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Impact of Surface and Subsurface Drip Irrigation Systems and Fertigation Managements on Yield and Water Use Efficiencies of Two Squash Varieties

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Abstract

Two squash varieties were grown under surface and subsurface drip irrigation systems at the experimental farm of the soils and water depart., Faculty of Agric., Assiut University, Egypt during the summer season of 2016 to study the impact of surface and subsurface drip irrigation and number of fertigation doses (3D = 3 doses, 6D = 6 doses, 9D = 9 doses and 12D = 12 doses) on the yield and water use efficiencies of two squash varieties (Eskendarany and Fadwa squash hybrid). The experiment was laid out in split spilt block design arrangement with three replicates. The Results showed that the highest mean values of squash fruit yield and water use efficiency were recorded from subsurface drip irrigation. Using the same amount of water with subsurface drip irrigation doubled the yield as compared with surface drip irrigation. Dividing the amount of fertilizer to 12 doses produced the highest yield and WUF. Increasing number doses from 3 to 6, 9, and 12 doses increased the squash fruits yield and WUF steadily to more than double. Fadwa squash hybrid produced higher yield compared to Eskendarany variety. The highest mean values of water use efficiency were recorded from subsurface drip irrigation with splitting the same amount of fertilizer to 12 doses in both varieties. It could be recommended that, to get economical yield and to increase water use efficiency, one should use subsurface drip irrigation and spilt the amount of fertilizer to 9 or 12 doses whish will not increase the farming coast but almost double the yield.

Keywords*: Surface drip, subsurface drip, fertigation management, water use efficiency, Squash varieties.*

Introduction

Egypt faces severe shortage in water and agricultural production. Use an irrigation technique that delivers small amounts of water at relatively short intervals with modern irrigation technique such as to drip and sprinkler irrigation systems. Drip irrigation was proven to be very efficient in the arid and semi-arid conditions of Egypt (Gameh 1978). Also using the laterals of drip irrigation lines on the surface or at deferent depths was tested in Assiut university since. 1975 - 1978 (Gameh 1978, Ragheb 1978, Abo-Alregal *et al.,* 2014).

As competition for water resources and the need for water conservation increases, adoption of drip fertigation system is a must in Egypt. The balanced application of NPK fertilizer rates play a great deal in vegetable production.

In modern agriculture, both fertilization and irrigation are important management factors for controlling yield quantity and quality (Bar-Yosef, 1999). The method of application of

fertilizer and irrigation water affects water and fertilizer use efficiency under arid and semi-arid conditions. Application of fertilizers with irrigation water has several advantages. Precisely application of fertilizer and water with suitable growth stages may increase the production (Gurusamy *et al*., 2011 and Kumar *et al*., 2011). Application of water at the time of actual need through drip irrigation to the effective root zone soil is the proper irrigation management system to save water. Crop yield response was very much dependent on the amount of water applied at different crop development stages than the overall seasonal water applied (Igbadun *et al*., 2006). Using this approach may increase crop yield. In arid and semi-arid environments, both efficient use of available water and fertilizer to produce higher yield with better quality of vegetables are in demand (Lovelli *et al.,* 2007 and Koutroubas *et al*., 2008). The objective of this work was to investigate the impact of surface and subsurface drip irrigation systems and number of fertigation doses on yield and water use efficiency of two squash varieties.

Material and Methods

A field experiment was conducted at the Experimental Farm Station of Soils and water Department, Faculty of Agricultural, Assiut University, situated at a latitude of 27^{o}, 11' N, a longitude of 31^{o} 10' E and 52 m above the sea level during the summer season of 2016 to study the impact of surface and subsurface drip irrigation and four fertigation splitting doses (3D = 3 doses, 6D = 6 doses, 9D = 9 doses and 12D = 12 doses) on the yield and water use efficiencies of two squash varieties (Eskendarany and Fadwa).

Sixteen treatments were used which included two irrigation systems and four fertigation splitting doses (3D = 3 doses, 6D = 6 doses, 9D = 9 doses and 12D = 12 doses). A randomized complete block design (RCBD) using a split split-plot arrangement with three replications was used in this experiment. The two squash varieties seeds (Eskendarany and Fadwa) were sown on the second of 15 March 2016. The physical and chemical properties of soil site are given in Table (1). Two seeds were planted in each whole at 0.3 meter between wholes and 0.7 meter between laterals.

Table 1. Some physical and chemical soil properties (0-30 and 30-60 cm)

Properties	0-30 cm	30-60 cm
Sand (%)	24.1	24.3
Silt (%)	62.4	62.5
Clay (%)	13.5	13.2
Texture	Si. L	Si. L
Field capacity (V%)	42.7	42.5
Witling point (V%)	21.1	20.1
$CaCO_3$ (%)	5.42	5.08
pH (1:2.5 suspension)	7.54	7.78
EC_e dS m^{-1}	0.99	0.95
Organic matter (g kg^{-1})	2.41	2.25
Total nitrogen (mg kg^{-1})	560	520
Available nitrogen (mg kg^{-1})	67.2	62.4
Available Olsen P (mg kg^{-1})	11.78	11.32
Available K (mg Kg^{-1})	256.1	477.4

The seedlings were thinned to secure one plant $hill^{-1}$. Drip irrigation system is set up of GR polyethylene pipe of 16 mm in diameter with auto emitters every 30 cm apart and 70 cm between the drip lines with flow rate of 4-liter $hour^{-1}$ $dripper^{-1}$ at pressure 1.5 bars. Experimental plot area was 7 m^2 (10 X 0.7 m). There was 1.20 m separation between each treatment and plot, respectively, in order to minimize water movement among different treatments. The irrigation treatments started directly after planting.

Nitrogen, phosphorus and potassium fertilizers were added according to the recommended doses. Nitrogen was added at rate of 122 kg N $fed.^{-1}$ as 365kg ammonium nitrate (33.5% N), phosphate rate of 31 kg P_2O_5 $fed.^{-1}$ as phosphoric acid and potassium at rate of 24 kg K_2O $fed.^{-1}$ as potassium sulfate 50 Kg (48% K_2O) were applied through fertigation. The amounts of fertilizers were divided into 3, 6, 9 and 12 equal doses.

The fertigation was started after 14 days from planting. These doses were given at 28, 14, 9 and 7 day intervals for 3, 6, 9 and 12 doses, respectively. The amounts of NPK fertilizers used per each dose are shown in Table (3). All cultural practices were followed as recommended for growing squash. None of the injected fertilizer exceed 1000 mg/l of irrigation water and the aced did not exceed 300 mg/l.

Table 2. The amounts of NPK fertilizers used per each dose

Fertigation treatments	Days intervals	Potassium Sulphate (kg fed^{-1})		Phosphoric acid (kg fed^{-1})		Ammonium nitrate (kg fed^{-1})	
		Total	Dose	Total	Dose	Total	Dose
3D	28	50	16.7	43	14.03	365	121.6
6D	14	50	8.3	43	7.2	365	60.8
9D	9	50	5.5	43	4.7	365	40.5
12D	7	50	4.2	43	3.6	365	30.4

Yield collection

Harvesting of squash fruits started after 50 days from planting and it was extended for 46 days as shown in the results. The number and weight of the fruits of each harvest were recorded. Three fresh plant samples were collected at age of 14, 42 and 70 days. Five guarded plants were collected randomly from each fertigation treatment to measure fresh and dry plant weight (g) and calculated per ton/fed.

Water use efficiency (kg/m^3)

$$WUE\ (kg\,m^{-3}) = \frac{\text{Fruits yield } (kg\ fed^{-1})}{\text{Total water applied } (m^3\ fed^{-1})}$$

Calculation of water consumptive use (CU)

Actual evapotranspiration was estimated by the sampling method and calculated according to the following formula:

C.U = {D x Bd x (Q_2-Q_1)/100}

Where:

C.U. = actual evapotranspiration (m).

D = soil depth (m).

Bd = bulk density of soil (Mg/m^3).

Q_2 = the percentage of soil moisture one day after irrigation (field capacity)

Q_1 = the percentage of soil moisture before next irrigation.

Soil water content was monitored before and after each irrigation event starting 14 days after sowing at soil depth intervals of 0–30 and 30–60 cm. Soil samples were taken at positions immediately under the drippers by soil auger. The samples were weighted and then oven dried. Percentage of soil moisture content at the tow depths was calculated on oven dry basis at 105 ^{o}C. The amount of water consumed in each irrigation treatment was obtained from the difference between soil moisture content before the following irrigation and one day after irrigation (field capacity).

Soil analysis

Composite soil samples were collected before cultivation from the top 0–30 and 30–60 cm. Air-dried, crushed, and sieved to pass through a 2-mm. Selected physical and chemical properties of the soil were determined according to Burt (2004). The soil pH was measured in 1:2.5 soil to water suspension using a digital pH meter. The electrical conductivity (EC) was estimated using the salt bridge method (Rhoades, 1982). Available soil nitrogen was extracted by 2 M potassium chloride, and then nitrogen in the extract was determined using micro-kjeldahl method Burt (2004). Available soil phosphorus was extracted by 0.5 M sodium bicarbonate solution at pH 8.5 according to Olsen *et al.* (1954) and phosphorus was determined by spectrophotometer. Available potassium was extracted by ammonium acetate method and was measured by flame photometry (Jackson, 1973).

Statistical analysis:

The results were statistically analyzed according to Gomez and Gomez (1984), using the computer MSTAT.C statistical analysis package by Freed *et al.* (1989). The least significant differences (L.S.D) at probability level of 5% was manually calculated to compare the differences among means.

Results & Discussion

A- Squash varieties

Table (3) shows a significant difference between both Squash varieties (FADWA (FAD) and ESKANDRANY (ESK)) in all studied traits. FADWA variety surpassed ESKANDRANY in all studied traits**.** FAD variety produced 121 fruits/pot (120708 fruits/fed) while ESK produced only 70 fruits/plot (70292 fruits/fed**).** This results are excepted since ESK usually infected with *Powdery Mildew* while FADWA HYBID is resistance to Powdery Mildew and its vegetative growth is better than ESK (Gubler *et al*.,1992). The flowering of FAD started earliest than ESK (Fig.1), and the cumulated number of FAD fruits/plot is higher than ESK. The average fruit weight did not affect with the variety, however FAD fruits was of higher weight than ESK fruits (0.128 kg/fruit FADWA and 0.114 kg/fruit ESK).

The results in Table (3) showed that the fresh weight of FAD squash plants were significantly higher than that of ESK variety. FAD plants fresh weight was 49.29 tons/fed, while ESK produced only 40.64 tons/fed. The dry weight of FAD plants was 7.58 tons/fed, while ESK produced only 6.25 tons/fed).

Water use efficiency (WUE) data presented in (Table 3) FADWA variety was very efficient for water utilization since one cubic meter of water produced 5.244 kg/m^3, while ESKANDRANY variety produced only 2.803 kg/m^3.

B- Drip irrigation system

Subsurface drip irrigation (SSD) produced higher values of all studied traits than surface drip irrigation (SD). Similar results were obtained by Abou Al-Rejal *et al* (2014), Fathia El-Mokh *et al* (2014) and Khalid *et al* (2016).

The results in Table (3) showed that the number of fruits of subsurface drip irrigation (SSD) was significantly higher than that of surface drip irrigation (SD). Subsurface drip irrigation (SSD) gave 167 fruits/plot (116875 fruits/plot), while surface drip irrigation (SD) produced only 74 fruits/plot (74125 fruits/plot). The cumulated number of fruits/plot of subsurface drip irrigation (SSD) is higher than surface drip irrigation (SD) and the flowering of FADWA started earlier than ESKANDRANY (Fig. 2).

Data in Table (3) show highly significantly fruits yield of subsurface drip irrigation (SSD) than surface drip irrigation (SD). The highest plot yield was 15.75 kg/pot (15.75 tons/fed) of subsurface drip irrigation (SSD) while, it was 7.83 kg/pot (7.82 tons/fed) only from surface drip irrigation (SD). The average fruit weight did not affect with the drip irrigation system, however subsurface drip irrigation (SSD) produced higher fruit weight (0.14 kg/Fruit) than surface drip irrigation (SD) 0.11 kg/Fruit.

Table 3. Effect of irrigation system and fertigation managements on biological yield and water use efficiency of Fadwa and Eskandrany squash varieties

Treatments			Biological yield		Fruits yield					WUE kg/m^3
Varieties	Irrigation	Doses	Fresh t/fed	Dry t/fed	No. /plot	Wt. Kg/plot	Average Wt. /Kg	No. /fed	Wt. t/fed	
FAD			49.29	7.58	121	15.36	0.128	120708	15.36	5.244
ESK			40.64	6.25	70	8.21	0.114	70292	8.20	2.803
F			**	**	*	**	n.s	*	**	**
	SD		37.02	5.70	74	7.83	0.104	74125	7.82	2.672
	SSD		52.92	8.14	167	15.75	0.138	116875	15.75	5.375
F			**	*	***	***	***	***	***	**
FAD	**SD**		39.92	6.14	94	10.15	0.111	94167	10.15	3.466
	SSD		58.66	9.03	147	20.57	0.145	147250	20.58	7.022
ESK	**SD**		34.11	5.25	54	5.50	0.97	54083	5.49	1.878
	SSD		47.17	7.26	87	10.93	0.131	86500	10.92	3.728
LSD (IxD) 5%			2.50	0.38	n.s	7.14.	n.s	n.s	0.72	0.25
		3D	32.93	5.07	53	7.06	0.125	52750	7.04	2.412
		6D	38.71	5.96	79	9.55	0.119	78833	9.55	3.261
		9D	46.43	7.14	110	13.67	0.121	110167	13.68	4.667
		12D	61.78	9.51	140	16.86	0.119	140250	16.87	5.756
LSD (D) 5%			6.02	0.93	10	4.87	n.s	9741	0.48	1.67
FAD		**3D**	36.51	5.62	66	9.90	0.145	66167	9.88	3.378
		6D	40.32	6.20	114	13.97	0.121	113667	13.97	4.768
		9D	51.00	7.85	142	18.30	0.128	142167	18.30	6.245
		12D	69.33	10.67	161	19.29	0.119	160833	19.30	6.585
ESK		**3D**	29.36	4.52	39	4.23	0.106	39333	4.20	1.445
		6D	37.11	5.71	44	5.14	0.117	44000	5.13	1.753
		9D	41.86	6.44	78	9.05	0.113	78167	9.05	3.088
		12D	54.23	8.34	120	14.44	0.120	119667	14.43	4.927
LSD (VxD) 5%			n.s	n.s	14	6.88	n.s	13776	0.68	n.s
	SD	**3D**	25.57	3.93	33	3.18	0.101	33333	3.15	1.085
		6D	33.64	5.18	67	6.33	0.94	67167	6.33	2.163
		9D	44.66	6.87	91	9.97	0.108	91167	9.97	3.403
		12D	44.20	6.80	105	11.83	0.113	104833	11.83	4.037
	SSD	**3D**	40.30	6.20	72	10.95	0.149	72167	10.93	3.738
		6D	43.79	6.74	91	12.77	0.144	90500	12.77	4.358
		9D	48.21	7.42	129	17.37	0.134	129167	17.38	5.930
		12D	79.37	12.21	176	21.90	0.125	175667	21.90	7.475
LSD (I x D) 5%			8.51	1.31	14	6.88	n.s	13776	0.68	0.24

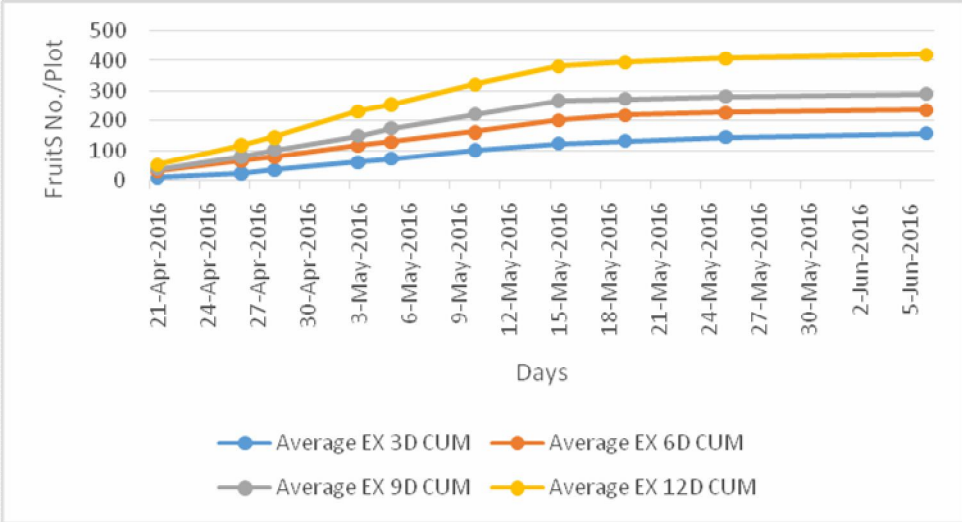

Fig.1: Cumulative effect of 4 Fertigation treatment on number of fruits doses the harvests

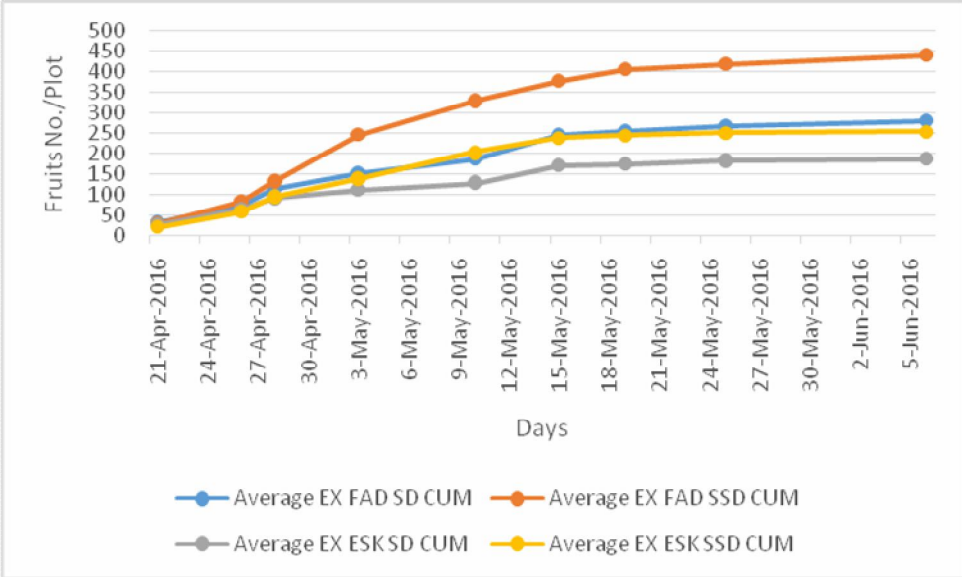

Fig. 2: Cumulative effect of surface drip irrigation (SD) and subsurface drip irrigation (SSD) only number of fruits of FADWA variety and ESKANDRANY variety

The results in Table (3) showed that the fresh weight of plants in subsurface drip irrigation (SSD) was significantly higher than that in surface drip irrigation (SD).

Subsurface drip irrigation (SSD) produced 52.92 tons/fed, while surface drip irrigation (SD) produced only 37.02 tons/fed. The capability of subsurface drip irrigation to improve growth and yield could be attributed to less water lost from subsurface drip compared with surface irrigation (Khalid *et al.,* 2016).

Applying water through the subsurface drip system was better than applying the water on the surface soil. The WUE reached 5.375 kg/m^3 with SSD. However, it was only 2.672 kg/m^3 with SD. Previous researchers show that crop marketable yield and quality and water use

efficiency have been improved through the use subsurface drip irrigation (SSD) Ayars *et al.,* 2001; Al-Omran *et al*., 2005; Hassanli *et al*., 2009). Abou Al-Rejal *et al* (2014) found that using SSD of potato gave the highest values of quantity and quality yield and water use efficiency as compared to surface drip irrigation.

C- Fertigation Management

It is Number of fruits very evident from the result that dividing the same amount of fertilizer to higher number of doses produced higher yield without increasing the farm coast. The fruit number produced from applying 3, 6, 9 and 12 doses were 53, 79, 110, and 140 fruits/plot (52750, 78833, 110167 and 140250 fruits/fed), respectively. Figure-1 shows the advantage of the higher number of doses in producing higher number of fruits during the harvesting periods**.**

Fruits yield of squash increased steadily with increasing number of fertigation doses (Table 3). The yield increased from 7.063 kg/plot when applying 3 doses to 9.55, 13.67 and 16.86 kg/plot when applying 6, 9 and 12 doses (7.04, to 9.55, 13.68 and 16.87 tons/fed), respectively. These increases were highly significant. Average fruit weight did not affect with dividing the doses since the fruits was harvested regularly, while arranging the average produced 3,6,9 and 12 doses was 0.125, 0.119, 0.121 and 0.119 kg/fruit.

Fresh weight of plants was increased with dividing the same amount of fertilizer to higher number of doses without increasing the farm coast. The Fresh weight of plants were 32.93, 38.71, 46.43 and 61.78 tons/fed by applying 3, 6, 9 and 12 doses, respectively. But, the dry weight of plants increased from 5.07 ton/fed when applying 3 doses to 5.96, 7.14 and 9.51 tons/fed, respectively, when applying 6, 9 and 12 doses, respectively. These increases were highly significant.

Increasing splitting the same amount of fertilizer from 3 doses to 6, 9 and 12 doses increased WUE from 2.412 kg/m^3 to 3.261, 4.667, 5.756 kg/m^3, respectively. Many authors (Nimje, 1991; Das and Ghosh,1993; Murat and Yildirim, 2004 and Abdel-Motagally *et al*., 2015) reported that increasing fertigation doses significantly affected yield, yield components and water use efficiency on some crops.

D- The effect of interactions between the three factors

1-Interaction effect of varieties and drip irrigation

The interaction of varieties and drip irrigation significantly increased the biological and fruits yield and water use efficiency (Tables 3). The same results reported by Thompson and Doerge,(1996), they found that the subsurface drip irrigation improved growth, yield and water use efficiency. Subsurface drip irrigation produced the higher number of fruits of FADWA variety, followed surface drip of the same variety. Subsurface drip irrigation of ESKANDRANY comes next and followed by surface drip. That may be because the flowering of FADWA variety was better than ESKANDRANY variety.

However, the yield of FADWA variety under SSD produced the highest fruits yield (20.58 tons/fed)

flowed by ESKANDRANY variety under SSD (10.92 tons/fed). The yield of FADWA variety under SD was next to yield of ESKANDRANY SSD (10.15 tons/fed). The lowest yield was produced from ESKANDRANY variety under SD which was (5.49 tons/fed). Average fruit weight did not affect with dividing the doses since the fruits was harvested regularly.

Data in Table (3), show that the subsurface drip irrigation produced the higher fresh weight of plants of FADWA variety followed surface drip of the same variety. Subsurface drip irrigation of ESKANDRANY comes next and followed by surface drip. That may be due to the factor growth of FADWA variety plants than ESKANDRANY variety.

The dry weight of FADWA plants was 9.03 tons/fed SSD system, but it was 6.14 ton/fed under SD system. However, the dry weight of ESKANDRANY plants was 7.26 ton/fed under SSD system and 5.25 ton/fed under SD system.

Applying water through the subsurface drip system to FADWA variety was better than applying the water on the surface soil. The WUE reached (7.022 kg/m^3) with SSD of FADWA variety, flowed by ESKANDRANY variety under SSD (3.728 kg/m^3), flowed by FADWA variety under SD (3.3.466 kg/m^3), flowed by ESKANDRANY variety under SD (1.878 kg/m^3).

2-Interaction effect of varieties and fertiagation doses

The interaction of varieties and fertiagation doses had a significant influence on some traits. The data in Table (3) showed the advantage of dividing the fertilizer into 12 and 9 doses with both varieties, on the number of fruits and yield. Arranging the number of fruits and yield will be:

FAD+12D>FAD+9D>ESK+12 D=FAD+6D>ESK+9D=FAD+3D>E SK+6D=ESK+3D, which produced 161, 142, 120, 114, 78, 66, 44 and 39 fruits/plot and 19.29, 18.30, 14.43, 13.97, 9.88, 9.05, 5.13 and 4.20 kg/plots, respectively. The average fruit weight did not affect with dividing the doses since the fruits was harvested regularly.

The data in Table (3) showed the advantage of dividing the fertilizer into 12 and 9 doses with both varieties, on the Fresh weight and of plants. The highest values of fresh and dry plants weight were recorded with treatment FAD+12D (69.33 and 10.67 ton/fed), while, the lowest values were recorded with treatment ESK+3D (29.36 and 4.52 ton/fed).

The interaction of varieties and fertigation doses had not significant affect on water use efficiency. Treatment FAD+12D gave the highest value (6.585 kg/m^3) of WUE and treatment ESK+3D gave the lowest value gave (1.445 kg/m^3). Therefor it is recommended to grow FADWA variety with splitting the fertilizer to 9 or 12 doses.

3-Interaction effect of drip irrigation and fertigation doses:

The interaction of irrigation system and fretigation doses had a significant effect on all studied traits except the average weight of fruit (Table 3). Subsurface drip irrigation (SSD) with 12 doses or 9 doses produced the highest number of fruits and yield, also the differences between 12D and 9D were not signifi-

cant. The number of fruits of surface drip irrigation (SD) with 12 doses comes next followed by 9 doses of surface (SD) which equals 6 doses subsurface (6D+SSD). While arranging the number of fruits produced by the eight interactions was as it follows:

SSD+12D>SSD+9D>SD+12D> SD+9D=SSD+6D>SSD+3D>SD+6D >SD+3D, which produced 176, 129, 105, 91, 91, 72, 67 and 33 fruits/plot, in the same order.

While arranging the yield produced by the eight interactions was as it follows:

SSD+12D>SSD+9D>SSD+6D> SD+12D>SSD+3D>SD+9D>SD+6D >SD+3D, which produced 21.90, 17.38, 12.77, 11.83, 10.93, 9.97, 6.33 and 3.15 kg/plot, respectively

It clear that the worst number of fruits or yield were produced from the interactions of surface drip (SD) with 3 or 6 fertigation doses.

Subsurface drip irrigation (SSD) with 12 doses or 9 doses produced the highest fresh and dry weight of plants, also the differences between 12D and 9D were not significant. Treatment SSD+12D produced the highest fresh weight of five plants of surface drip irrigation (SD) with 9 doses comes next followed by 12 doses of surface (SD) which equals 6 doses subsurface (6D+SSD). While arranging the Fresh weight of plants produced by the eight interactions was as it follows:

SSD+12D>SSD+9D>SD+9D>S D+12D>SSD+6D>SSD+3D>SD+6D >SD+3D, which produced 79.37, 48.21, 44.66, 44.20, 43.79, 40.30, 33.64, 25.57. ton/fed, in the same order. Dry weight of plants produced by the eight interactions was high with applying SSD,12 or 9 doses the order was as it follows:

SSD+12D>SSD+9D>SD+9D>S D+12D>SSD+6D>SSD+3D>SD+6D >SD+3D, which produced 12.21, 7.42, 6.87, 6.80, 6.74, 6.20, 5.18 and 3.93 tons/fed, in the same order.

Water use efficiency (WUE) was effected by the interaction between fertigation doses and drip irrigation system. Highest value of WUE recorded by treatment SSD+ 12D (7.475 kg/m^3) but lowest value recorded by treatment SD+3D (1.085 kg/m^3)

Data in Tables (2&3) that the worst Fresh weight or Dry weight of plants or water use efficiency were produced from the interactions of surface drip (SD) with 3 or 6 fertigation doses, while the best WUE were in FADWA of SSD and 12, 9 and 6 doses.

4-The triple interactions of varieties, irrigation system and Fertigation doses:

The results of the triple interaction of the three factors were presented in Table (4) and fig. (3 and 4). It had a significant influence on number and weight of fruits yield and water use efficiency but, not a significant influence on biological yield.

The highest number of fruits from the three interactions were produced from:

FAD+SSD+12D>FAD+SSD+9 D>ESK+SSD+12D>FAD+SSD+6D> FAD+SD+9D, which produced 209, 159, 142, 129 and 126 fruits/plot, in the same order.

While, the worst number of fruits from the interactions were produced from:

ESK+SD+3D<ESK+SD+6D<FAD+SD+3D<ESK+SSD+3D=ESK+SSD+6D, which produced 27, 36, 40, 52 and 52 fruits/plot, in the same order.

It is clear that ESKANDRANY variety should not recommended for producing squash, since it produced the lowest number of fruits and yield with surface drip with 3 Fertigation doses.

Arranging the yield produced by the interacted factor was as it follow:

FAD+SSD+12D>FAD+SSD+9D>FAD+SSD+6D>ESK+SSD+12D>FAD+SSD+3D, which produced 25.87, 22.40, 18.37, 17.93 and 15.67 tons/fed, respectively. Therefore, FADWA variety is very recommended to be cultivated with subsurface drip irrigation (SSD) with splitting the fertilizer into 12 or 9 doses at least. While, ESKANDRANY may be cultivates under (SSD) with 12 doses only if it is the only available variety.

On the other hand, the lowest yield of squash was produced from the following interactions:

ESK+SD+3D<ESK+SD+6D<FAD+SD+3D<ESK+SD+9D<ESK+SSD+3D, which produced 2.20, 3.10, 4.10, 5.73 and 6.20 Tons/fed, respectively. These amounts of yield do not cover the coast invented. Average fruit weight did not affect with dividing the doses since the fruits were harvested regularly.

The results of the interaction of the three factors were presented in Table (4). The highest values of fresh weight from the interactions were arranged in descending order:

FAD+SSD+12D>ESK+SSD+12D>FAD+SSD+9D>FAD+SD+12D>FAD+SD+9D, which produced 91.00, 67.73, 54.77, 47.67and 47.23 ton/fed, respectively. While, the worst values of fresh weight from the interactions were in the following ascending order:

ESK+SD+3D<FAD+SD+3D<ESK+SD+6D<FAD+SD+6D<ESK+SSD+3D, which produced 21.02, 30.12, 32.61, 34.67 and 37.70 ton/fed, respectively.

It is clear that ESKANDRANY variety and FADWA variety is not recommended for producing squash, since it produced the lowest fresh weight of plants and dry weight of plants with surface drip with 3 and 6 fertigation doses.

Highest dry weight of plants produced by the interacted factor were it following in descending order:

FAD+SSD+12D>ESK+SSD+12D>FAD+SSD+9D>FAD+SD+12D>FAD+SD+9D, which produced 14, 10.42, 8.43, 7.33 and 7.27 tons/fed, respectively. Therefore, FADWA variety is very recommended to be cultivated with subsurface drip irrigation (SSD) with splitting the fertilizer into 12 or 9 doses at least. While ESKANDRANY may be cultivates under (SSD) with 12 doses only if it is the only available variety.

On the other hand, the lowest dry weight of plants was produced from the following interactions in ascending order:

ESK+SD+3D<FAD+SD+3D<ESK+SD+6D<FAD+SD+6D<ESK+SSD+3D, which produced 3.23, 4.63, 5.02, 5.33 and 5.80 tons/fed, respectively. These amounts of yield do not cover the coast invented.

Table 4. Interaction of irrigation and fertigation managements on biological and fruits yield and water use efficiency of Fadwa and Eskandrany squash varieties

Treatments			Biological yield		Fruits yield					WUE kg/m^3
Varieties	Irrigation	Doses	Fresh t/fed	Dry t/fed	No. /plot	Wt. Kg/plot	Average Wt. /Kg	No. /fed	Wt. t/fed	
FAD	SD	3D	30.12	4.63	40	4.11	0.12	40000	4.10	1.403
		6D	34.67	5.33	98	9.58	0.99	98333	9.57	3.270
		9D	47.23	7.27	126	14.20	0.11	125667	14.20	4.847
		12D	47.67	7.33	113	12.73	0.11	112667	12.73	4.343
	SSD	3D	42.90	6.60	92	15.68	0.17	92333	15.67	5.353
		6D	45.98	7.07	129	18.36	0.14	129000	18.37	6.267
		9D	54.77	8.43	159	22.39	0.14	158667	22.40	7.643
		12D	91.00	14.00	209	25.86	0.12	209000	25.87	8.827
ESK	SD	3D	21.02	3.23	27	2.24	0.84	26667	2.20	0.767
		6D	32.61	5.02	36	3.10	0.89	36000	3.10	1.057
		9D	42.08	6.47	57	5.74	0.11	56667	5.73	1.960
		12D	40.73	6.27	97	10.93	0.11	97000	10.93	3.730
	SSD	3D	37.70	5.80	52	6.22	0.13	52000	6.20	2.123
		6D	41.60	6.40	52	7.18	0.15	52000	7.17	2.450
		9D	41.64	6.41	100	12.36	0.13	99667	12.37	4.217
		12D	67.73	10.42	142	17.94.	0.13	142333	17.93	6.123
LSD (VxIxD) 5%			n.s	n.s	19.5	9.74	n.s	19482	0.96	0.33

Water use efficiency (WUE) produced by the three interacted factor were arranged as it following in descending order:

FAD+SSD+12D>FAD+SSD+9D>FAD+SSD+6D>ESK+SSD+12D>FAD+SSD+3D, which produced 8.827, 7.643, 6.267, 6.123 and 5.353 kg/m^3, respectively. Therefore, FADWA variety is recommended to be cultivated with subsurface drip irrigation (SSD) with splitting the fertilizer into 12 or 9 or 6 or 3 doses at least. While ESKANDRANY may be cultivates under (SSD) with 12 doses only if it is the only available variety.

On the other hand, the lowest WUE was produced from the following interactions in ascending order:

ESK+SD+3D<ESK+SD+6D<FAD+SD+3D<ESK+SD+9D<ESK+SSD+3D, which produced 0.767, 1.057, 1.403, 1.960 and 2.12 3kg/m^3, respectively. These amounts of yield do not cover the coast invented.

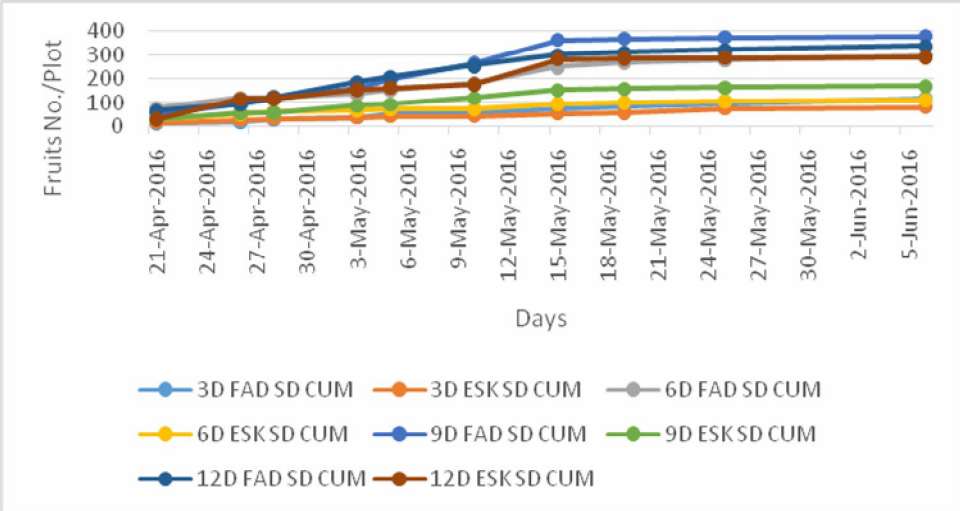

Fig. 3: Cumulative effect of 4 Fertigation treatment on number of fruits of FADWA variety (FAD) and ESKANDRANY variety under surface drip irrigation (SD).

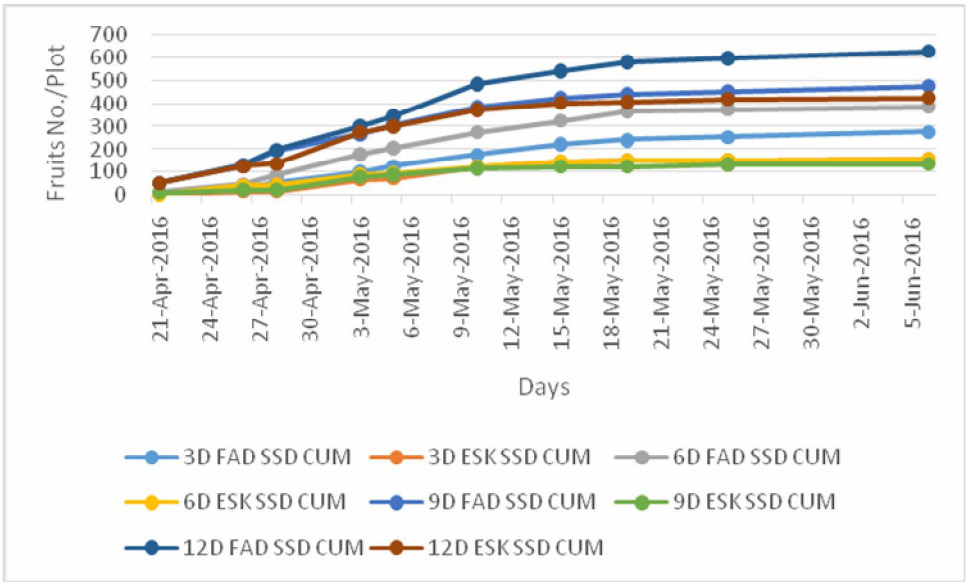

Fig.4: Cumulative effect of 4 Fertigation treatment on number of fruits of FADWA variety (FAD) and ESKANDRANY variety under subsurface drip irrigation (SSD).

Conclusion

The current study showed that Fadwa variety surpassed Eskendarany in biological yield, fruits and water use efficiency of Squash crop. The Subsurface drip irrigation (SSD) surpassed the surface drip irrigation (SD) in biological yield, fruits and water use efficiency of Squash crop. Treatment 12 dose gives the maximum biological yield, fruits and water use efficiency of Squash crop.

The SSD irrigation method with 12 Fertigation dose is recommended for Squash production under arid environment.

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تأثير استخدام نظامى الرى بالتنقيط السطحى والتحت سطحي وادارة التسميد مع ماء الري علي المحصول وكفاءة استخدام الماء لصنفين من الكوسة

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الملخص

فى هذا البحث تم زراعة صنفين من الكوسة تحت نظامى الري بالتنقيط السطحي والــري بالتنقيط تحت السطحي في المزرعة التجريبية لقسم الاراضى والمياه بكليــة الزراعــة، جامعــة أسيوط خلال الموسم الصيفي لعام ٢٠١٦ لدراسة تأثير نظم الري بــالتنقيط الــسطحي والــري بالتنقيط تحت السطحي وعدد جرعات التسميد على المحصول وكفاءة استخدام الميــاه بواســطة صنفي الكوسة الاسكندراني والهجين فدوى. وكان تصميم التجربة بنظام القطع المنشقة مع ثلاثة مكررات. وأظهرت النتائج أن أعلى متوسط محصول ثمار الكوسة واعلي كفاءة استخدام الميــاه سجلت من الري تحت السطحي بالتنقيط. ادي استخدام نفس كمية المياه مقارنة فى الري بالتنقيط تحت السطحي الى تضاعف العائد مقارنة مع الري بالتنقيط السطحي. وادي تقسيم كمية الــسماد من ٣ إلى ١٢ جرعة الى الحصول علي اكبر محصول. وادت زيادة تقسيم جرعات السماد مــن ٣ الى ٦، ٩، ١٢ جرعة الى مضاعفة محصول ثمار الكوسة إلى اكثر من الضعف.

وظهر ان إنتاج هجين الكوسة فدوى تفوق على صنف الاسكندرانى. وسجلت أعلى القــيم كفاءة استخدام المياه من الري تحت السطحي بالتنقيط مع تقسيم نفس كمية السماد إلى ١٢ جرعة في كلا الصنفن .

ويوصى البحث انه للحصول على اعلى مردود اقتصادي وزيادة كفاءة اســتخدام الميــاه، يجب استخدام الري بالتنقيط تحت السطحي وتقسيم كمية من الأسمدة إلى ٩ او ١٢ جرعة حيــث يؤدى ذلك الى زيادة المحصول الى ما يقرب من الضعف.