Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 9 (12): 2330-2334, 2009
ISSN 1812-5654

Growth Response of Palm Trees to the Depth and Frequency Period of Irrigation by Bubblers in Khuzestan, Iran

[1]D. Khodadadi-Dehkordi, [2]H.A. Kashkuli and [2]A. Bavi
[1]Department of Irrigation and Drainage Engineering, Research and Science Branch,
Islamic Azad University, Tehran, Iran
[2]Department of Irrigation and Drainage, Faculty of Water Sciences Engineering,
Shahid Chamran University, Ahwaz, Iran

Abstract: Based on the shortage of water resources in Iran country and the high evapotranspiration rate in Khuzestan region (2044 mm year^{-1}), an irrigation system on Estamaran (Sayer) palm trees in the experimental farm of Shahid Rajaee of Omidiyeh plain was conducted. This study had two purposes, namely irrigation frequency period and suitable depth of irrigation application of the Estamaran palm trees in Omidiyeh region. Irrigation frequency was the primary treatment and the evapotranspiration estimating methods were the secondary treatments. Three irrigation levels i.e., one day long (A1), two day long (A2) and three day long (A3), were used as irrigation frequency period. Also the evapotranspiration estimating methods used were, Penman Monteith 100% (B1), Penman Monteith 70% (B2), Class A Pan 100% (B3) and Class A Pan 70% (B4). Since, this study had three replications, 36 palm trees were selected for this experiment. Irrigation scheduling was done according to SCS recommendations. Experimental design was according to split plot method in a randomized complete block design. Finally by measuring different growth indices of palm trees (number of leafs, number of thorn and leaflet length) at about two years (2006-2008), the results showed that the A1B2 treatment (Penman Monteith 70% and daily irrigation), at index of number of leaves, had a significant difference at 5% level. So, it recommended as the best treatment in this plan. In comparison with the uncontrolled bubbler irrigation by local farmers, using A1B2 treatment from Aug. to Nov. (2008) (the peak months for evapotranspiration data), would have 7344 m^3 water saving per hectare per month.

Key words: Penman monteith, class a pan, irrigation scheduling, evapoteranspiration, irrigation depth and frequency, estamaran palm trees

INTRODUCTION

Yearly total rainfall received on the surface in Iran is about 400 Billion Cubic Meters (BCM), out of which 280 BCM is lost through evapotranspiration and the remaining 120 BCM either runs on the surface or infiltrates to raise soil moisture or joins to groundwater. A third of the total surface water of the country (about 34 BCM) flows through rivers passing the vast Khuzestan plain. The soil and climate of Khuzestan is suitable for diverse agronomic and horticultural farming throughout the year, KWPA (2003). One of the major crops in this province is date palm. Although this crop is adapted to dry conditions; higher yields can be obtained with irrigation. With about 30 million palm trees covering a total area of 216 thousand ha, the total date production in Iran is about 900 thousand tons. In spite of the importance of this crop, so far little is known about the potential of increasing of yield for this crop through modern irrigation methods, To determine the proper irrigation depth and interval for Estamaran date palm trees grown on Omidiyeh experimental field, this field research experiment is designed. Date palms are more able to adapt to scarce of water supply. Furr and Armstrong (1955) reported that prolonged periods of severe water shortage during the growing season had adverse effects on the growth of leaves and on size, grade and yield of fruits. Hussein and Hussein (1982) suggested that an irrigation interval of 4 weeks applying 71 mm per irrigation was the most suitable in date palms. Hilal *et al*. (1986) showed that the low frequency periods and high volume of water per irrigation were more favorable for date palms growth. Comparing drip versus bubbler irrigation was more favorable for date palms growth. Comparing drip versus bubbler irrigation for 5 years on mature Deglet Noor date palms, Reuveni (1975) found that drip was superior to

Corresponding Author: D. Khodadadi-Dehkordi, Department of Irrigation and Drainage Engineering, Research and Science Branch, Islamic Azad University, Tehran, Iran Tel: +989161118307 Fax: +986113776657

bubbler irrigation in term of total yield and other growth parameters. He related this effect to higher water availability with drip compared to bubbler. In the same experiment as reported here, Bacha *et al*. (1998) showed that the average yield was higher in trickle irrigation system than in other two systems (basin and bubbler). Also, Al-Amoud *et al*. (2000) showed that trickle irrigation system gave the best water use efficiency followed by basin and then bubbler and that an annual water volume of 100 m^3 per tree have produced the highest water use efficiency. The date palms are considered highest salt tolerant fruit crop and expected to give its 100% yield potential at soil electrical conductivity (saturation extract, ECe) value of 4.0 dS m^{-1} and at irrigation water electrical conductivity (ECw) value of 2.7 dS m^{-1} and still can give 50% of its yield potential at ECe value of 18 dS m^{-1} and ECw value of 12 dS m^{-1}, (Ayers and Westcot, 1985). Hassan and El-Azayem (1990) tested 11 fruit species for salinity tolerance and found that date palms were the most salinity tolerant of all. Salt tolerance of date palms varies with cultivars. For example, Akhlas cultivar has lower soil salinity tolerance compared to Ruzaiz at Al-Hassa oasis of Saudi Arabia by Abderrahman and Abdelhadi (1990). However, Nimah (1985) stated that salt accumulation was higher in the surface layer of the soil for trickle irrigation system compared to bubbler. Date palms are more able to adapt to scarce of water supply.

MATERIALS AND METHODS

This investigation is part of large study on the combined effects of irrigation systems and water regimes on date palms in an oat-stubble field at the research farmland, located southeast Khuzestan Province of Iran at 49° 42' 30'' E and 30° 50' N, during the period of July (2006) through November (2008). The experiments were designed as split plot method based on Complete Randomized Blocks (CRB) by 12 treatments and 3 replications (total number of 36 trees). The main variable factor was irrigation frequency period, taken at 3 levels; daily (A1), two days (A2) and three days (A3) intervals. The secondary variable factor was the method of estimating of depth of applied irrigation based on Penman Monteith method 100% (B1), Penman Monteith 70% (B2) Class A Pan 100% (B3) and Class A Pan 70% (B4). Irrigation water was carried through a 90 mm sub main, feeding a number of 32 mm manifolds. Laterals took water from these manifolds and delivered water to the bubblers besides palm trees grown at a distance of 8×8 m. The soil of the experimental site was sandy loam with pH of about 8 and ECe of 1.8 dS m^{-1}. Final intake rate of soil was 6-8 mm h^{-1} which improved by the addition of organic matter to basins.

Preparations before starting irrigation included:

- Separating the selected trees
- Separating female pods (in order to restriction of the time of the experiment and the need for having significant vegetative growth results, in the mentioned time, female pods were pruned. Consequently the present study has not any yield data whereas vegetative growth was the most important factor to focus)
- Weeding
- Pruning and cutting
- Maturing with fertilizer application
- Marking and tagging leaflets and thorns for growth measurement
- Calibration of bubblers for a fixed discharge of 222 L h^{-1} with an inlet pressure of 2.5 bars

Table 1 shows the average of water qualitative analysis of the irrigation, from July 2006 through November 2008.

Irrigation water requirement of palm trees was calculated using Penman Monteith method and potential evapotranspiration of reference crop (ET_0), estimated with Pan Evaporation record, as followed:

$$ET_0 = Kp.\ Epan$$

where, Kp is pan coefficient and Epan is pan evaporation (mm day^{-1}).

ET_0 was also estimated by Penman Monteith method, using computer software (Cropwat 7.0, FAO's FTP-server). A crop coefficient (Kc) of 0.9 was used for date palm. Effective rainfall was estimated using 80% probable mean monthly rainfall.

$$Pe = [1.252496 \times Pm^{(0.82416)} - 2.93522] \times 10^{(0.00095512 \times ETc)}$$

where, Pe is effective rainfall (mm $month^{-1}$), Pm is mean rainfall (mm $month^{-1}$) and ETc is crop evapotranspiration.

Considering that in drip irrigation, soil surface evaporation losses are minimal and almost all the water consumed is lost by transpiration, calculation of mean daily transpiration of date palm is given by American Soil Conservation Service (1992):

Table 1: Average of water qualitative analysis

			Solution cations (meq L^{-1})					Solution anions (meq L^{-1})						
EC×10^6	pH	TDS	Ca	Mg	Na	K	SUM	CO_3^{2-}	HCO_3^-	Cl^-	SO_4	SUM	SP	SAR
2151	7.2	1858	8.4	3.6	11.5	0.1	29.5	-	1.2	16.7	11.35	29.25	59	7.1

Table 2: Average of water requirement of treatments

	ETc and Td (mm day^{-1}) and Pe80% (mm month^{-1})											
	Penman-Monteith100%			Penman-Monteith 70%			Class A Pan 100%			Class A Pan 70%		
Month	ET_C	Td	Pe80%	ET_C	Td	Pe80%	ET_C	Td	Pe 80%	ET_C	Td	Pe80%
July-Aug.	16.23	3.50	-	11.36	2.45	-	6.72	1.45	-	4.71	1.01	-
Aug.-Sep.	15.05	3.24	-	10.53	2.27	-	5.19	1.12	-	3.64	0.78	-
Sep.-Oct.	11.38	2.45	-	7.96	1.71	-	4.23	0.91	-	2.96	0.64	-
Oct.-Nov.	8.30	1.79	8.50	5.80	1.25	7.21	2.43	0.52	5.80	1.70	0.37	5.50
Nov.-Dec.	3.98	0.86	38.07	2.79	0.60	35.19	1.32	0.28	31.94	0.93	0.20	31.13
Dec.-Jan.	2.90	0.62	36.00	2.02	0.43	33.96	1.03	0.22	31.81	0.72	0.15	31.17

Table 3: Average of the net depth of irrigation (mm) for all treatments for peak month's data

Treatments	Months	A1B1	A1B2	A1B3	A1B4	A2B1	A2B2	A2B3	A2B4	A3B1	A3B2	A3B3	A3B4
Net	July-Aug.	3.50	2.45	1.45	1.01	7.00	4.90	2.90	2.02	10.5	7.35	4.35	3.03
irrigation	Aug.-Sep.	3.24	2.27	1.12	0.78	6.48	4.54	2.24	1.56	9.72	6.81	3.36	2.34
depth (mm)	Sep.-Oct.	2.45	1.71	0.91	0.64	4.90	3.42	1.82	1.28	7.35	5.13	2.73	1.92
	Oct.-Nov.	1.51	1.01	0.33	0.19	3.02	2.02	0.66	0.38	4.53	3.03	0.99	0.57

Table 4: Average of gross depth of irrigation (mm) for all treatments for peak month's data

Treatments	Months	A1B1	A1B2	A1B3	A1B4	A2B1	A2B2	A2B3	A2B4	A3B1	A3B2	A3B3	A3B4
Gross irrigation	July-Aug.	4.47	3.13	1.853	1.290	8.94	6.26	3.71	2.58	13.42	9.39	5.56	3.87
depth (mm)	Aug.-Sep.	4.14	2.90	1.430	1.000	8.28	5.80	2.86	1.99	12.42	8.70	4.29	2.99
	Sep.-Oct.	3.13	2.18	1.160	0.820	6.26	4.37	2.33	1.64	9.39	6.55	3.49	2.45
	Oct.-Nov.	1.93	1.29	0.420	0.243	3.86	2.58	0.84	0.49	5.79	3.87	1.26	0.73

$$Td = Ud\ [Ps/100+0.15\ (1-Ps/100)]$$

where, Td is mean maximum daily transpiration (corrected with 80% effective rainfall), Ud is mean maximum daily consumptive use and Ps is percent of plant coverage (Ps = 7.7%).

Table 2 shows that during Nov.-Dec. and Dec.-Jan., 80% probable monthly effective rainfall exceeds mean maximum monthly transpiration for date palm; therefore there was no irrigation for this period.

The net depth of applied irrigation (In) is derived as:

$$In = Td.\ Fi$$

where, Fi is frequency period of irrigation.

Table 3 shows the average of the net depth of irrigation (mm) for all treatments for peak month's data (July- Nov) (2006-2008). Because all variables (net depth, gross depth, etc.) were maximum in July through November (2006-2008), in order to abbreviation, putting data of other months in the tables are ignored. So data of July through November (2006-2008) were presented as sample.

Gross depth of irrigation (Ig) is estimated by:

$$Ig = (In.\ Tr)/(Ea/100)$$

where, Tr is transpiration ratio during peak period (in this plan estimated 1.15) and Ea is irrigation efficiency, beside Ea is given as per:

$$Ea = Eu \times Et$$

Table 5: Average of daily gross water requirement for all treatments for peak month's data

	Gross water requirement (L day^{-1})			
Treatments	July-Aug.	Aug.-Sep.	Sep.-Oct.	Oct.-Nov.
$A_{1,2,3}B1$	286	265	200	124
$A_{1,2,3}$ B2	200	186	140	83
$A_{1,2,3}$ B3	119	92	74	27
$A_{1,2,3}$ B4	83	64	52	16

where, Eu is uniformity of dripping (in this plan estimated 90%) and Et is crop water use efficiency (in this plan estimated 1).

Table 4 shows the average of gross depth of irrigation (mm) for all treatments for peak month's data (July- Nov.) (2006-2008).

Gross daily requirement of a crop in liters per day, estimated by the following equation:

$$G = (Ig/Fi) \times Sp \times Sr$$

where, Sp is distance between trees in each row and Sr is distance between rows of trees.

Time of water application, Ta (h), is calculated by the following equation:

$$Ta = G/(Np \times qa) \times Fi$$

where, Np is number of bubblers surrounding a tree and qa is bubbler discharge (l/h).

Table 5 shows the average of daily gross water requirement for all treatments for peak month's data (July- Nov.) (2006-2008).

RESULTS AND DISCUSSION

According to the results of the variance analysis for all the treatments in crop characteristics including number of leaves, thorns and length of leaflets, in about two years period of experiment, it was determined that A1B2 treatment (Penman Monteith 70% and daily irrigation), at index of number of leaves, has significant difference at 5% level and recommended as the best treatment in this plan. Data in Table 6 are the number of leaves for all the treatments before start of study. Data in Table 7 are the number of leaves for all the treatments in end of study.

From the point of view of water saving, recommendation of A1B2 treatment is the most appropriate one, because it can leads to saving about 7344 m^3 water per hectare per month (only for period of July through November (2008) compared to uncontrolled bubbler irrigation by local farmers, in the part of experimental farm of Shahid Rajaee, that had 3.87 hectare area, 610 date palm trees and bubblers with discharge of about 750 L h^{-1} and daily irrigation interval at July-Sep, two days at Sep-Oct and three days at Oct-Nov. (Table 8).

In a series of research conducted by the Work Group of Agricultural Products of Iran (WGAPI), Penman Monteith method was compared with FAO-24 (Corrected Penman, Radiation and Blany Criddle method) for many weather stations (IRNCID, 2002). Penman-Monteith was selected as the most appropriate method. Therefore, it concludes that ET_0 by Class A Pan method can be used more advantageously in Omidiyeh which is a dry region. It can be concluded, for Estamaran date palm in Omidiyeh region, if enough water was available, treatment A1B2 is the most appropriated treatment, but if less water was available, treatments using Class A Pan method are more appropriate also Comparison of reference potential evapotranspiration by

Table 6: No. of leaves measured for any treatments

Replication	Primary treatments	Secondary treatments	No. of leaves
R1	A1	B1	13
		B2	8
		B3	8
		B4	6
	A2	B1	8
		B2	15
		B3	16
		B4	14
	A3	B1	9
		B2	20
		B3	9
		B4	13
R2	A1	B1	14
		B2	4
		B3	16
		B4	16
	A2	B1	12
		B2	15
		B3	13
		B4	10
	A3	B1	6
		B2	14
		B3	12
		B4	14
R3	A1	B1	9
		B2	15
		B3	14
		B4	11
	A2	B1	13
		B2	14
		B3	13
		B4	7
	A3	B1	18
		B2	14
		B3	18
		B4	13

Table 7: No. of leaves measured for any treatments

Replication	Primary treatments	Secondary treatments	No. of leaves
R1	A1	B1	49
		B2	48
		B3	40
		B4	36
	A2	B1	43
		B2	54
		B3	47
		B4	43
	A3	B1	43
		B2	58
		B3	39
		B4	41
R2	A1	B1	50
		B2	44
		B3	48
		B4	46
	A2	B1	47
		B2	54
		B3	44
		B4	39
	A3	B1	40
		B2	52
		B3	42
		B4	42
R3	A1	B1	44
		B2	54
		B3	45
		B4	40
	A2	B1	47
		B2	52
		B3	43
		B4	35
	A3	B1	51
		B2	51
		B3	47
		B4	40

Table 8: Comparison of the water requirement of A1B2 treatment with uncontrolled bubbler irrigation in the part of experimental farm

Irrigation frequency period and depth	Total water volume cubic meters for 3.87 ha			
	July-Aug.	Aug.-Sep.	Sep.-Oct.	Oct.-Nov.
A1B2 treatment	3782.0	3517.26	2562.0	1518.9
Uncontrolled bubbler irrigation (frequency period and depth that is presently performed on the farm)	14182.5	14182.50	6862.5	4575.0

Table 9: Comparison of potential evapotranspiration for peak month's data

Method of estimation	Reference crop potential evapotranspiration (mm/day)					
	July-Aug.	Aug.-Sep.	Sep.-Oct.	Oct.-Nov.	Nov.-Dec.	Dec.-Jan.
Penman Monteith	18.03	16.72	12.64	9.21	4.42	3.21
Class A Pan	7.47	5.77	4.7	2.7	1.47	1.14

Penman Monteith and Class A Pan in the Omidiyeh for peak months is shown in Table 9.

REFERENCES

Abderrahman, W.A. and Y.M. Abdelhadi, 1990. Effect of salt tolerance levels on farming of date palms varieties: A case study. Arid Soil Res. Rehabilit., 4: 269-272.

Al-Amoud, A.I., M.A. Bacha and A.M. Al-Darby, 2000. Seasonal water use of date palms in central region of Saudi Arabia. Agric. Eng. J., 9: 51-62.

American Soil Conservation Service (ASCS), 1992. National engineering handbook. Section 7, Part 15.

Ayers, R.S. and D.W. Westcot, 1985. Water quality for agriculture. FAO Irrigation Drainage Paper No. 29. Food and Agriculture Organization of the United Nation, Rome, ISBN: 92-5-102263-1.

Bacha, M.A., A.I. Al-Amoud and A.M. Al-Darby, 1998. Response of seleg date palms trees to basin, bubbler and trickle irrigation systems using different irrigation regimes. Proceedings of 1st Saudi Symposium for Agricultural Sciences, 1998, Riyadh, Saudi Arabia, pp: 251-269.

Furr, J.R. and W.W. Armstrong, 1955. Growth and yield of khadrawy date palms irrigated at different intervals for two years. Date Growers Inst. Rept., 32: 3-7.

Hassan, M.M. and A.I. A.Al-Azayem, 1990. Differences in salt tolerance of some fruit species. Egypt. J. Hortic., 17: 1-8.

Hilal, M., M. Salem and M. Salim, 1986. Irrigation scheduling and nitrogen fertilization of palms. Proceedings of the 2nd Symposium on the Date Palm in Saudi Arabia, Mar. 3-6, Kingdom of Saudi Arabia.

Hussein, F. and M.A. Hussien, 1982. Effect of irrigation on growth, yield and fruit quality of dry dates grown at Aswan. Proceedings of the 1st Date Palms under Saline Water Irrigation Conference, 1982, Al-Hassa, KSA., pp: 245-248.

IRNCID, 2002. Evaluation and comparison of evapotranspiration estimation methods. WGSWU, Report Tehran, Iran.

KWPA., 2003. Water Balance and Conjunctive use Department, Water Balance and Consumptive Studies of Rivers in Khuzestan Province. Annual Report, Ahwaz, Iran.

Nimah, M., 1985. Localized versus trickle irrigation systems. Proceedings of the 3rd Trickle Irrigation Congress, 1985, Fresno, California, USA., pp: 552-554.

Reuveni, O., 1975. Drip versus sprinkler irrigation of date palms. Date Growers Inst. Rept., 51: 3-5.