

# Plant-Water Relations and Productivity of Date Palm (*Phoenix dactylifera* L.) Cultivars.

## العلاقة بين بعض أصناف نخيل البلح وإحتياجاتها المائية، وتأثيرها على الإنتاج

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**Abstract:** The present investigation deals with the plant-water relation and its effect on chlorophyll content and productivity in six date palm cultivars. Growth and yield of date palm cultivars differed at the expense of same level of relative water content. Maktoomi showed a significantly higher leaflet area coupled with a higher amount of chlorophyll pigments that led to higher yield per tree. Kowariah recorded a poor yield by having significantly lower chlorophyll content and leaflet area. Relative Water Content (RWC) had no effect on the fruit quality. Correlation among the relative water content, chlorophyll content, leaf specific mass and yield was also analyzed. Most of the pairs of parameters exhibited a highly significant correlation for the six cultivars. Apart from physiological parameters, the effect of male pollinator with suitable combination of female variety had a great effect on the fruit set and yield of date palm.

**Keywords:** Date Palm, *Phoenix dactylifera* yield, Chlorophyll, leaf specific mass, Relative Water Content.

**المستخلص:** تناولت الدراسة العلاقة بين الإحتياجات المائية وتأثيرها على مادة اليخضور والإنتاج لدى ست أصناف من نخيل البلح. وجد من هذه الدراسة أن نمو وإنتاج أصناف النخيل تحت الدراسة تتفاوت في إحتياجاتها لمعدل المياه النسبي. من الأصناف تحت الدراسة وجد أن صنف مكتومي زادت المساحة الورقية الخضراء مصحوبا بالزيادة في نسبة صبغات اليخضور والتي انعكست بالإيجاب على معدل رنتاجية المحصول، على عكس محصول صنف الخويرة. كما وجد أن النسبة المئوية للمحتوى المائي لم تكن لها أي تأثير يذكر على جودة الثمار.

**كلمات مدخلية:** نخيل البلح، أصناف البلح، اليخضور، معدل المياه، المساحة الورقية، الإنتاج

### Introduction:

Date palm (*Phoenix dactylifera* L.) is one of the most important fruit crops cultivated in arid regions in Middle East and Arabian lands. The number of known date palm varieties distributed all over the world are approximately 500 out of which only 450 are alone found in the Kingdom of Saudi Arabia (Bashah, 1996). Date palm is a dioecious plant and its obligate out breeding habit makes its progeny strongly heterogeneous (Munier, 1981). The entire tree of date palm is utilized to provide food (dates), shelter, fuel, fiber, clothing, furniture and many other products. Accordingly palm tree has been called the tree of life (Martin, 1978).

Fruit set, fruit quality and yield of many date palm cultivars are expected to be associated with the problem of incompatibility of the pollen from unidentified male trees. Farmers are pollinating

since long time with limited background knowledge of genotype of the males. The pollens not only contribute the male gametes but also the growing pollen tube secretes chemicals responsible for the development of fruits. As high as 30.7% to 38.8% seedless fruits have been recorded in Samani and Zaghoul cultivars respectively as a result of bagging the spathes (Rabeh and Kassem, 2003). Parthenocarpy could also be induced in date palm by the application of certain growth regulators at low concentrations (Abd-Alaal *et al.*, 1982). A positive effect of fruit thinning has been observed on yield and fruit quality of date palm. The optimum favourable yield and good fruit quality could be obtained in date palm with thinning at Pollination stage (Moustafa, 1993).

Plant-water relations of date palm tree with respect to its productivity were evaluated in order to understand the physiological behavior of this

important desert crop. Date palm appears to be a low self-compatible crop. Always a low yield is obtained whenever the pollen of the same cultivar is employed in the crossing (EL-Ghayaty, 1982; Higazy *et al.*, 1982; Abo-Hassan, 1982). The identification of male and female date palm cultivars based on DNA fingerprinting is in progress in our laboratories (Askari *et al.*, 2003; Al-Khalifah and Askari, 2003). The selection of male plants of good quality that match with female cultivars are urgently required to involve in the crossing programme that will maximize the yield and improve the quality of the fruits.

### Materials and Methods

Six cultivars (ten plants each) namely Barhee, Koweriah, Maktoomi, Nabtet-Ali, Sabbakah and Sukkary of date palm were tagged for the present investigation. Care was taken to select the plants of same age from the same orchard. Leaflet samples were collected from the four sides of each individual adult plant from the middle portion of leaf. On an average the fully expanded mature leaf contained 80-90 pairs of leaflets. The leaflets collected from one individual plant were pooled together before weighing. Fresh weight, turgid weight and oven dry weight (80°C for 48 hours), were taken for all the samples. The leaflet samples were brought to full turgor by enclosing them in a moist chamber for 12 hours. Full turgid weight was obtained by reweighing them. Saturated water deficit (SWD), relative water content (RWC) and water content in relation to dry matter were calculated following the method given by Weatherly (1950).

Leaflets were collected from base, middle and top of leaves from each tagged palm tree. 50 leaflets were measured from each sample by using leaf area meter (CI-203) Laser area meter CID, Inc. Washington, USA). Leaf specific mass (dry matter accumulation per square centimeter area of leaf) was calculated by dividing the dry weight of known amount of leaflets by its total area (James and Bell, 2001). Similarly water content per square Centimeter of leaflet was calculated.

The photosynthetic pigment of leaflets were extracted in N, N-Dimethylformamide (DMF) and total chlorophyll content was determined Spectrophotometrically (Spectronic 20 D+) according to the method of Moran (1982) using the following formula.

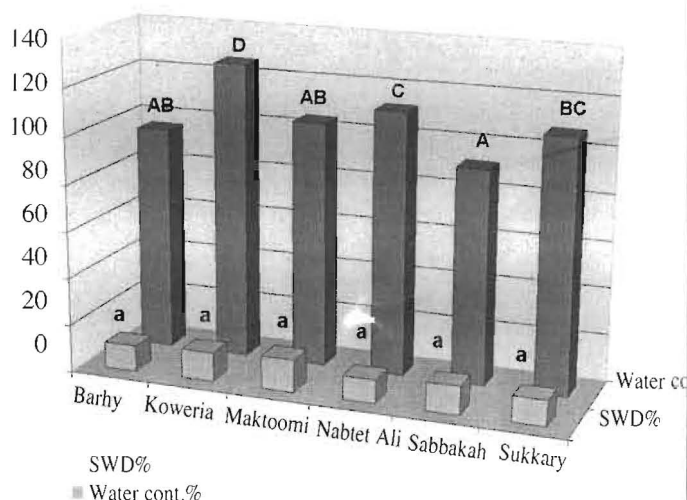
$$Ct = 7.04 A_{664} + 20.27 A_{647}$$

Obtained data were analyzed statistically for standard deviation, least significant difference (LSD) and correlation coefficient according to

Snedecor and Cochran (1973). Computed mean values for all the parameters of each tagged plant were used as replicates.

### Results

Productivity in relation to chlorophyll and water content of six cultivars of date palm was studied. Relative water content of leaves showed a close range of 86.33% to 89.97% and no significant difference was found among the six cultivars (Table 1). No significant difference was also observed for SWD among the six cultivars within a range of 10.02% to 13.65%, the minimum for Nabtet-Ali and a maximum for Maktoomi. Significant differences were observed for water content in relation to dry matter of leaves, a minimum of 0.91 time (91%) for Sabbakah and a maximum of 1.26 times for Koweriah (Fig 1). An analysis of dry matter



**Fig.1:** Variation in water content and water deficit in the leaves of date palm cultivars. Bars having same superscript are not significantly different separated on LSD ( $p < 0.05$ ) analysis.

accumulation per square centimeter of leaf (leaf specific mass) showed a significant minimum value of 18.68 mg for Koweriah and a maximum of 26.71 mg for Barhee cultivar. Maktoomi, Nabtet-Ali and Sabbakah did not differ significantly from each other. A significant low amount of 20.70 mg was recorded for Barhee and a significant high of 26.69 mg was found for Nabtet-Ali. A maximum significant expansion of leaflets was found in Barhee and a lowest in Sukkary cultivar. The analysis of total chlorophyll content for six cultivars revealed a range of 0.9503 mg to 1.6487 mg per g fresh weight of leaf, the significant minimum value was recorded for Koweriah and a maximum for Maktoomi. Yield per plant showed a great variation. A range of 60 Kg

**Table 1:** Some growth parameters and yield of date palm (*Phoenix dactylifera* L.) cultivars.

Cultivars	RWC (%)	LSM (mg)	WC/cm <sup>2</sup> (mg)	Leaflet area (cm <sup>2</sup> )	Chlorophyll (mg)	Yield/tree (Kg)
Barhee	89.09 a + 2.05	26.71 c + 1.03	20.70 a +0.46	516.32 b +40.62	1.4021 bc ±0.1327	120 c +5.00
Koweria	87.73 a +4.32	18.68 a +4.39	23.45 ab +5.07	268.09 a +93.82	0.9503 a +0.1465	60 a +4.35
Maktoomi	86.33 a +1.13	24.03 bc +1.16	25.04 ab +3.12	512.84 b +56.57	1.6487 c +0.2536	170 e +8.71
Nabtet Ali	89.97 a +1.65	23.86 bc +1.16	26.69 b +3.65	366.71 ab +78.98	1.1129 ab +0.1333	100 b +8.66
Sabbakah	88.01 a +3.16	25.00 bc +2.03	22.90 ab +2.92	318.19 a +70.37	1.2167 b +0.1480	150 d +9.16
Sukkary	89.04 a +2.06	21.78 ab +2.22	23.33 ab +2.15	259.23 a +39.51	1.1617 ab +0.1143	100 b +4.35
LSD(p<0.05)	4.378	4.297	5.760	155.97	0.2785	13.263

RWC - Relative Water Content; LSM - Leaf Specific Mass; WC - Water Content  
Values having same letter are not significantly different.

to 170 Kg was recorded for six cultivars. All the cultivars differed significantly from each other in productivity per plant (Table 1).

#### Correlation among the Selected Parameters RWC / Chlorophyll content

Koweriah, Maktoomi, Sabbakah and Sukkary exhibited a higher degree of positive correlation ( $p < 0.01$ ) between their RWC of leaf and total chlorophyll content. Barhee showed correlation of a low magnitude ( $p < 0.05$ ) while no significant correlation was found for Nabtet Ali for this pair of parameters (Table 2).

#### Chlorophyll Content / Leaf Specific Mass

Barhee and Koweriah did not show any significant correlation between total chlorophyll content and leaf specific mass. A higher degree of positive correlation was observed for Nabtet-Ali, Sabbakah and Sukkary ( $p < 0.01$  for this pair of parameters. Maktoomi showed a moderate degree of positive correlation ( $p < 0.05$ ).

#### Chlorophyll Content / Yield

Yield of six cultivars was correlated positively and significantly with the amount of total chlorophyll content present in the leaf. The degree of correlation was quite high ( $p < 0.01$ ) for all the cultivars except Sabbakah (Table 2).

#### Inter Varietal Correlation

Correlation among the selected parameters of date palm was analyzed based on performance of six cultivars. A negative and non-significant correlation was obtained between RWC of leaf and total chlorophyll content for the overall performance of date palm in Saudi Arabia. Correlation between chlorophyll content and leaf specific mass was found to be positive but non-significant. Yield per plant showed a positive and significant correlation ( $p < 0.05$ ) with total chlorophyll content of leaf (Table 2).

#### Discussion

Growth performance and yield of six cultivars of date palm differed significantly from each other at the expense of same amount of relative water content or under the same magnitude of water stress. Fruit characteristics of cultivars Hilwa is reported to perform better under moderate to high water stress treatments. Irrigation of date palm tree at 40% to 60% depletion of total soil moisture content has been found to be adequate for reasonable date production without significant adverse effect on date fruit quality (Hussain *et al.*, 1993). Relative water content played a highly significant role in the synthesis of chlorophyll in Koweriah, Maktoomi, Sabbakah and Sukkary as revealed by their correlation coefficient between these two parameters. Barhee and Maktoomi showed a significantly higher photosynthetic area having a higher amount of total chlorophyll content

**Table 2:** Correlation among the selected variables of date palm (*Phoenix dactylifera* L) cultivars.

Cultivars	RWC/Chl	Chl/LSM	Chl/Yield
Barhee	0.7604*	0.4570 <sup>NS</sup>	0.8156**
Koweria	0.9808**	0.4106 <sup>NS</sup>	0.9477**
Maktoomi	0.9994**	0.6936*	0.9050**
Nabtet Ali	0.5042 <sup>NS</sup>	0.9998**	0.7668**
Sabbakah	0.8817**	0.8345**	0.7478*
Sukkary	0.9389**	0.9632**	0.9246**
Date Palm (Intervarietal)	-0.4959 <sup>NS</sup>	0.6422 <sup>NS</sup>	0.8600*

\*\* Significant ( $p < 0.01$ ); \* Significant ( $p < 0.05$ ); NS - Non Significant; RWC-Relative Water Content; Chl - Chlorophyll; LSM - Leaf Specific Mass

hereby giving a higher yield. Al-Wasel (1999) reported a quite low leaflet area for Barhee. Al-Khateeb *et al.* (2003) observed a highest water use efficiency and rate of photosynthesis for another cultivar Khalas. This indicated that date palm cultivars greatly varied in their productivity based on their physiological requirements.

Barhee, Maktoomi and Sabbakah having significantly higher leaf specific mass also possessed a significantly higher yield. Leaf specific mass of six cultivars ranged from 0.01868 to 0.02671 g per square centimeter of leaflet. This variation has also been observed in *Eucalyptus*. Twenty one species of *Eucalyptus* from Australia has been found to show leaf specific mass in the range of 0.008 to 0.031 g per square centimeter with a mean value of 0.017 g per square centimeter of leaf (James and Bell, 2001). Yield per plant ranged from 60 kg to 170 kg for six date palm varieties under investigation. More or less same yield for six cultivars has been observed by different workers (Bashah, 1996; Ibrahim and Khalifah, 1998; El-Shazly, 1999). The yield of other cultivars like Zaghoul-119 Kg, Samani-153 Kg, (Rabeh and Kassem, 2003) and Seewy-132 Kg (Moustafa, 1993) also fall in the same range. Khan and Khan (1993) reported a very low yield of 30 to 80 Kg. per tree for six Pakistani date palm cultivars.

Dry matter accumulation in unit area of leaf was greatly influenced by chlorophyll content in Nabtet-Ali, Sabbakah and Sukkary cultivars. Yield per tree of six cultivars was highly correlated with

chlorophyll content having a wide range of correlation ( $r=0.7478$  to  $0.9477$ ). A comparative low magnitude of correlation between chlorophyll and yield in higher yielding cultivars like Barhee and Sabbakah is suggestive of having the interference of superior male pollinator that led to higher production of fruits. A positive relationship between high rate of photosynthesis and high amount of chlorophyll has been observed in recently expanded leaves of ten date palm cultivars by Al Khateeb *et al.* (2003). Correlation between chlorophyll and yield of *P. dactylifera* based on the performance of six cultivars in Saudi Arabia was also found to be significant at 5% level.

The fruit quality was not affected by RWC of leaf. The fruits of Sukkary, Sabbakah and Nabtet Ali were considered best and eaten when they are dry while those of Maktoomi, Barhee and Koweria were preferred to be consumed at fresh stage.

The effect of 17 date pollinators on the fruit set, yield and fruit quality has been investigated by different workers. Fruit setting, dropping, yield and some physical and chemical fruit properties are found to be affected by pollen source and female variety. Yield is always low whenever male and female of same variety is crossed. Selection and identification of suitable male pollinator is of great importance for improving the productivity and fruit qualities of different date cultivars (El-Amer *et al.*, 1993; El-Ghayaty, 1982; Higazy *et al.*, 1982; Abo-Hassan, 1982).

## Conclusions

Water was not directly responsible for the varied growth of six date palm cultivars. Relative water content had no effect on the fruit quality. Apart from leaf area and chlorophyll content the effect of a suitable male pollinator in combination with female variety had a positive effect on the yield of date palm.

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