Egyptian J. Desert Res., 56, No.2, 333-346 (2006)

DETERMINATION OF OPTIMUM WATER REQUIREMENTS FOR TOMATOES AND SQUASH UNDER ARID CONDITIONS AT EL-MAGHARA REGION, EGYPT.

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This work is an attempt to clarify the effect of irrigation timing, dripper discharge and their interaction in improving water use efficiency and water economy of tomatoes and squash vegetables under arid conditions of El-Maghara, North Sinai Governorate, Egypt.

The study was conducted in strip split design with three replicates. The treatments include: two irrigation times (quarter and half hour daily) and two GR drippers with discharge of 4 and 8 liter/hour.

It is suggested to irrigate tomatoes and squash vegetables with half daily hour irrigation timing by GR dripper with 4 liter/hour discharges. These management gave the best water use efficiency (9.12 and 1.62 kg/m^3), water economy (7.37 and 1.47 kg/m^3), investment ratio (1.44 and 1.16 LE/ILE) and raised Beneficiary factor (Bf) by about 77 and 89 % for both tomatoes and squash vegetables, respectively at the same conditions should be carefully evaluated to the studied area. Meanwhile, there are some profitable treatment in the experiment could be adopted with lower gain.

Keywords: irrigation timing, dripper discharge, tomatoes, squash, water use efficiency, water economy, crop coefficient, environmental stress coefficient.

Suitable water for irrigation is a scarce commodity nowadays as it represents ≈ 1 % of the global amount of water as a whole. So, the modernization of irrigation systems had been urgent especially in the new cultivated lands, which have problems in providing water for durable use in agriculture. Under these conditions there are two important directions; one is the macro-techniques of modern cultivation like nursery and greenhouses for establishing either fully or semi-atomized systems. The second is the microtechniques in operating these systems with highest level of efficiencies as to get at least two goals; conservation of the limited source of water and getting the highest beneficial use of water in producing different crops by means of enhancing the water-use efficiency. In this direction this work has been designed as to predict the micro-irrigation technique under greenhouses conditions as to achieve the former goals under El-Maghara experiment station, middle of Sinai on tomato and squash crops.

El-Gindy *et al.* (1991) found that the seasonal consumptive use of water by squash were 267.0, 242.4 and 226.0 mm under a soil moisture tension of 0.35, 0.45 and 0.55 bar, respectively. The previous studies on these crops show that crop coefficient (kc) values of tomato were 0.64, 1.03, 1.48 and 0.73 during vegetative, flowering, fruit set and fruit development stages, respectively (Andre and Churata, 1992).

Several investigators conclude that water use efficiency and water economy increased with decreasing the amount of irrigation water, increasing irrigation intervals and by adding organic matter (Doorenbos and Pruitt, 1984; Doorenbos and Kassam, 1986; Allen *et al.*, 1998). Environmental stress (Ks), which resulted from soil water shortage, low soil fertility, or soil salinity, can cause some types of plants to accelerate their reproductive cycle. Local research and observation is critical to identify the magnitudes and extent of these adjustments (Rana *et al.*, 1996 ; Allen *et al.*, 1998).

This work is an attempt to clarify the effect of irrigation timing, dripper discharge and their interaction to improve water use efficiency and water economy of tomatoes and squash vegetables.

MATERIALS AND METHODS

The current work was carried out inside semi-closed (2 months close and 2 months open) green house in the Agricultural Experimental Station of the Desert Research Center at EL–Maghara region, about 90 km south of El-Arish city, north Sinai Governorate during season 2004.

The meteorological station is located inside the experimental field site whose altitude is about 200 meter above sea level, at latitude 30°35` N and longitude 33°20` E. Meteorological data for the 5 years (1999-2003) (Table,1a) were collected to compute potential evapotranspiration (ETo) rates by Penman–Monteith equation using CROPWAT, software version 5.7 (Smith, 1992) .

TABLE (1a). Meteorological data of EL–Maghara region during 5 years (1999-2003).

Elements / Month	Max. temp. (°C)	Min. temp. (°C)	Avg. air temp. (°C)	Relative humidity (%)	Wind speed (km/hr)	Sunshine hours (n)	Total rain (mm)	Solar radiation (w/m²)	ETo (mm/day)
Jan.	21.85	7.28	14.56	83.29	8.37	7.70	6.57	0.12	2.23
Feb.	22.25	7.42	14.83	81.50	7.77	8.20	6.97	0.16	2.61
Mar.	25.78	8.59	17.19	79.55	8.18	8.30	3.62	0.21	3.65
Apr.	30.32	10.11	20.21	72.69	8.99	9.60	0.81	0.24	5.29
May	33.70	11.23	22.47	75.33	8.41	10.90	0.52	0.26	6.24
June	37.82	12.61	25.22	77.99	7.57	12.60	0.00	0.30	7.16
July	40.80	13.60	27.20	77.80	6.27	12.40	0.00	0.28	7.23
Aug.	42.39	14.13	28.26	77.84	6.31	11.40	0.00	0.28	6.97
Sep.	40.02	13.34	26.68	78.02	5.75	10.60	0.00	0.27	5.78
Oct.	35.50	11.83	23.67	78.53	7.04	9.30	4.09	0.22	4.55
Nov.	33.13	11.04	22.09	76.39	7.22	7.80	8.43	0.16	3.50
Dec.	29.03	9.68	19.35	77.02	6.66	7.00	13.53	0.14	2.64
Annual	32.72	10.91	21.81	78.00	7.38	9.65	44.55	0.22	4.82

ETo = potential evapotranspiration w/m² = watt/m²

TABLE (1b). Meteorological data of EL–Maghara region during the growing period in 2004 season.

Elements	Max. temp. (°C)	Min. temp. (°C)	Avg. air temp. (°C)	Relative humidity (%)	Wind speed (km/hr)	Sunshine hours (n)	Total rain (mm)	Solar radiation (w/m²)	ETo (mm/day)
Jan.	22.11	7.40	14.76	83.25	8.34	7.80	6.63	0.13	2.26
Feb.	22.40	7.61	15.01	80.27	7.79	8.23	6.85	0.15	2.66
Mar.	25.69	8.64	17.17	79.68	8.16	8.50	3.75	0.22	3.66
Apr.	30.85	11.12	20.99	73.12	8.93	9.70	1.12	0.23	5.31
May	33.14	12.15	22.65	76.13	8.89	11.13	0.55	0.25	6.23
June	37.91	12.66	25.29	78.00	7.57	12.50	0.00	0.28	7.16
July	40.69	13.72	27.21	77.64	6.36	12.38	0.00	0.27	7.24
Aug.	42.84	15.12	28.98	78.25	6.38	11.20	0.00	0.26	6.97

ETo = potential evapotranspiration w/m² = watt/m²

The physical and chemical characteristics of the studied soil site are recorded in tables (2a and b). The relevant physical and chemical properties of the soil of the experimental site were determined according to Richards (1954). The soils are non-saline and non-alkali. Soil texture is sandy having (5.29 to 5.40 %) w/w available moisture.

The study was conducted in strip split design in which three replicates for each treatment were used. The experiments include two green houses, the area of which is equal 330 m^2 (55 x 6 m) each. The treatments include: two irrigation times, quarter and half hour daily by drip irrigation system with GR dripper with discharge of 4 and 8 liter/hour.

TABLE (2a). Some physical properties of the soils selected for experimental work.

Soil depth (cm)	Particle size distribution %				Texture class	Particle density (g /cm^3)	Bulk density (g/cm^3)	Porosity (%)	Organic matter (%)	Moisture content (%)		Available soil water (%)	Infiltration rate	
	Coarse sand	Fine sand	Silt	Clay						Field capacity	Wilting point		cm/hr	Class
0-30	0.36	93.21	3.87	2.56	Sand	2.64	1.56	40.91	0.33	9.93	4.56	5.37	33.67	Very Rapid
30-60	0.82	92 67	3.64	2.87	Sand	2.65	1.59	40.00	0.37	9.87	4.48	5.39		
60-90	0.89	92.11	3.71	3.29	Sand	2.63	1.58	39.92	0.34	10.11	4.71	5.40		
90-120	0.45	93.55	2.89	3.11	Sand	2.64	1.55	41.29	0.39	9.91	4.62	5.29		
120-150	1.35	92 77	2.93	2.95	Sand	2.61	1.57	39.85	0.32	10.05	4.68	5.37		

TABLE (2b). Some chemical and physico-chemical properties of the soils selected for experimental work.

Soil depth (cm)	CaO_3 (%)	pH soil paste	E.C (dsm^{-1})	Soluble cations (me/l)				Soluble anions (me/l)			
				Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	$SO_4^=$	Cl^-
0-30	3.41	7.35	2.40	6.70	3.50	13.50	0.31	0	1.20	7.01	15.80
30-60	3 75	7.44	2.41	6.54	3.45	13.81	0.29	0	1.87	7.47	14.75
60-90	3.82	7.51	2.40	6.61	3.41	13.67	0.34	0	1.95	7.12	14.96
90-120	3.58	7.68	2.38	6.50	3.34	13.75	0.25	0	1.34	7.27	15.23
120-150	3.66	7.73	2.36	6.48	3.48	13.37	0.27	0	1.65	6.58	15.37

Seeds of tomatoes and squash were sown in lines on January 15th and April 15th, 2004. The distance between the lateral tubes were one meter, drippers and plants were half meter each other. All plants received the recommended doses of organic (chicken manure 20 m^3/fed) fertilizers, once in each season. Mineral fertilizations were applied as NPK of (100 kg N/fed & 50 kg P_2O_5/fed & 120 kg K_2O/fed) and (50 kg N/fed & 50 kg P_2O_5/fed & 120 kg K_2O/fed) for tomatoes and squash respectively, as fertilizers every two irrigation times.

At the end of growth seasons, both crops were harvested on May 25th and August 23rd 2004 for tomatoes and squash, respectively.

The chemical analysis of irrigation water (Table, 3) was carried out using the standard method. The analysis, revealed that the water is highly saline with medium sodium contents, i.e., C_4 S_2 water (Richards, 1954). The amount of applied irrigation water is shown in table (4).

To determine the actual water consumption soil moisture tension was measured by tensiometer, while moisture content was determined by weighing method and hence the actual evapotranspiration was calculated by the following equation according to Doorenbos and Pruitt (1984):

$$ETa = (M_{.2}\,\% - M_{.1}\,\%) \times d_b \times D \times 1000$$

Where :

ETa = actual evapotranspiration (mm).

$M_{.2}$ = Moisture content after irrigation (%).

$M_{.1}$ = Moisture content before irrigation (%).

d_b = Bulk density of soil (g / cm^3).

D = Active root depth (0.5 m).

TABLE (3). Chemical analysis of the irrigation water of El-Maghara research station.

Season	pH	E.C.		S.A.R	T.D.S (ppm)	Units	Soluble cations				Soluble anions				Class
		ppm.	mmhos/cm				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	
Winter	7.7	2961.44	4.63	6.49	2859.86	ppm.	142.7	232.8	541.2	9.38	12.9	203.2	682.5	1137	$C_4 S_2$
						epm.	7.12	19.15	23.53	0.24	0.43	3.33	14.21	32.06	
						%	14.23	38.27	47.02	0.48	0.86	6.66	28.40	64.08	
Summer	7.5	3195.65	4.99	5.65	2803.97	ppm.	266.3	155.7	469.4	85.6	10.5	783.4	629.7	795.0	$C_5 S_2$
						epm.	13.29	12.81	20.41	2.19	0.35	12.84	13.11	22.42	
						%	27.29	26.30	41.91	4.50	0.72	26.35	26.91	46.02	

S.A.R = Sodium adsorption ratio, T.D.S. = Total dissolved solids, epm = equivalent per million. ppm = part per million

TABLE (4). Irrigation water applied of tomato and squash crops grown under green house at El-Maghara region.

Treatments	Tomato (m^3/fed)				Treatments	Squash (m^3/fed)				Tomato & squash (mm / day)			
	Time hour & emitter discharge					Time hour & emitter discharge				Time hour & emitter discharge			
	Quarter hour	Half hour	Quarter hour	Half hour		Quarter hour		Half hour		Quarter hour		Half hour	
Month	4 l/h	8 l/h	4 l/h	8 l/h	Month	4 l/h	8 l/h	4 l/h	8 l/h	4 l/h	8 l/h	4 l/h	8 l/h
Jan	108.0	216.0	216.0	432.0	Apr	108.0	216.0	216.0	432.0	1.71	3.43	3.43	6.86
Feb	208.8	417.6	417.6	835.2	May	223.2	446.4	446.4	892.8	1.71	3.43	3.43	6.86
Mar	223.2	446.4	446.4	892.8	Jun	216.0	432.0	432.0	864.0	1.71	3.43	3.43	6.86
Apr	216.0	432.0	432.0	864.0	Jul	223.2	446.4	446.4	892.8	1.71	3.43	3.43	6.86
May	108.0	216.0	216.0	432.0	August	93.6	187.2	187.2	374.4	1.71	3.43	3.43	6.86
Annual	864.0	1728.0	1728.0	3456.0	Annual	864.0	1728.0	1728.0	3456.0	1.71	3.43	3.43	6.86

At the end of the experiment, all plants were harvested and yield recorded. Data were statistically analyzed according to Snedecor and Cochran (1989). The water use efficiency was calculated by dividing the crop yield by the amount of seasonal evapotranspiration (Giriappa, 1983). The water economy was calculated by dividing the crop yield by the amount of water added as kg/m^3 (Talha *et al.*, 1980). The crop coefficient was calculated by dividing the actual evapotranspiration (ETa) by potential evapotranspiration (ETo) according to Yaron *et al.* (1973). The environmental stress coefficient (Ks) was calculated by dividing the actual evapotranspiration by maximum crop evapotranspiration (ETc) according to Allen *et al.*, (1998). The beneficiary factor (Bf) was calculated by dividing the actual evapotranspiration by the applied irrigation water (Diw) as reported by Allen *et al.* (1998). The investment Ratio (IR) = Output LE / Input LE = costs (Rana *et al.*, 1996).

RESULTS AND DISCUSSION

Crops yield

Table (5) shows the obtained data of the tested two crops; i.e. tomato and squash, with different irrigation treatments. The data reveal a significant increase for tomatoes and squash fruit yield by increasing irrigation time, with substantial differences between treatments. The yield increased with drippers discharge of 4 L/hr at 30 minutes daily, but higher rates decreased the yields proportionally. Therefore, the highest values of tomatoes and squash fruit yield were associated with half hourly irrigation with discharge of 4 liter/hour. These results are in agreement with findings of El-Gindy *et al.* (1991), Andre and Churata (1992) and El-Nagar (2002).

TABLE (5). Effect of irrigation time and dripper discharge and their interaction on tomato and squash yields grown under green houses at El-Maghara region.

Time hour	Emitter discharge	Tomato yield			Squash yield		
		kg/plant	kg/green house	kg/fed	kg/plant	kg/green house	kg/fed
Quarter hour	4 l/h	0.86	517.30	6207.60	0.15	87.46	1049.52
	8 l/hr	1.39	831.20	9974.40	0.30	178.24	2138.88
Average		1.12	674.25	8091.00	0.22	132.85	1594.20
Half hour	4 l/h	1.77	1061.40	12736.80	0.35	212.28	2547.36
	8 l/hr	1.51	904.70	10856.40	0.31	188.14	2257.68
Average		1.64	983.05	11796.60	0.33	200.21	2402.52
L.S.D. 0.05	Time		*	1639.63		**	276.31
	Discharge		ns	1069.77		**	161.74
	Interaction		**	756.32		***	114.35

ns = Non significant, * = Significant at 0.05, ** = Significant at 0.01, *** = Significant at 0.001

Actual Evapotranspiration (ETa)

Table (6) shows that there is a significant decrease for water consumptive use of water by tomatoes and squash crops associated with decreasing irrigation time and drippers discharge. There is also a substantial difference between treatments; the lowest values of ETa were associated with ¼ hourly application rates daily with a discharge of 4 liter/hour. The data reveal some findings as follows;

a- Increasing water application, so ETa values (Table 6) by two folds (from 4 to 8 L/hr at 15 minutes daily) increase the yielded crops by ≈ 60 % and 104 % for tomato and squash respectively, this impress higher response for squash than tomato for increasing irrigation water at this level.

TABLE (6). Effect of irrigation time and dripper discharge and their interaction on water consumptive use of tomato and squash crops grown under green houses at El-Maghara region.

Treatments	Tomato, ETa (m^3/fed)				Treatments	Squash, ETa (m^3/fed)			
	Time hour & Emitter discharge					Time hour & Emitter discharge			
	Quarter hour		Half hour			Quarter hour		Half hour	
Month	4 l/h	8 l/h	4 l/h	8 l/h	Month	4 l/h	8 l/h	4 l/h	8 l/h
Jan	55.4	56.1	56.7	76.2	Apr	81.9	134.2	141.8	149.3
Feb	201.0	239.9	257.0	274.1	May	196.6	373.7	377.6	542.9
Mar	220.0	420.5	436.2	503.9	Jun	214.2	420.8	424.6	772.4
Apr	215.5	429.7	430.9	752.2	Jul	222.6	444.0	445.3	665.3
May	102.7	214.8	215.5	303.7	August	91.7	180.2	180.7	226.6
Annual	794.6	1361.1	1396.2	1910.0	Annual	807.1	1552.9	1570.0	2356.5
L.S.D. 0.05	279.9	*			Time	229.2	**		
	51.32	***			Discharge	144.9	***		
	36.29	***			Interaction	102.5	***		

* = significant at 0.05, ** = significant at 0.01, *** = significant at 0.001

b- Using the same amount of irrigation water, which resulted in almost the same ETa values (with 8 L/hr at 15 minutes and 4 L/hr at 30 minutes), the yields increased by ≈ 28 % and 19 % for tomato and squash respectively by increasing irrigation time. This behaviour indicate the importance of irrigation management under modern irrigation systems as the shorter time of water application could cause large shape of water cone under the cultivated plants than the large time. So, it is suggested that these conditions will oblige plants to consume more energy to enlarge their roots as well which could be reflected on somehow weak shoots growth compared with the lower rate of water application.

c- Doubling the water application (from 4 to 8 L/hr at 30 minutes daily), which in turn, gives two folds, ETa values increase by 37 and 50 % for tomato and squash respectively. However, this treatment gave considerable decrease in crop yields by ≈ 15 % and 13 % for tomato and squash, respectively. This behaviour could be attributed to the high leaching rates, which accumulate the nutrient at a far distance from the plant roots. Therefore, much more energy will be consumed to benefit from the leached nutrients, which could be reflected in smaller shoots growth than the moderate rates of water application.

d- Statistical correlation values between: a- applied irrigation water, b- consumed water and crops yield of tomato and squash gave polynomial relations;

Tomato yield (kg/fed) $y = -0.0024x^2+12.206x$ (I.W.A.m^3/fed)-2538.8
$r=0.884^{**}$ $R^2= 0.7816$

Tomato yield (kg/fed) $y = -0.0079x^2 + 25.689x$ (ETa m^3/fed) $- 9223.9$
$r=0.886^{**}$ $R^2= 0.7847$

Squash yield (kg/fed) $y = -0.0006x^2 + 3.0439x$ (I.W.A. m^3/fed)-1135
$r=0.943^{**}$ $R^2= 0.8886$

Squash yield (kg/fed) $y = -0.0011x^2 + 4.2755x$ (ETa m^3/fed) - 1681.5
$r = 0.950^{**}$ $R^2 = 0.9033$

Where: N= 12 & Tabulated r-value at 0.05 = 0.553 and at 0.01 = 0.684

The polynomial equations show that the ETa values are better correlated to the yields in comparison to the applied irrigation water for tomato and squash. It is important to note that if we interpolate the inflection point on the polynomial curves (the highest r value) it gives the following:

1- About 11800 kg/fed with using 1700 m^3/fed of ETa values for tomato and 2500 kg/fed with using 2000 m^3/fed of ETa values for squash.
2- Irrigation management by decreasing the rate of water application by doubling the time of application (from 15 to 30 minutes) with the same amount of irrigation water gave actually high yields than interpolated with polynomial curve. This may indicate that even with this predicted value the irrigation management could enlarge the benefit from this amount of water with increasing the time of application. So, the expected yield by this assumption could reach to 15000 kg/fed and 3000 kg/fed for tomato and squash, respectively.

The crop yields corresponding to mean ETa values as extracted from the relation are 16 ton/fed and 3 ton/fed for tomato and squash, respectively which are in agreement with the findings of Doorenbos and Kassam (1986). Similar trends were obtained by El-Gindy *et al.* (1991), Andre and Churata (1992) and El-Nagar (2002).

Water Use Efficiency of Crops (WUE)

Data presented in Table (7) reveal that the highest value of WUE is associated with irrigated time, half daily hour with discharge 4 liter/hour. This management strategy gave the best water use efficiency of 9.12 and 1.62 kg/m^3 for both tomatoes and squash vegetables, respectively given the same conditions in the studied area.

TABLE (7). Water use efficiency WUE and water economy (WEco) of tomato and squash crops grown under green houses at El-Maghara region.

Time hour	Emitter discharge	Tomato		Squash	
		WUE kg/m^3	WEco. kg/m^3	WUE kg/m^3	WEco. kg/m^3
Quarter hour	4 l/h	7.81	7.18	1.30	1.21
	8 l/h	7.33	5.77	1.38	1.24
Average		7.57	6.48	1.34	1.23
Half hour	4 l/h	9.12	7.37	1.62	1.47
	8 l/h	5.68	3.14	0.96	0.65
Average		7.40	5.26	1.29	1.06

Table (7) shows the WUE data from tables (5 and 6) for ETa values and the corresponding values of tomato and squash crops. The data reveal the following notes:

1- Doubling ETa values under 15 minutes application with 4 and 8 L/hr drippers, the WUE values decreased by ≈ 6 % for tomato while increased by ≈ 6 % for squash.
2- Using the same ETa values by 8 L/hr for 15 minutes and 4 L/hr for 30 minutes the WUE values increased by ≈ 24 % and 17 % for tomato and squash crops. This indicates how we can manage the irrigation systems under similar conditions and achieve more beneficial use from a unit of water consumed.

Doubling ETa values by using 8 L/hr instead of 4 L/hr for 30 minutes daily gave the lowest WUE values overall the tested treatments. From this parameter, it can be conclude that despite the relatively high yields corresponding to these treatments, the net benefit from per unit of water consumed is very low compared to the other treatments. Similar trends were obtained by El-Gindy *et al.* (1991), Andre and Churata (1992) and El-Nagar (2002).

Water Economy of Crops (W. Eco.)

The same trends for water use efficiency were observed in table (7) for water economy. The highest value of W. Eco. is associated with irrigated time, half daily hour with discharge 4 liter/hour. These managements strategies gave the best water economy of 7.37 and 1.47 kg/m^3 for both tomatoes and squash vegetables, respectively. Similar trends were obtained by Allen *et al.* (1998) and El-Nagar (2002).

Crop Coefficient (Kc) of Crops

Data presented in table (8) reveal that significant increases for crop coefficient of tomato and squash crops have occurred by increasing irrigation time and drippers discharge. This indicates that if crop yields are to be used as parameters to the efficient use of water, there the Kc values for 4 l/hr dripper with 30 minutes are the most acceptable values for application. Similar trends were obtained by Doorenbos and Kassam (1986); El-Gindy *et al.* (1991); Andre and Churata (1992) and Allen *et al.* (1998).

TABLE (8). The best crop coefficient of tomato and squash crops grown under green houses at El-Maghara region.

Tomato	Half hour	Squash	Half hour
Month	4 l/h	Month	4 l/h
Jan	0.40	Apr	0.42
Feb	0.79	May	0.47
Mar	0.92	June	0.47
Apr	0.64	July	0.47
May	0.55	August	0.47
Annual	0.66	Annual	0.46

Environmental Stress Coefficient (Ks)

Environmental stress coefficient (Ks) is used as a reduction factor for planting and is useful in estimating the irrigation needs of crops. (Table 9), also shows data for soil water limiting conditions, Ks < 1. Where there is no soil water stress, $Ks_w = 1$.

The data reveal that the best treatment in water application (4 l/hr for 30 minutes) which results in 16 and 31 % of water being saved for tomato and squash crops, respectively after recalculation. Similar trends were reported by Rana *et al.* (1996) and Allen *et al.* (1998).

TABLE (9). Environmental stress coefficient (Ks) of tomato and squash crops for the best treatment grown under green houses at El-Maghara region.

Tomato	Season 2004	FAO Kc	Ks Half hour
Month	ETo mm/day		4 l/h
Jan.	2.26	0.40	0.99
Feb.	2.66	0.80	0.99
Mar.	3.66	1.00	0.92
Apr.	5.31	1.15	0.56
May	6.23	0.75	0.73
Annual	4.02	0.82	0.84

Squash	Season 2004	FAO Kc	Ks Half hour
Month	ETo mm/day		4 l/h
Apr.	5.31	0.50	0.85
May	6.23	0.70	0.67
June	7.16	0.95	0.50
July	7.24	0.75	0.63
August	6.97	0.60	0.79
Annual	6.58	0.70	0.69

FAO Kc = crop coefficient from FAO book, ETo = potential evapotranspiration

Beneficiary Factor (Bf)

Data in table (10) show that the beneficiary factor (Bf) increases by decreasing irrigation time and drippers discharge. Table (10) also shows the calculated Bf values for all treatments. The data indicate clearly the beneficial water use by the three lower water application treatments than the highest one of 8 l/hr for 30 minutes. So, the resulting Bf values for this treatment are more or less quite close, while those of the last treatment are very low indicating over-use of water application to produce sufficient yield crop.

TABLE (10). Beneficiary factor (Bf) of tomato and squash crops grown under green houses at El-Maghara region.

Treatments	Tomato: Time hour & emitter discharge			
	Quarter hour		Half hour	
Month	4 l/h	8 l/h	4 l/h	8 l/h
Jan.	0.51	0.26	0.26	0.18
Feb.	0.96	0.57	0.62	0.33
Mar.	0.99	0.94	0.98	0.56
Apr.	1.00	0.99	1.00	0.87
May	0.95	0.99	1.00	0.70
Annual	0.88	0.75	0.77	0.53

Treatments	Squash: Time hour & emitter discharge			
	Quarter hour		Half hour	
Month	4 l/h	8 l/h	4 l/h	8 l/h
Apr.	0.76	0.62	0.66	0.35
May	0.88	0.84	0.85	0.61
June	0.99	0.97	0.98	0.89
July	1.00	0.99	1.00	0.75
August	0.98	0.96	0.97	0.61
Annual	0.92	0.88	0.89	0.64

This may be attributed to the reduction amounts of water percolating under shorter irrigation time and low water discharge compared with water less for the treatment of 8 L/hr for 30 minutes. Similar trends were stated by Allen *et al.* (1998) and El-Nagar (2002).

Economical Assessment

The economical evaluation of the experimental findings in any research is of great importance depending on the net return of such treatments, which could guide the farmer to use it, or not. The values of investment ratio (IR) are illustrated in table (11). The data reveal the following notes:

1- The highest IR value for the overall treatment is the application of 4 l/hr for 30 minutes for both tomato and squash.
2- The similar amount of total water but with high application rate (4 l/hr for 15 minutes) gave somehow sufficient (IR) value for tomato, while loss with squash.
3- The two extremes of treatment for both crops seem to be inapplicable depending on the lowest IR values resulted from them.

It is suggested that irrigating tomatoes and squash vegetables with irrigation time, half daily hour with dripper discharge 4 liter/hour (1643 and 1847 m^3/fed) could gave the best values of investment ratio (1.44 and 1.16 LE/ILE, respectively) under the same conditions. However, more work needs to be carried out to determine accurate results for other conditions.

TABLE (11). Input and output items of tomatoes and squash crop grown under green houses at El-Maghara region.

Items	Economical items	Tomato yield				Squash yield			
	Management	Quarter hour		Half hour		Quarter hour		Half hour	
		4 l/h	8 l/h	4 l/h	8 l/h	4 l/h	8 l/h	4 l/h	8 l/h
List of Input	land preparation, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Greenhouses, (on season), LE/fed	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
	Seeds, LE/fed	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
	Cultivation, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Irrigation, LE/fed	216.00	432.00	432.00	864.00	216.00	432.00	432.00	864.00
	Organic Fertilizer, LE/fed	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
	Mineral Fertilizer, LE/fed	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Weed Control, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Pest Control, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Labors Costs, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Machines, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Fuel, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Harvesting, LE/fed	40.00	40.00	40.00	40.00	30.00	30.00	30.00	30.00
	Crop Transport, LE/fed	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Rent (on season), LE/fed	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
	Total Input, LE/fed	1996.0	2212.0	2212.0	2644.0	1986.0	2202.0	2202.0	2634.0
List of Output	Yield, kg/fed	6207.60	9974.40	12736.80	10856.40	1049.52	2138.88	2547.36	2257.68
	Price, LE/kg	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00
	Total Price, LE/fed	1551.9	2493.6	3184.2	2714.1	1049.5	2138.9	2547.4	2257.7
	Net Income, LE/fed	-444.1	281.60	972.2	70.10	-936.48	-63.12	345.36	-376.32
Investment Ratio, LE		0.78	1.13	1.44	1.03	0.53	0.97	1.16	0.86

CONCLUSION

It is suggested to irrigate tomatoes and squash vegetables with irrigation time, half daily hour by GR dripper with discharge 4 liter/hour. The irrigation rate was intended to be around 2 liter/plant/day. This type of management gave the best water use efficiency (9.12 and 1.62 kg/m^3), water economy (7.37 and 1.47 kg/m^3), investment ratio (1.44 and 1.16 LE/ILE) and raised beneficiary factor (Bf) by about 77 and 89 % for both tomatoes and squash vegetables, respectively at the same conditions. More research needs to be done to confirm these results.

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Received: 05/02/2006
Accepted: 03/06/2006

تقدير الاحتياجات المائية المثلي للطماطم والكوسة تحت الظروف الجافة بمنطقة المغارة – مصر.

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يهدف هذا البحث إلى دراسة تأثير زمن الرى وتصرف النقاطات المختلفة والتفاعل بينهما على ترشيد استهلاك مياه الرى لبعض محاصيل الخضر تحت ظروف الري بالتنقيط في الأراضي الجافة بمحافظة شمال سيناء وعلى كفاءة استخدام المحصول للمياه واقتصاديات المياه.

أقيمت تجربة صوب حقلية بمزرعة محطة بحوث المغارة من خلال تصميم قطع منشقة مرة واحدة خلال موسم ٢٠٠٤ لدراسة تأثير كلا من أزمنة الرى المختلفة وتصرفات نقاطات الري المختلفة والتفاعل بينهما على محصولى الطماطم والكوسة وكفاءة استخدامها للمياه تحت ظروف الصوب والرى بالتنقيط. تضمنت التجارب أثنين من زمن الرى (ربع & نصف ساعة يوميا) وأثنين من تصرف نقاط الرى (٤ & ٨ لتر/ساعة) وثلاثة مكررات، ورويت التجربة بنظام الري بالتنقيط.

أوصت الدراسة بري محصولى الطماطم والكوسة نصف ساعة يوميا بنقاطات GR تصرفها ٤ لتر / ساعة والتى أعطت أعلى كفاءة لاستخدام المحصول للمياه الى ٩,١٢ & ١,٦٢ كجم/م^{3} مياه، ورفعت اقتصاديات المياه الى ٧,٣٧ & ١,٤٧ كجم/م^{3} مياه ، وعائد إستثمار الجنيه الى حوالى ١,٤٤ & ١,١٦ جنيه ، ورفعت معامل الإفادة من مياه الرى الى ٧٧ & ٨٩ % لكل من محصولى الطماطم والكوسة على الترتيب وذلك تحت الظروف المشابهة لمنطقة الدراسة مع ملاحظة وجود معاملات إيجابية أخرى داخل التجربة أقل من هذه المعاملة.