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Yield Response of Squash (*Cucurbita pepo* L.) to Water Deficit under East Owainat Conditions

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AN EXPERIMENT was performed during two summer successive seasons of 2016 and 2017, at a private farm in the East Owainat area, New valley Governorate, Egypt, to study the effect of subsurface soil covered techniques by plastic sheet. Treatments included uncovered (UCS), half covered (HCS), full covered (FCS) at different applied irrigation water levels (IR=100, 90, 80, 70, 60, 50 and 40% calculated based on crop evapotranspiration) under surface (SDI) and sub- surface drip (SSDI) irrigation systems. The marketable yield, crop quality parameters, actual evapotranspiration (ETa), water use efficacy (WUE), irrigation water use efficiency (IWUE) and yield response factor (Ky) for summer squash fruits "*Cucurbita pepo* L." were investigated. The results showed that (1) the marketable yield and studied quality parameters except total soluble solid (TSS) and acidity pH of summer squash fruits gave the highest values under FCS, IR=100% and SSDI treatment for both seasons. (2) Seasonal ETa gave the lowest values: 100.48 and 98.95 mm for both seasons, respectively, under UCS, IR= 40% and SDI treatment. (3) The maximum values of summer squash fruits WUE and IWUE were 25.27 and 16.38 kg m^{-3}; 25.59 and 16.52 kg m^{-3} for both seasons, respectively, under FCS, IR= 60% and SSDI treatment.(4) The lowest values of Ky for summer squash fruits were 0.03 and 0.05 for both seasons respectively, under FCS, IR= 90% and SSDI treatment. This study concluded that the cultivation of summer squash under FCS, IR= 60% and SSDI treatment can possibly save about 42 and 44% of the applied irrigation water and increased marketable yield of the summer squash fruit about 16 and 15% for both seasons, respectively, compared with that under the control treatment (UCS, IR= 100% and SDI).

Keywords: Covered soil, Squash, Actual evapotranspiration, Water use efficiency,Irrigation water use efficiency, Yield response factor

Introduction

Agriculture needs a large amount of irrigation water, and this quantity will increase in the future due to the large population increase. The best agriculture practice, defined as that optimizes water use, and is a clef to beat this problem through the refinement of water use efficiency. So, most of the water is not lost (*e.g.* evaporated back to the atmosphere, lost by drainage, deep percolation and surface runoff) but completely used by plants to produce biomass. Therefore, knowing of the water flow during the soil-vegetation system to maximize the fecund water deprivation (transpiration) and minimize the non-productive water deprivation is decisive. Many studies have been executed to quantify these flows by plants, but they showed difficulties in quantifying the proportional contribution of soil evaporation (Es) and transpiration (Et) from total evaporation (E) (Zhang et al., 2010). The surplus irrigation and deep percolation of the irrigation water in the regional sandy loam soil resulted in depressed water use efficiency and water lack in critical growth interval of the crop (Brown and Butcher, 1999). Squash is one of the most remarkable vegetable crops in the world due to its existence as a trade crop for fields and greenhouses. Summer squash is cultivated in most Mediterranean countries as one of the major vegetables (Mohammad, 2004). The depth of roots for the summer squash is shallow and sensitive to soil water content. Too much moisture or water shortage may damage fruits

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and roots; thus, soils good drainage are proper for summer squash. The summer squash was grown in northern Egypt affected significantly by water stress. The maximum fruit yields, fruit numbers, lengths and diameters were recorded at (ETc 100%) treatment. The yield and yield component values were decreased by an excess (ETc 125% and ETc 150%) or deficit (Etc 50% and ETc 75%) of water stress (Amer, 2011 and El-Dewiny, 2011). The thick, non-permeable polyethylene sheets were buried 60 cm wide and 0.06 mm thick under the irrigation lines at a depth of 30 to 40 cm from the soil surface. The results showed increased moisture content and storage capacity of the soil in the area of the spread of the roots decrease and reduce the rate of deep penetration of the soil (Barth, 1995). The usage of mulch is known to be operative in decreasing soil evaporation and saving water (Zhang et al., 2014). The use of plastic sheets for irrigation in arid and semi-arid areas of the world achieves major benefit due to water saving and salt apportionment ability of plastic sheets by decreasing the deep percolation losses (Memon et al., 2017). Under mulched soil condition the moisture content decreased by about 52% at depth 2 cm, 83% at 5 cm and 95% at 10 cm and generally the soil moisture content in the surface layer (0-60 cm) for mulched soil was higher than the bare soil (Kumar and Lal, 2012).Mulching is effective to observation of salts accumulation in soil profile, border of growth weeds and decrease the surface soil evaporation (Terasaki et al., 2009). A major number of experiments have been carried out to investigate the effect of plastic mulch and drip irrigation on yield amelioration of many crops in various agro-climatic zone and soil status. The yields increased by about 20–60% under drip irrigation system in some studies (Sivanappan et al., 1974). Also, mulch of soil raises water use efficiency (WUE). The mulch is any substance placed on the surface of the soil to protect against sun radiation and thus reduce evaporation. There are many types of mulch such as wheat straw, rice straw, plastic film, grass or wood (Yaghi et al., 2013). The marketable yield, WUE and IWUE of corn increased by using the mulch treatment compared with the no mulch. The results reported that using inhumed spongy clay recorded the maximum yield, WUE and IWUE compared with surface and subsurface drip irrigation systems. So that, it is an important method to rise water use efficiency in cultivating corn plant in arid and semi-arid conditions (Kanani et al., 2016). The drip irrigation system is one of the effective methods to increase water use efficiency under conditions of water poverty and rationalization of water use in agricultural production need to study, research and use of modern technology (Atta et al., 2011). The sub-surface drip irrigation system entombed at 0.35 m let regular soil moisture; reduce evaporative loss and distribution water immediately to the plant root zone ameliorative vegetative growth and yield properties. So, it is recommended to apply subsurface drip irrigation system at a depth of 0.35 m to irrigated corn under Tunisian specific conditions at the Mediterranean region (Douh and Boujelben, 2011). Using sub-surface drip irrigation system SDI can save irrigation water by 35–55% when growing corn compared to classical irrigation systems. In recent years, a subsurface drip irrigation system has been able to compete with other classical irrigation systems in maize cultivation in the Great Plains, USA, (Lamm and Trooien, 2003). Irrigation scheduling plays an important role in raising the irrigation water use efficiency (IWUE) of many vegetable crops produced (Zotarelli et al., 2009). The yield response factor is the index what if the crop is sensitive to deficit irrigation water or not. Also, the yield response factor greater than unity led to the predicted yield rate reduction with increasing deficit irrigation water. So that, it is usually used in irrigation management (Steduto et al., 2012). The yield response factor is known to reduce crop yield always by water stress into the root zone under deficit irrigation water and as well, the yield reduces by rising excessive irrigation. The relationship between crop yield and water stress can be shown from irrigation experiments in which a major range of irrigation implementation is carried out (Amer, 2010).

This study aimed to investigate the effect of soil cover techniques by plastic sheet for cultivation lines at different applied irrigation water levels under surface and sub-surface drip irrigation system on summer squash crop production, quality growth parameters, actual evapotranspiration, water use efficiency, irrigation water use efficiency and yield response factor.

Materials and Methods

Experiments layout

Field experiments were performed in the East Owainat area, New valley Governorate, Egypt at (23° 37` 25`` N: 29° 17` 31`` E. 58 m a.s.l) during two summer successive seasons of 2016 and 2017.

In split-split plot design with three replicates, the experimental was divided into 40 m^2 plots; each bounded by 1.5 m wide barren to avoid horizontal infiltration. The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1989), using Co-state software program. The summer squash (*Cucurbita pepo L.*) was irrigated at seven applied irrigation water levels (IR=100, 90, 80, 70, 60, 50 and 40% calculated based on crop evapotranspiration) under three cover soil techniques for cultivation lines by plastic sheets, show in Fig. 1 uncovered (UCS), half covered (HCS) and full covered (FCS) under surface (SDI) and sub-surface drip irrigation (SSDI). In the case of half covered soil technique, canals were dug down the lines to be cultivated with spaces 1.5 meter between each channel and the other at depth 50 cm using a canal drilling machine (ditcher). All canals were covered using plastic sheets with thickness 200 µm, the canal are then re-filled again, taking into account leaving the first 10 cm of the soil surface without plastic sheets for easy soil servicing operations without damaging the plastic sheet buried. In the case of full covered soil technique, sub surface soil was covered as above, in addition to covering the surface of the soil with perforated plastic sheets which allows the exit of the plants only.

The length (L) cm, diameter (D) cm, total soluble solid TSS (%), acidity pH (-) and marketable yield (MY) Mg/ha were determined for summer squash fruits. While, the actual evapotranspiration (ETa) mm, water use efficiency (WUE) kg m^{-3}, irrigation water use efficiency (IWUE) kg m^{-3} and yield response factor (Ky) were calculated for all cover soil techniques at different applied irrigation water stress under surface and sub-surface drip irrigation for all summer squash plant plots.

Soil properties

Soil samples were collected for some physical and chemical soil properties. The methodological procedures were according to Page et al. (1982) and Klute (1986) (Tables 1and 2)

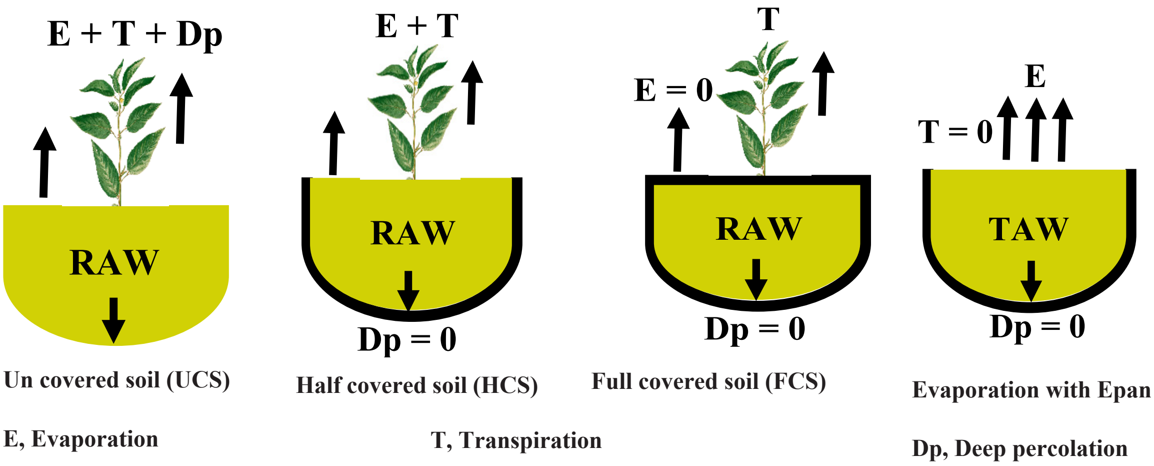

Fig. 1. Effect of soil cover techniques for cultivation lines by plastic sheet on losses of irrigation water

TABLE 1. Some physical properties of experimental soil

Soil depth (cm)	Particle size distribution %					Textural class	OM %	ρ_b g/cm^3	Ks cm/h	FC %	WP %	AW %
	C. sand	M. sand	F. sand	Silt	Clay							
0-15	21.06	53.57	9.39	9.15	6.83	**S**	0.42	1.56	10.69	9.12	3.15	5.97
15-30	21.28	53.32	9.76	8.89	6.75	**S**	0.37	1.58	11.13	8.75	3.03	5.72
30-45	21.43	53.28	9.94	8.76	6.59	**S**	0.34	1.61	11.46	8.38	2.89	5.49

TABLE 2. Some chemical properties of experimental soil

Soil depth (cm)	ECe (dS m^{-1})	pH	$CaCO_3$ %	CEC meq / 100 g soil	Soluble ions (meq/l) in the saturated soil paste							
					Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	$CO_3^=$	$SO_4^=$
0-15	1.07	8.23	7.45	5.61	6.11	0.34	3.27	0.98	6.53	0.36	-	3.81
15-30	1.13	8.11	7.57	5.39	6.28	0.47	3.39	1.16	6.84	0.49	-	3.97
30-45	1.15	7.06	7.70	5.13	6.32	0.51	3.45	1.22	6.91	0.54	-	4.05

Quality of irrigation water

Chemical analyses of the irrigation water were measured according to Ayers and Westcot (1994) **(**Table 3).

Evapotranspiration (ET)

Both reference and crop evapotranspiration, ETo and ETc, respectively, shown in Tables 4 and 5 were calculated using Penman-Monteith equation FAO 56 method (Allen et al., 1998).

Applied irrigation water levels IR

The amounts of applied irrigation water levels (IR) for summer squash plant shown in Table 6 were calculated using the equation:

- IR100, 90, 80,70, 60, 50,40%= (ETc - pe)Kr / Ea) + LR (mm $period^{-1}$) (Keller and Karmeli, 1974)

Where: Kr, correction factor for limited wetting according to the 80% squash canopy coverage, Kr = 0.90. (Smith, 1992).
Ea, irrigation efficiency for drip, 90% (Allen et al., 1998).
Pe, effective rainfall, 0 mm $season^{-1}$.
LR, leaching requirements, under salinity levels of irrigation water (0.11 x ETc), mm.

TABLE 3. Some 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	7.85	0.54	2.34	2.52	0.56	1.38	0.94	2.71	1.83	-	0.86

TABLE 4. Calculated reference evapotranspiration (mm day^{-1}) through summer squash plant growth period.

Month	Feb	Mar	Apr	May
ETo mm day^{-1}	3.37	4.52	6.19	7.05

TABLE 5. Calculated crop evapotranspiration (ETc), mm through summer squash plant growth period

Stages	Initial	Develop.	Mid	Late	Seasonal
Planting date	**23/2 to 9/3**	**10/3 to 8/4**	**9/4 to 3/5**	**4/5 to 18/5**	**23/2 to 18/5**
Period length (day)	20	30	25	15	90
Kc_{FAO} (-)	0.50	0.73	0.95	0.75	--------
ETo (mm)	60.9	148.96	157.33	105.75	472.94
$ETc_{100\%}$ (mm)	30.45	108.74	149.46	79.31	367.96
Eff. Rainfall (mm)	0	0	0	0	0

TABLE 6. Calculated applied irrigation water (IR), mm through summer squash plant growth period

IR (%)	Applied irrigation water (mm)				
	Growth Stages				
	Initial	Development	Mid	Late	Seasonal
100	33.70	120.35	165.41	87.78	407.24
90	30.33	108.32	148.87	79.00	366.52
80	26.96	96.28	132.33	70.22	325.79
70	23.59	84.25	115.79	61.45	285.08
60	20.22	72.21	99.25	52.67	244.35
50	16.85	60.18	82.71	43.89	203.63
40	13.48	48.14	66.16	35.11	162.89

- Readily available water water RAW = 1000 (θFC − θPWP). Zr . P (Allen et al.,1998)

Where: θFC, water content at field capacity, (%).
θPWP, water content at permanent wilting point, (%).
Zr, rooting depth, m.
P, soil water depletion fraction for no stress (Squash P = 0.50).

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

Where: M2, moisture content after irrigation %.
M1, moisture content before irrigation %.
db, specific density of soil .
D, mean depth, mm.

- Water use efficiency WUE = MY / ETa (kg m^{-3}) (Howell et al., 2001)

Where: MY, marketable yield of summer squash plant, (kg ha^{-1}).

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

Where: IR, seasonal applied irrigation water, (m^3), (Table 6).

- Yield response factor (Ky)
- Yield response factor (Ky)

(Allen et al.,1998)

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

Where: ETa, actual evapotranspiration, mm $season^{-1}$.
ETm, crop evapotranspiration (without stress), mm $season^{-1}$.
Ym, maximum yield at IR100 %, t h^{-1}.

Results and Discussion

Effect of covered soil techniques and applied irrigation water levels under surface and sub-surface drip irrigation treatments on studied quality parameters of summer squash fruits

Data in Fig. 2 and 3 showed that the values of quality parameters for summer squash fruits such as length (L) cm and diameter (D) cm increased with increasing applied irrigation water stress (IR) for all treatments except total soluble solid (TSS)% and acidity (pH) decreased with increasing IR. Also, data illustrated a significant superiority of full covered soil technique (FCS) compared with half covered soil (HCS) and uncovered soil (control) (UCS) technique for all treatments. In addition, sub-surface drip irrigation (SSDI) had a clear effect on all treatments compared to surface drip irrigation (SDI). The results recorded the same trend for both seasons 2016 and 2017. The highest values of summer squash fruits L and D were (14.29 and 3.49 cm) for the 1st season; (14.61 and 3.57 cm) for the 2nd season respectively, except TSS and pH were (4.11 and 5.05 %) for the 1st season; (4.02 and 4.94 %) for the 2nd season, respectively, under FCS, IR=100% and SSDI treatment. While, the lowest values of summer squash fruits L and D were (10.78 and 1.73 cm) for the 1st season; (10.95 and 1.76 cm) for the 2nd season respectively, except TSS and pH were (6.29 and 7.26 %) for the 1st season; (6.14 and 7.11 %) for the 2nd season respectively under UCS, IR= 40% and SDI treatment. These results are consistent with the findings of Lamm and Trooien (2003), Amer (2011) and El-Dewiny, 2011.

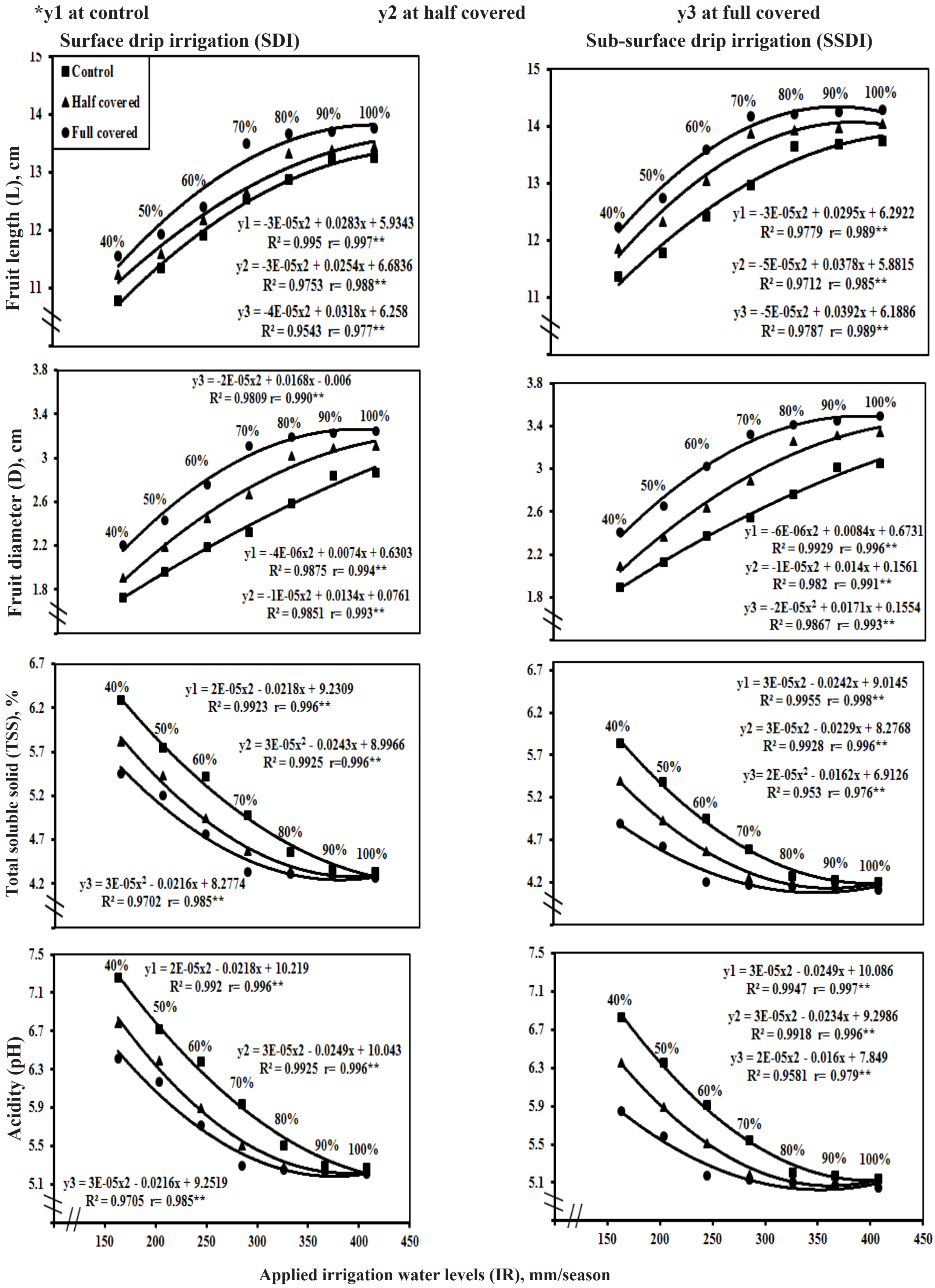

Fig. 2. Relationships between applied irrigation water levels (IR), mm/season and some fruit quality parameters of the squash at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for season 2016

***y1 at control y2 at half covered y3 at full covered**

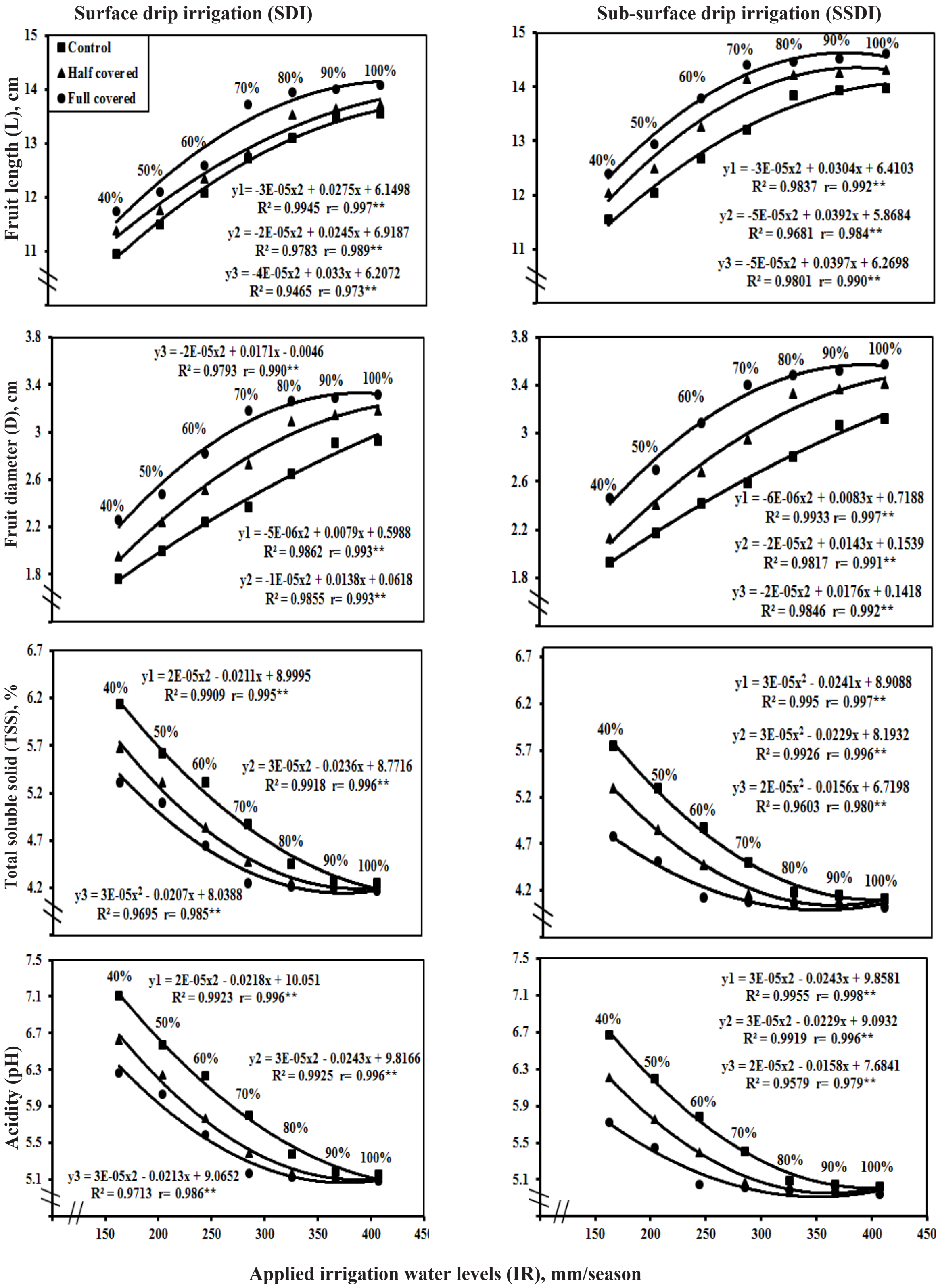

Fig. 3. Relationships between applied irrigation water levels (IR), mm/season and some fruit quality parameters of the squash at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for season 2017

Moreover, Fig. 2 indicated that the relationships between IR, mm and studied quality parameters of summer squash fruits for season 2016 were highly significant positively correlated except TSS and pH were highly significant negatively correlated L (r = 0.997**, 0.988** and 0.977**) and D (r = 0.994**, 0.993** and 0.990**) except TSS (r = -0.996**, -0.996** and -0.985**) and pH (r = -0.996**, -0.996** and -0.985**) for all covered soil techniques (UCS, HCS and FCS) respectively, under SDI treatment, while, L (r = 0.989**, 0.985** and 0.989**) and D (r = 0.996**, 0.991** and 0.993**) were except TSS (r = -0.998**, -0.996** and -0.976**) and pH (r = -0.997**, -0.996** and -0.979**) for all covered soil techniques (UCS, HCS and FCS) respectively, under SSDI treatment.

Meanwhile, Fig. 3 showed that the relationships between IR, mm and studied quality parameters of summer squash fruits for season 2017 achieved the same results for all covered soil techniques (UCS, HCS and FCS) respectively, under SDI and SSDI treatments.

Effect of covered soil techniques and applied irrigation water levels under surface and sub-surface drip irrigation treatments on marketable yield of summer squash fruits

Data in Fig. 4 and 5 showed that the values of marketable yield (MY) Mg/ha for summer squash fruits increased with increasing IR for all treatments. Also, data represented significant superiority of FCS compared to HCS and UCS for all treatments. In addition, SSDI had a clear effect on all treatments compared to SDI. The results recorded the same trend for both seasons 2016 and 2017. The highest values of MY for summer squash fruits were (14.95 and 15.12 Mg/ha) for both seasons, respectively, under FCS, IR=100% and SSDI treatment, while, the lowest values were (3.56 and 3.70 Mg/ha) for both seasons, respectively, under UCS, IR= 40% and SDI treatment. These results may be attributed to the full covered soil with plastic sheet prevents surface soil evaporation and as well deep percolation consequently, increasing the storage capacity in the sandy soil. Thus, maximizing the utilization of irrigation water for plant, if compared to the conventional method. In addition, the subsurface drip irrigation system can provide irrigation water near the root spreading area of the squash plant, which is sensitive to the lack of irrigation water, which increases the productivity under the treatment conditions, these results are in accordance with Douh and Boujelben (2011), Zhang et al. (2014) and Memon et al. (2017).

Moreover, Fig. 4 shows that the relationships between IR, mm and marketable yield of summer squash fruits for season 2016 were highly significant positively correlated MY (r = 0.997**, 0.991** and 0.995**) for all covered soil techniques (UCS, HCS and FCS) respectively, under SDI treatment. On the other hand, MY (r = 0.993**, 0.995** and 0.977**) for all covered soil techniques (UCS, HCS and FCS) respectively, under SSDI treatment.

Meanwhile, Fig. 5 reports that the relationships between IR, mm and marketable yield of summer squash fruits for season 2017 achieved the same results for all covered soil techniques were (UCS, HCS and FCS) respectively, under SDI and SSDI treatments.

Effect of covered soil techniques and applied irrigation water levels under surface and sub-surface drip irrigation treatments on seasonal actual evapotranspiration of summer squash fruits

Data in Fig. 4 and 5 illustrate that the values of seasonal actual evapotranspiration (ETa) mm for summer squash fruits decreased with decreasing IR for all treatments. Also, data indicated significant effect of FCS compared to HCS and UCS for all treatments. In addition, SSDI had a clear effect on all treatments compared to SDI. The results recorded the same trend for both seasons 2016 and 2017. The lowest values of seasonal ETa were (100.48 and 98.65 mm) for both seasons respectively, under FCS, IR= 40% and SSDI treatment, while, the highest values of seasonal ETa were (376.15 and 360.03 mm) for both seasons respectively, under UCS, IR=100% and SDI treatment. These results may be attributed to that the sandy soil full covered with plastic sheet stopped the evaporation from surface soil. Moreover, the sub-surface drip irrigation system decrease water losses by evaporation because the irrigation lines buried at deep 30 cm. It is also, the water stress of the irrigation water added reduces the actual water consumption; these results are in agreement with that found by Terasaki et al. (2009), Yaghi et al. (2013) and Douh and Boujelben (2011).

Moreover, Fig. 4 shows that the relationships between IR, mm and seasonal ETa of summer squash fruits for season 2016 were highly significant positively correlated seasonal ETa (r = 0.998**, 0.999** and 0.999**) for all

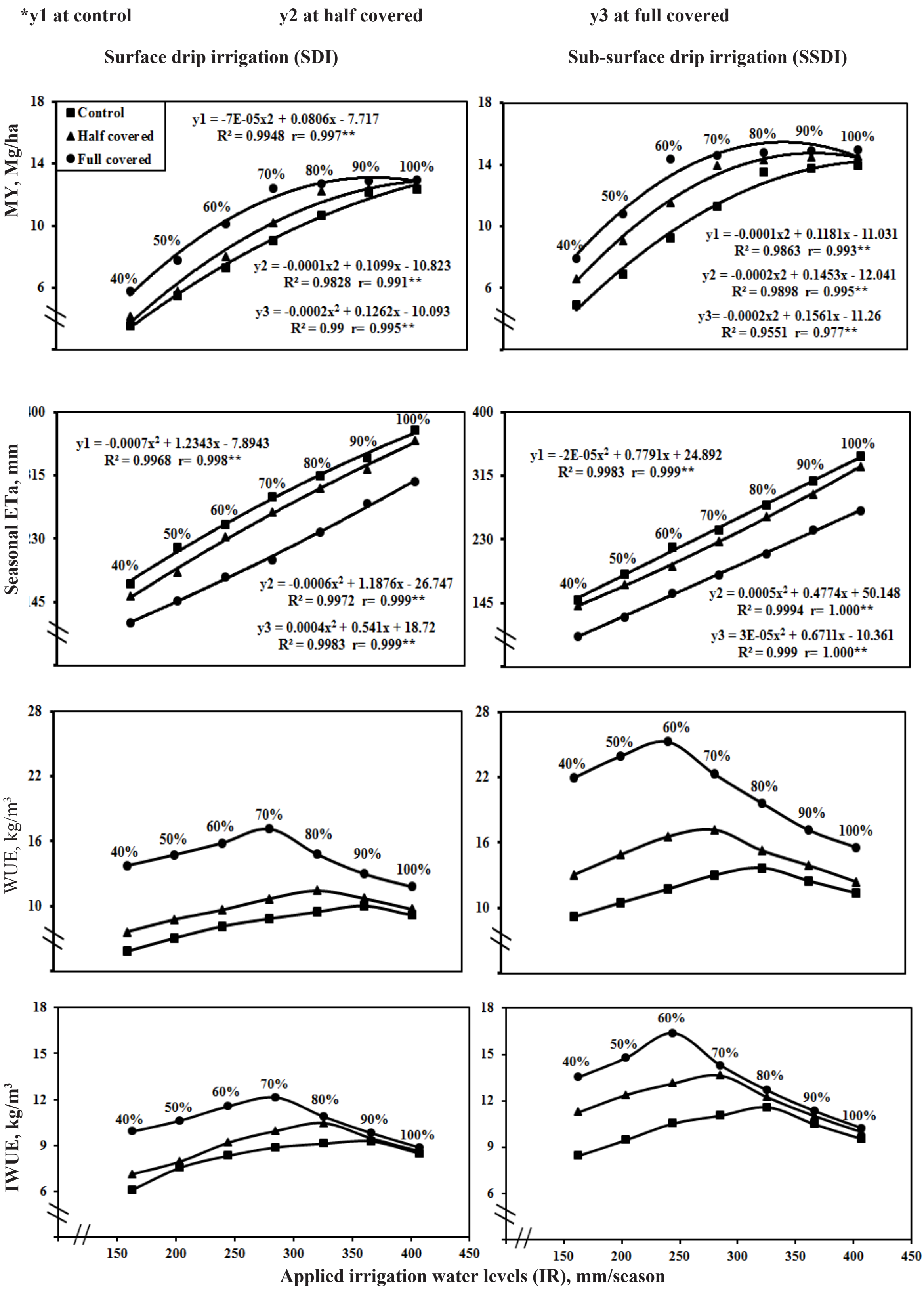

Fig. 4. Relationships between applied irrigation water levels (IR), mm/season and both of the marketable yield (MY), Mg/ha, seasonal actual evapotranspiration (ETa), mm, water use efficiency (WUE) and irrigation water use efficiency (IWUE) of the squash at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for season 2016

covered soil techniques (UCS, HCS and FCS) respectively, under SDI treatment, while, seasonal ETa (r = 0.999**, 1.000** and 1.000**) for all covered soil techniques were (UCS, HCS and FCS) respectively, under SSDI treatment.

Meanwhile, Fig. 5 shows that the relationships between IR, mm and seasonal ETa of summer squash fruits for season 2017 achieved the same results for all covered soil techniques (UCS, HCS and FCS) respectively, under SDI and SSDI treatments.

Effect of covered soil techniques and applied irrigation water levels under surface and sub-surface drip irrigation treatments on water use efficiency and irrigation water use efficiency of summer squash fruits

Data in Fig. 4 and 5 report that the highest values of water use efficiency (WUE) and irrigation water use efficiency (IWUE) for summer squash fruits were (25.27 and 16.38 kg m^{-3}); (25.59 and 16.52 kg m^{-3}) for both seasons respectively, under FCS, IR= 60% and SSDI treatment. While, the lowest values were (5.84 and 6.09 kg m^{-3}); (6.48 and 6.33 kg m^{-3}) for both seasons, respectively, under UCS, IR= 40% and SDI treatment. Meanwhile, the values of WUE and IWUE under FCS, IR= 60% and SSDI treatment were increased significantly by about (176 and 94 %); (162 and 91 %) for both seasons, respectively, compared to that under the control treatment (UCS, IR= 100% and SDI). These results may be attributed to that the sandy soil full covered with plastic sheet prevents surface soil evaporation and as well deep percolation. Also, the subsurface drip irrigation system and water stress decrease surface soil evaporation, consequently, increasing the storage capacity in the sandy led to increase marketable yield with decrease in water consumption, these results were similar to those indicated by Zotarelli et al., 2008; Yaghi et al., 2013 and Kanani et al., 2016.

Effect of covered soil techniques and applied irrigation water levels under surface and sub-surface drip irrigation treatments on summer squash yield response factor (Ky)

Data in Fig. 6 show that the crop yield response factor (Ky) for summer squash fruits indicates a linear relationship between the relative reduction in actual evapotranspiration 1-(ETa/ETmax) and the relative reduction in yield 1-(Ya/Ymax). These relationships for season 2016 were highly significant positively correlated Ky (r = 0.978**, 0.947** and 0.853**) for all covered soil techniques (UCS, HCS and FCS) respectively, under SDI treatment. While, Ky were (r = 0.931**, 0.847** and 0.773*) for all covered soil techniques (UCS, HCS and FCS) respectively, under SSDI treatment. Also, Fig. 6 reported that the relationships between 1-(ETa/ETmax) and 1-(Ya/Ymax) for season 2017 achieved the same results for all covered soil techniques (UCS, HCS and FCS) respectively, under SSDI treatment.

Moreover, Fig. 7 indicates that the values of Ky for summer squash fruits decreased with increasing IR at all covered soil techniques under SDI and SSDI treatments. The lowest values of Ky for summer squash fruits were 0.03 and 0.05 for both seasons respectively, under FCS, IR= 90% and SSDI treatment. The maximum values were 1.32 and 1.30 for both seasons, respectively,under UCS, IR= 40% and SDI treatment. These results may be attributed to that the yield response factor is the index what if the crop is sensitive to deficit irrigation water or not. Also, The yield response factor greater than unity led to that the predicted yield rate reduction with increasing deficit irrigation water. So that, it is usually used in irrigation management, and these results are in harmony with the finding of Amer (2010) and Steduto et al. (2012).

Economic study for used full covered soil treatment

The full coverage soil by plastic sheets at applied irrigation level 60% under sub-surface drip irrigation was very economical because the costs of drilling canals and cover it with plastic sheets at depth of 50 cm and burial of drip irrigation lines at depth 20 cm. It took digging and filling the canals 4 hours of work / fed and the cost of hour 500 EGP so that the costs of digging and filling become (4 hours * 500 EGP/hour = 2000 EGP). While, the feddan needed about 300 kg of plastic sheets (cost kg =50 EGP) so that the costs of plastic sheets / fed = 300 kg * 50 EGP = 15000 EGP / fed. The total cost of this treatment 17000 EGP / fed the life span of plastic sheets about five years. On the other hand, the squash is cultivated three times per year and the increase in yield was about 2500 kg compared to that under traditional treatment (uncovered soil and applied irrigation level 100%under surface drip irrigation). And on the assumption that the price of 1 kg squash was 1 EGP. Therefore, the profit of application full coverage soil with plastic sheets at applied irrigation level 60% under sub-surface drip irrigation transaction on five years was (2500 kg/fed * 3 times / year *1 EGP * 5 years = 37500 EGP/ fed / 5 years), 17,000 LE the cost of digging, filling and covering the canals deducted from the total profit to become the net profit during the five years = 20500 EGP. In addition to, this treatment provides about 44% of the amount of irrigation water added that can be used to reclaim more desert land and cultivate it with the same crop.

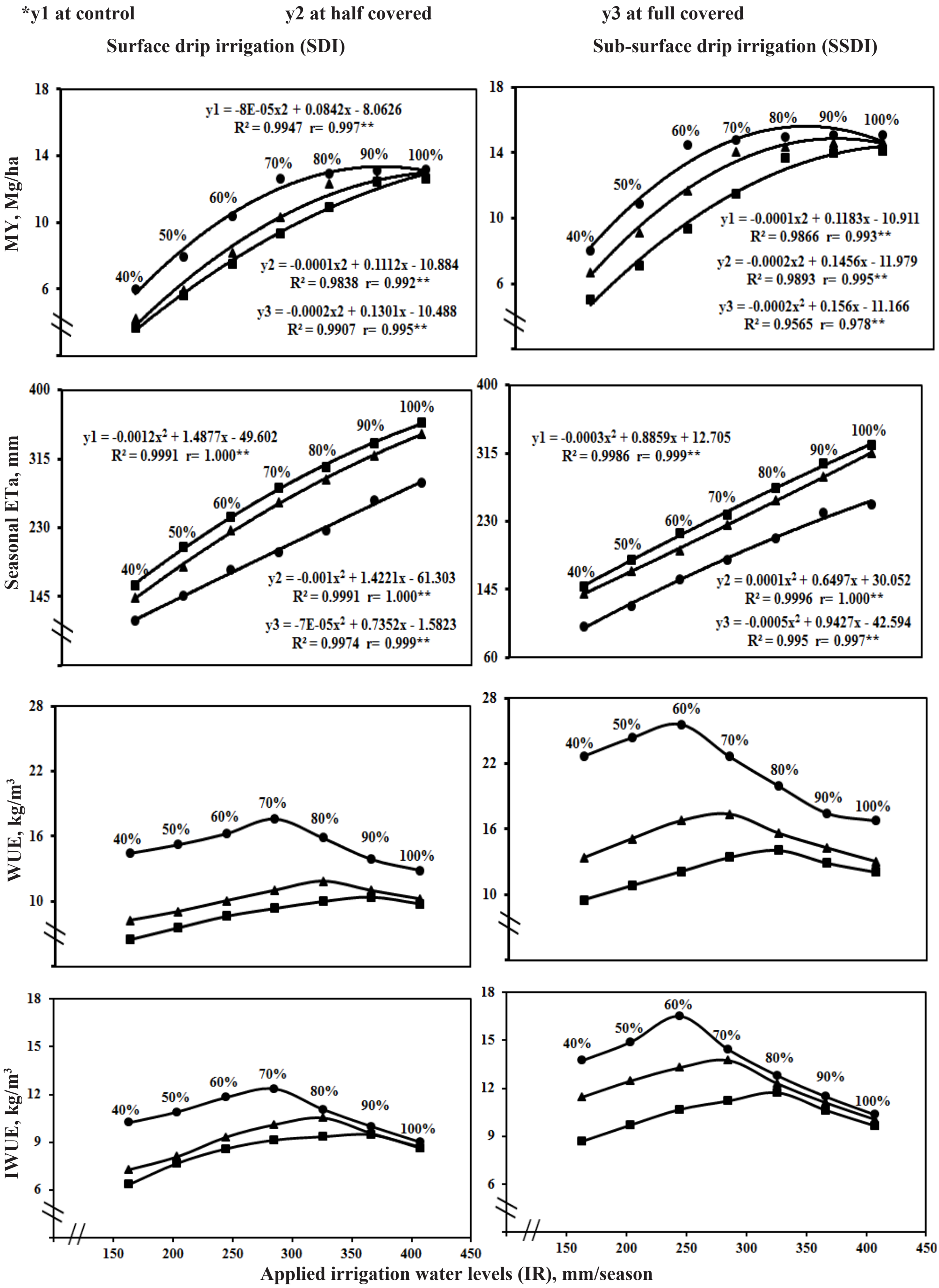

Fig. 5. Relationships between applied irrigation water levels (IR), mm/season and both of the marketable yield (MY), Mg/ha, seasonal actual evapotranspiration (ETa), mm, water use efficiency (WUE) and irrigation water use efficiency (IWUE) of the squash at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for season 2017

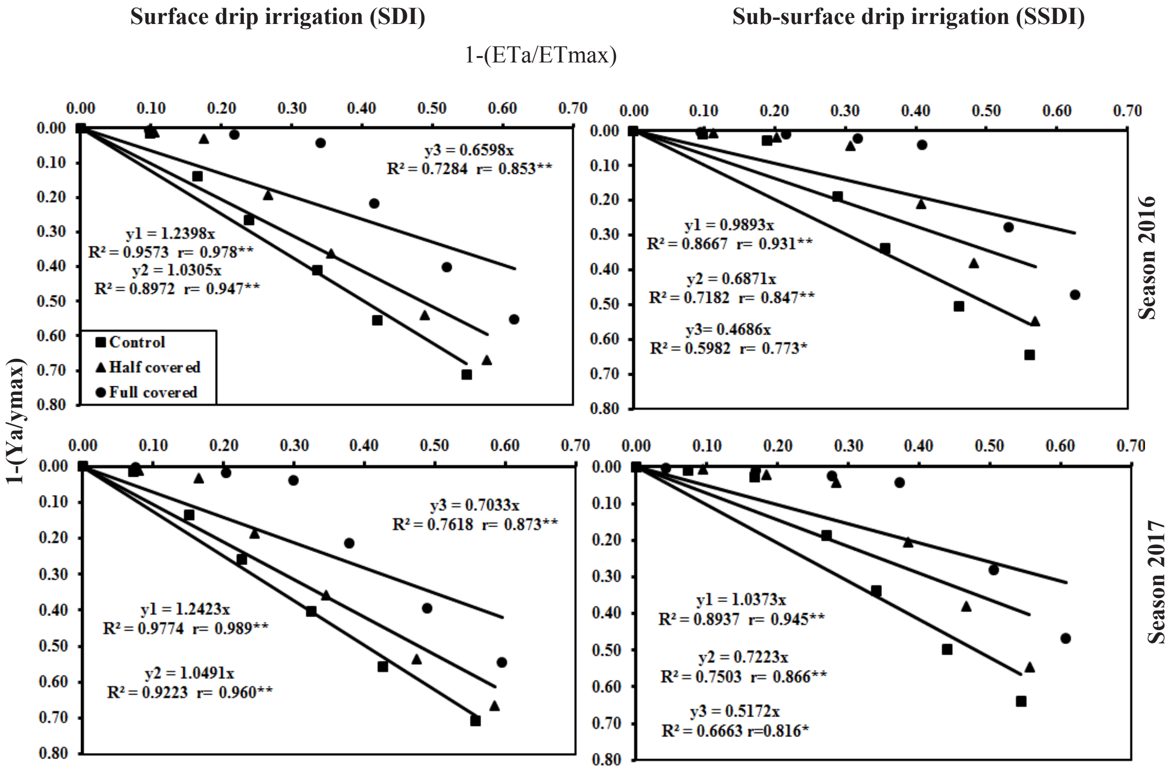

Fig. 6. Relationships between decreases in marketable yield (Ya) and deficit of applied irrigation water levels (IR) for squash plant at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for seasons 2016/ 2017

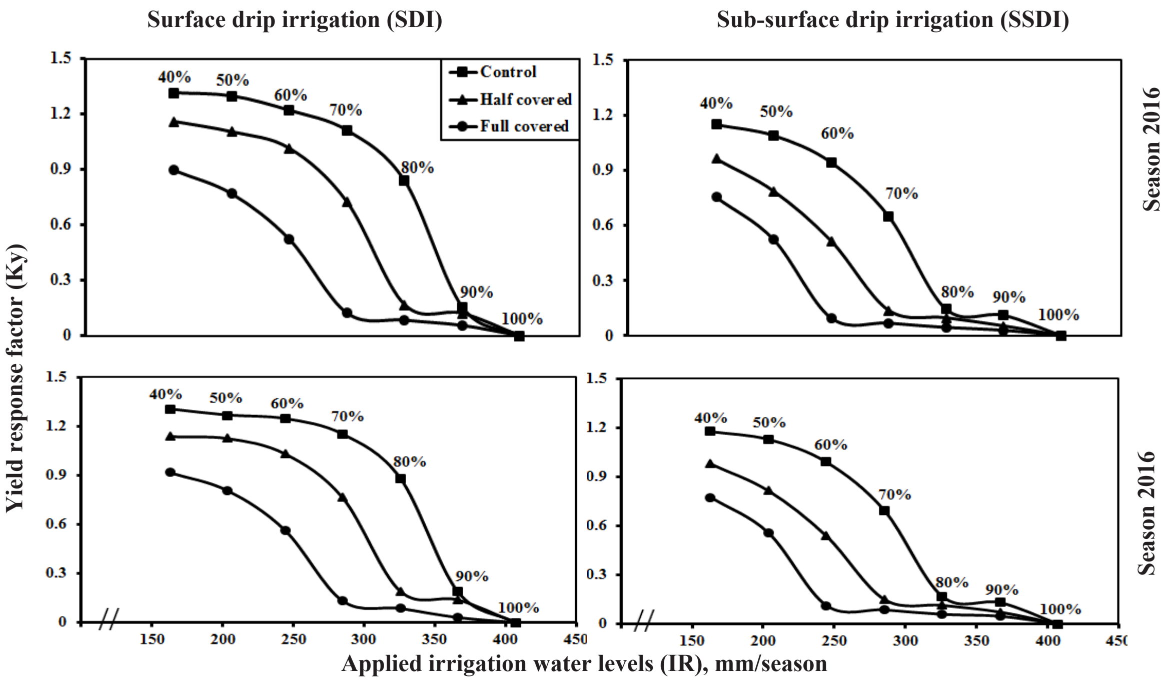

Fig. 7. Effect of applied irrigation water levels (IR), mm/season on yield response factor (Ky) of the squash at different soil cover techniques by plastic sheet under surface and sub-surface drip irrigation treatments for seasons 2016/2017

Conclusion

This study evaluated the effectiveness of the soil cover techniques (by plastic sheet)cultivation lines at different applied irrigation water levels stress under surface and sub-surface drip irrigation on summer squash fruits yield production, quality, seasonal ETa, WUE, IWUE and Ky under East Owainat sandy soil. The study concluded that the marketable yield and studied quality parameters for summer squash fruits gave the highest values under FSC, IR=100% and SSDI treatment. On the other hand, the seasonal ETa for summer squash fruits gave the lowest values under FCS, IR= 40% and SSDI treatment. Meanwhile, the values of summer squash fruits WUE and IWUE under FCS, IR= 60% and SSDI treatment increased significantly by about (176 and 94 %); (162 and 91 %) for both seasons, respectively, compared with that under the control treatment (UCS, IR= 100% and SDI). Finally, the minimum values of Ky for summer squash fruits were 0.03 and 0.05 for both seasons respectively, under FCS, IR= 90% and SSDI treatment.

So, it is recommended to apply FCS, IR= 60% and SSDI treatment to cultivate summer squash under East Owainat conditions to save about 42 and 44% of applied irrigation water and increase marketable yield of summer squash fruits by about 16 and 15% for both seasons respectively, compared to that under control treatment (*i.e.* UCS, IR= 100% and SDI).

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أستجابة محصول الكوسة لنقص المياه تحت ظروف شرق العوينات

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أجريت هذه التجربة فى منطقة شرق العوينات بمحافظة الوادى الجديد – جمهورية مصر العربية وكانت أحداثياتها كالتالى (٢٣° ٣٧´ ٢٥´´ شمالا : ٢٩° ١٧´ ٣١´´ شرقا) وأرتفاع ٥٨ متر فوق مستوى سطح البحر خلال موسمين زراعة صيفية ٢٠١٦ و٢٠١٧ بأستخدام التصميم الأحصائى القطع المنشقة مرتين وثلاثة مكررات لكل معاملة. تم رى نبات الكوسة بسبع مستويات من مياه الرى المضافة ١٠٠ , ٩٠ , ٨٠ , ٧٠ , ٦٠ , ٥٠ , ٤٠ ٪ محسوبة على أساس البخر نتح المحصولى المزروعة بثلاثة تقنيات للتغطية التحت سطحية لخطوط التربة بالبولى ايثلين ذو سمك ٢٠٠ ميكرون (بدون تغطية – نصف تغطية – كاملة التغطية) وذلك تحت نظامى الرى بالتنقيط السطحى والتحت سطحى وقد تم دراسة تأثيرهذه المتغيرات على كل من أنتاجية وقياسات الجودة لنبات الكوسة وكذلك الأستهلاك المائى الفعلى وكفاءة الأستهلاك المائى للري ومعامل أستجابة المحصول للنقص فى كميات مياه الرى المضافة تحت ظروف التجربة وقد أوضحت النتائج المتحصل عليها الأتى :

١- سجلت ثمارالكوسة أعلى قيم لقياسات الجودة فيما عدا المواد الصلبة الذائبة والحموضة عند أستخدام تقنية التغطية الكاملة للتربة بالبلاستيك وأضافة ١٠٠٪ من مياه الرى بنظام الرى بالتنقيط التحت سطحى.كما سجلت أعلى أنتاجية لثمارالكوسة (١٤,٩٥ و١٥,١٢طن/هكتار) لكلا الموسمين على الترتيب تحت نفس المعاملة.

٢- سجلت ثمارالكوسة أدنى قيم للأستهلاك المائى الفعلى (١٠٠,٤٨, ٩٨,٦٥ مم/موسم) لكلا الموسمين على الترتيب عند أستخدام تقنية التغطية الكاملة للتربة بالبلاستيك وأضافة ٤٠٪ من مياه الرى بنظام الرى بالتنقيط السطحى.

٣- سجلت ثمارالكوسة أعلى قيم لكفاءة الأستهلاك المائى وكفاءة الإستهلاك المائي للري (٢٥,٢٧ و١٦,٣٨ كجم/م^{٣}) و(٢٥,٩٥ و١٦,٥٢ كجم/م^{٣}) لكلا الموسمين على الترتيب عند أستخدام تقنية التغطية الكاملة للتربة بالبلاستيك وأضافة ٦٠ ٪ من مياه الرى بنظام الرى بالتنقيط التحت سطحى.

٤- سجلت ثمارالكوسة أدنى قيم لمعامل أستجابة محصول الكوسة للنقص فى كميات مياه الرى المضافة (٠,٠٣ و٠,٠٥) لكلا الموسمين على الترتيب عند أستخدام تقنية التغطية الكاملة للتربة بالبلاستيك وأضافة ٩٠ ٪ من مياه الرى بنظام الرى بالتنقيط التحت سطحى.

لذا يمكن التوصية بزراعة نبات الكوسة الصيفى بأستخدام تقنية التغطية الكاملة للتربة بالبلاستيك وأضافة ٦٠ ٪ من مياه الرى بنظام الرى بالتنقيط التحت سطحى تحت ظروف شرق العوينات وذلك لأن هذه المعاملة توفرحوالى ٤٢ و ٤٤ ٪ من مياه الرى المضافة وكذلك تزيد من أنتاجية ثمارالكوسة بحوالى ١٦ و١٥ ٪ لكلا الموسمين على الترتيب مقارنة بالمعاملة التقليدية (التربة الغير مغطاة بالبلاستيك وأضافة ١٠٠٪ من مياه الرى بأستخدام الرى بالتنقيط السطحى) .