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Irrigation Water Management of Date Palm under El-Baharia Oasis Conditions

Amr Sadik[1], Ali Abd El–Aziz[1], Ahmed El-Kerdany[2]

[1]Soil Chemistry and Physics Department , Desert Research Center and [2]Palm Institute, Agricultural Research Center, Egypt

THIS EXPERIMENT was performed during two successive seasons, 2015/2016 and 2016/2017, at a private farm in the El-Baharia Oasis area, Giza Governorate, Egypt, to study the effect of different irrigation systems (deep drip (DIS), micro jet (MIS), bubbler (BIS)) and applied irrigation water levels (IR: 100,85,70%) under mulched soil (MS) and un-mulched soil (UMS) and to determine the marketable yield (MY), crop quality parameters, actual evapotranspiration (ETa), water-use efficiency (WUE), irrigation water-use efficiency (IWUE), yield response factor (Ky) and actual crop coefficient (Kca) for date palm trees (*Phoenix dactylifera* L.). The experimental design was a split-split plot design with three replicates. The results showed that the MY and studied quality parameters (except the total soluble solid (TSS) content) of the date palm fruits were highest under the DIS, IR=100% and MS treatment for both seasons. For the 1st and 2nd seasons, the lowest seasonal ETa values were 564.41 and 526.78 mm, respectively under the DIS, IR=70% and MS treatment;the maximum date palm fruit WUE and IWUE were 3.22 and 1.55 kg $m^{-3}$and 3.61 and 1.62 kg m^{-3}, respectively under the DIS, IR=70% and MS treatment; the minimum Ky for date palm fruits was 0.16 and 0.12, respectively under the DIS, IR85% and MS treatment; and the minimum seasonal Kca values for the initial (I), development (D), mid-season (M), and late-season (L) growth stages were 0.29, 0.17, 0.28, 0.18 and 0.23 and 0.29, 0.15, 0.25, 0.14 and 0.21, respectively under the DIS, IR=70% and MS treatment. This study concluded that the cultivation of date palm trees under the DIS, IR=70% and MS treatment could save approximately 38% of the IR and increase the MY of date palm fruit by approximately 20 and 22% for the 1st and 2nd seasons, respectively, compared with the control treatment (BIS, IR=100% and UMS).

Keywords: Date palms, Actual evapotranspiration, Water-use efficiency, Irrigation water-use efficiency, Yield response factor

Introduction

Date palms are highly tolerant to water and temperature stress, which affects the quantity and quality of the crop (Anon, 2002).The maximum growth parameters and marketable yield (MY) for date palm fruit have been recorded at 100% crop evapotranspiration (ETc), followed by 75% ETc and 50% ETc, which may be because water applied at 100 % ETc is sufficient for crop water requirements while the other amounts were not (Ibrahim et al., 2012). The application of a subsurface drip irrigation system increased the MY of date palm fruit by approximately 163 kg/palm, with a decrease in water consumption compared with surface drip irrigation of 120 kg/palm (Al-Amoud, 2006).California desert areas have illustrated that deep drip irrigation systems (DIS) can be highly efficient compared to surface drip or traditional surface irrigation. The DIS recorded more than twice the vine weight of the surface drip irrigation and a six-fold increase compared with that of traditional surface irrigation under conditions in Africa. Roots extended horizontally by 0.60 munder a surface drip irrigation system, by 1m with traditional surface irrigation and by 1.75 m with the DIS (Bainbridge, 2006). A modern study of mature date palm trees detected that the subsurface drip irrigation system increased yield productivity and reduced the need for added irrigation water compared with surface drip irrigation methods. In addition,the water-use efficiency (WUE) for date palms achieved significant increases using subsurface drip irrigation (Al-Amoud and Al-Saud, 2011).The results showed that

*Corresponding author: ali_amr5555562@yahoo.com
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drip irrigation systems produce a greater water distribution of approximately 97% compared with the bubbler irrigation system (BIS), which has a distribution of approximately 62% when applied for date palm irrigation (Al-Amoud, 2008). In the case of mulched soil (MS), the moisture content decreased by approximately 95% at a depth of 10 cm, 83% at 5 cm and 52% at 2 cm (Diaz et al., 2005). This study concluded that the soil moisture content in the surface layer (0-60 cm) of MS was higher than that of bare soil (Ramakrishna et al., 2006).

Mulching can effectively reduce soil surface evaporation, limit the growth of weeds and control salt accumulation in the soil profile (Terasaki et al., 2009).Under drip and flood irrigation systems, the annual actual evapotranspiration of date palm is approximately 55 and 137 m^3/tree in the Eastern region, respectively and approximately 78 and 195 m^3/tree in the central region, respectively (Alazba, 2004). In the Kingdom of Saudi Arabia,the seasonal actual evapotranspiration for date palm trees was approximately 1644 mm,whereas the crop coefficient (Kc) was approximately 0.56 to 0.70 (Kassem, 2007).The actual crop coefficients (Kca) for all treatments were lower than the the oretical Kc values mentioned by the FAO. MS reduced the Kc values compared with un-mulched soil (UMS)(El-Nady and Borham, 2009).The accuracy and clarity of the crop coefficient model are largely dependent on empirical estimates, including time variations in the crop coefficients during the growing season, the salinity of the irrigation water and the status of water within the plant. These differences lead to crop coefficients that are not always accurate (Bhantana and Lazarovitch, 2010).

The Kca of date palms in Jordan ranged from 0.50 to 1.18, indicating that this value was not constant across the growing season. The Kca is calculated based on the actual evaporation for various stages of growth (Mazahrih et al., 2012). The yield response factor is an indicator of whether the crop is tolerant to water stress. The yield response factor is larger than unity and the expected yield ratio decreased with increasing deficit evapotranspiration (Kirda et al., 1999a). The yield response factor (Ky) is the coefficient used to indicate crop sensitivity to a water deficit at any growth stage, and it is commonly used in irrigation management (Steduto et al., 2012). The WUE can be increased through effective irrigation methods, such as drip irrigation. Because of increasing water poverty, the use of water for agricultural production must be reduced via innovation research and modern technology transfers (Al-Zahrani et al., 2011; Atta et al., 2011).This study aimed to investigate the effect of irrigation systems and applied irrigation water (IR) levels in MSand UMS on the crop production, growth parameter quality, actual evapotranspiration, WUE, IWUE,Ky and Kcas.

Materials and Methods

Experiments

Field experiments were performed in El-Baharia Oasis, Giza Governorate, Egypt, at (28° 19` 10`` N: 28° 57`35``E. 130 m a.s.l.) during the seasons 2015/2016 and 2016/2017. In a split-split plot design with three palm trees as the replicates, date palm trees were planted with 7.0 m spacing between rows and 7.0 m spacing between trees, and the age of the palm trees was 8 years. The obtained data were subjected to a statistical analysis according to Snedecor and Cochran (1989) using the Co-state software program. Figure 1 shows the date palm trees (*Phoenix dactylifera* L.). Semi-dry dates of the Siwy variety were irrigated using three IR conditions (IR=100, 85 and 70% of ETc), and three irrigation systems (DIS, micro jet irrigation system (MIS) and BIS) in MS and UMS were studied, with plastic sheets placed around the palm.

The length (L) cm, diameter (D) cm, moisture content (MC) %, total soluble solid (TSS) content, total protein (P) %, total sugar (TS)%, fruit weight (FW) g, yield per palm (YP) kg and MY in Mg/ha were determined for the date palm fruits. The actual evapotranspiration (ETa) mm, water-use efficiency (WUE) kg m^{-3}, irrigation water-use efficiency (IWUE) kg m^{-3}, Ky and Kca were calculated with various IR conditions for irrigation systems with MS and UMS for all date palm tree plots.

Soil characteristics

Soil samples were collected to determine the physical and chemical soil characteristics. The methodological procedures followed the methods described by Page et al. (1982) and Klute (1986) as shown in Tables 1&2.

Quality of irrigation water

Chemical analyses of the irrigation water were performed according to the methods described by Ayers and Westcot (1994) and are presented inTable 3.

TABLE 1. Physical characteristics of the experimental soil

Soil depth (cm)	Particle size distribution %					Textural class	OM %	ρ_b g/cm³	Ks cm/h	FC %	WP %	AW %
	C. sand	M. sand	F. sand	Silt	Clay							
0-20	4.32	24.15	61.71	5.24	4.58	S	0.52	1.52	12.42	13.56	3.91	9.65
20-40	3.87	23.91	60.58	6.19	5.45	S	0.45	1.56	13.19	12.74	3.47	9.27
40-90	3.21	23.49	60.06	6.93	6.31	S	0.39	1.61	13.36	12.38	3.29	9.09

C=coarse; M=medium; F=fine

TABLE 2. Chemical characteristics of the experimental soil

Soil depth (cm)	EC(dS m^{-1})	pH	$CaCO_3$ %	CEC cmole kg^{-1}	Soluble ions (meq/l) in saturated soil paste extract							
					Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
0-20	4.69	7.48	6.51	8.15	21.43	2.01	13.17	10.29	19.34	2.87	-	24.69
20-40	4.57	7.53	4.95	8.29	20.27	1.93	12.89	9.61	18.61	2.35	-	23.74
40-90	3.93	7.61	3.37	8.41	18.51	1.19	11.64	8.96	16.89	2.04	-	21.37

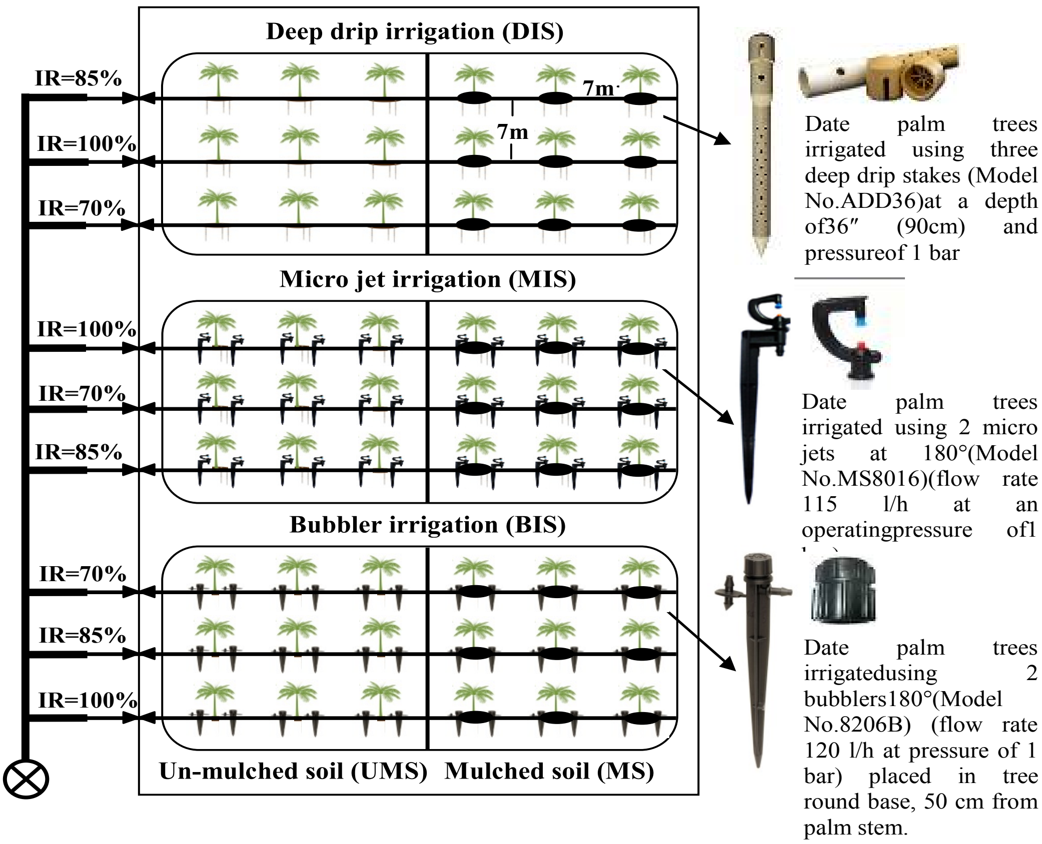

Fig.1. Field experiment layout in El-Baharia Oasis

TABLE 3. Chemical analysis of irrigation water

Sample	pH	EC dS m^{-1}	SAR	Soluble cations, meq/l				Soluble anions, meq/l			
				Na^+	K^+	Ca^{++}	Mg^{++}	CL^-	HCO_3^-	$CO_3^=$	$SO_4^=$
Mean	7.93	0،47	1.95	2.01	0.56	0.78	1.35	2.3	1.73	-	0.67

Reference evapotranspiration (ETo)

The reference evapotranspiration (ETo) shown in Table 4 was calculated using the Penman-Monteith equation FAO 56 method (Allen et al., 1998).

Crop evapotranspiration (ETc)

The ETc shown in Table 5 was calculated using the following equation:

ETc=KcFAO.ETo (mmperiod-1) (Allen et al.1998)

where KcFAO is the crop coefficient from FAO No.(56); and ETo is the reference crop evapotranspiration, mm period-1.

TABLE 4. Calculated reference evapotranspiration (mm day^{-1}) over the date palm tree growth period

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
ETo mm day^{-1}	5.20	6.95	8.05	8.84	8.02	7.47	6.50	5.15	3.55	2.79	2.87	3.89

TABLE 5. Calculated crop evapotranspiration (ETc, mm)over thedate palm tree growth period

Stage	Initial	Develop.	Mid	Late	Seasonal
Planting date	**1/3 to 28/7**	**29/7 to 1/9**	**2/9 to 29/1**	**30/1 to 28/2**	**1/3 to 28/2**
Period length (day)	150	35	150	30	365
Kc_{FAO} (-)	0.80	0.90	1.00	0.80	--------
ETo (mm)	1109.01	262.13	624.37	114.66	2110.17
$ETc_{100\%}$ (mm)	887.21	235.92	624.37	91.73	1839.23
Eff. Rainfall (mm)	2	0	1	1	4

Applied irrigation water IR

The amounts of IR for the date palm trees shown in Table 6 were calculated using the following equation:

IR 100, 85, 70% = (ETc-pe)Kr/Ea)+LR (mm period-1)

(Keller and Karmeli, 1974)

where Kr represents the correction factor for limited wetting based on the percent coverage by canopy at 70%, where Kr=0.80 (Smith, 1992).

Ea represents the irrigation efficiency for the bubbler, micro jet and deep dripper (80,85 and 90% respectively) (Allen et al., 1998).

Pe represents the effective rainfall, 4 mm season-1.

LR represents the leaching requirements, under salinity levels of irrigation water (0.02 x ETc), mm.

- Actual evapotranspiration ETa=(M2%–M1%)/100.db.D (mm) (Doorenbos and Pruitt, 1984)

where M represents the moisture content after irrigation, %.

M1 represents the moisture content before irrigation, %.

db represents the specific density of soil.

D represents the mean depth, mm.

- Water-use efficiencyWUE=MY/ETa (kg m-3) (Howell et al., 2001)

where MY represents the marketable yield of date palm trees, (kg ha-1).

- Irrigation water-use efficiency IWUE=MY/IR (kg m-3) (Michael, 1978)

where IR represents the seasonal applied irrigation water (m3) (Table (6)).

- Yield response factor (Ky)

$$\left[1-\frac{MY}{Y_m}\right]=K_y\left[1-\frac{ETa}{ETm}\right]$$

- (Allen et al., 1998)

where ETa represents the actual evapotranspiration, mm season-1.

ETm represents the crop evapotranspiration (without stress), mm season-1.

Ym represents the maximum yield at IR100 %, t h-1.

- Actual crop coefficient(Kca)=ETa/ETo (Allen et al.,1998)

TABLE 6. Calculated applied irrigation water (IR) in mm over the date palm tree growth period

IS	IR (%)	Applied Irrigation Water (mm) Growth Stages				
		Initial	Development	Mid	Late	Seasonal
Bubbler	**100**	904.58	241.07	637.00	92.73	1875.38
	85	768.89	204.91	541.45	78.82	1594.07
	70	633.21	168.75	445.90	64.91	1312.77
Microjet	**100**	852.50	227.19	600.33	87.39	1767.41
	85	724.63	193.11	510.28	74.28	1502.30
	70	596.75	159.03	420.23	61.17	1237.18
Deep drip	**100**	806.22	214.85	567.74	82.65	1671.46
	85	685.29	182.62	482.58	70.25	1420.74
	70	564.35	150.40	397.42	57.86	1170.03

Results and Discussion

Effect of IR and irrigation systemunder the MS and UMS treatments on the studied quality parameters of date palm fruits

The data in Fig. 2, 3, 4 and 5 showed that the studied quality parameters L(cm), D(cm),MC(%),P (%) and TS (%) increased as the IR increased for all treatments,whereas the TSS (%) decreased with increasing IR. The data revealed the significant superiority of the DIS compared to the BIS and MIS for all treatments. In addition,the MS near the date palm trees had a clear effect on all treatments. The results recorded the same trend for both seasons (2015/2016 and 2016/2017). The highest L, D, MC, P and TS values were 4.15 cm, 2.23 cm, 23.75%, 2.08% and 56.49% for the 1st season, respectively, and 4.31 cm, 2.31 cm, 24.79%, 2.11% and 57.75% for the 2nd season, respectively, whereas the TSS values were 39.04 and 40.29% for the 1st and 2nd seasons, respectively under the DIS, IR=100% and MS treatment. The lowest L, D, MC, P and TS values were 2.85 cm, 1.26 cm, 12.73%, 1.09% and 28.95% for the 1st season, respectively and 2.93 cm, 1.29 cm, 13.45%, 1.12% and 30.78% for the 2nd season, respectively, whereas theTSS values were 67.96 and 69.73% for the 1st and 2nd seasons under the BIS, IR=70% and UMS treatment. These results are consistent with the findings of Bainbridge (2006) and Ibrahim et al. (2012).

Moreover, Fig. 2 and 3 indicate that significant positive correlations occurred between the IR (mm) and studied quality parameters of the date palm fruits for season 2015/2016 (except for TSS). For all irrigation systems (DIS, MIS and BIS) under the UMS treatment, positive correlations were observed for L (r=0.982**, 0.995** and 1.000**), D (r=0.990**, 0.999** and 1.000**), MC (r=0.978**, 0.996** and 0.999**), P (r=0.985**, 0.997** and 1.000**) and TS (r=0.979**, 0.995** and 1.000**), whereasnegative correlations were (r=0.964**, 0.944** and 1.000**), P (r=0.965**, 0.919** and 1.000**) and TS (r=0.969**, 0.942** and 1.000**), whereas negatively correlations were observed for TSS (r=-1.000**, -0.998** and -0.976**).

Figures 4 and 5 showed that the relationships between IR (mm) and the studied quality parameters of the date palm fruits for season 2016/2017were the same for all irrigation systems (DIS, MIS and BIS) under the MS and UMS treatments.

Effect of IR and irrigation systemunder the MS and UMS treatments on yield production of date palm fruits

The data in Fig. 4, 5, 7 and 8 show that the FW(g), YP(kg) and MY(Mg/ha) for the date palm fruits increased with increasing IR for all treatments. The data revealed that the DIS was significantly superior to theBIS and MIS for all treatments. In addition, the MS near date palm trees had a clear effect on all treatments. The same trend was achieved for 2015/2016 and 2016/2017. The highest values of FW, YP and MY were 13.80 g, 102.16 kg/palm and 20.84 Mg/haand 13.98 g, 105.29 kg/palm and 21.48 Mg/hafor the 1st and 2nd seasons, respectively, under theDIS, IR=100% and MS treatment, whereas the lowest values were 5.31 g, 48.45 kg/palm and 9.88 Mg/haand 5.41 g, 51.67 kg/palm and 10.54 Mg/ha for the 1st and 2nd seasons, respectively, under theBIS, IR=70% and UMS treatment. These results may be attributed to the soil water distribution under the DIS, which was superior tothat of the other systems.In addition to mulching, the soil effectively preservedthe soil moisture content, and these results are consistent with those of Ramakrishna et al.(2006), Al-Amoud(2006) and Al-Amoud(2008).

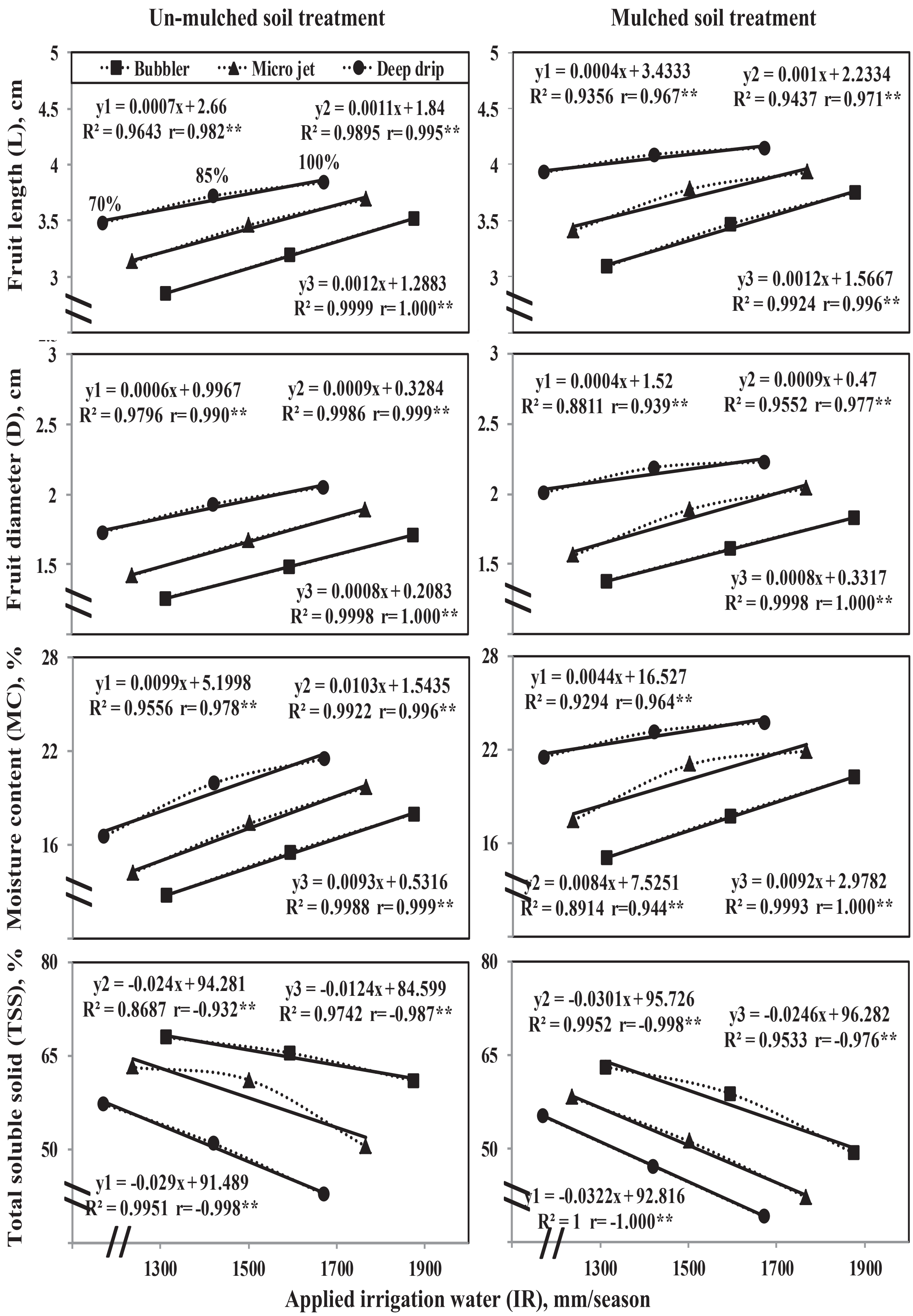

Fig. 2. Correlations between the applied irrigation water (IR) (mm/season) and fruit quality parameters for date palms with various irrigation systems under mulched and un-mulched soil treatments for 2015/2016

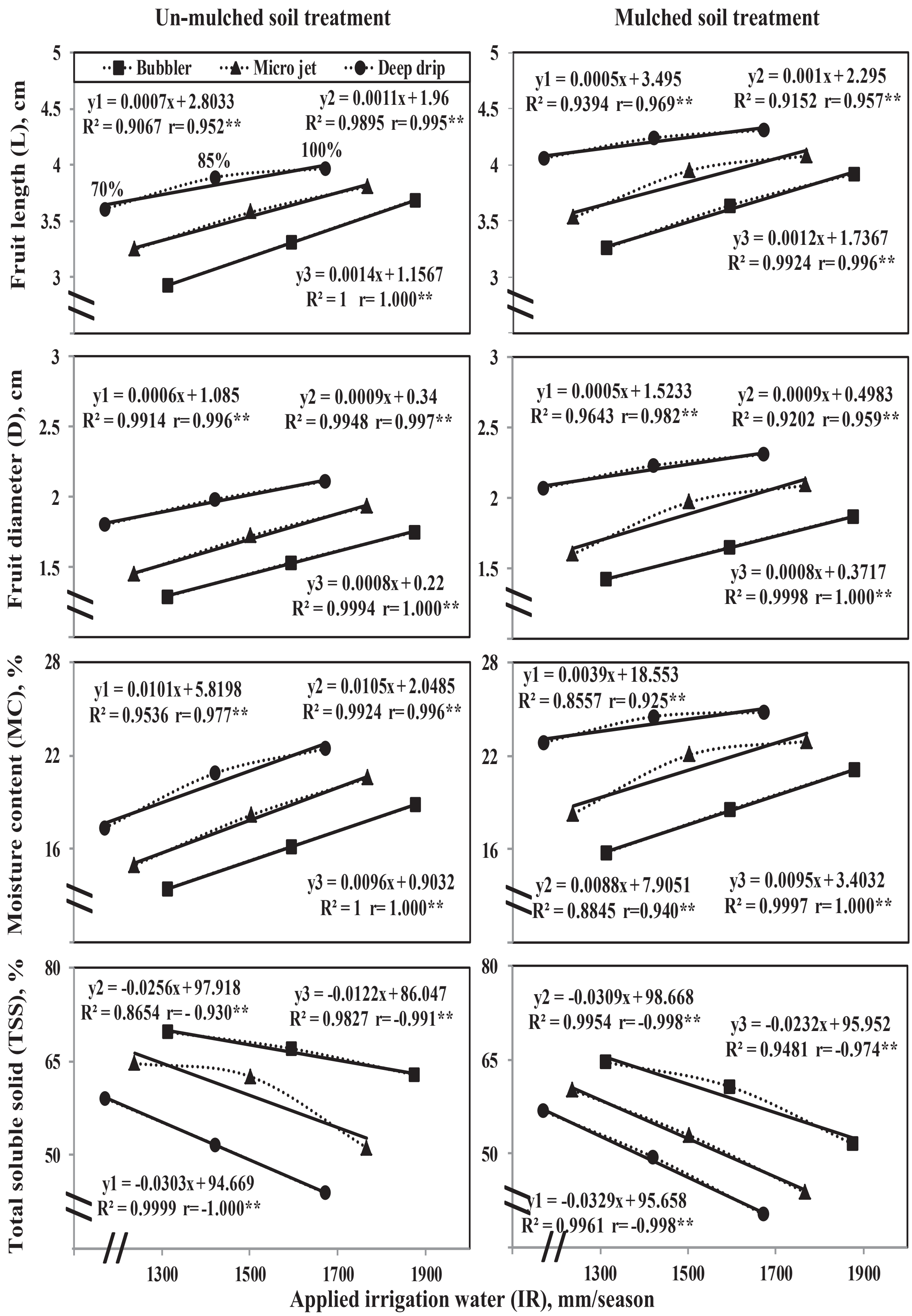

Fig. 3. Correlations between the applied irrigation water (IR) (mm/season) and fruit quality parameters for date palms with various irrigation systems under the mulched and un-mulched soil treatments for 2016/2017

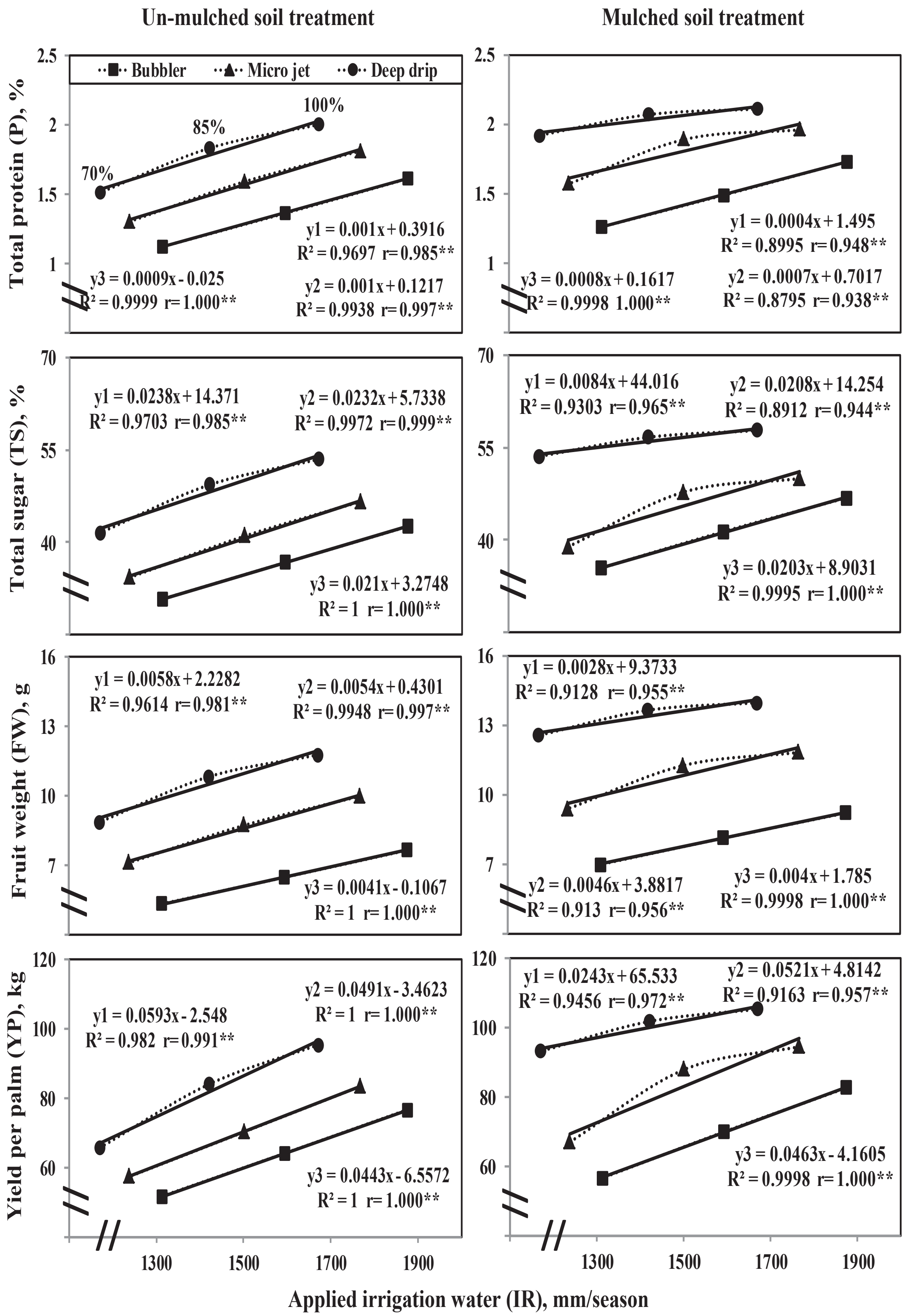

Fig. 4. Correlations between the applied irrigation water (IR) (mm/season) and fruit quality parameters for date palms with various irrigation systems under mulched and un-mulched soil treatments for 2015/2016.

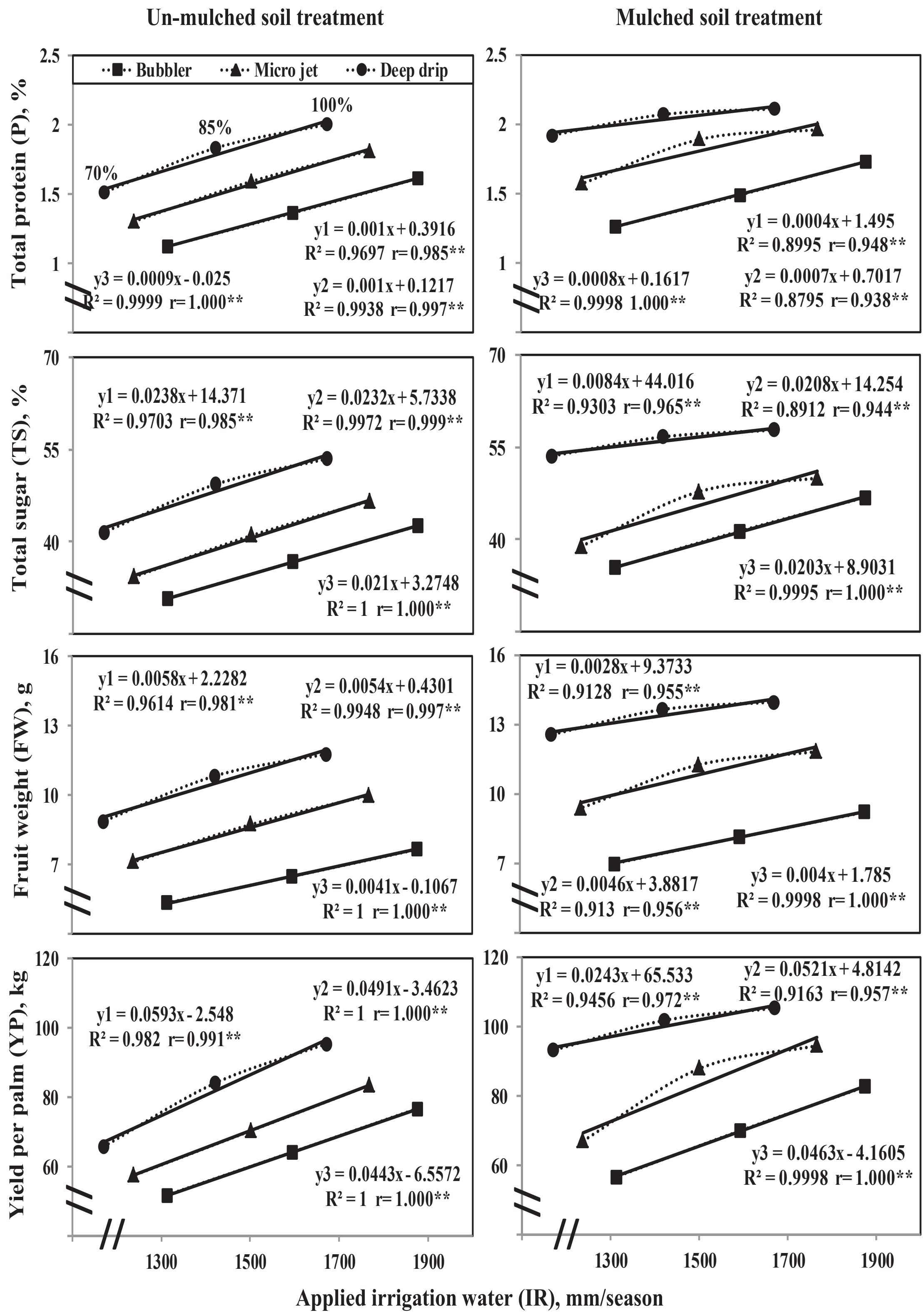

Fig. 5. Correlations between the applied irrigation water (IR) (mm/season) and fruit quality parameters for date palms with various irrigation systems under mulched and un-mulched soil treatments for 2016/2017.

Moreover, Fig. 4 and 7 show that in season 2015/2016,significant positive correlations occurred between IR(mm) andthe FW (r=0.975**, 0.996** and 1.000**) and YP and MY (r=0.995**, 1.000** and 1.000**) for all irrigation systems (DIS, MIS and BIS, respectively)under the UMS treatment and between IR (mm) and FW (r=0.976**, 0.954** and 1.000**) and YP and MY (r=0.985**, 0.972** and 1.000**) for all irrigation systems (DIS, MIS and BIS, respectively)under the MS treatment.

In addition, Fig 5 and 8 show that in season 2016/2017, the sameresults were observed between IR(mm) and the above yield production factors of date palm fruits for all irrigation systems (DIS, MIS and BIS)under the MS and UMS treatments.

Effect of IR and irrigation systemunder MS and UMS treatments on ETaof date palm fruits

The data in Fig. 6, 7 and 8 show that the ETa(mm) values for date palm fruits decreased as the IR decreased for all treatments. In addition,the ETa of the DIS under the MS treatment decreased compared with that of the other treatments. The ETa of the growth stages decreases as follows:initial (I) > mid-season (M) > development (D) > late-season (L). The lowest ETa values for the I, D, M, L growth stageswere 321.96, 45.09, 176.82, 20.54 and 564.41 mm and317.11, 39.58, 153.95, 16.14 and 526.78 mm for the 1st and 2ndseasons,respectively, under the DIS, IR=70% and MS treatment, whereas the highest ETa values forthe same growth stages were 702.37, 187.53, 465.91, 79.75 and 1435.56 mmand 690.56, 178.38, 454.32, 72.53 and 1395.79 mmthe 1st and 2nd seasons, respectively,under the BIS, IR=100% and UMS treatment. These results may be attributed to the effects of theDIS, water stress and soil mulch, which alleffectively reducedthe soil surface evaporation.These results areconsistent with those of Alazba(2004), Kassem(2007) and Terasaki et al.(2009).

Moreover, Figure 7 indicates that significant positive correlations occurredbetween the IR(mm) and seasonal ETa of date palm fruits (r=0.896**, 0.954** and 0.951** and r=0.968**, 0.945** and 0.950**) for season 2015/2016 withall irrigation systems (DIS, MIS and BIS, respectively)under the UMS and MS treatments, respectively. Figure 8shows that the same correlations were observed between the IR (mm) and seasonal ETa in 2016/2017for all irrigation systems (DIS, MIS and BIS)under the MS and UMS treatments.

Effect of IR and irrigation system under the MS and UMS treatments on the WUE and IWUE of date palm fruits

The data in Figures 7 and 8show that the highest WUE and IWUE for date palm fruits were 3.22 and 1.55 kg m^{-3} and3.61 and 1.62 kg m^{-3} for the 1st and 2ndseasons, respectively, under the DIS, IR=70% and MS treatment.The lowest values were 0.84 and 0.75 kg m^{-3}and 0.91 and 0.80 kg m^{-3} for the 1st and 2nd seasons, respectively, under the BIS, IR=70% and UMS treatment. Meanwhile, the WUE and IWUE values under theDIS, IR=70% and MS treatment increased significantly by approximately204 and 92%and 222 and 95% for the 1st and 2nd seasons, respectively, compared withthe control treatment (BIS, IR=100% and UMS). These results may be attributed to the effects of deep drip irrigation and soil mulch, whichled to increasedMYs with decreased water consumption.These results were similar to those reported byAl-Amoud and Al-Saud(2011), Al-Zahrani et al.(2011) and Atta et al.(2011).

Effect of IR and irrigation system under MS and UMS treatments on date palm Ky values

The data in Fig. 9 show that the Ky for date palm fruits presents a linear relationship between the relative reduction in actual evapotranspiration 1-(ETa/ETmax) and the relative reduction in yield 1-(Ya/Ymax). Significant positive correlations were observed between 1-(ETa/ETmax) and 1-(Ya/Ymax) for season 2015/2016 with Ky (r=0.847**, 0.952** and 0.945** and r=0.909**, 0.842** and 0.952**) for all irrigation systems (DIS, MIS and BIS, respectively)under the UMS and MS treatments respectively. Fig. 9 also shows that the same correlations were observed for season 2016/2017 for all irrigation systems (DIS, MIS and BIS)under the MS and UMS treatments.

Figure 10 also shows that the Ky for date palm fruits decreased as the IR increased in all irrigation systems under the MS and UMS treatments. The lowest values of Ky for date palm fruits were 0.16 and 0.12 for the 1st and 2nd seasons, respectively, under the DIS, IR=85% and MS treatment.The maximum values were 1.95 and 1.89 for the 1st and 2nd seasons, respectively, under theBIS, IR=70% and UMS treatment. These results may be attributed to date palm trees'high tolerance for water and temperature stress.These results are consistent with the findings of Kirda et al. (1999a) and Steduto et al. (2012).

Effect of IR and irrigation system under the MS and UMS treatments on theKca for date palm fruits

The data in Fig.11 show that theKca for date palm fruits decreasedas the IR decreased for all treatments. In addition,under the DIS and MS treatment, theKca decreased compared with that of the other treatments. The Kca values decreased with the growth stages as follows:M>D>I>L. The lowest Kcavalues for the I, D, M, L growth stages were 0.29, 0.17, 0.28, 0.18 and 0.23and 0.29, 0.15, 0.25, 0.14 and 0.21for the 1st and 2nd seasons, respectively, under theDIS, IR=70% and MS treatment, whereas the highest values forthe same growth stages were0.63, 0.72, 0.75, 0.70 and 0.70and 0.62, 0.68, 0.73, 0.63 and 0.67 for the 1st and 2nd seasons,respectively, under the BIS, IR=100% and UMS treatment. These results could be attributed to the effects of deep drip irrigation, water deficits and soil mulch, whichall effectively reduce evapotranspiration and therefore the actual yield coefficient.These results are similar to those reported by El-Nady and Borham(2009), Bhantana and Lazarovitch(2010) and Mazahrih et al.(2012).

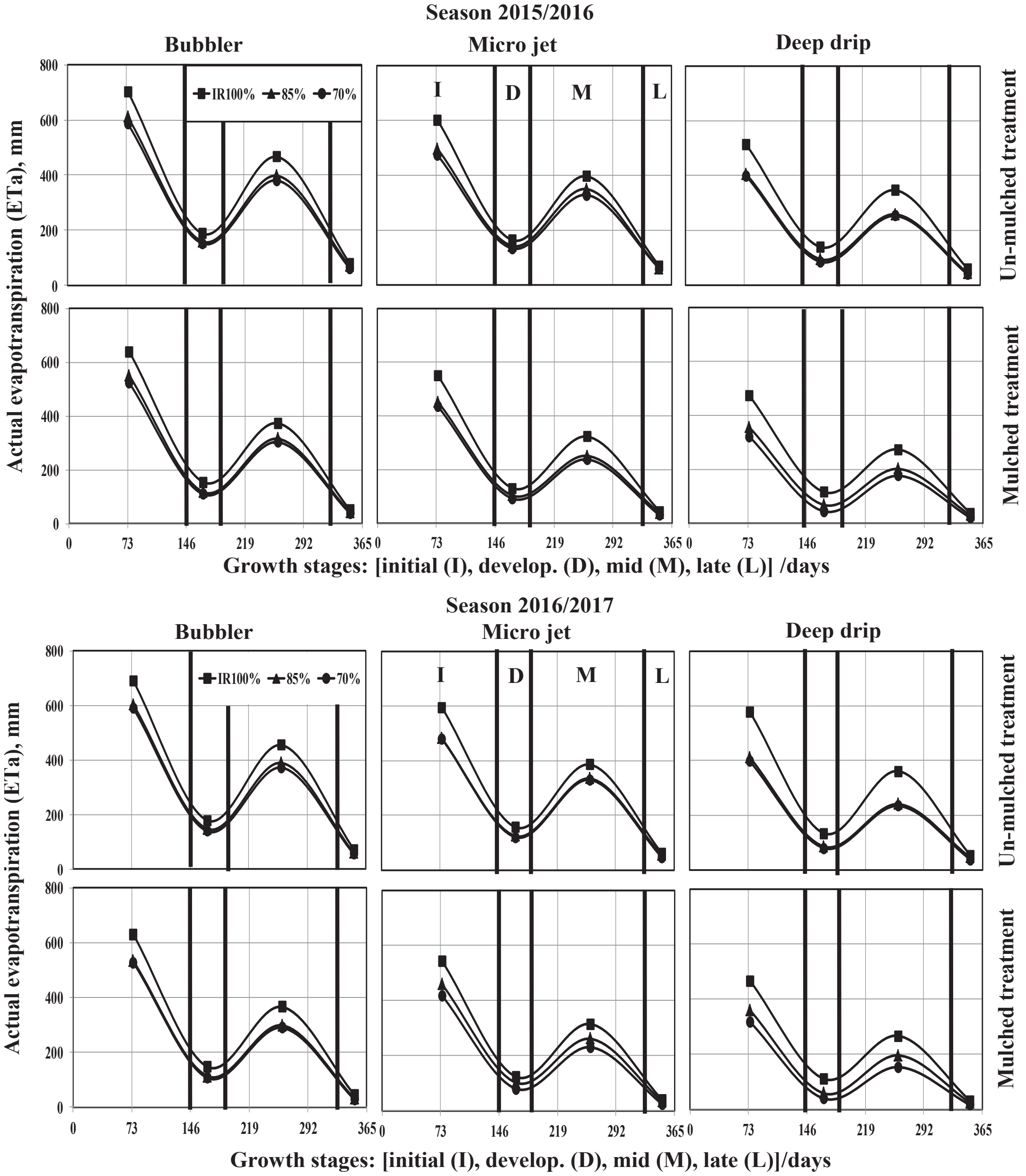

Fig. 6. Actual evapotranspiration (ETa) (mm) for all growth stages (initial (I), develop. (D), mid (M), late (L))/ days affected by the irrigation systems at different applied irrigation water (IR) % under the mulched and un-mulched soil treatments for seasons 2015/2016-2016/2017.

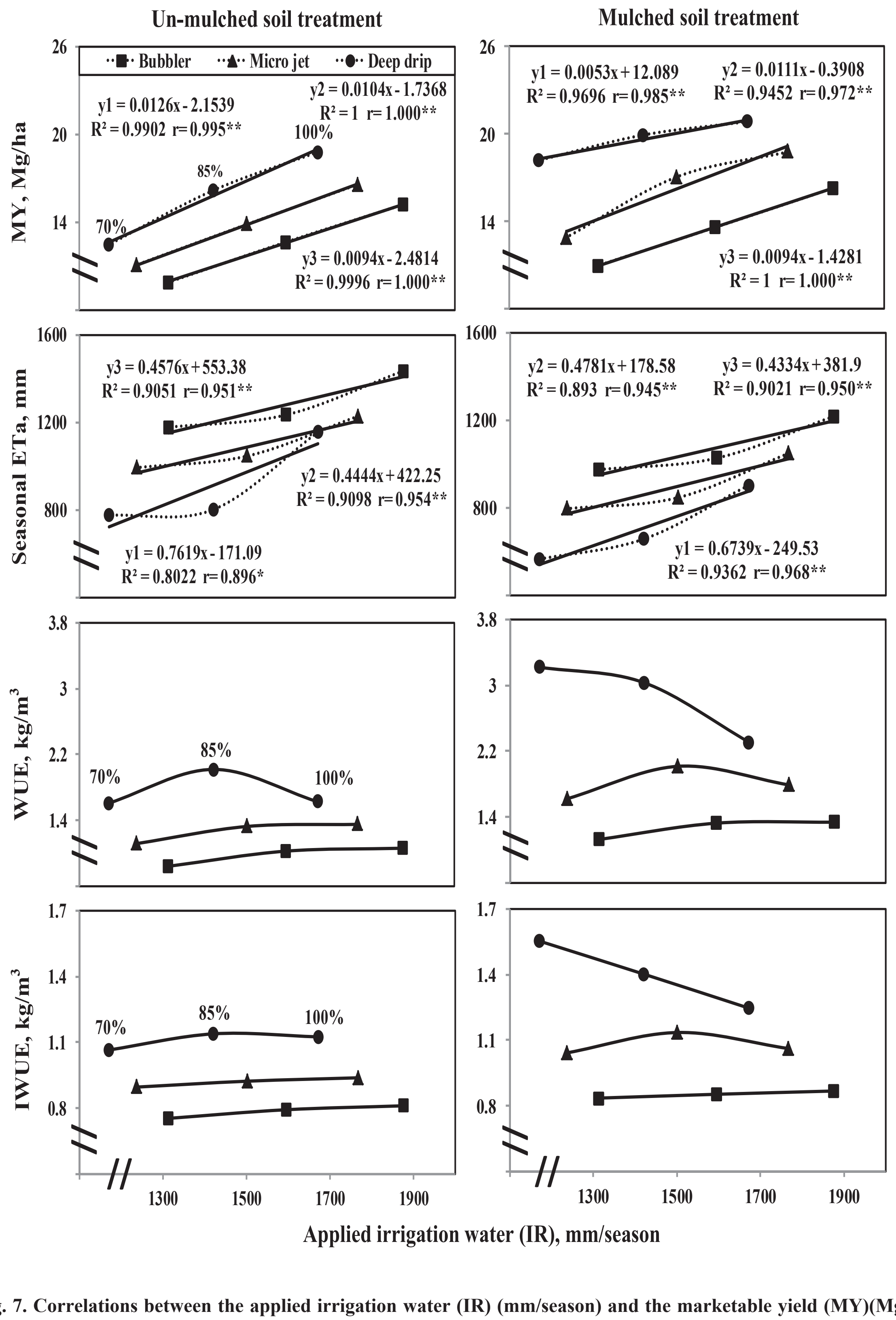

Fig. 7. Correlations between the applied irrigation water (IR) (mm/season) and the marketable yield (MY)(Mg/ha), seasonal actual evapotranspiration (ETa)(mm), water use efficiency (WUE) and irrigation water use efficiency (IWUE) of date palm for various irrigation systems under mulched and un-mulched soil treatments for season 2015/2016.

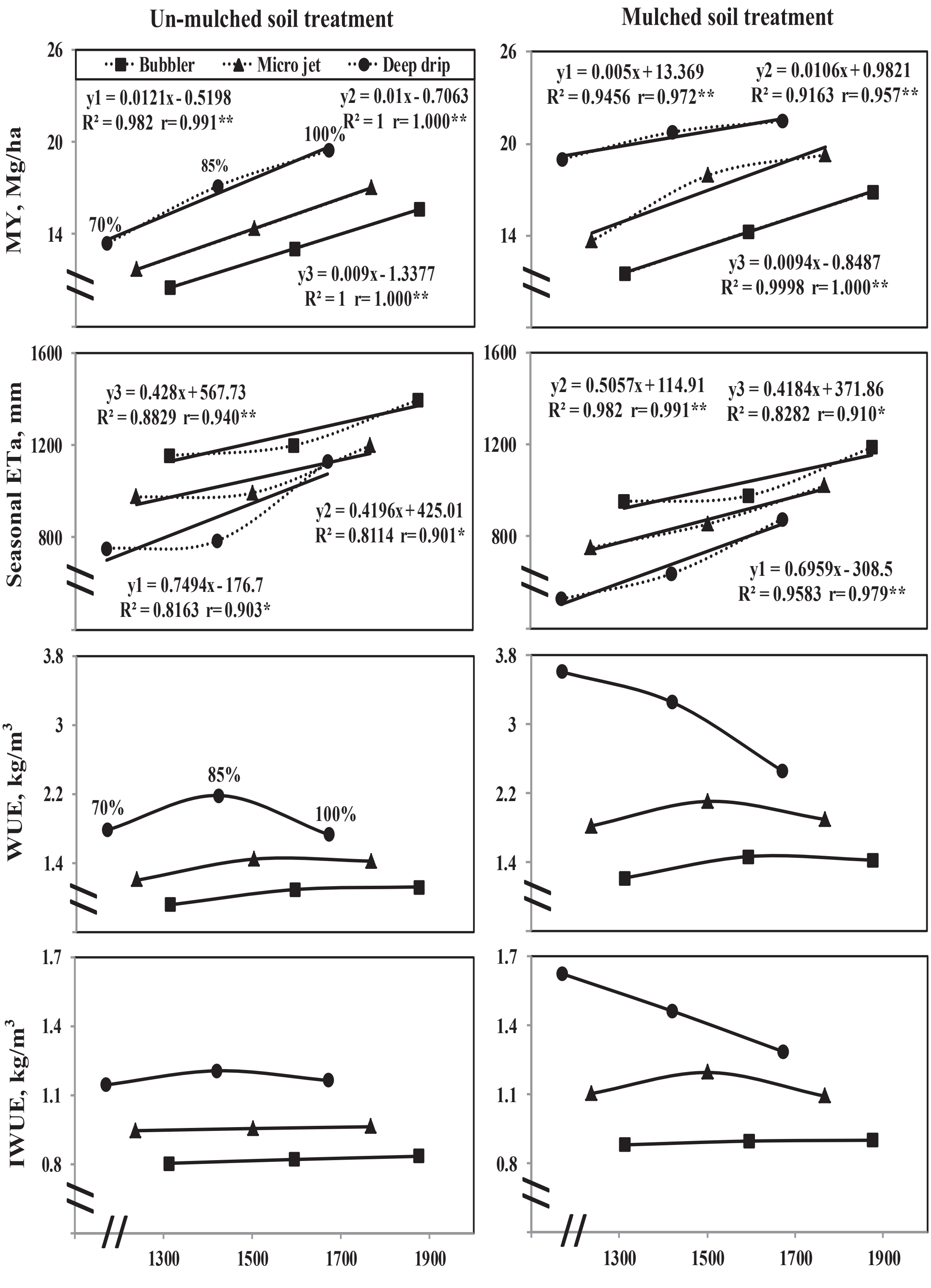

Fig. 8. Correlations between the applied irrigation water (IR) (mm/season) and the marketable yield (MY) (Mg/ha), seasonal actual evapotranspiration (ETa) (mm) water use efficiency (WUE) and irrigation water use efficiency (IWUE) for date palm with various irrigation systems under mulched and un-mulched soil treatments for seasons 2016/2017.

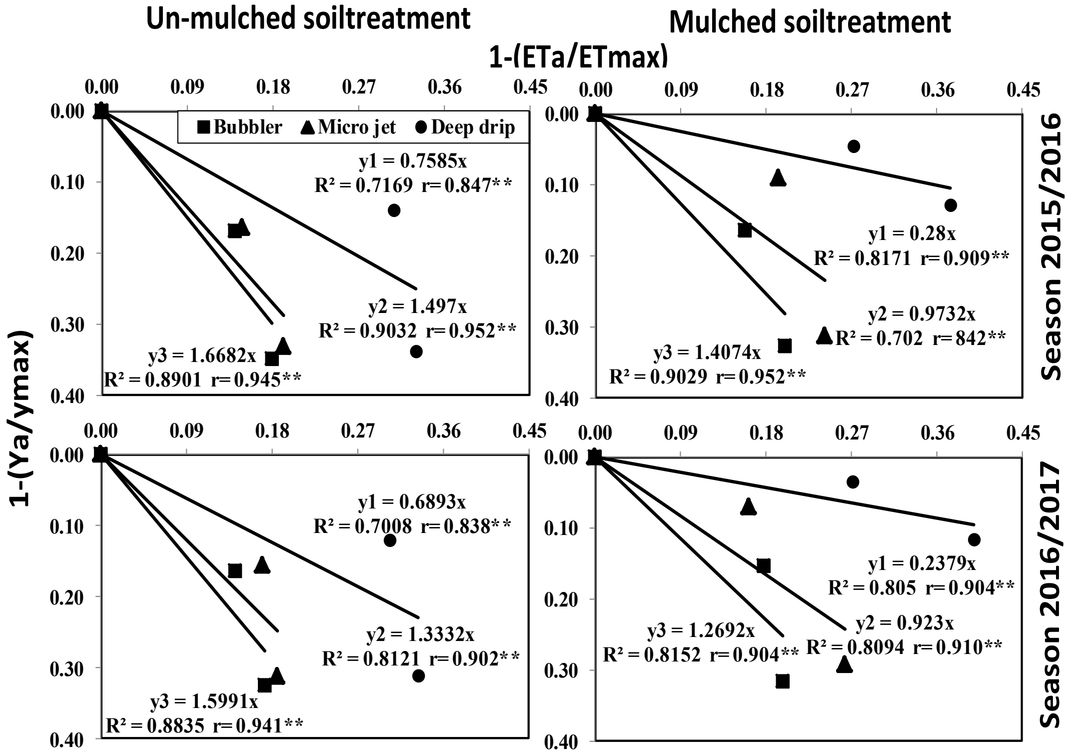

Fig. 9. Relationship between decreases in marketable yield (Ya) and deficit of applied irrigation water (IR)for date palm trees with various irrigation systems under mulched and un-mulched soil treatments

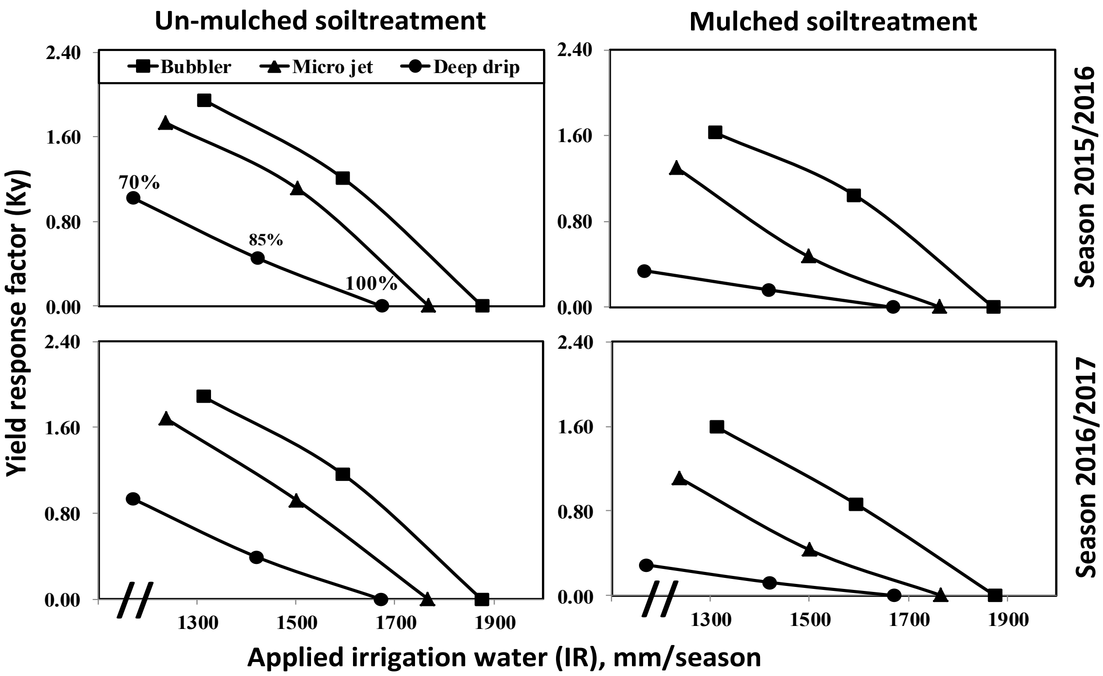

Fig. 10. Effect of applied irrigation water (IR), mm/season on yield response factor (Ky) of date palm with various irrigation systems under mulched and un-mulched soil treatments for seasons 2015/2016-2016/2017.

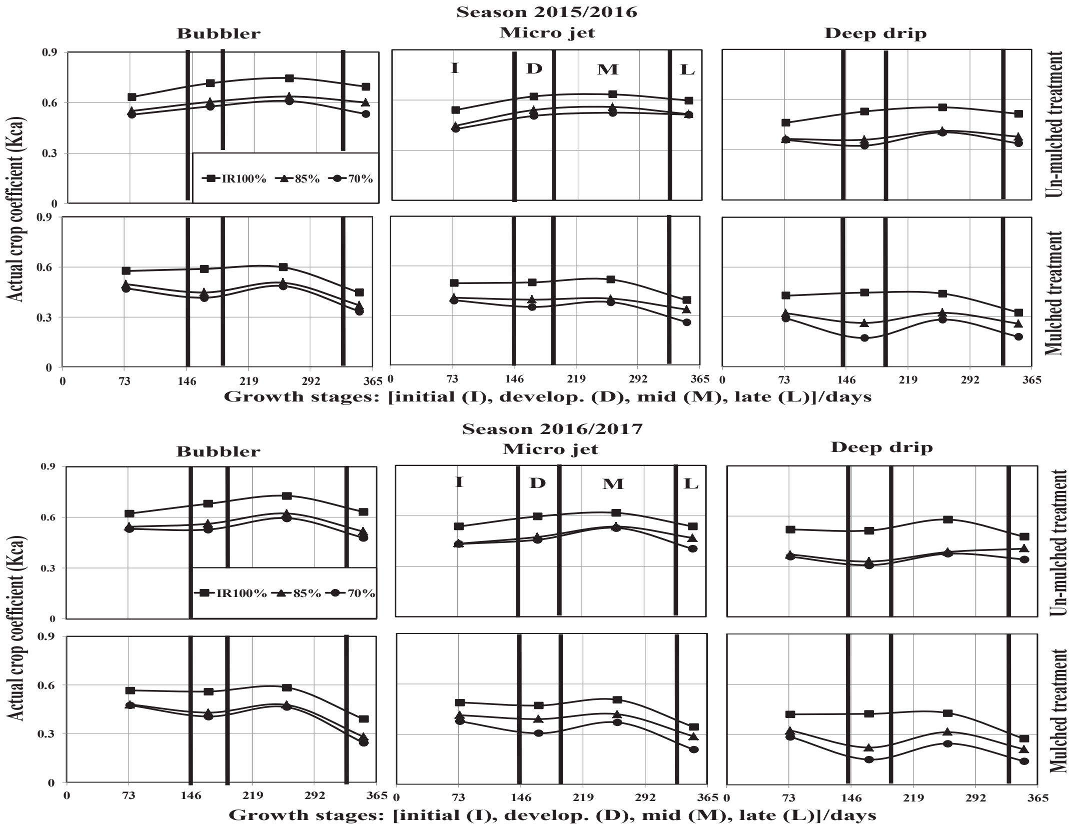

Fig. 11. Actual crop coefficient (Kca) for all growth stages (initial, I – development, D – Mid, M – late, L)/days affected by irrigation systems with various applied irrigation water (IR, %) under mulched and un-mulched soil treatments for seasons 2015/2016-2016/2017

Conclusions

This study applied irrigation water stress and evaluated the effect of different irrigation systems inMS and UMSonthe datepalm fruit yield production, quality parameters, seasonal ETa, WUE, IWUE, Ky and Kca in El-Baharia Oasis sandy soil. The results indicatedthat the highestMY and studied quality parameter values for date palm fruit were observedunder the DIS, IR=100% and MS treatment. Thelowest seasonal ETa and Kcavalues were observed under the DIS, IR=70% and MS treatment. The minimum values of Ky were 0.16 and 0.12 for the 1st and 2nd seasons, respectively, under the DIS, IR=85% and MS treatment. Finally, the WUE and IWUE values increased significantly under theDIS, IR=70% and MS treatment by approximately 204 and 92% and222 and 95% for the 1st and 2nd seasons, respectively, compared withthe control treatment (BIS, IR=100% and UMS).Thus, this study recommends using theDIS, IR=70% and MS treatmentto cultivate date palm trees under El-Baharia Oasis conditions to conserve approximately 38% of theIR and increase the MY of date palm fruit by approximately 20 to 22%.

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إدارة مياه الرى لنخيل البلح تحت ظروف الواحات البحرية

عمرو صادق محمد[1] على أحمد على عبد العزيز[1] أحمد يسرى عبد الغنى الكردانى[2]
[١]قسم كيمياء وطبيعة الأراضى – مركز بحوث الصحراء.
[٢]معهد بحوث النخيل – مركز البحوث الزراعية.

أجريت هذه التجربة فى منطقة الواحات البحرية بمحافظة الجيزة – جمهورية مصر العربية وكانت أحداثياتها كالتالى (٢٨° ١٩´ ١٠´´ شمالا : ٢٨° 57´35´´شرقا) وأرتفاع 130 مترفوق مستوى سطح البحرخلال موسمى الزراعة ٢٠١٥/٢٠١٦-٢٠١٦/٢٠١٧ بأستخدام التصميم الأحصائى القطع المنشقة مرتين وثلاثة مكررات من أشجار نخيل البلح النصف جاف صنف (سيوى) عمرها ٨ سنوات مزروعة بمسافات ٧x٧ مترلكل معاملة. ويتم رى أشجار النخيل بثلاثة مستويات من مياه الرى المضافة ١٠٠ ,٨٥ ,٧٠٪ محسوبة على أساس البخر نتح المحصولى وتضاف بثلاثة طرق للرى (بالنقاطات العميقة Deep dripper – الرشاشات الصغيرة Micro jet – الرى الفقاعى Bubbler)وذلك لمساحة التربة المغطاة والغير مغطاة بالبلاستيك حول كل نخلة وقد تم دراسة تأثير هذه المتغيرات على كل من انتاجية وقياسات الجودة لمحصول النخيل وكذلك الأستهلاك المائى الفعلى وكفاءة الأستهلاك المائى والأروائى ومعامل أستجابة المحصول للنقص فى كميات مياه الرى المضافة ومعامل المحصول الحقيقى تحت ظروف التجربة وقد أوضحت النتائج المتحصل عليها الأتى :

١- سجلت قيم معاملات ثمار البلح السيوى المروية بأستخدام النقاطات العميقة وأضافة ١٠٠٪ من مياه الرى مع تغطية مساحة التربة حول أشجار النخيل بالبلاستيك أعلى قيم لقياسات الجودة عدا قيم المواد الصلبة الذائبة وكذلك سجلت أعلى أنتاجية لثمار البلح (٢٠,٨٤ و٢١,٤٨طن/هكتار) لكلا الموسمين على الترتيب.

٢- سجلت علاقات الأرتباط بين كميات مياه الرى المضافة (مم/موسم) وكل من قياسات الجودة وأنتاجية ثمار البلح أرتباطا معنويا موجبا فى جميع المعاملات عدا العلاقات مع المواد الصلبة الذائبة أظهرت أرتباطا معنويا سالبا لكلا الموسمين.

٣- سجلت قيم المعاملات المروية بأستخدام النقاطات العميقة وأضافة ٧٠٪ من مياه الرى مع تغطية التربة بالبلاستيك أدنى قيم للأستهلاك المائى الفعلى(٥٦٤,٤١ و ٥٢٦,٧٨ مم/موسم) لكلا الموسمين على الترتيب.

٤- سجلت قيم المعاملات المروية بأستخدام النقاطات العميقة وأضافة ٧٠٪ من مياه الرى مع تغطية التربة بالبلاستيك أعلى قيم لكفاءة الأستهلاك المائى والأروائىلثمار البلح السيوى (٣,٢٢ و١,٥٥ كجم/م٣) و(٣,٦١ و١,٦٢ كجم/م٣) لكلا الموسمين على الترتيب.

٥- سجلت قيم المعاملات المروية بأستخدام النقاطات العميقة وأضافة ٨٥٪ من مياه الرى مع تغطية التربة بالبلاستيك أدنى قيم لمعامل أستجابة محصول البلح (٠,١٦ و٠,١٢) لكلا الموسمين على الترتيب.

٦- سجلت قيم المعاملات المروية بأستخدام النقاطات العميقة وأضافة ٧٠٪ من مياه الرى مع تغطية التربة بالبلاستيك أدنى قيم لمتوسط معامل المحصول الفعلى لنخيل البلح تحت ظروف التجربة (٠,٢٣ و٠,٢١) لكلا الموسمين على الترتيب.

لذا يمكن التوصية بزراعة البلح السيوى بأستخدام النقاطات العميقة وأضافة 70% من مياه الرى مع تغطية مساحة التربة حول أشجار النخيل بالبلاستيك تحت ظروف الواحات البحرية وذلك لأن هذه المعاملة توفرحوالى 38% من مياه الرى المضافة وكذلك تزيد من أنتاجية ثمار البلح بحوالى 20 و 22% لكلا الموسمين على الترتيب مقارنة بالمعاملة التقليدية (الزراعة بأستخدام الرى الفقاعى وأضافة 100% من مياه الرى بدون تغطية التربة بالبلاستيك) .