SCHEDULING SUPPLEMENTARY DRIP IRRIGATION REQUIREMENTS OF DATE PALM TREES IN SOILS SUBJECTED TO CONTRIBUTION FROM GROUND WATER DEPTHS UNDER EL-FAYOUM CONDITIONS

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ABSTRACT

Date palm (*Phoenix dactylifera, L.*) has been focused by researchers to maximize its production (quantity and quality) and more specifically to its water management aiming to find the most effective and economic amounts of water needed for optimum fruit quality.

Three different locations of different soil texture (clay, clay loam and sandy loam) were chosen at Fayoum Governorate. At each location, four sites of different ground water table depth (gwtd), i.e. ≈ 40, 80, 120 and 160 cm already grown with date palm trees; were selected for this study. Within each site 3 date palm trees variety "Balady" aged from 8-10 years (as replicates) were the task of this study. The selected sites of the tested soils were analyzed for some soil physical and chemical properties. The ground water table depth at each site was measured in an observation well of 10 cm diameter that was dug to 180 cm depth, then, the weighted averages of (gwtd) were calculated. The actual evapotranspiration (ET_c) of date palm for all the year 2004 under El-Fayoum conditions was calculated and the contribution from the tested (gwtd) of the site ($ET_{c.g}$) to the date palm consumptive use was estimated.

Results showed that the maximum value of total yearly contribution from ground water table to water consumptive use for date palm (1069.31 mm) was found in the clay soil with the gwtd (≈ 40 cm), while the minimum value (161.35 mm) was observed in the sandy loam soil with the gwtd (≈160 cm). Highly significant negative correlations were indicated between the values of total yearly contribution (ET_{c-g}, mm) and the values of (gwtd), and, their simple regression equations showed significant relationships as follows:

For the clay soil : r = - 0.985 and $Y_1 = 1240.50 - 5.34 X$.
For the clay loam soil : r = - 0.989 and $Y_2 = 1215.00 - 5.75 X$.
For the sandy loam soil : r = - 0.972 and $Y_3 = 1016.30 - 5.70 X$.
Where: Y is the ET_{c-g} (mm) and X is the gwtd (cm).

Results showed also that the minimum value of the net requirement needs (ETn) for date palm (414.67 mm/year) is seen in clayey soil with the gwtd (≈ 40 cm), while the maximum value (1322.22 mm/year) was observed in the sandy loam soil with the gwtd (≈160 cm). Highly significant positive correlations were detected between the values of the net requirements needs (ETn) and that of gwtd, meanwhile, their simple regression equations showed significant relationships as follows:

For the clay soil : r = + 0.965 and $Y_1 = 249.15 + 5.31 X$.
For the clay loam soil : r = + 0.971 and $Y_2 = 266.76 + 5.79 X$.
For the sandy loam soil : r = + 0.945 and $Y_3 = 467.10 + 5.70 X$.
Where: Y is the ETn (mm/year) and X is the gwtd (cm).

The net requirement needs values (ETn) were considered as the net supplementary drip irrigation requirements (NSDIR) and calculated in m^3/feddan/year for date palm trees. Consequently, scheduling the monthly NSDIR as liter/tree/day through all months of the year, as well as, the needed number of drippers were presented for the application in the studied soils and ground water table depths under Fayoum Governorate conditions.

Key words: Water management, ground water table depth (gwtd), observation well, El-Fayoum conditions, actual evapotranspiration (ET_c), contribution from ground water table ($ET_{c.g}$), net supplementary drip irrigation requirement (NSDIR).

INTRODUCTION

Date palm (*Phoenix dactylifera, L.*) has been cultivated very long time ago. There is archeological evidence of its cultivation in eastern Saudi Arabia in 4000 B.C. It was refered and regarded as a symbol of fertility, and depicted in base relief on coins and paints in some ancient Egyptian tombs.

Date palm production in Egypt covers the whole area of the country from the Mediterranean coast up to Aswan; besides, a big portion of the native production comes from the oasises of Siwa, Bahariya, Farafra, Dakhla and Kharga. Date palm tree is tolerant to high stresses of soil salinity, waterlogging and drought. Meanwhile, its production (quantity and quality) was found sensitive to poor irrigation and drainage conditions (Abu-Khalid *et al.*, 1982). Hussein and Hussein (1983) showed that irrigation treatments of date palm based on twelve water applications per year (300 m^3/feddan each time) at about four weeks intervals is suitable for normal growth of variety Sakkoti date palm in Egypt. Abdelrahman and Al-Nabulsi (1993) concluded that the calculated values in case of using drip irrigation method were 38% less than that of using surface method for date palm in five regions of date palm in the Kingdom of Saudi Arabia. Hussein *et al.* (1993) found that irrigation of date palm tree at 40-60% depletion of total available soil water would be adequate for reasonable date palm production with minimum adverse effect on date fruit quality and quantity. Snyder (1993) reported that crop coefficient values (Kc) are factors that multiplied by ETo to estimate ETc. The (Kc) factors account for crop morphology, crop physiology and water management to some measures of evaporation.

In the eastern and central regions of Saudi Arabia, Al-Omran and Shalaby (1992) found that the total water requirement is 4021 mm under surface irrigation with water of EC=1 dS/m and there was no reductions in yield due to salinity. Al-Amoud *et al.* (2000) conducted a field experiment to investigate the response of date palm trees to different water regimes (50,100 and 150 % of pan evaporation rate) using three irrigation systems (basin, bubbler and trickle) and they concluded that the maximum yield and water use efficiency were obtained from date palm trees irrigated with trickle irrigation system followed by the basin method. Also, they found a general trend of yield increase as irrigation quantity increased with the tested systems of irrigation. Silmani and Zayani (1998) studied the effect of water regime on the development and yield of young date palm in arid regions, and found that irrigation net-work had an average efficiency of 70 % and the water use efficiency ranged from 0.42 to 0.59 kg/m^3. It was added that, at eight years after planting, a survival rate of 85 % was recorded with an average monthly water supply of 33-48 mm. Hussain *et* *al.* (1993) found that the actual measured daily mean of water requirement of date palm in Al-Hassa, Kingdom of Saudi Arabia is 6.18, 4.84, 2.82 and 1.76 mm per day. The total annual water requirement of date palm trees were 2256, 1635, 1029, and 642 mm ha^{-1} for trees irrigated at 20%, 40%, 60%, and 80% moisture depletion of total available soil water. Nail (2003) pointed out that the greatest is obtained water consumptive use of "Seewy" date palm trees variety when irrigation is applied at 60 % of available water (7257 m^3/feddan/year) as compared to irrigation at 20 % of available water (5470 m^3/feddan/year).

The contribution from ground water table is distanced from the bottom of root zone of the cultivated crop and increased with the increase in soil matrix suction of the root zone (Kharshenko et al, 1971 and Ragab and Amer, 1988)). Under El-Fayoum governorate (Egypt) conditions**,** the previous researches showed a significant contribution from shallow ground water depths to the evapotranspiration and irrigation requirements of cultivated legume crops (El-Shakweer et al, 1982 and El-Shakweer, 1985). Aly (2000) found that the contribution values from shallow ground water table depth was 6.51% in loamy sand soils and was 23.64% in clay soils to maize crop water requirements. Also, it was found that the contribution values from shallow ground water table depth 21.66% in loamy sand soils and 22.58% in clay soils to the wheat crop water requirements. Xainying *et al.* (1998) found that evapotranspiration values of the three-years old date palm trees are less dependent on the ground water table than those of the two-years old. They concluded that roots of the three years old trees were developed enough to reach soil capillary zone. However, Hussein *et al.* (1993) reported that fresh weight and fruit volume of date palm did not show significant effect due to different irrigation treatments.

In El-Fayoum governorate (Egypt), date palm trees were grown for long time either in collected farms and/or as disturbed (scattered) trees. According to the Information Center of El-Fayoum Governorate (2004). The total area of collected date palm farms in El-Fayoum Governorate are about 1131.3 feddan (mostly in Senours and Tamia districts), which yield about 9570.8 ton annually (mostly Seewy and Zaghloul varieties). On the other hand, the disturbed (scattered) date palm trees amount to 562306 trees (mostly in Fayoum and Senours districts), which yield about 52120.4 ton annually (mostly Seewy and Amhat varieties) and presently "Zaghloul" cultivar has been introduced to Fayoum as a promising cultivar. Accordingly, the total yield production of date palm varieties in El-Fayoum are about 61691.2 ton/year, which is still below the optimum level of production and urgently needs maximizing.

The aim of this study is to estimate and schedule the net supplementary irrigation requirement needs by drip irrigation system to date palm trees after calculating the expected contribution from the tested ground water table depths in different soils of different textures under El-Fayoum conditions.

MATERIALS AND METHODS

Three different locations differing in there texture (clay, clay loam and sandy loam) were selected in the year 2004 at Meniet El-hait village Etsa district, Garfas village, Senours district and Menshat Tantawy village, Senours district, Fayoum, Egypt, respectively. At each location, four sites of different ground water table depths i.e. ≈ 40, 80, 120, 160 cm that already grown with 3 date palm trees, "Balady" variety of ages 8-10 years were chozen for this study. All the tested sites were subjected to the same agricultural management practices. Soil samples from each site were analyzed for physical properties and chemical properties according to Klute (1986) and Page *et al.* (1982) respectively, as shown in Table (1).

The contribution from ground water table to evapotranspiration and complementary drip irrigation water requirements were estimated according to the following measurements:

Table 1. Physical and chemical properties of the studied soils.

Soil property	Location		
	Meniet El-hait	Garfas	Menshat Tantawy
Particle size distribution			
Coarse sand, %	3.46	7.34	25.40
Fine sand, %	15.54	31.39	53.14
Silt, %	32.39	27.46	6.14
Clay, %	48.61	33.81	15.32
Texture class	Clay	Clay loam	Sandy loam
Hydraulic conductivity, cm/hr	0.16	0.74	2.15
Field capacity, %	42.20	35.14	21.17
Wilting point, %	23.30	17.87	9.06
Available water, %	18.90	17.27	12.11
PH (in soil paste extract)	7.48	7.62	7.23
EC_e (dS/m)	3.64	3.21	1.16
Soluble cations (meq/l)			
Ca^{++}	7.38	7.14	3.71
Mg^{++}	5.41	4.71	2.57
Na^{+}	23.33	20.57	5.86
K^{+}	0.63	0.59	0.18
Soluble anions (meq/l)			
$CO_3^{=}$	-	-	-
HCO_3^{-}	2.13	2.14	1.71
Cl^{-}	10.50	9.71	2.57
$SO_4^{=}$	24.12	21.16	8.04
$CaCO_3$, %	4.34	6.31	7.35

*Each value within the table represents the mean of analysis of layers 0-40, 40-80, 80- 120 and 120-160 cm.

1. Measuring ground water table depth (gwtd) and calculating its weighted average (w.av.gwtd):

An observation well of 10 cm diameter was dug to 180 cm depth at each of the four sites of all location to measure the depth of the ground water table level by means of a graduated tap, at weekly intervals (Morrison, 1983). Thereafter, their weighted averages were calculated for all the growing season 2004 as shown in Table (2).

Table 2. Weighted average of ground water table depth for date palm under the studied soils and depths of ground water.

Location	Soil texture	Ground water table depth (cm)*			
		≈ 40	≈ 80	≈ 120	≈160
Meniet El-hait	Clay soil	39.7	79.7	120.0	160.2
Garfas	Clay loam soil	40.2	80.1	119.8	160.1
Menshat Tantawy	Sandy loam soil	40.1	80.2	120.2	159.8

*Each value is the mean of 4 replicates.

2. Calculation of the potential evapotranspiration (ET_o):

The climatic data presented in Table (3) were used for the calculation of evapotranspiration (ET_o) using the modified Penman equation as follows (FAO, 1979):

$$ET_o = W.R_n + (1-W) * F(U) * (e_a - e_d).$$

Where:

W is the temperature and altitude dependent weighting factor.

R_n is the total net radiation as mm/day or $R_n = 0.75\ R_s - R_n\ L$.

R_s is the incoming short wave radiation in mm/day either measured or obtained from: $R_s = (0.25 + 0.5\ n/N)\ R_a$.

R_a is extra- terrestrial radiation in mm/day.

n is the mean actual sunshine during the day in hour/day.

N is the maximum possible sunshine duration in hour/day.

$R_n$is the long wave radiation mm/day as a function of temperature F(t), actual vapour pressure $F(e_d)$ and sunshine duration F(n/N) or calculated from: $Rn\ L = F(t) * F(n/N) * F(e_d)$.

F(U)is the wind function calculated as: F(U) = 0.27 (1-U/100),where, (U) measured in Km/day at 2m height.

(e_a-e_d) is the vapour pressure defect ,i.e., the difference between the saturation vapour pressure (e_a) at mean T in mbar and the actual vapour pressure (e_d) in mbar. Where, $e_d = e_a * RH/100$ and RH is the relative humidity.

RnL is the net long wave radiation mm/day as a function of temperature, F(t), actual vapour pressure, F(ed) and sunshine.

3. Calculation of the water consumptive use (ET_c) of date palm:

The actual evapotranspiration (ET_c) of date palm was calculated according to FAO (1979) as follows: $ET_c = K_c * ET_o$

Where:

ET_o is the potential evapotranspiration, mm/day; calculated from Penman equation based on Table (3) data.

K_c is the crop coefficient for date palm.

Table 3. Climatic data*(2004) used to estimate the reference evapotranspiration (ETo) according to modified Penman under El-Fayoum conditions.

Month	Temperature, c°			Humidity %	Wind-speed, Km/day	Sun-shine, Hours	Solar radiation, $Mj/m^2/day$	Rain Fall, mm	ET_o Penman mm/day
	Aver	Max.	Min.						
Jan.	15.0	21.2	8.8	58.4	143	6.9	12.5	2	1.8
Feb.	16.2	23.8	8.6	60.2	159	7.8	15.5	0	2.1
Mar.	17.8	25.2	10.4	55.8	195	8.7	19.7	0	3.9
April	21.4	29.7	13.1	51.3	200	9.9	23.6	0	5.1
May	31.8	41.3	22.2	26.1	215	10.7	25.7	0	9.9
Jun.	28.0	36.5	19.4	51.8	215	11.1	26.6	0	8.1
July	30.2	39.0	21.3	51.3	195	13.2	29.5	0	8.5
Aug.	28.7	36.1	21.2	53.3	191	12.4	27.3	0	6.3
Sept.	26.4	34.2	18.5	52.7	203	11.4	23.7	0	5.8
Oct.	25.1	31.8	18.3	53.9	180	9.6	18.3	0	4.2
Nov.	20.9	28.1	13.7	54.8	171	7.7	13.3	0	3.2
Dec.	14.7	21.2	8.2	58.9	166	6.6	10.9	8	1.8
Year	23.0	30.7	15.3	52.38	185	9.6	20.7	10	1855.3

*The used climatic data (2004) was obtained from the Fayoum Agrometoerological Station, where is located at El-Fayoum Governorate (altitude 29.3 N° and longitude 30.85 E°).

4. Estimation the contribution from ground water table to consumptive use ($ET_{c.g}$) of date palm:

The contribution from the tested different ground water tables ($ET_{c.g}$) to date palm evapotranspiration was estimated using the empirical equation presented by Kharshenko et al (1971) as follows:

$$ET_{c.g} = ET_c/K_{s.g}$$

Where:

ET_c is the actual evapotranspiration for date palm trees.

$ET_{c.g}$ is the contribution from the tested ground water table.

$K_{s\text{-}g} = e^{MH}$. The value of e^{MH} is equal to the coefficient for calculating the capillary rise of ground water table ($K_{s.g}$).

H is the water table depth in meter.

M is a parameter depending on soil texture and stage of plant growth.

The calculated $K_{s\text{-}g}$ values are presented in the results in Table (5).

RESULTS AND DISCUSSION

The complementary drip irrigation water requirements for date palm trees were estimated in the three studied soils (clay, clay loam and sandy loam) of different ground water table depths (gwtd) i.e. ≈ 40, 80, 120 and 160 cm.

1- Water consumptive use (ET_c):

Table (4) shows the values of water consumptive use (ET_c) mm/day, the potential evapotranspiration (mm/day) and the crop coefficient (K_c) during all months of the year 2004. Data in Table (4) show that the water consumptive use values gradually increased from January (1.39 mm/day) up to May (8.32 mm/day), then, the values decreased till December (1.13 mm/day). Therefore, the lowest values of ET_c were obtained during December while the highest were at May. From the obtained results, it could be concluded that the highest increment of ET_c was in summer months than others, this is attributed to the temperature, wind speed and net radiation, while humidity was lower in summer. These findings and statements are consistent with those mentioned by Ragab and Amer (1988), Caspari *et al.* (1994), Livett *et al.* (1995) and Nail (2003).

Table 4. Potential evapotranspiration (ET_o) mm/day, water consumptive use (ET_c) mm/day and crop coefficient (K_c) for date palm under Fayoum conditions during the year 2004.

Month	ET_o	K_c	ET_c
Jan.	1.8	0.77	1.39
Feb.	2.1	0.89	1.87
Mar.	3.9	0.92	3.59
Apr.	5.1	0.90	4.59
May	9.9	0.84	8.32
Jun.	8.1	0.83	6.72
Jul.	8.5	0.79	6.72
Aug.	6.3	0.77	4.85
Sep.	5.8	0.74	4.29
Oct.	4.2	0.70	2.94
Nov.	3.2	0.67	2.14
Dec.	1.8	0.63	1.13
Consumption / year :			
cm	185.53	-	148.357
m^3/feddan	7792.29	-	6230.994

2-The coefficient ($K_{s\text{-}g}$) for calculating the capillary rise of ground water under different soil textures and ground water table depths:

Values of the coefficient ($K_{s\text{-}g}$) for estimating the capillary rise of ground water under different soil textures and ground water table depths are presented in Table (5). The empirical equation presented by Kharshenko *et al* (1971) was used for estimating the capillary rise ($K_{s\text{-}g}$) as follows:

$$K_{s\text{-}g} = ET_O / e^{mH} \quad \text{(mm /day)}$$

Where: H is water table depth in meters, and m is a parameter that depends on soil texture and stage of plant growth.

Table 5. Coefficient values ($K_{s\text{-}g}$) for calculating the capillary rise of ground water table under different soils and ground water table depths.

Soil texture	water table depth (cm)			
	≈ 40	≈ 80	≈ 120	≈ 160
	$K_{s\text{-}g}$ values			
Clay	1.387	1.923	2.667	3.396
Clay loam	1.453	2.111	3.068	4.457
Sandy loam	1.740	3.027	5.267	9.163

3- Contribution from ground water table (ET_{c-g}) to evapotranspiration of date palm under different soil textures and ground water table depths:

Table (6) shows the monthly contribution from ground water table (ET_{c-g}) to evapotranspiration under the studied soil textures and ground water depths as calculated according to the previously mentioned equation: $ET_{c.g} = ETc/K_{s.g}$. Data in table (6), show that the maximum values for contribution of ground water table (ET c-g) to water consumptive use (6.00 mm/day) were associated with the heavy textured soils (clay soil) under shallow ground water table depth (≈ 40 cm) during May 2004, while the minimum values for contribution (0.12 mm/day) were obtained for the light textured soil (sandy loam soil) under deep ground water table (≈ 160 cm) during December 2004.

Data in table (6) also indicated that the values of (ET_{c-g}) were decreased in all of the tested soils with the increase in ground water table depth up to 40 cm. (ET_{c-g}) values were highest in May for all the tested soils and ground water depths.

Data in table (7) and Figure (1) show the calculated values of total yearly contribution (ET_{c-g}, mm) and their percentages from ground water table values relative to total water consumptive use (ET_c) calculated according to the following equation:

$$\text{Contribution \%} = (ET_{c-g} / ET_c) * 100$$

The maximum percentage of total yearly contribution from ground water table to water consumptive use for date palm (72.07 %) was associated with the clay soil under the (≈ 40 cm) ground water table depth, while the minimum value (10.88%) was observed in the sandy loam soil with the (≈160 cm) ground water table depth. It can be concluded that the contribution percentages from the ground water table depth to date palm tree irrigation requirements are affected by each of the rate and extent of the capillary rise, the moisture and aeration conditions, the ability of crop roots to reach the capillary fringe and by the climatic conditions.

Simple correlation and regression analysis were applied in an attempt to describe the relationship between the total yearly contribution values from ground water table (ET_{c-g}, mm) and ground water table depth. Data obtained are shown in Figure (1). It is clear that there is a highly significant negative correlation between the values of total yearly contribution (ET_{c-g}, mm) and the ground water table depth in the clay soil ($r_1 = -0.985$), clay loam ($r_2 = -0.989$) and sandy loam soil ($r_3 = -0.972$). The obtained regression equations were as follows:

$Y_1 = 1240.50 - 5.34\,X$ (for the studied clay soil)

$Y_2 = 1215.00 - 5.75\,X$ (for the studied clay loam soil)

$Y_3 = 1016.30 - 5.70\,X$ (for the studied sandy loam soil)

Where:

Y is the total yearly contribution from ground water table (ET_{c-g}, mm).

X is the ground water table depth (cm).

These equations indicate that there are decreases in the contribution values from ground water table (ET_{c-g}, mm) equal to 5.34, 5.75 and 5.70 for every one cm of ground water table depth for each of clay (Y_1), clay loam (Y_2) and sandy loam soils (Y_3), respectively. The above-mentioned findings and statements may cope with those stated by Hassan (1980), Ibrahim (1983), Jensen *et al.* (1990) and Paratap *et al.* (1994). In this connection, Al-Kafaf *et al.*

(1998) reported that the effective crop rooting zone volume refers to the volume of the soil at which roots extract 80 % of the water utilized by the tree. They also found significant increases was indicated in both the vertical and horizontal root distribution from planting the offshoots to the seventh year, but no significant increase in root distribution was detected after the seventh year.

Table 6. Contribution from ground water table (ET c-g, mm/day) to water consumptive use of date palm and their percentages during the year 2004 as affected by soil texture and ground water table depth.

Soil texture	Ground water table (cm)	$ET_{c.g}$ as	Month											
			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Clay	40	mm/d	1.00	1.35	2.59	3.31	6.00	4.84	4.84	3.50	3.09	2.12	1.54	0.81
		% *	71.9	72.2	72.1	72.1	72.1	72.0	72.0	72.2	72.0	72.1	72.0	71.7
	80	mm/d	0.72	0.97	1.87	2.39	4.32	3.50	3.50	2.52	2.23	1.53	1.11	0.59
		% *	51.8	51.9	52.1	52.1	51.9	52.1	52.1	52.0	51.9	52.0	51.9	52.2
	120	mm/d	0.52	0.72	1.35	1.72	3.12	2.52	2.52	1.82	1.61	1.10	0.80	0.42
		% *	37.4	38.5	37.6	37.5	37.5	37.5	37.5	37.5	37.5	37.4	37.4	37.2
	160	mm/d	0.41	0.55	0.97	1.35	2.45	1.98	1.98	1.43	1.16	0.80	0.63	0.33
		% *	29.5	29.4	27.0	29.4	29.5	29.5	29.3	29.5	27.0	27.2	29.4	29.2
Clay loam	40	mm/d	0.96	1.29	2.47	3.16	5.73	4.62	4.62	3.34	2.95	2.02	1.47	0.78
		% *	69.1	69.0	68.8	68.8	68.9	68.8	68.8	68.9	68.7	68.7	68.7	69.0
	80	mm/d	0.66	0.89	1.70	2.17	3.94	3.18	3.18	2.30	2.03	1.39	1.01	0.54
		% *	47.5	47.6	47.3	47.3	47.4	47.3	47.3	47.4	47.3	47.3	47.2	47.8
	120	mm/d	0.45	0.61	1.17	1.50	2.71	2.19	2.19	1.58	1.40	0.96	0.70	0.37
		% *	32.4	32.6	32.6	32.7	32.6	32.6	32.6	32.6	32.6	32.6	32.7	32.7
	160	mm/d	0.31	0.42	0.81	1.03	1.87	1.51	1.51	1.09	0.96	0.66	0.48	0.25
		% *	22.3	22.5	22.6	22.4	22.5	22.5	22.6	22.5	22.4	22.4	22.4	22.1
Sandy loam	40	mm/d	0.80	1.08	2.06	2.64	4.78	3.86	3.86	2.79	2.47	1.69	1.23	0.65
		% *	57.6	57.8	57.4	57.5	57.5	57.4	57.4	57.5	57.6	57.5	57.5	57.5
	80	mm/d	0.40	0.62	1.18	1.52	2.75	2.22	2.22	1.60	1.42	0.97	0.71	0.37
		% *	34.5	33.2	32.9	33.1	33.1	33.0	33.0	33.0	33.9	32.9	33.2	32.7
	120	mm/d	0.26	0.36	0.68	0.87	1.58	1.28	1.28	0.92	0.81	0.56	0.41	0.22
		% *	18.7	19.3	18.9	19.0	19.0	19.0	19.0	19.0	18.9	19.0	19.2	19.5
	160	mm/d	0.15	0.20	0.39	0.50	0.91	0.73	0.73	0.53	0.47	0.32	0.23	0.12
		% *	10.8	10.7	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.8	10.6

*As % of the calculated water consumptive use (ETc).

Table 7. Total yearly contribution from ground water table to water consumptive use of date palm (ET_{c-g}, mm) and it their percentages as affected by soil texture and ground water table depth.

Soil texture	Ground water table depth (cm)							
	≈ 40		≈ 80		≈ 120		≈160	
	ET_{c-g}	% *	ET_{c-g}	% *	ET_{c-g}	% *	ET_{c-g}	% *
Clay	1069.21	72.07	771.58	52.01	556.73	37.53	429.02	28.92
Clay loam	1020.93	68.82	721.12	48.61	483.72	32.61	333.08	22.45
Sandy loam	852.85	57.49	488.27	32.91	282.04	19.01	161.35	10.88

- As % of the calculated water consumptive use (ETc).

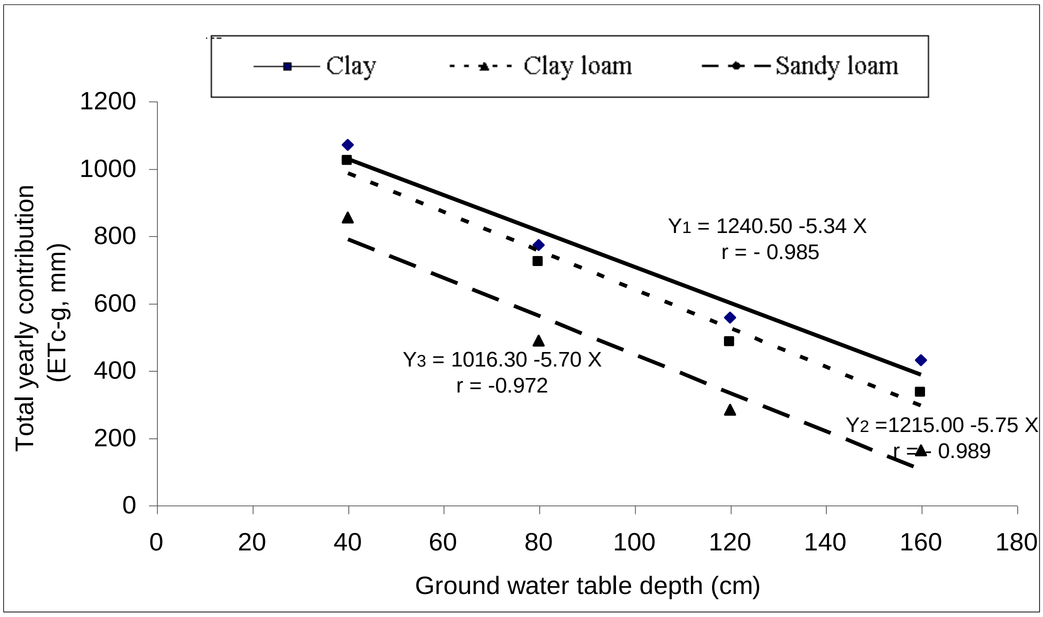


Figure 1. Total yearly contribution from ground water table to water consumptive use of date palm (ET_{c-g}, mm/year) as affected by soil texture and ground water table depth.

Where: Y_1, Y_2 and Y_3 is the total yearly contribution from ground water table depth (ET_{c-g}, mm/year) in the clay, clay loam and sandy loam soils, respectively and X is the ground water table depth (cm).

4- Net evapotranspiration (ET_n) by date palm under different soil textures and ground water table depths:

Table (8) shows the net evapotranspiration (ET_n) values of date palm under different soil textures and ground water depths that calculated by difference as follows: $ET_n = ET_c – ET\ c\text{-}g$.

The minimum net evapotranspiration (ET_n) values (0.32 mm/day)for date palm trees were obtained at the tested heavy textured soil (clay soil) with shallow ground water table (≈ 40 cm) during December 2004, while the maximum values (7.41 mm/day) were observed with the light textured soil (sandy soil) under (≈160 cm) ground water table depth during May 2004. Maximum values of the net evapotranspiration (ET_n) were detected during May for all the studied soils.

Data in table (9) and Figure (2) indicated that the net evapotranspiration values were decreased in all the studied soils when ground water table depth decreased from 160 to 120, 80 and 40cm., respectively. Mostly, the values of (ET_n) were increased in light textured soils morethan the clay soil. Simple correlation and regression analysis were applied in an attempt to describe the relationship between the net evapotranspiration (ETn, mm/year) values and ground water table depth. Results of analysis are shown in Figure (2). It is clear that there is a highly significant positive correlation between the net evapotranspiration (ETn, mm/year) values in the clay soil (r_1= 0.965), clay loam (r_2= 0.971) and sandy loam soil (r_3= 0.945). The obtained regression equations were as follows:

Y_1 = 249.15 + 5.31 X (for the studied clay soil)

Y_2 = 266.76 + 5.79 X (for the studied clay loam soil)

Y_3 = 467.10 + 5.70 X (for the studied sandy loam soil)

Where:

Y is the net requirements needs (ETn, mm/year).

X is the ground water table depth (cm).

Calculated increases in the net evapotranspiration (ETn, mm/year) values were 5.31, 5.79 and 5.70 for every one cm of ground water table depth for each of clay (Y_1), clay loam (Y_2) and sandy loam soils (Y_3), respectively. These results may be due to the increase in the capillary rise of clay soil than the sandy loam soil, and to the associated increases in meteorological factors especially temperature at summer season.

Table 8. Net evapotranspiration (ET_n, mm/day) values of date palm during the year 2004 as affected by soil texture and ground water table depth.

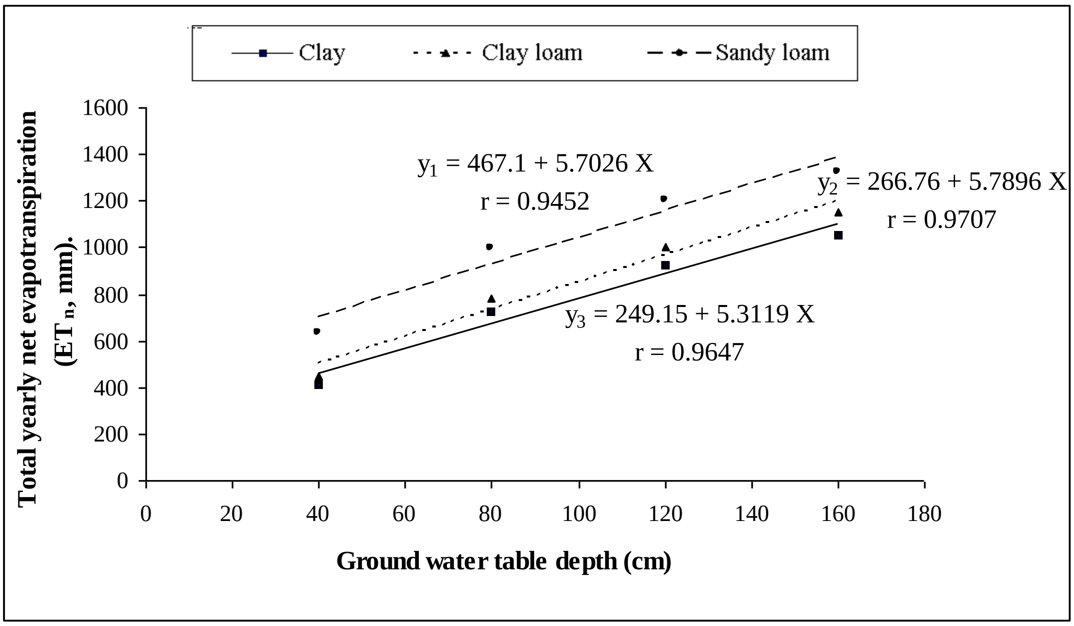
Soil texture	Ground water table (cm)	ET_n as	Month											
			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Clay	40	mm/d	0.39	0.52	1.00	1.28	2.32	1.88	1.88	1.36	1.20	0.82	0.60	0.32
		% *	28.1	27.8	27.8	27.9	27.9	28.0	28.0	27.8	27.9	27.9	28.0	28.3
	80	mm/d	0.67	0.90	1.72	2.20	4.00	3.22	3.22	2.33	2.06	1.41	1.03	0.54
		% *	48.2	48.1	47.9	47.9	48.1	47.9	47.9	48.0	48.0	47.9	48.1	47.8
	120	mm/d	0.87	1.15	1.72	2.87	5.20	4.20	4.20	3.03	2.06	1.41	1.34	0.71
		% *	62.6	61.5	47.9	62.5	62.5	62.5	62.5	62.5	48.0	47.9	62.6	62.8
	160	mm/d	0.98	1.32	2.62	3.27	5.87	4.74	4.74	3.42	3.13	2.14	1.51	0.80
		% *	70.5	70.6	72.9	71.2	70.6	70.5	70.5	70.5	72.9	72.8	70.6	70.8
Clay loam	40	mm/d	0.43	0.58	1.12	1.43	2.59	2.10	2.10	1.51	1.34	0.92	0.67	0.35
		% *	30.9	31.0	31.2	31.3	31.1	31.3	31.3	31.1	31.2	31.3	31.3	31.0
	80	mm/d	0.73	0.98	1.89	2.42	4.38	3.54	3.54	2.55	2.26	1.55	1.13	0.59
		% *	52.5	52.7	52.6	52.7	52.6	52.7	52.7	52.6	52.7	52.7	52.8	52.2
	120	mm/d	0.94	1.26	2.42	3.09	5.61	4.53	4.53	3.27	2.89	1.98	1.44	0.76
		% *	67.6	67.4	67.4	67.3	67.4	67.4	67.4	67.4	67.3	67.3	67.3	67.3
	160	mm/d	1.08	1.45	2.78	3.56	6.45	5.21	5.21	3.76	3.33	2.28	1.66	0.88
		% *	77.7	77.5	77.4	77.6	77.5	77.5	77.5	77.5	77.6	77.5	77.6	77.9
Sandy loam	40	mm/d	0.59	0.79	1.53	1.95	3.54	2.86	2.86	2.06	1.82	1.25	0.91	0.48
		% *	42.4	42.2	42.6	42.5	42.5	42.6	42.6	42.5	42.4	42.5	42.5	42.5
	80	mm/d	0.99	1.25	2.40	3.07	5.57	4.50	4.50	3.25	2.87	1.97	1.43	0.76
		% *	71.2	66.8	66.8	66.9	66.9	67.0	67.0	67.0	66.9	67.0	66.8	67.3
	120	mm/d	1.13	1.51	2.91	3.72	6.74	5.44	5.44	3.93	3.48	2.38	1.73	0.91
		% *	81.3	80.7	81.1	81.1	81.0	81.0	81.0	81.0	81.1	80.9	80.8	80.5
	160	mm/d	1.24	1.67	3.20	4.09	7.41	5.99	5.99	4.32	3.82	2.62	1.91	1.01
		% *	89.2	89.3	89.1	89.1	89.1	89.1	89.1	89.1	89.0	89.1	89.3	89.4

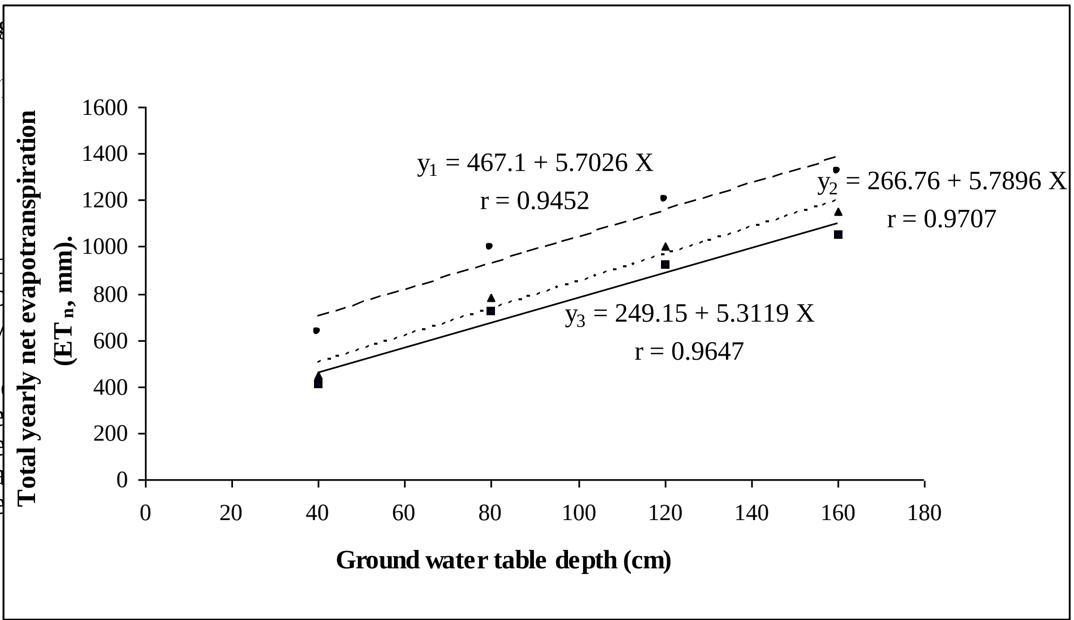
*As % of the calculated water consumptive use (ETc).

Table 9. Total yearly net evapotranspiration (ET_n, mm) values by date palm and their percentages as affected by soil texture and ground water table depth.

Soil texture	Ground water table depth (cm)							
	≈ 40		≈ 80		≈ 120		≈160	
	ET_n	% *	ET_n	% *	ET_n	% *	ET_n	% *
Clay	414.67	27.95	724.41	48.83	926.84	62.47	1055.45	71.14
Clay loam	451.48	30.43	781.05	52.65	999.85	67.39	1150.49	77.55
Sandy loam	630.72	42.51	994.99	67.07	1201.53	80.99	1322.22	89.12

*As % of the calculated water consumptive use (ETc).





ground water table depths at Fayoum.

Data in table (11) show that the maximum complementary net irrigation requirements values as m^3/fed./day were needed during May while the minimum needs were at December, 2004.

The complementary net irrigation requirements as (liter/ date palm tree/day) under the tested soil textures and ground water table depths, are given in table (11) and were calculated as follows (one feddan = 4200 square meters):

Net irrigation requirements (L/tree/month) = (Maximum net irrigation requirements during May month /42) * 1000

This was applied on the bases that: One feddan contains 42 date palm trees when the spacing between trees is 10 m×10 m (as recommended).

Considering that a dripper discharge is 40 liter/day, the calculated number of drippers needed /tree is shown in Table (11). Data obtained indicated that the drippers number needed/tree in the drip irrigation system is depended on ground water table depth and soil texture class, where, the needed number of drippers increased in the sandy loam compared with the clay soil especially in May under deeper ground water table. Salvadore and Smajstrla (1996) reported that applying water by drip irrigation is related to the amount of water evaporated. They added that the water service class A pan would be a convenient method to schedule irrigation as these pan evaporation data are generally available in most farming areas.

Table 10. Implementing the complementary net irrigation requirements ET_n, (m^3/fed./day) during the growth season of date palm grown under different soil textures and ground water table depths and the total yearly net irrigation requirements (m^3/fed./year)

Soil texture	Ground water table (cm)	Month												Total net irri. require. (m^3/fed. / year)
		Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec	
Clay	40	1.64	2.18	4.20	5.38	9.74	7.90	7.90	5.71	5.04	3.44	2.52	1.34	1741.614
	80	2.81	3.78	7.22	9.24	16.80	13.52	13.52	9.79	8.65	5.92	4.33	2.27	2990.358
	120	3.65	4.83	9.41	12.05	21.84	17.64	17.64	12.73	11.26	7.73	5.63	2.98	3892.608
	160	4.12	5.54	11.00	13.61	24.65	19.91	19.91	14.36	13.15	8.98	6.34	3.36	4429.170
Clay L.	40	1.81	2.44	4.70	6.01	10.88	8.82	8.82	6.34	5.63	3.86	2.81	1.47	1943.088
	80	3.07	4.12	7.94	10.16	18.40	14.87	14.87	10.71	9.49	6.51	4.75	2.48	3280.410
	120	3.95	5.29	10.16	12.77	23.56	19.03	19.03	13.73	12.14	8.32	6.05	3.19	4193.070
	160	4.54	6.09	11.68	14.95	27.09	21.88	21.88	15.79	13.99	9.58	6.97	3.70	4832.058
Sandy L.	40	2.48	3.32	6.43	8.19	14.87	12.01	12.01	8.65	7.64	5.25	3.82	2.02	2653.488
	80	4.16	5.25	10.08	12.89	23.39	18.90	18.90	13.65	12.05	8.27	6.01	3.19	4178.958
	120	4.75	6.34	12.22	15.62	28.31	22.85	22.85	16.51	14.62	10.00	7.07	3.82	5046.426
	160	5.21	7.01	13.44	17.18	31.12	25.16	25.16	18.14	16.04	11.00	8.02	4.24	5553.324

Table 11. Daily complementary required net drip irrigation (L/tree/day) and number of drippers needed per one tree grown under the tested soil textures and ground water table depth at Fayoum.

Soil texture	Ground water table (cm)	Net* & ND+	Month											
			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Clay	40	Net	39	52	100	128	232	188	188	136	120	82	60	32
		ND+	1	1	3	3	6	5	5	3	3	2	2	1
	80	Net	67	90	172	220	400	322	322	233	206	141	103	54
		ND+	2	2	4	6	10	8	8	6	5	4	3	1
	120	Net	87	115	224	287	520	420	420	303	268	184	134	71
		ND+	2	3	6	7	13	10	10	8	7	5	3	2
	160	Net	98	132	262	324	587	474	474	342	313	214	151	80
		ND+	2	3	7	8	15	12	12	9	8	5	4	2
Clay loam	40	Net	43	58	112	143	256	210	210	151	134	92	67	35
		ND+	1	1	2	4	6	5	5	4	3	2	2	1
	80	Net	73	98	189	242	438	354	354	255	226	155	113	59
		ND+	2	2	5	6	11	9	9	6	6	4	3	1
	120	Net	94	126	242	304	561	453	453	327	289	198	144	76
		ND+	2	3	6	8	14	11	11	8	7	5	4	2
	160	Net	108	145	278	356	645	521	521	376	333	228	166	88
		ND+	3	4	7	9	16	13	13	9	8	6	4	2
Sandy loam	40	Net	59	79	153	195	354	286	286	206	182	125	91	48
		ND+	1	2	4	5	9	7	7	5	5	3	2	1
	80	Net	99	125	240	307	557	450	450	325	287	197	143	76
		ND+	2	3	6	8	14	11	11	8	7	5	4	2
	120	Net	113	151	291	372	674	544	544	393	348	238	173	91
		ND+	3	4	7	9	17	14	14	10	9	6	4	2
	160	Net	124	167	320	409	741	599	599	432	382	262	191	101
		ND+	3	4	8	10	18	15	15	11	10	7	5	3

Net* = Net drip irrigation requirements (L./tree/day), and
ND+ = The number of drippers needed/tree.

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جدولة الاحتياجات المائية التكميلية للري بالتنقيط لنخيل البلح في أراضى متأثرة بمساهمة الماء الأرضى من أعماق مختلفة تحت ظروف الفيوم

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يهدف منتجي نخيل البلح إلى تطبيق أفضل المعاملات الزراعية للتوصل إلي أفضل إنتاج ذو جودة عالية كما ونوعا، ونظام الخدمة المائية الجيد يهدف إلى زيادة إنتاجية نخيل البلح وتحسين خواص الثمار من خلال حساب كمية الماء اللازمة لكل نخلة للوصول إلى افضل إنتاج كما ونوعا.

ولتحقيق هذه الدراسة تم اختيار ثلاثة مواقع أرضية بمحافظة الفيوم مختلفة في القوام (طينية- طميية طينية – طميية رملية) وبداخل كل موقع أرضى تم اختيار أربعة مواقع مختلفة في مستوى الماء الارضى بها (٤٠، ٨٠، ١٢٠، ١٦٠ سم) وكانت تلك المواقع منزرعة بنخيل البلح من صنف "البلدي المجهل" وعمره يتراوح بين ٨-١٠ سنوات أثناء إجراء هذه الدراسة. وأجريت التحليلات الطبيعية والكيميائية للتربة في الثلاث مواقع المختارة ، وتم قياس مستوى الماء الارضى خلال بيزومترات قطر فتحاتها ١٠ سم وعمقها ١٨٠سم وبصفة دورية لتحديد المتوسط الموزون لمستوى الماء الارضى ، وتم حساب معدل البخرنتح القياسي لنخيل البلح(ET_o) من بيانات المناخ لعام ٢٠٠٤ فى المنطقة التي درست باستخدام معادلة بنمان المعدلة ، وأمكن التوصل إلى قيم البخرنتح لنخيل البلح (ET_c) بعد معرفة قيم معامل المحصول Kc من الدراسات السابقة. كما تم حساب قيم مساهمة الماء الارضى (ET_{c-g}) في الاحتياجات المائية لنبات نخيل البلح (مم/يوم، مم/سنة، %).

وتوضح النتائج أن أعلى قيمة (١٠٦٩.٣١مم/سنة) لمساهمة الماء الارضى في الاحتياجات المائية لنخيل البلح كانت موجودة في حالة الاراضى الطينية ذات مستوى الماء الارضى الضحل (٤٠سم) بينما كانت اقل قيمة لمساهمة الماء الارضى (١٦١.٣٥ مم/سنة) موجودة في حالة الاراضى الطميية الرملية ذات مستوى الماء الارضى العميق (١٦٠سم). ووجدت علاقة سالبة عالية المعنوية بين قيم مساهمة الماء الارضى في الاحتياجات المائية لنخيل البلح (مم/سنة) وعمق مستوى الماء الارضى وكان معامل الارتباط مساويا – ٠.٩٨٥ في حالة الاراضى الطينية ، - ٠.٩٨٩ في حالة الاراضى الطميية الطينية ، - ٠.٩٧٢ في حالة الاراضى الطميية الرملية. وكانت معادلات الانحدار التي توضح هذه العلاقة كما يلي:

ص١ = ١٢٤٠.٥٠- ٥.٣٤ س (للتربة الطينية)

ص٢ =١٢١٥.٠٠ - ٥.٧٥ س للتربة الطميية الطينية)

ص٣ =١٠١٦.٣٠- ٥.٧٠ س (للتربة الطميية الرملية)

حيث: ص هي قيم مساهمة الماء الارضى فى الاحتياجات المائية لنخيل البلح (مم/سنة).
س هي مستوى الماء الارضى (سم).

وأمكن حساب الاحتياجات المائية الفعلية (ETn) (مقدرة بكل من مم/يوم، مم/سنة، %) من قيم الاستهلاك المائى المحسوبة (ET_c)، وتوضح النتائج أن اقل قيمة للاحتياجات المائية الفعلية (ETn) كانت موجودة في حالة الاراضى الطينية (٤١٤.٦٧ مم/سنة) ذات مستوى الماء الارضى الضحل (٤٠سم) بينما كانت أعلى قيمة للاحتياجات المائية الفعلية (١٣٢٢.٢٢ مم/سنة) موجودة في حالة الاراضى الطميية الرملية ذات مستوى الماء الارضى العميق (١٦٠سم). ووجدت علاقة موجبة عالية المعنوية بين قيم الاحتياجات المائية الفعلية (ETn)

لنخيل البلح (مم/سنة) وعمق مستوى الماء الارضى، وكان معامل الارتباط مساويا + ٠.٩٦٥ في حالة الاراضى الطينية ، + ٠.٩٧١ في حالة الاراضى الطمبية الطينية ، + ٠.٩٤٥ في حالة الاراضى الطميية الرملية. وكانت معادلات الانحدار التى توضح هذه العلاقة كما يلي:

$ص_{١}$ = ٢٤٩.١٥+٥.٣١ س (للتربة الطينية)

$ص_{٢}$ =٢٦٦.٧٦ +٥.٧٩ س (للتربة الطميية الطينية)

$ص_{٣}$ =٤٦٧.١٠+ ٥.٧٠ س (للتربة الطميية الرملية)

حيث: ص هي قيم الاحتياجات المائية الفعلية(ETn) لنخيل البلح (مم/سنة)،

س هي مستوى الماء الارضى(سم).

وباعتبار قيم الاحتياجات المائية الفعلية (ETn) (م٣/فدان/سنة) التي تم حسابها على أنها هي كمية المياه اللازمة لعمل جدولة لنظام الري بالتنقيط لنخيل البلح تحت ظروف الأراضى وعمق مستوى الماء الأرضى التى درست ، أمكن إعداد جدول زمني شهري على مدار العام للتطبيق الحقلي لتوزيع مياه الري بالتنقيط على نخيل البلح موضحا به كمية ماء الري بالتنقيط اللازمة لكل شجرة (لتر/شجرة/يوم) وعدد النقطات اللازمة لكل نخلة على حدة، وذلك للتطبيق تحت ظروف الأراضى وأعماق الماء الأرضى التى درست فى محافظة الفيوم.