DATE PALM PRODUCTION AND WATER PRODUCTIVITY UNDER SUBSURFACE DRIP IRRIGATION SYSTEM

H. Al-Wahaibi[1], M. Ben Salah[2] and Y. Al-Raisi[1]

[1] Directorate General of Agriculture and Livestock Research, Ministry of Agriculture and Fisheries, P.O. Box 50 Seeb121, Sultanate of Oman, hamdanssw@hotmail.com.

[2] International Center for Agricultural Research in Dry Area. Date palm project Regional coordinator in GCC Countries-Muscat Office.

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Abstract: The majority of date palm cultivation in Oman is irrigated using flood irrigation method and just limited area irrigated by Bubbler Irrigation (BI) system. Subsurface Drip Irrigation (SDI) has been proved as a water saving method that increase both crop production and Water-Use efficiency (WUE). However, it is being not tested for date palm irrigation. An experiment at Al-Kamil Research Station in Al-Sharqiyah North governorate was conducted from 2013 to 2016 to evaluate subsurface drip irrigation system in terms of date palm production and Water Productivity (WP) for date palm irrigation and compared with bubbler irrigation system which is recommended for date palms irrigation. Four irrigation treatments were 100% ETc using bubbler irrigation, 60%, 40% and 20% ETc Subsurface irrigation system. Irrigation scheduling was developed based on crop evapotranspiration (ETc= ETo x Kc), ETo was calculated by Penman-Monteith equation on CROPWAT program using climatic data from nearby weather station. Crop coefficient was taken to be 0.90 (FAO, 1991). The results show no significant differences in fruit production between date palm trees irrigated by 100% ETc using bubbler system and those irrigated with 60% of the water requirement under sub-surface drip irrigation system. Fruit production was significantly reduced under the irrigation with 40% and 20% of ETc under sub-surface drip irrigation system as compared to that irrigated with 60% ETc. The highest WP of 4.7 kg/m3 was obtained at the rate of 20% of the water requirements under sub-surface drip irrigation system. All the results proved that sub-surface drip irrigation system contributes to 40% water saving without reduction in fruit production of date palm trees.

Key words: Date palm, Water productivity, Subsurface drip irrigation

INTRODUCTION

Oman is in arid regions, where water quantity and quality is the limiting factor for agriculture production. Average annual rainfall does not exceed 100 mm and agriculture production depends entirely on irrigation from groundwater which has been depleted in some agriculture areas. Therefore, efficient water application methods are necessary to increase water use efficiency and productivity of agriculture crops. Date palm is the main fruit crop cultivated in Oman. There are more than 7.5 Million date palm trees in Oman and about 75% of trees are irrigated by the basin flood irrigation method, which has an efficiency of not more than 60%. The remaining 25% is irrigated by bubbler irrigation system which is recommended by the irrigation specialists in the country.

Subsurface drip irrigation system has been proved to give higher water use efficiency and better WP than other irrigation systems. Ayars et al. (2015) stated that subsurface drip irrigation improves WUE since undesirable water loss can be reduced or eliminated such as evaporation from soil surface evaporation, deep percolation and water runoff. Several previous studies indicated that subsurface drip irrigation is one of the promising technologies that contributes to improve water use efficiency and productivity in addition it is considered as the most effective way to provide water and nutrient directly to the plant and to increase productivity of crops (Thomson et al., 2002, 2003). This subsurface drip irrigation represents the recent improvement of irrigation as it significantly reduces losses of direct evapotranspiration, runoff, and deep percolation (Hanson and May, 2007). Many studies suggest the use of subsurface drip irrigation as a water saving technology in arid areas, but it is necessary to study and examine the performance and the efficiency of the subsurface drip irrigation in comparison with other irrigation systems such as bubbler irrigation systems in these areas.

The main objective of this study is evaluating SDI system on date palm productivity and water use efficiency as compared to bubbler irrigation system which is currently used for irrigating date palm in Sultanate of Oman.

MATERIALS AND METHODS

The experiment was conducted in Al-Kamil Research Station in Al-Sharqiyah North governorate, Sultanate of Oman (22^o 14' 13.00 N, 59^o 11' 04.00 E) during 2013-2016 growing seasons. The soil at the experimental site is sandy loam has an average electrical conductivity of 1.1 dS/m and pH of 7.8. The Field Capacity and Permanent Wilting Point of the soil are 23.2% and 13.5% respectively. The experiment consisted of four irrigation treatments in RCBD with three replications each of 3 date palm trees. The total number of trees is 36. The applied irrigation treatments were managed based on different percentage from evapotranspiration (ETc), which was calculated by using CROPWAT program using climatic data from weather station located at the Al Kamil Research Station. Crop coefficient was taken to be 0.90 (FAO, 1991). The tested irrigation treatments were T1: 100 % ETc using BI, T2: 60% ETc using SDI, T3: 40 % ETc SDI, and T4: 20 % ETc SDI. Irrigation scheduling was developed based on the crop evapotranspiration, ETc (ET0 x Kc), ETo was calculated by Penman-Monteith equation on CROPWAT (Table1). The time of irrigation for both BI and SDI systems was calculated based on the discharge for each irrigation system. Two bubblers each of 4 liter/min were place at the basin of each tree. Ditches were dug around each date palm tree with a depth of 50 cm and at a distance 120cm from the tree trunk (Fig. 1). The subsurface drip lines each of 60 drippers were placed at the ditch around the tree trunk (Fig. 2). The size of subsurface dripline is 13 mm and the drippers spaced 50cm with discharge rate of 4 l/h. The actual water applied was measured using water meters. The soil water was measured using soil moisture sensors. They were placed at a depth of 30cm, 60cm and 90cm from soil surface. Date palm production was measured at fresh stage and water productivity was calculated as a ratio between the marketable yield and the seasonal values of actual water application using the following equation WUE = Y/W (Howell, 2001).

RESULTS AND DISCUSSION

The results are presented in table 2, showed that there are no significant differences in fruit production between date palm trees irrigated by (100%) of the water requirements using BI system and those irrigated with 60% of the water requirements using SDI system. The average fruit production reaches 78.7kg/tree. Fruit production significantly reduced when irrigating by 40% and 20% of its water requirements under subsurface drip irrigation system. The average fruit production reduced to 69.3kg /tree.

The results also indicated that the water productivity (kg/m^3) increased as irrigation water decreased and the highest water productivity 4.7 kg/m^3 was obtained at the rate of 20% of the water requirements under SDI system. WP was higher by 53.8% when irrigating with 60% of the water requirements using SDI compared to irrigation by 100% of the water requirements using BI system. The results proved that SDI system contributes to (40%) water saving without reduction in fruit production of date palm trees.

CONCLUSION

The aim of this experiment was to evaluate SDI system in terms of date palm production and WP for date palm irrigation and compared with BI. The results yield and water productivity proved that SDI system contributes to 40% water saving without reduction in fruit production of date palm trees. However, WP increased by 53% compared to BI system. Water requirements of date palm can be reduced from 7800 m^3/ha to 4680 m^3/ha if BI is replaced by SDI.

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Tables

Table 1. Irrigation scheduling calculation based on ETo calculated by using CROPWAT program using climatic data from weather station located at the Al Kamil Research Station and Crop coefficient was taken to be 0.90 (FAO, 1991).

Month	ET_o mm	Kc	ETc mm	Irrigated area m^2	Total Water applied
January	2.82	0.9	2.5	38	96
February	3.97	0.9	3.6	38	136
March	4.36	0.9	3.9	38	149
April	5.45	0.9	4.9	38	186
May	6.99	0.9	6.3	38	239
June	7.64	0.9	6.9	38	261
July	7.23	0.9	6.5	38	247
August	6.93	0.9	6.2	38	237
September	6.48	0.9	5.8	38	222
October	5.76	0.9	5.2	38	197
November	4.13	0.9	3.7	38	141
December	3.32	0.9	3.0	38	114

Table 2. Date palm Yield and water productivity under the four irrigation treatments

Treatments	**Yield (Kg/tree)**	**WP (Kg/m^3)**
Irrigation with 100 % of ETc using bubbler system	79.0 ^{a}	1.3 ^{d}
Irrigation with 60 % of ETc using Subsurface drip system	78.3 ^{a}	2.0 ^{c}
Irrigation with 40 % of ETc using Subsurface drip system	69.8 ^{b}	2.7 ^{b}
Irrigation with 20 % of ETc using Subsurface drip system	68.8 ^{b}	4.7 ^{a}
LSD	**8.4**	**0.45**

LSD = 0.45, Values with different superscripts are significantly different at p=0.05

Figures

Fig. 1. Ditches around the date palm trunk (Radius 120 cm and Depth 50 cm)

Fig. 2. Installation of the subsurface drip lines around tree