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Effect of regulated deficit irrigation on water use efficiency and growth and fruiting Berhi date palm under heat stress conditions

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Abstract

This work was carried out during three successive seasons of 2021, 2022 and 2023 on Barhi date palm grown on sandy loamy soil in a south valley agricultural research station (Toshka) at Abo simple, Aswan governorate, Egypt to evaluate the effectiveness of irrigation regulated water levels (100, 80, 70 and 60% IR) on growth, yield, fruit quality and irrigation water use efficiency. Results showed that the studied growth traits and quality fruit parameters of the date palm were highest under the 100% or 80% for the tested seasons. Data referred to all the studied properties significantly affected with increasing water supply. No significant difference due to irrigate via irrigation regulated at 100 or 80% IR. In addition, irrigation levels with 70% or 80% of IR enhanced irrigation water use efficiency in the three tested seasons. Thus, this study recommends using the 70 to 80 % of IR to irrigate Barhi date palm under Toshka conditions to get the high yield with good fruit quality, in addition increasing the water use efficiency.

Introduction

Water deficiency is a major constraint in arid and semi-arid region. These region most affected by climate change due to the scarcity of water in it. Crops that require less irrigation water and those which are considered drought tolerant such as the date palm are dominant in these regions **[1]**.

Date palm is a large tree, and its water requirements is comparatively high, it's consumption vary from area to another, due to many factors, mainly climate and soil, however, the annual water requirements for a mature date palm may range between 115 and 306 cubic meters **[2]**. Reservation of water and maximization of water use efficiency in arid and semi-arid regions through modern irrigation technologies have become key for sustainable crop production. Although highest date palm production is achieved when

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providing full irrigation water requirements by traditional methods, the same production can be achieved with significantly less water application, up to 50% less, by using modern irrigation systems **[3]**.

Water deficiency is a major constraint in arid and semi-arid regions. Crops that require less irrigation water and those, which are considered drought-tolerant such as date palm ***(Phoenix dactylifera L.),*** are dominant in these regions **[4]**. The optimum date palm response to drip irrigation is due to the nature of the system where water is delivered in a slow process for relatively long period of time through drippers, this process provides better control and distribution for water through soil profile to an extent that, losses due to evaporation and deep percolation reduced to the minimum, therefore, date palm tree could make use of almost all water delivered **[5]**. The date palm needs sufficient water of acceptable quality to enable it to reach its full yield potential. Comparison with drip irrigation system have shown high water distribution performance with an average of 97% emission uniformity.

Date palm water requirement may reduce to less than 40 m^3 per tree with the application of subsurface drip irrigation **[6]**. Reducing water supply of date palm to 50% produced a similar yield with high quality; however, water requirement varied according to climate, tree age and location **[7]**. The crop coefficient of date palm was not constant throughout the growing season and ranged from 0.5 to 1.18, based on growth stages. Application of 133, 164, 182 and 199 m^3 per tree per season produced 33.5, 36, 37.8 and 42.49 kg per tree respectively. The actual date palm water use ranged from 59.4 to 80 m^3 per tree per season **[8]**.

Deficit irrigation (DI) has been extensively studied as a valuable and sustainable production strategy in dry areas by applying water shortage to growth stages **[9]**. Use of deficit irrigation reduced the amount of production, but it saved the amount of water compared to full irrigation. One of the methods used in deficit irrigation is the regulated deficit irrigation (RDI), during which there is a shortage of irrigation for a certain period and full irrigation is released for another period. Applying deficit irrigation to palms grown in dry areas, maximize water productivity and improve fruit quality, but negatively affect production **[10, 11, 12, 13]**.

The objectives of this study were to determine the optimum growth, yield, and water use- efficiency as affected irrigation requirements (recommended regime 100%, 80%, 70 or 60% from recommended regime of Barhi date palm.

Materials and Methods

This study was carried out during three successive seasons of 2021, 2022 and 2023 in a South Valley Agricultural Research Station (Toshka), at Abo-Simpl, Aswan

Governorate, Egypt. Barhi date palm trees of 10 years old grown in sandy loam soil, and spaced 7x7 m. Laboratory work of this study was conducted in Pomology Department, Faculty of Agriculture, Aswan University, Egypt.

Twelve female palms trees of healthy with no visual nutrient deficiency symptoms, nearly uniform in shape, size and productivity were chosen and devoted to achieving this experiment.

The experiment involved four levels of Regulated Deficit Irrigation (RDI).

The treatments were as follows:

A1: Irrigation at 100% of IR for all growth stage (control)

A2: irrigation at 100% of IR in flowering stage, growth and development fruit and Irrigation at 80% of IR in Mature fruit stage and after harvesting stage.

A3: irrigation at 100% of IR in Flowering stage, growth and development fruit and Irrigation at 70% of IR in Mature fruit stage and after harvesting stage.

A4: irrigation at 100% of IR in flowering stage, growth and development fruit and irrigation at 60% of IR in Mature fruit stage and after harvesting stage.

The experiment was designed as complete randomized block with three replicates for each treatment and each replicate was represented by one

Estimation of irrigation water requirements for date palm using weather parameters are incorporated into the ETo multiplying the reference crop Evapotranspiration. ETo, by a crop coefficient, Kc according to FAO **[14]**. the same (methodology was adopted by many studies **[15]**.

IR = Kc x ETo x LF x IE x R x Area (fed)/1000

Where:

IR = Irrigation requirements (m/fed.).

Kc= Crop coefficient (0.40-0.80) according to **[16, 17]**.

ETo= Reference crop Evapotranspiration (mm/day).

LF= Leaching fraction (assumed 20% of irrigation water).

IE= Irrigation efficiency of the irrigation system in the field (assumed 85%).

R= Reduction factor (35-70% cover in this study).

Area= The irrigated area one feddan = 4200 m^2).

1000= To convert from mm to cubic meter (m).

In addition, the water needs of date palms and per fed. was calculated according to the following equations.

Irrigation water requirement for date palm m3/Fed./Month

$$\mathbf{IR = ETc \times 4.2 \times 15}$$

Where:

IR = Irrigation requirements (m3 /fed/Month).

ETc = Palm Evapotranspiration (mm/day).

4.2 = To convert from mm to m3/fed.

15 = Number of Irrigation times.

Then, the estimated palm water requirement and irrigation scheduling program are presented in Table (1).

Table (1): Total amount water/fed/month as 100, 80, 70 and 60% of IR.

Months	ETC/ mm day	100% ETC		80% ETC		70% ETC		60% ETC	
		L/tree/ 2 day	M^3/ fed/M	L/tree/ 2 day	M^3/ fed/M	L/tree/ 2 day	M^3/ fed/M	L/tree/ 2 day	M^3/ fed/M
Jan.	4.41	217	277	173.6	221	151.9	193	130.2	166
Feb.	5.48	270	345	270	345	270	345	270	345
Mar.	6.7	330	422	330	422	330	422	330	422
Apr.	7.51	370	473	370	473	370	473	370	473
May	9.4	464	592	464	592	464	592	464	592
Jun.	10.21	504	643	504	643	504	643	504	643
Jul.	9.67	477	609	381.5	487	333.9	426	286.2	365

Aug.	9.65	476	607	380.8	485	333.2	424	285.6	364
Sep.	8.57	422	539	337.6	431	595.4	377	235.2	323
Oct.	7.05	348	444	278.4	355	243.6	310	208.8	266
Nov.	5.51	272	347	217.6	277	190.4	242	163.2	208
Dec.	4.03	198	253	158.4	202	138.6	177	118.8	151
Total			5552		4933		4624		4318

In general, the following measurements were determined during the three studied seasons.

1- Number of newly growing leaves were determined at the end of growth season. In addition, four mature leaves were chosen on each palm to determine number of pinnae/leaf and pinnae area (cm^2) as pinnae area = length x max. width x 0.84, according to **[18]**. The whole leaf area (m^2) was obtained from multiplying the pinnae area by the number of pinnae/leaf.

2- Yield: All bunches were harvested at khalal stage, bunches of each palm were picked and weighed, then the yield/palm (kg) was recorded.

3- Fruit physical and chemical properties: Fifty fruits were taken at harvest date from each palm to determine some physical and chemical fruit characteristics. Physical characteristics including fruit weight and pulp percentage as well as fruit length and diameter which measured by vernier caliper. Whereas, the chemical constituents were total soluble solids percentage by using a hand refractometer as well as sugar content (total, reducing & non-reducing) according Lane and Eynon, volumetric and total acidity as g. malic acid per 100 g pulp was determined according to procedure as outlined **[19]**. As well as percentage of tannin in the fruits was determined using the Indigo Carmen indicators. Titration was carried out using 0.1 N potassium permanganate solutions. Tannins in fresh weight were calculated (as total tannins percentage) according to the following equation:

1 ml potassium permanganate (0.1 N) = 0.00416 g tannins according to **[20]**.

4- irrigation water-use efficiency (IWUE) kg m^{-3} were recordedand.

Data were tabulated as well as statistically analysed and differences between treatments means were compared using L.S.D. test at 5% level according to **[21, 22]**.

Results

Data in Tables (2 & 3) showed the effect of regulated deficient irrigation levels on vegetative grow, i.e. new leaves number/palm/year, leaf length, leaflets area and total chlorophyll of Barhi date palm during 2021, 2022 and 2022 seasons. It is obvious from the data that results took similar trend during the three studied seasons.

Results clearly show that the studied growth traits increased as the irrigation water increased from 60 to 100% of irrigation requirement, IR. No significant differences between 100 and 80% of irrigation regulated (IR). The highest new leaves, leaf length, total leaf area and total chlorophyll obtained due to use 100% of IR compared the lowest one recorded by using 60% of IR.

The recorded new leaves was (20.44, 20.17, 19.78 and 18.37 leaf as an av. of the three studied seasons) for using 100, 80, 70 and 60% of IR, respectively. The corresponding total leaf area (2.89, 2.84, 2.73 and 2.57 m^2) and total chlorophyll (93.38, 92.05, 88.46 and 80.73 SPAD). Then, the increment percentage of New leaf attained (11.26, 9.80 & 7.68%), total leaf area (12.45, 10.51 & 6.23%) and total chlorophyll (15.68, 14.04 & 9.59%) due use 100, 80 and 70% IR compared to 60% IR, respectively.

Table (2): Effect of regulated deficit irrigation in some leaf traits of Barhi date palm during 2021, 2022 and 2023 seasons.

Char. / Season / Treat.	New leaves				Total leaf area				Leaf length			
	2021	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
100%	20.33 A	20.33 A	20.67 A	**20.44 A**	2.83 A	2.91 A	2.92 A	**2.89 A**	4.69 A	4.86 A	4.93 A	**4.83 A**
80%	19.84 AB	20.33 A	20.33 A	**20.17 A**	2.79 AB	2.87 AB	2.85 AB	**2.84 A**	4.63 A	4.79 A	4.87 A	**4.70 AB**
70%	19.33 B	19.67 AB	20.33 A	**19.78 B**	2.68 B	2.73 B	2.78 B	**2.73 B**	4.48 AB	4.62 AB	4.69 AB	**4.60 B**
60%	18.60 B	18.67 B	17.85 B	**18.37 C**	2.53 C	2.59 C	2.58 C	**2.57 C**	4.31 B	4.43 B	4.51 B	**4.42 C**
LSD	0.88	0.83	0.81	**0.51**	0.13	0.15	0.12	**0.08**	0.26	0.28	0.28	**0.16**

Table (3): Effect of regulated deficit irrigation on leaflets area and total chlorophyll and bunch weight of Barhi date palm during 2021, 2022 and 2023 seasons.

Char. / Season / Treat.	Leaflets area				Chlorophyll SAPD				Bunch weight (kg)			
	2021	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
100%	123.5 A	120.8 A	122.8 A	**122.4 A**	93.74 A	92.56 A	93.85 A	**93.38 A**	14.00 A	14.33 AB	14.67 A	**14.33 A**
80%	118.6 A	121.5 A	122.1 A	**120.7 A**	90.29 A	92.75 A	93.11 A	**92.05 A**	13.62 A	14.50 A	14.18 A	**14.10 AB**
70%	110.8 B	117.3 A	120.2 A	**116.1 B**	83.76 B	89.83 A	91.78 A	**88.46 B**	13.33 A	13.67 B	14.26 A	**13.75 B**
60%	104.6 C	108.3 B	105.9 B	**106.3 C**	79.73 B	81.78 B	80.65 B	**80.72 C**	12.38 B	12.83 D	13.33 B	**12.85 C**
LSD	5.68	6.19	5.84	**3.44**	4.89	4.99	4.94	**2.88**	0.71	0.78	0.82	**0.45**

Yield components:

Data in Tables (3 & 4) showed that the effect of regulated deficit irrigation on yield components of Barhee date palm during 2021, 2022 and 2023 seasons. It is obvious from the data that results took similar trend during the three studied seasons.

Results indicate that yield components i.e., bunch weight and yield kg/palm significantly varied due to irrigation requirements used from 60 to 100% IR. It could be noticed that yield/palm and bunch weight were significantly increased with increasing IR from 60 to 100%. In this respect, the best treatment that gave the highest significant yield/palm (194.8 & 189.3 kg) and bunch weight (14.33 & 14.10 kg as an av. of the three studied seasons) due to use 100 or 80% of IR, respectively. On other hand, the least values recorded of the palm that irrigated by 60% of IR, where it recorded (12.85 kg and 139.3 kg as an av. of the three studied seasons). No significant differences were found due to decreased the irrigation water used from 100 to 70%. So, in general economic view, it concluded that to use 70 to 80% water used to get economic yield.

The recorded bunch weight was (14.33, 14.10, 13.75 & 12.85 kg) and yield/palm was (194.8, 189.3, 174.9 & 139.3 kg/palm as an av. of the three studied seasons) due to use 100, 80, 70 and 60% of IR, respectively. Then the corresponding increment percentage of yield/palm due to 100 & 80 or 70 over 60% IR attained (39.89, 35.89 & 25.56%), respectively.

Table (4): Effect of regulated deficit irrigation on yield, fruit weight and pulp % of Barhi date palm during 2021, 2022 and 2023 seasons.

Season	Yield/palm (kg)				Fruit weight				Pulp %			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
100%	176.8 A	206.0 A	201.6 A	**194.8 A**	17.00 A	17.29 A	17.53 A	**17.27 A**	93.20 A	93.18 A	93.41 A	**93.26 A**
80%	169.9 A	205.6 A	193.1 AB	**189.3 A**	16.90 A	17.45 A	17.50 A	**17.28 A**	91.98 A	92.68 A	92.51 A	**92.39 A**
70%	157.1 B	181.7 B	186.1 B	**174.9 B**	16.50 A	16.87 A	17.23 A	**16.89 A**	92.36 A	92.75 A	92.85 A	**92.65 A**
60%	123.5 C	145.8 C	148.6 C	**139.3 C**	15.50 B	15.83 B	15.57 B	**15.63 B**	89.30 B	90.11 B	89.86 B	**89.76 A**
LSD	7.39	10.11	9.88	**5.69**	**0.93**	**0.98**	**1.06**	**0.59**	**2.18**	**2.46**	**2.58**	**1.42**

Fruit quality:

A- Fruit physical characteristics:

Results in Tables (5 & 6) indicate that fruit weight, fruit dimensions and flesh percentage were significantly affected by different irrigation water amount used during three studied seasons. In general data showed positive correlation occurred between irrigation amount water used and physical fruit properties. Data referred that used 80 or 100% IR recorded the highest value compared to use 60% of water amount. In general view, the highest values of fruit physical properties were noticed in palms irrigated with 80 or 100% of IR, while the lowest values were recorded in palms that irrigated with 60%. No significant differences due to decreased the amount of irrigation water used from 100 to 70%.

The recorded fruit weight was (17.27, 17.28, 16.89 & 15.63%) and flesh % (93.26, 92.65, 92.39 & 89.76%) and fruit length (3.61, 3.60, 3.54 & 3.33 cm) and fruit diameter (2.58, 2.54, 2.54 & 2.38 cm as an av. of the three studied seasons) due to irrigate with 100,

80, 70 and 60% of IR, respectively.

Moreover, the increment percentage of fruit weight attained (10.48, 10.56 & 8.06%) and flesh % (3.90, 3.22 & 2.93%, respectively.

These results showed that no significant differences were seen due to decrease the irrigation water amount from 100 to 70% of IR. So, from an economic standpoint it could be concluded that irrigated the palm with 70 to 80% of estimated water amount.

Table (5): Effect of regulated deficit irrigation on fruit dimension and TSS of Barhi dates during 2021, 2022 and 2023 seasons.

Season	Fruit diameter				Fruit length				Total soluble solids %			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
100%	2.56 A	2.57 A	2.60 A	**2.58 A**	3.64 A	3.64 A	3.58 A	**3.61 A**	45.2 A	45.8 A	45.6 A	**45.6 A**
80%	2.52 A	2.56 A	2.55 A	**2.54 A**	3.53 A	3.53 A	3.55 A	**3.54 A**	45.3 A	46.1 A	46.5 A	**45.9 A**
70%	2.51 A	2.53 A	2.58 A	**2.54 A**	3.66 A	3.66 A	3.60 A	**3.60 A**	45.3 A	45.5 A	46.1 A	**45.0 A**
60%	2.38 B	2.33 B	2.42 B	**2.38 B**	3.35 B	3.38 B	3.25 B	**3.33 B**	43.8 B	44.1 B	43.9 B	**43.4 B**
LSD	**0.08**	**0.09**	**0.08**	**0.05**	0.11	0.14	0.11	**0.07**	**1.10**	**1.22**	**1.28**	**0.72**

Table (6): Effect of regulated deficit irrigation on total soluble solids, acidity and tannins of Barhi date palm during 2021, 2022 and 2023 seasons.

Season	Acidity %				Tannins %				Water use efficiency kg/ml			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
100%	0.121 B	0.115 B	0.123 B	**0.120 B**	0.209 B	0.196 B	0.210 B	**0.205 C**	2.71 B	3.16 B	3.09 B	**2.98 B**
80%	0.123 B	0.117 B	0.125 B	**0.122 B**	0.212 B	0.201 B	0.215 B	**0.209 BC**	2.98 A	3.54 A	3.33 A	**3.26 A**
70%	0.125 B	0.118 B	0.127 B	**0.123 B**	0.216 B	0.204 B	0.216 B	**0.215 B**	2.89 AB	3.34 AB	3.42 A	**3.22 A**
60%	0.134 A	0.131 A	0.136 B	**0.134 A**	0.226 A	0.219 A	0.228 A	**0.224 A**	2.43 C	286 C	2.93 B	**2.74 C**
LSD	**0.005**	**0.005**	**0.006**	**0.003**	**0.009**	**0.009**	**0.010**	**0.006**	**0.23**	**0.28**	**0.30**	**0.16**

B- Fruit chemical characteristics:

It is clear from the results in Tables (7 & 8) that using 70 to 100% irrigation water amount significantly resulted in improving fruit chemical properties, in terms of increasing TSS%, sugar contents and decreasing the acidity and tannins in relative to used 60% IR.

As for TSS% and sugar contents, the results in Tables (7 & 8) reveal the irrigation 100, 80, 70% of estimated water in descending order gave better results (45.6, 45.9 & 45.0) and (40.9, 40.7 & 40.5% as an av. of the three studied seasons) due to 100, 80 or 70% of IR, respectively. On the other hand, using 60% scored the lowest value in this respect (43.4 & 38.6%), respectively.

Then, the corresponding increment percentage of total soluble solids attained (5.07, 5.76 & 3.69%) due to 100, 80 and 70% compared to 60% (IR), respectively.

Moreover, no significant differences were found due to decreased the irrigation water amount from 100 to 70% of IR. So, from economic view, it concluded that irrigate with 70

to 80% of water amount estimated to get best dates quality.

With regard to acidity % and tannins contents, use 100, 80 or 70% IR reduced such studied traits as compared with used 60% IR.

In general, the lowest percentage of fruit chemical properties except acidity and tannins contents were found in date harvest from palm that irrigated with 60% IR. On the other hand, irrigated with 100, 80 or 70% IR recorded the highest value in this respect. No significant differences were found due to decrease the irrigation water levels from 100 to 70% of IR. So, in general economic view, it concluded that irrigated by 70 to 80% of IR to get high yield with good dates quality.

Irrigation Water Use Efficiency (IWUE)

Recorded data (Table 8) proved that 80% irrigation regulated gave the highest values compared with the other IR used. The highest value of I. W.U.E. for date palm were 3.26 & 3.22 kg m^{-3} under 80 or 70% of IR. No significant differences due to irrigate via 80 or 70% of irrigation regulated (IR). The recorded IWUE values was 2.98, 3.26, 3.22 and 2.74 kg m^{-3} as an av. of the three studied seasons due to use 100, 80, 70 or 60% IR, respectively. The increment percentage of IWUE attained (8.76, 18.98 & 17.52% as an av. of the three studied seasons) due to use 100, 80 or 70% IR compared to use 60% of IR, respectively. In other words, improvement of I.W.U.E. may be attributed with available water formed in the root zone, but not the amount of applied water.

Table (7): Effect of regulated deficit irrigation on sugar contents of Barhi date palm during 2021, 2022 and 2023 seasons.

Season	Total sugar %				Reducing sugar %				Non-reducing sugar %			
	2021	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
100%	40.5 A	41.2 A	40.9 A	**40.9 A**	29.6 A	30.0 A	29.9 A	**29.8 A**	10.9 A	11.2 A	11.0 A	**11.0 A**
80%	39.9 A	41.0 A	41.3 A	**40.7 A**	29.3 A	29.7 A	30.1 A	**29.7 A**	10.6 A	11.3 A	11.2 A	**11.0 A**
70%	39.6 A	40.8 A	41.1 A	**40.5 A**	29.0 A	29.3 A	29.9 A	**29.4 A**	10.6 A	11.5 A	11.2 A	**11.1 A**
60%	38.3 B	38.5 B	38.9 B	**38.6 B**	27.8 B	27.9 B	28.3 B	**28.0 B**	10.2 B	10.7 B	10.6 B	**10.5 B**
LSD	**1.19**	**1.09**	**1.24**	**0.71**	**0.72**	**0.81**	**0.78**	**0.46**	**0.32**	**0.38**	**0.35**	**0.21**

Discussion

Date palm is a large tree and its water requirements is comparatively high. Reservation and maximization of water use efficiency in arid and semi-arid regions through modern irrigation technologies have become key for sustainable crop production **[4]**. Use the deficit irrigation reduced the net production, but it saved the amount of water used compared to full irrigation. Most importance features of the regulated deficit irrigation (RDI) that is a shortage or irrigation for a certain period and full irrigation for another period **[9]**.

All previous mentioned growth parameters of date palm tended to increase by increasing amounts of applying water among any irrigation system. Thus, it can be concluded that, the active photosynthesis net assimilation relative growth rates affected by the amount of water **[23]**. Drip irrigation system provided the crop with adequate water requirement at the root zone due to their high performance and efficiency. The result agrees with the result obtained **[24]**.

These irrigation levels seem to be enough to provide the palm trees with their water requirements. A similar trend was reported by **[8]**. Sometimes increasing water supply insignificantly increased date yield **[7]**. An additional possible explanation of these results is that drip irrigation offers better distribution of water in the soil. As a result, the root volume wetted beneath the surface is larger due to lateral movement of water, and the slow application and redistribution of soil water provide better soil aeration.

Conclusion

The results for the study showed that, all the studied properties significantly affected with increasing water supply. In addition using irrigation regulated (IR) with 80 or 70% IR enhanced yield and improved irrigation water use efficiency in tested seasons. Thus, this study recommends using the 70 to 80% IR to improve water use efficiency and get high yield with good quality of Barhi date palm trees under Toshka, Abo simple , Aswan conditions.

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تأثير نقص الري المنظم علي كفاءة استخدام الماء ونمو وإثمار نخيل البلح البرحي تحت ظروف الإجهاد الحراري

الملخص العربي

أجريت هذه الدراسة خلال مواسم 2021 حتي 2023 بالمزرعة البحثية الخاصة بمحطة بحوث جنوب الوادي – توشكا – أبو سمبل – أسوان – مصر، بهدف دراسة تأثير نقص الماء المنظم علي كفاءة استخدام الماء ونمو وإثمار نخيل البلح البرحي، حيث تم استخدام ثلاثة مستويات من نقص الماء (80 ، 70 ، 60% من المقنن المائي) مقارنة باستخدام 100% من المقنن المائي المحسوب بناءاً علي معادلات النتح بخر.

وقد أظهرت النتائج التالي:

- أحدث نقص تدريجياً في صفات النمو الخضري والمحصول نتيجة نقص معدل الماء من 100% حتي 60% من المقنن المائي المحسوب.
- لم تسجل فروق معنوية نتيجة نقص مستوي الماء من 100 حتي 80%.
- سجلت أفضل صفات ثمرية عند استخدام 80% من المقنن المائي مقارنة بباقي المعاملات.

- سجل أعلي كفاءة لاستخدام ماء الري نتيجة الري بمستوي 80 أو 70% من المقنن المائي بدون تسجيل فروق معنوية بينهما.

من نتائج هذه الدراسة فإنه يمكن نقص منظم للمقنن المائي بمعدل من 20–30% وذلك لزيادة كفاءة استخدام ماء الري مع إنتاج محصول عال ذو خصائص ثمرية جيدة لنخيل البلح البرحي تحت ظروف توشكا– أبو سمبل – أسوان.