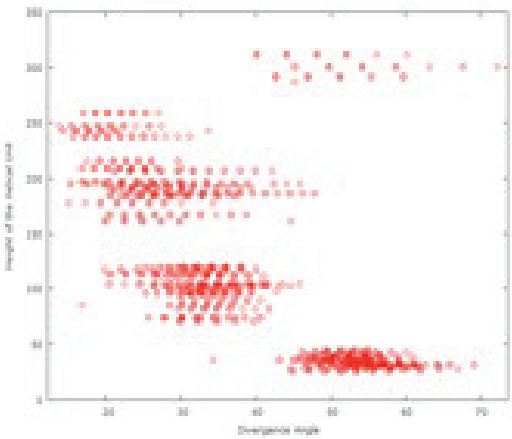

Figure 4.

Table 1. The Gretl output for the multinomial logit based on the experimental matrix

Logit Model, for n=5895 Observations, Dependant Variable = Var ∋ {1,2,3,4,5,6,7}

	Coefficient	Std. Error	t-Student	p-critique	
Height of Helical Unit (B)	-0,005127	0,0002242	-22,8661	<0,00001	***
Ortostical Distance (A)	-0,093862	0,0056447	-16,6284	<0,00001	***
Slope Angle (α)	-0,038982	0,0014744	-26,4376	<0,00001	***
Divergence Angle(θ)	-0,028524	0,0012188	-23,4023	<0,00001	***
Residuals Sum Square	1263,296			Sdt. Div. Reg.	0,563534
R2	0,9727S02			Adjusted R2	0,972675
F(5, 3978)	28349,72			p-Value (F)	0,000000
Schwarz Criteria	6770,991			Hannan-Quinn	6750,692

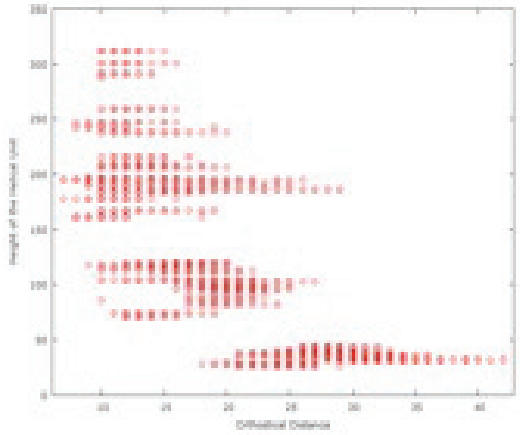

Figure 5.

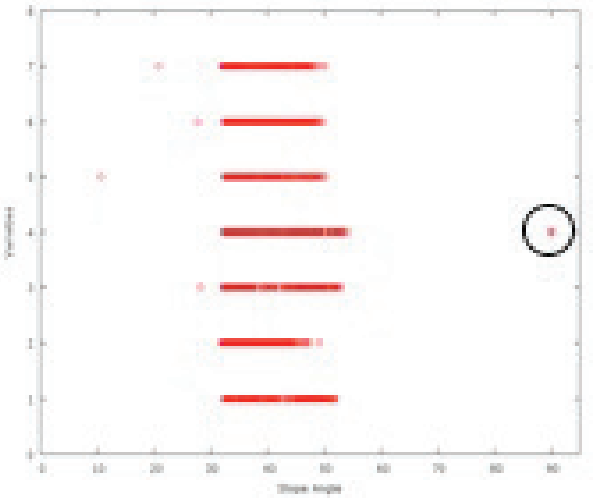

Figure 7.

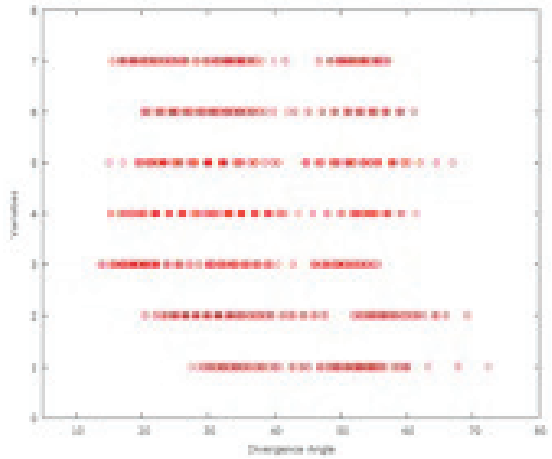

Figure 6.