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IRRIGATION INTERVAL, OXYGENATED WATER AND SEED SOAKING FOR IMPROVING WATER PRODUCTIVITY AND SQUASH PRODUCTION

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Abstract

A field experiment was conducted at Sakha Horticulture Research Station Farm, Kafr El-Sheikh Governorate under drip irrigation system, during the two growing seasons 2017 and 2018 to study the effect of irrigation periods as: every 4 days (I1); 6 days (I2) and 8 days (I3). It included also water quality; as mixed raw with ozonized water. In addition to hydrogen peroxide (Q1), hydrogen peroxide (Q2), ozonated water (Q3) and raw water (Q4). It referred to with seed soaking (S1) and without (S2) in a split-split plot design with three replications. The results showed that the highest values of applied water, and consumptive use were recorded under I1 in the two growing seasons and the values were 53.87 and 53.35 cm for applied water and 48.85 and 48.44 cm for consumed water in the first and second season, respectively. On the other hand, the highest mean values for water productively (WP), economic water productivity (EWP), productivity of irrigation water (PIW) and economic productivity of irrigation water (EPIW) were recorded under I3 the lowest applied and consumed water in the two seasons and the value tended to reduce, gradually, with increasing the irrigation applied water. Results showed also, all characteristics of squash yield, its component and quality were significantly affected by irrigation interval, water quality and soaking seeds in both seasons. All vegetative measurements, fruit yield, yield components and quality recorded the highest values under irrigation every 4 days, water quality mixed with ozonated water plus hydrogen peroxide and seed soaking in ozonated water in the two growing seasons.

Key words: Irrigation interval, water productivity, oxygenated water, squash crop

Introduction

For centuries humans have been concerned with efficient use of water in crops production. The ability to grow crops and manage their needs for water is necessary for the civilization. Greater efficiencies of water use in agriculture, recycling of water through water treatment plants in industries can play a catalytic role in saving this valuable resource. Without appropriate management, irrigated agriculture which is a major part of agriculture system can be detrimental to the environment and endanger sustainability. Undoubtedly, the arid and semi-arid regions with limitation of fresh water and large population, there is a significant stress on the agricultural sector to reduce the consumption of limited fresh water for irrigation for the other sectors Abd El Raouf, et al., 2020 a, b. Squash is considered one of the important vegetable crops in the world as well as Egypt. Also, it is being a commercial crop for fields and greenhouses. In spite of, squash fruits have been produced in most Mediterranean region as one of the main vegetables (Mohammad 2004). Summer squash (Cucurbita pepo L.) is one of the most important cucurbits crops in Egypt. It is grown as a summer crop, but can be grown around the year. Squash had high nutritional values due to its high content of carbohydrates, amino acids, vitamins and minerals. The last statistics for the cultivated area of squash was 22761 ha on small fields which are less than 1 ha (Economic Affairs Sector, (EAS), 2016). In agriculture, the stress on irrigation is going to be increased day by day to meet the food needs of rapidly growing world population. The world population increased from 3.0 billion in 1959 to 6.0 billion by 1999, a doubling that occurred over 40 years and is currently increasing by about 80-85 million people per year. The United Nation projections that the world population in 2050 could be 7.3 to 10.7 billion if the reproduction fertility declines and it will be 14.4 billion if the world's population continues to increase at the present rate. The thing of concern is that major population growth is in developing world where the natural resources were reported by (Annoymous, 2009).

Moreover, Amer (2011) showed that squash yield was significantly affected by irrigation quantity under northern Egypt, that maximum fruit yields and its components were obtained from well-watered treatments (1.0 ETc - Crop Evapotranspiration). The yield and yield component values were decreased by deficit (0.50 ETc and 0.75 ETc) or an excess (1.25 ETc and 1.5 ETc) of irrigation quantities. Sadik and Abd El-Aziz (2018) revealed that at summer season squash was grown in the East of El Owainat area, New Valley Governorate, Egypt under drip irrigation significantly affected by water stress. The marketable yield and studied quality parameters except total soluble solid (TSS) and acidity value of summer squash fruits gave the highest values under IR=100% crop evapotranspiration treatment for both seasons. 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 IR= 60% crop evapotranspiration treatment. In Egypt, ELQuosy, 1998 showed that irrigated agriculture was the predominant type of farming, the per capita share from water for different purposes was decreased gradually to less than the water poverty edge, 1000 m3 per annum. Irrigation common use is more than 85% of the total conventional water supply. So, tremendous efforts should be implemented in this sector to rationalize water at the national level. One of the most effective ways for irrigation is to determine crop water needs with accumulation pan evaporation is essential for maximizing the productivity from each unit of applied water. Water sources in Egypt are limited compared to increasing demand for water. Therefore, adjusting water management in both new and old lands comes as a major component of agricultural development (Okasha et al 2020). Refai and

Hassan (2019) illustrated that irrigation squash plants at 1.0 IW (irrigation water): CPE (cumulative pan evaporation, mm day-1) recorded the highest values of growth traits such as plant height and number of leaves plant-1. Data also show that medium irrigation regime (0.8 IW: CPE) gave the maximum values of physical and economic irrigation water productivity (PIWP and EIWP). So, they concluded that irrigating squash plants with 0.8 IW: CPE to save about 20% of irrigation water and improve squash productivity. Hydrogen peroxide is an environmentally friendly compound and considered as a GRAS (Generally Regarded As Safe) as well as permissible in organic crop production (NOP, 2003). There are many uses for H2O2 in agriculture; Hydrogen peroxide plays also multiple functions in plant defence against pathogens, where it may possess direct microbicidal activity, used for cell-wall reinforcing processes, necessary for phytoalexin synthesis, that may trigger programmed cell death of plants during the hypersensitive response that restricts the spread of infection, act as a signal in the induction of SAR, and induced defence genes as interpreted by (Kuzniak and Urbanek, 2000). Al-Mughrabi (2007) showed that treated potato with by H2O2 significantly higher emergence % and total yield. Li et al., 2007 studied that on using H2O2 increased roots fresh weight on cucumber. Moreover, on spraying H2O2 with pharma plant turbo increased the early and total yields while it decreased the disease severity for cucumber as mentioned by (Hafez et al., 2008). This oxygen enriched water feeds the plant's root development which improves plant health and growth. Beneficial aerobic bacteria also thrive in this oxygen rich environment. The increase in oxygen means that many diseased plants are quick to recover. Few later decades, scientists referred about the use of application of ozonated water (O3wat) directly onto plants to control diseases. For example, O3 water has been used as an alternative of chemicals for the control of powdery mildew on cucumbers as shown by Fujiwara et al., 2009. Hydrogen peroxide, H2O2 is an important reactive oxygen species (ROS) molecule that served as a signal of oxidative stress and activation of signaling cascades as a result of the early response of the plant to biotic stress (Mejía-Teniente et al., 2013). It was also affected other airborne diseases, including early blight and leaf mould on tomato (He et al., 2015). Mazuela (2010) concluded that oxygen supply had an effect on water uptake and improved water efficiency in terms of kg produced per liter of water consumed.

The main objective was to study the effect of irrigation interval, water quality using oxygenated water and seed soaking in ozonated water on yield, quality and water productivity for squash crop under drip irrigation system.

Material and Method

A field experiment was conducted at Sakha Horticulture Research Station Farm under drip irrigation system, during the two growing seasons of 2017and 2018 to study the effect of irrigation interval; irrigation every 4 days (I1), 6 days (I2) and 8 days (I3) and water quality; mixed water with ozonated water (Q1), hydrogen peroxide(Q2), ozonated water plus hydrogen peroxide (Q3) and water only (Q4) and with seed soaking (S1) and without soaking (S2) in a split-split plot design with three replications. The site located at Kafr EL Sheikh Governorate (the Middle North of the Nile Delta), which located at (31¯ 07° N Latitude, 30¯ 57° longitude) with an elevation of about 6.0 meters above mean sea level. Data presented in Table 1 which showed meteorological parameters (MP) during the studied interval, recorded from Sakha Agro- meteorological Station. The MP included; air temperature (T, °C), relative humidity (RH, %), wind speed (U2, Km/ day at 2 m height) and evaporation pan (Ep, mm).

Table 1: Some agro-meteorological parameters in the first and second seasons.

Month*	T (°c)			RH (%)			U_{2} km d^{-1}	Pan Evap. (mmday^{-1})
	Max.	Min.	Mean	Max.	Min.	Mean		
2017 Season								
June	32.50	28.10	30.30	80.10	51.40	65.75	102.6	7.10
July	34.20	29.00	31.60	84.40	57.60	71.00	80.90	6.44
Aug.	33.90	28.30	31.10	85.90	55.30	70.60	70.20	6.04
Sep.	32.50	25.90	29.20	86.30	50.30	68.30	85.70	5.37
2018 Season								
June	32.60	25.30	28.95	75.50	48.00	61.75	98.60	7.71
July	34.20	25.40	29.80	82.60	51.00	66.80	89.50	7.37
Aug.	33.90	25.20	29.55	82.40	51.40	66.90	76.00	6.42
Sep.	32.80	23.50	28.15	83.10	48.30	65.70	68.70	4.98

* Source: Agro-meteorological station at Sakha 31^{0}-07' N Latitude, 30^{0}-57'E Longitude, N. elevation 6 m.

Soil particle size distribution and bulk density were determined as described by Klute (1986). Field capacity and permanent wilting point were determined according to James (1988). While available water was calculated by the difference between field capacity and permanent welting point. Chemical characteristics of soil were determined as described by Jackson (1973) and all data are presented in Table 2.

The site of the experiment was ploughed twice by using chisel plougher. A disk harrow was also used to find a suitable size of aggregates and then, the soil was laser leveling. The field of the experiment area was divided into 24 plots, each plot was 63 m2 (21 X 3) = 1/65 fed., and isolated from the other to prevent horizontal water movement. Squash cv (Mabrouka, hybrid) is a summer crop seedling, 18 days age, was transplanted under dripper on one side of the ridge in hills spaced 0.40 m apart giving a plant density of about three plants m-2, squash planted on 2 June 2017 in first, and in second season planted on 8 June, 2018. The amounts of fertilizers were applied according to recommendations of Horticulture Research Institute, Agricultural Research Center (ARC). Nitrogen fertilizer was added as 300 kg ammonium nitrate; 100 nitrogen unit fed-1. Nitrogen was fed in doses were applied fertigation with a plastic tank in drip irrigation system until 10 days before harvesting. The phosphates fertilizer was applied in the two seasons during tillage preparation as the recommended dose of 150 kg single superphosphate (15.5 P2O5/ fed.). The added potassium fertilizer was 100 Kg potassium sulfate fertigation after holding interval.

Table 2: Particle size distribution, bulk density, some both soil-water characters and chemical soil properties of the experimental site (means of 2017 and 2018 seasons)

Soil layer depth (cm)	Particle size distribution			Textural classes	Bulk density (Kgm^{-3})	Soil- water constant		
	Sand%	Silt%	Clay%			F.C* (%,wt/wt)	P.W.P** (%,wt/wt)	A.W*** (%,wt/wt)
0-15	10.70	28.50	60.80	Clayey	1.17	45.45	24.70	20.75
15-30	11.78	29.60	58.62	Clayey	1.19	43.50	23.64	19.86
30-45	12.28	31.32	56.40	Clayey	1.20	41.24	22.41	18.83
45-60	15.12	32.56	52.32	Clayey	1.22	40.15	21.82	18.33
Mean	12.47	30.50	57.03	Clayey	1.20	42.59	23.14	19.45

Chemical Soil characteristics

	pH **1:2.5** S.W.S****	EC dSm^{-1}	Soluble cations, $meqL^{-1}$				Soluble anions, $meqL^{-1}$			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0-15	8.18	2.18	4.55	3.98	12.69	0.58	-	4.99	10.35	6.46
15-30	8.19	2.37	4.64	4.12	14.48	0.46	-	5.27	9.13	9.30
30-45	8.15	2.92	5.12	4.22	19.44	0.42	-	7.48	10.22	11.50
45-60	7.99	3.02	5.18	5.14	19.55	0.39	-	8.65	9.49	12.12
Mean	-	2.62	4.88	4.36	16.54	0.46	-	6.60	9.80	9.84

FC* = Field capacity, PWP** = Permanent wilting point and AW*** = Available soil water**** S.W.S soil water suspension

Experimental layout:

All agricultural practices for crop were implemented according to the technical recommendations of A.R.C.

The treatments under study

main plots were allocated to irrigation intervals: -

I1 – Irrigation every 4 days

I2 – Irrigation every 6 days and

I3 – Irrigation every 8 days

Sub plot treatments (irrigation water quality)

Q1: irrigation water mixed with ozonated water + hydrogen peroxide,

Q2: irrigation water mixed with hydrogen peroxide,

Q3: irrigation water mixed with ozonated water, and

Q4: pure irrigation water.

Ozonated water added at concentration of 0.5-0.7 mg / l from oxygenated generator.

Sub-sub plot treatments (seed soaking)

S1: seed soaking and

S2: without soaking

Irrigation system:

The drip irrigation system which installed in the experimental field consists of a control unit with contained a venture injector, control valves and a water flow meter, fertilizer tank and pressure devices. Drip laterals of 16 mm in diameter and 20 m in length had in-line emitters spaced 0.4 m part, each manufacturing discharge 4 L/h at pressure of 1 bar. Drip irrigation lines were spaced 0.75 m apart, equally spaced between each other rows of crop under investigation.

Irrigation water:

The potential of reference evapotranspiration (ETo) was calculated according to the following formula (Doorenbos and Pruitt, 1977):

ETo = Kp x Epan mm/da

Where: ETo = Reference evapotranspiration in mm/day.

Kp = (Pan coefficient) which was considered as 0.85 for pan Evaporation.

Therefore, Computation of crop consumptive use (ETc) was as follows (Doorenbos and Pruitt, 1977):

ETc = ETo x Kc mm/day

Where:

ETo = the rate of reference evapotranspiration.

Kc = crop coefficient.

Values of K c which quoted from FAO No. 33 are depended upon growth stage of squash crop.

AW= (ETC mm*1000/4200) m3 fed^{-1}

Some irrigation relationships:

Water consumptive use, cm:

Water consumptive use was calculated as soil moisture depletion (SMD) according to Hansen et al., 1979.

$$Cu = SMD = \sum_{i=1}^{i=N} \frac{\theta_2 - \theta_1}{100} * Dbi * Di * A$$

Where:

CU = Water consumptive use in the effective root zone, cm,

Θ2 = Gravimetric soil moisture percentage 48 hours after irrigation,

Θ1= Gravimetric soil moisture percentage before irrigation,

Dbi = soil bulk density (Mg m-3) for the given depth,

Di = soil layer depth (20 cm),

i = number of soil layers each (15 cm) depth and

A= irrigation area (fed)

Productivity of irrigation water PIW kg m^{-3}:

Productivity of irrigation water (PIW) was calculated according to Ali et al., 2007.

$$PIW = \frac{GY}{AW}$$

Where:

PIW = productivity of irrigation water (kg m-3), Gy = yield g/fed, and

AW = Applied water (m3/fed.). (Irrigation water + effective rainfall)

Note: effective rainfall = incident rianfall *0.7 (Novica, 1979)

Water productivity WP kg m-3:

Water productivity is generally defined as crop yield per cubic metre of water consumption. It was calculated according to (Ali et al., 2007)

$$WP = \frac{GY}{ET}$$

Where:

WP = water productivity (kg m-3),

GY = yield (kg fed-1) and

ET = Total water consumption through the season (m3 fed-1.).

Economic productivity of irrigation water and economic water productivity (L.E. m-3)

Irrigation productivity of irrigation water can be expressed as economical productivity (EPIW) and (EWP) according to Molden, 1997. It was calculated as follows:

$$EPIW = \frac{Gross\ value\ of\ product\ L.E.fed^{-1}}{total\ amount\ of\ irrigation\ applied\ water\ (m^3 fed^{-1}}$$

$$EWP = \frac{Gross\ value\ of\ product\ L.E.fed^{-1}}{total\ amount\ of\ irrigation\ cosumed\ water\ (m^3 fed^{-1}}$$

Some Crop yield measurements and calculations:

Vegetative and growth Measurements

Plant height (cm)

Number of leaves per plant

Leaves dry weight, gm

Leaf area per plant (dm2)

Chlorophyll content (mgdm-2): determined spectrobolometrically at 60 days after transplanting as described by Moran and Porath (1982).

Fruit yield, yield components and quality

- Early fruit yield (yield of first three picking),
- Total fruit yield (tonfed-1)
- Mean fruit weight (g)
- Total Soluble Solids (TSS %)

Mineral content

Nitrogen (%) was determined in the digestion product using the micro-kjeldahl method (AOAC, 1980). Phosphorus (%) was determined colorimetrically at 725 µm (King, 1951). Potassium (%) was determined using a flame photometer (Jackson, 1973).

Statistical analysis:

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez, 1984. Means of the treatment were compared by the least significant difference (LSD) at 5% level and 1 % level of significance which developed by Waller and Duncan, 1979.

Results and Discussion

Influence of irrigation and water quality on some studied water relations and its efficiencies.

Applied irrigation water:

Presented data in Table (3) showed that seasonal values of applied irrigation water (A.W.) for squash crop were clearly affected with irrigation treatments, water quality and soaking the seeds in the two growing seasons and the highest applied water recorded under I1 with the values 2160.6 and 2240.7 m3 fed-1 in the first and second season respectively. While the lowest values were recorded by I3 with values of 1685.6 and 1706.0 m3 fed-1 in the first and second season respectively. In general, the values of seasonal amount of applied water could be descended in the order I1>I2>I3. Increasing the values of seasonal applied water under irrigation treatment I1 (low interval, 4 days /interval) comparing with the other treatments I2 (moderate interval, 6 days /interval) and I3 (longer interval, 8days /interval) might be attributed to increasing number of irrigations under the conditions of this treatment as results of decreasing irrigation interval between watering. These results are in agreement with those obtained by Farag et al, 2015.

Water consumptive use (cm)

Data in the same previous Table (3) and figure (1) clearly showed that the mean values of squash consumptive use were affected by irrigation treatments, water quality and seed soaking in the two growing seasons. Concerning the effect of irrigation treatments, the highest values were recorded under irrigation treatments I1 (4 days interval, without stress) compared with the other stress treatments I2 and I3. The highest mean values were 45.85 and 48.44 cm by the irrigation treatment I1, while the lowest were 36.01 and 36.41 cm) by irrigation treatment I3. Increasing the mean values of squash consumptive use under irrigation treatment I1 which received a large number of watering through the growing season might be attributed to increasing number of irrigations under the conditions of this treatment because of decreasing irrigation intervals and the fact that frequently watered plants used extra water because they found it much more easily without suffering from water deficit. So, increasing amount of water applied and hence increasing the values of consumptive use. Regarding the interaction effect, results in Table (3) show that the effects among the different combinations as the lowest values of CU were obtained in plants grown under the lowest amount of irrigation water with irrigation water only and soaking seeds in ozonated water. On the other hand, the highest values of CU were obtained in plants grown under the highest amount of irrigation water with application water quality mixed with hydrogen peroxide with soaking seeds in ozonated water. These results are in harmony with These results are in agreements with Ertek et al. (2004); for summer squash whom stated that if other conditions were equal, roots of plants in wet soil will extract more water than those grown in the dried soil. A positive linear relationship was obtained between applied water and consumptive use (fig 1). They are highly significant (with correlation coefficient values, r = 0.99 and 0.98 in the first and second seasons respectively. The positive relationship indicated that consumptive use increased with the applied water increased.

Table 3: Seasonal applied water ($m^3 fed.^{-1}$, cm), consumptive use (cm) for squash crop in the two growing seasons.

Irrigation Interval (I)	Water Quality (Q)	Seed Soaking (S)	Applied water, season						CU, cm		
			m^3 fed.$^{-1}$			cm					
			1st Season	2nd Season	Over all mean	1st Season	2nd Season	Over all mean	1st Season	2nd Season	Over all mean
I_1	Q_1	S_1	2160.6	2240.7	2250.7	51.44	53.35	52.40	47.18	49.55	49.87
		S_2	2160.6	2240.7	2250.7	51.44	53.35	52.40	46.78	48.75	49.27
	Mean Q_1		2160.6	2240.7	2250.7	51.44	53.35	52.40	46.98	49.15	49.56
	Q_2	S_1	2160.6	2240.7	2250.7	51.44	53.35	52.40	46.99	50.02	50.00
		S_2	2160.6	2240.7	2250.7	51.44	53.35	52.40	45.87	50.87	49.87
	Mean Q_2		2160.6	2240.7	2250.7	51.44	53.35	52.40	46.43	50.445	49.94
	Q_3	S_1	2160.6	2240.7	2250.7	51.44	53.35	52.40	46.24	47.88	48.56
		S_2	2160.6	2240.7	2250.7	51.44	53.35	52.40	44.87	46.88	47.38
	Mean Q_3		2160.6	2240.7	2250.7	51.44	53.35	52.40	45.55	47.38	47.97
	Q_4	S_1	2160.6	2240.7	2250.7	51.44	53.35	52.40	44.98	47.44	47.71
		S_2	2160.6	2240.7	2250.7	51.44	53.35	52.40	43.85	46.15	46.50
	Mean Q_4		2160.6	2240.7	2250.7	51.44	53.35	52.40	44.42	46.80	47.11
Mean I_1			2160.6	2240.7	2200.7	51.44	53.35	52.40	45.85	48.44	48.65
I_2	Q_1	S_1	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.95	42.44	42.70
		S_2	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.29	41.95	42.12
	Mean Q_1		1976.2	2014.7	1995.5	47.05	47.97	47.51	42.62	42.20	42.41
	Q_2	S_1	1976.2	2014.7	1995.5	47.05	47.97	47.51	43.22	42.57	41.92
		S_2	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.95	41.56	42.26
	Mean Q_2		1976.2	2014.7	1995.5	47.05	47.97	47.51	43.08	42.07	42.58
	Q_3	S_1	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.00	41.20	41.60
		S_2	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.75	42.85	42.80
	Mean Q_3		1976.2	2014.7	1995.5	47.05	47.97	47.51	42.38	42.03	42.20
	Q_4	S_1	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.50	42.66	42.58
		S_2	1976.2	2014.7	1995.5	47.05	47.97	47.51	42.22	41.99	42.11
	Mean Q_4		1976.2	2014.7	1995.5	47.05	47.97	47.51	42.36	42.33	42.34
Mean I_2			1976.2	2014.7	1995.5	47.05	47.97	47.51	42.61	42.15	42.38
I_3	Q_1	S_1	1685.6	1706.0	1695.8	40.13	40.62	40.38	37.55	38.15	37.85
		S_2	1685.6	1706.0	1695.8	40.13	40.62	40.38	37.01	37.55	37.28
	Mean Q_1		1685.6	1706.0	1695.8	40.13	40.62	40.38	37.28	37.85	37.56
	Q_2	S_1	1685.6	1706.0	1695.8	40.13	40.62	40.38	36.50	37.02	36.76
		S_2	1685.6	1706.0	1695.8	40.13	40.62	40.38	36.75	37.18	36.97
	Mean Q_2		1685.6	1706.0	1695.8	40.13	40.62	40.38	36.63	37.10	36.86
	Q_3	S_1	1685.6	1706.0	1695.8	40.13	40.62	40.38	35.48	36.17	35.83
		S_2	1685.6	1706.0	1695.8	40.13	40.62	40.38	34.89	35.55	35.22
	Mean Q_3		1685.6	1706.0	1695.8	40.13	40.62	40.38	35.19	35.86	35.52
	Q_4	S_1	1685.6	1706.0	1695.8	40.13	40.62	40.38	35.00	35.08	35.04
		S_2	1685.6	1706.0	1695.8	40.13	40.62	40.38	34.89	34.55	34.72
	Mean Q_4		1685.6	17060	1695.8	40.13	40.62	40.38	34.95	34.82	34.88
Mean I_3			1685.6	1706.0	1695.8	40.13	40.62	40.38	36.01	36.41	36.21
Mean I			1940.8	1987.1	1964.0	46.21	47.30	46.76	42.49	42.33	42.21

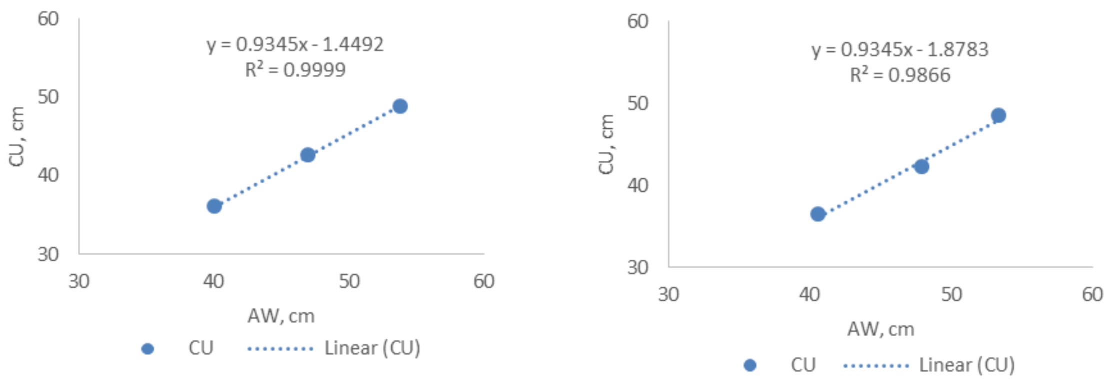


Fig. 1: Correlation between irrigation water applied, cm fed^{-1} and water consumed, cm fed^{-1} overall spring application and seed soaking in the two growing seasons.

Productivity of irrigation water PIW, kg m-3, water productivity WP, kg m-3 and economic water productivity EWP, L.E. m-3

Productivity of irrigation water, water productivity and economic water productivity were computed to evaluate the treatments for maximum yield per unit of water applied in the field. Data presented in Table (4) and fig (2) demonstrate that, PIW, WP, EPIW and EWP were affected by irrigation water interval; the values were increased under increasing water stress conditions in the two growing seasons. The highest values of PIW, WP, EPIW and EWP for summer squash were (8.66 and 9.65 kg m-3); (9.40 and 10.49 kg m-3); (34.65 and 37.59 LE m-3) and (38.60 and 41.95 LE m-3) for both seasons respectively, under I3, irrigation every 8 days treatment. The lowest values were 7.89 and 8.69 kg m-3; 8.20 and 9.03 kg m-3; 31.58 and 32.78 LE m-3 and 34.78 and 36.11 LE m-3 for both seasons, under I1, irrigation every 4 days, respectively. Meanwhile, the values of PIW, WP, EPIW and EWP under I2, irrigation every 6 days treatment were increased significantly by about 6.0 and 6.3 %; 6.0 and 9.1 %, 5.92 and 6.07% and 6.22 and 9.11 % for both seasons, respectively, compared to that under the control treatment I1, irrigation every 4 days. Increasing the mean values of PIW, WP, EWIP and EWP under water stress conditions comparing with non-stressed ones might be due to decreasing amount of water applied under the conditions of these treatments. Also, these results could be attributed to the significant differences among squash yield, evapotranspiration and water applied values as previously shown. These results are in agreement with Ertek et al. (2004) obtained the highest irrigation water use efficiency (IWUE) values for summer squash under the lowest irrigation conditions (45% of Class A pan evaporation).

For water quality and seed soaking; irrigation water mixed with ozonated water + hydrogen peroxide (Q1) and seed soaking in ozonated water (S1) give the highest values for all irrigation interval in both seasons. A negative linear relationship was obtained between applied water, cm and PIW and WP, kg m-1 (fig 2). They are highly significant with correlation coefficient values, r = 0.97 and 0.99 for PIW and 0.98 and 0.95 for PW in the first and second seasons respectively. The negative relationship indicated that PIW and WP, kg m-1 decreased with the applied water increased.

Table 4: Effect of irrigation interval, water quality and seed soaking on early and fruit yield (ton fed^{-1}), productivity of irrigation water (kgm^{-3}) and water productivity (WP, kg m^{-3}) for squash crop in the two growing seasons.

Irrigation Interval (I)	Water quality (Q)	Seed Soaking (S)	PIW, kg m^{-3} 1st Season	PIW, kg m^{-3} 2nd Season	WP, kg m^{-3} 1st Season	WP, kg m^{-3} 2nd Season	EPIW, L.E. m^{-3} 1st Season	EPIW, L.E. m^{-3} 2nd Season	EWP, L.E. m^{-3} 1st Season	EWP, L.E. m^{-3} 2nd Season
I_1	Q_1	S_1	9.01	9.60	9.89	10.59	36.04	38.41	39.59	42.36
		S_2	8.69	9.46	9.47	10.37	34.68	37.84	37.88	41.49
	Q_2	S_1	8.01	8.34	8.88	9.29	32.44	33.38	35.53	37.15
		S_2	7.94	7.94	8.76	8.60	31.75	31.77	35.02	34.41
	Q_3	S_1	7.94	7.99	8.81	8.78	31.75	31.95	35.24	35.13
		S_2	7.32	7.82	8.13	8.70	29.30	31.28	32.55	34.80
	Q_4	S_1	7.06	7.38	7.74	8.11	28.24	29.53	30.97	32.44
		S_2	7.10	7.02	7.88	7.76	28.41	28.10	31.53	31.06
Mean I_1			7.89	8.20	8.69	9.03	31.58	32.78	34.78	36.11
I_2	Q_1	S_1	9.69	9.95	10.80	11.42	38.77	39.82	43.19	45.69
		S_2	9.39	9.89	10.41	11.13	37.57	39.57	41.64	44.54
	Q_2	S_1	8.60	855	9.59	10.08	34.41	34.21	38.36	40.34
		S_2	8.50	8.31	9.30	9.73	33.99	33.26	37.21	38.93
	Q_3	S_1	8.50	8.61	9.53	10.07	33.99	34.46	38.12	40.27
		S_2	7.85	8.50	8.47	9.28	31.39	34.02	33.91	37.12
	Q_4	S_1	7.28	8.16	8.02	9.09	29.11	32.67	32.09	36.37
		S_2	7.34	7.80	8.06	8.65	29.36	31.18	32.23	34.61
Mean I_2			8.39	8.72	9.27	9.93	33.57	34.90	37.09	39.73
I_3	Q_1	S_1	9.81	10.16	10.89	11.31	39.25	40.63	43.55	45.26
		S_2	9.59	9.96	10.48	1.08	38.36	39.83	41.92	44.33
	Q_2	S_1	9.01	9.32	10.00	10.32	36.05	37.29	40.03	41.32
		S_2	8.57	8.73	9.58	9.69	34.28	34.91	38.30	38.76
	Q_3	S_1	8.88	9.40	9.92	10.49	35.52	37.63	39.70	41.97
		S_2	8.26	9.31	9.14	10.43	33.04	37.26	36.58	41.74
	Q_4	S_1	7.70	9.21	8.61	10.51	30.79	37.18	34.45	42.03
		S_2	7.48	9.00	8.56	10.04	29.93	36.00	34.26	40.16
Mean I_3			8.66	9.40	9.65	10.49	34.65	37.59	38.60	41.95
Mean I			8.32	8.77	9.21	9.82	33.27	35.09	36.82	39.26
LSD 0.05			0.0022	0.0063	0.017	0.0129	----	----	----	----
F test	I		***	**	**	***	----	----	----	----
	Q		**	**	**	**	----	----	----	----
	S		***	**	**	**	----	----	----	----
	I* Q		**	**	**	**	----	----	----	----
	I*S		**	NS	NS	*	----	----	----	----
	Q *S		**	**	**	*	----	----	----	----
	I* Q *S		**	**	NS	*	----	----	----	----

*, **, *** and NS: significant at $p \leq 0.05$, 0.01, 0.001or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.

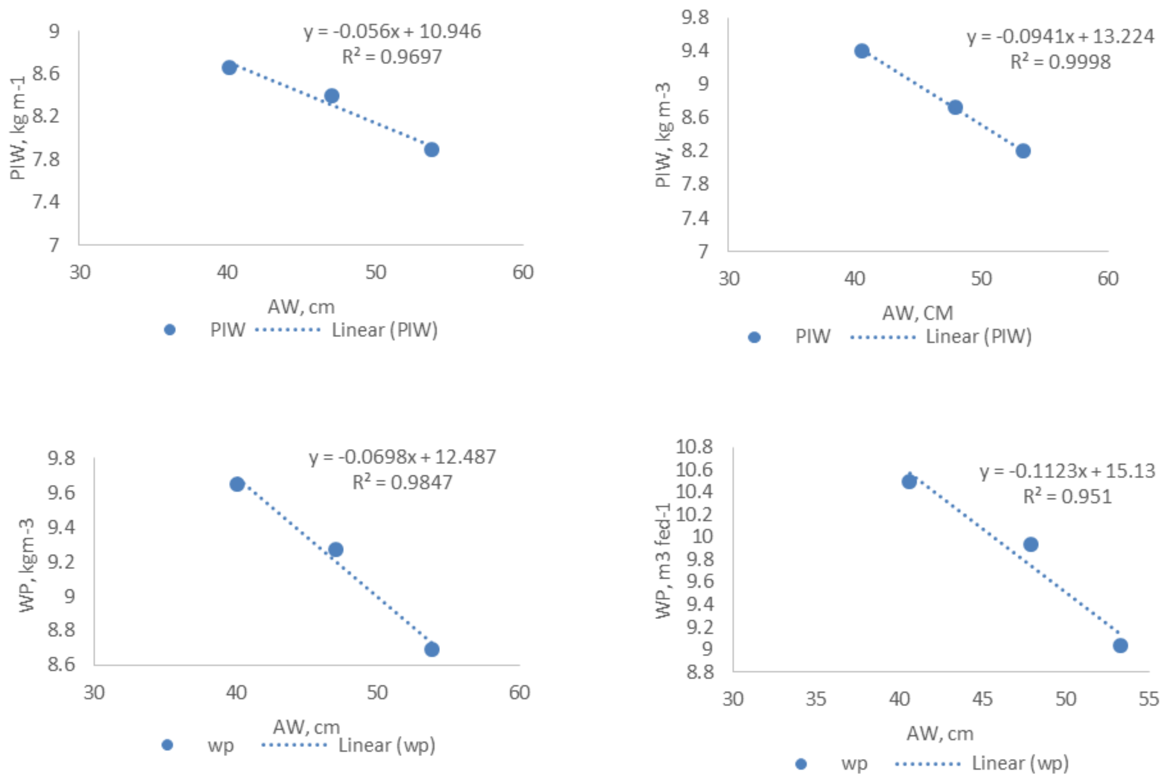


Fig. 2: Correlation between irrigation water applied, cm fed^{-1} and PIW, WP kg m^{-3} overall water quality and seed soaking in the two growing seasons.

Effect of irrigation interval, water quality and seed soaking on summer squash yield and its component.

Early and total fruit yield, kg fed-1

A squash fresh fruit early and fruit yield related to its corresponding uniform irrigation water applied interval in the two growing seasons as shown in Table 5 and Fig. 3 It decreased as water applied decreased in deficit irrigation due to plant stress causing by drier soil. Irrigation with I1 maximized squash yield and its component with the highest (5.99 and 17.89 ton fed-1); (5.91 and 18.40 ton fed-1) for early and fruit yield in both seasons respectively. On the other hand, the lowest value (4.88 and 14.62 ton fed-1); (4.80 and 16.05 ton fed-1) for early and fruit yield in both seasons respectively which yielded from the irrigation water applied of I3 (longer interval, 8days /interval). These findings are in agreement with those of Cabello et al. (2009) on melon showed that increasing irrigation intervals caused significant decreases in total fruit yield and marketable yield in the two summer seasons, also Amer (2011) found that squash yield, were significantly decreased by the reduction of applied irrigation water. These results showed that when the summer squash crop is given its irrigation water requirement every 4 days, 514.4 and 533.0 mm of water is required in first and second seasons respectively, but a Figure of 470.5 and 479.7 mm is required when deficit irrigation resulted in saving water of 8.6 % (≈ 185.8 m3 fed-1.,) and 10.0% (≈ 226.0 m3 fed-1.,) of the crop water requirement is applied in the two seasons with a reduction in fresh yield (≈7.1% and 4.5%) compared with the traditional or local irrigation. These results are agreement with Ertek et al. (2004) concluded that irrigation quantities had significant effects on summer squash yield and there were relationships between the yield and its components with irrigation water amount were positively linear.

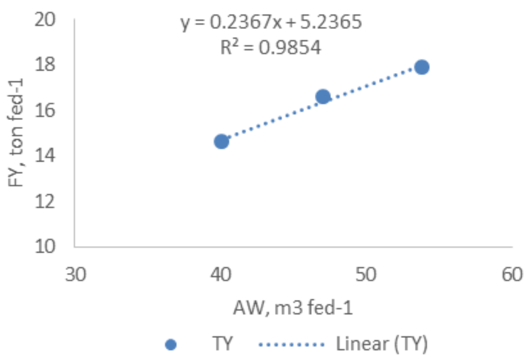
Squash fruit yield was significantly enhanced water quality had significant effects on early and yield. However, the significantly high values were achieved with Q 1 (irrigation water mixed with ozonated water + hydrogen peroxide) under all irrigation interval treatments early and yield exhibited lower values under other water quality and can be arranged in this descending order: Q 1> Q 2> Q3> Q4 under different irrigation treatments and soaking seeds. This positive effect may be by providing more strong plants capable of absorbing nutrients which reflected on different plant physiological process. These results are agreement with He et al., 2015

Concerning with the effect of soaking seeds, data in the same table obviously showed that, the mean values of summer squash early and fruit yield were significant affected by seed soaking in comparison with without soaking.

Regarding the interaction effect between irrigation, water quality and seed soaking treatments, it is clearly noticed that plants irrigated with I1, irrigation every 4 days and water quality mixed with ozonated water + hydrogen peroxide with seed soaking in most cases produced the maximum early and fruit yield per fed, in both seasons.

Table 5: Effect of irrigation interval, water quality and seed soaking on early and fruit yield (ton fed^{-1}), productivity of irrigation water (kgm^{-3}) and water productivity (WP, kg m^{-3}) for squash crop in the two growing seasons.

Irrigation Interval (I)	Water quality (Q)	Seed Soaking (S)	Early yield ton $fed.^{-1}$		Fruit yield ton $fed.^{-1}$		Rate of decrease in yield%	
			1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	Q_1	S_1	7.46	7.21	20.86	22.04	---	---
		S_2	6.28	6.65	19.80	21.24	5.08	3.63
	Q_2	S_1	6.63	6.26	18.65	19.51	10.6	11.48
		S_2	6.23	5.34	17.97	18.38	13.85	16.61
	Q_3	S_1	5.86	6.13	18.22	17.66	12.66	19.87
		S_2	5.34	5.33	16.36	17.13	21.57	22.28
	Q_4	S_1	5.32	5.75	15.60	16.16	25.22	26.68
		S_2	4.78	4.61	15.51	15.05	25.64	31.76
Mean I_1			5.99	5.91	17.87	18.40	-----	-----
I_2	Q_1	S_1	6.88	6.53	19.48	20.36	-----	-----
		S_2	5.75	6.02	18.49	19.62	5.08	3.63
	Q_2	S_1	6.10	5.67	17.41	18.03	10.62	11.44
		S_2	5.67	4.87	16.78	16.99	13.86	16.55
	Q_3	S_1	5.40	5.58	16.81	17.42	13.71	14.44
		S_2	4.91	4.85	15.22	16.70	21.87	17.98
	Q_4	S_1	4.79	5.23	14.32	16.29	26.49	19.99
		S_2	4.31	4.20	14.29	15.26	26.64	25.05
Mean I_2			5.48	5.37	16.60	17.58	-----	-----
I_3	Q_1	S_1	6.13	5.81	17.17	18.13	-----	-----
		S_2	5.15	5.35	16.29	17.48	5.13	3.59
	Q_2	S_1	5.11	5.04	15.34	16.06	10.66	11.42
		S_2	5.38	4.33	14.78	15.13	13.92	16.55
	Q_3	S_1	4.33	5.01	14.79	15.94	13.86	12.08
		S_2	4.75	4.35	13.40	15.58	21.96	14.07
	Q_4	S_1	4.31	4.70	12.66	15.48	26.27	14.62
		S_2	3.87	3.77	12.55	14.57	26.91	19.64
Mean I_3			4.88	4.80	14.62	16.05	-----	-----
Mean I			5.45	5.36	16.36	17.34	-----	-----
LSD 0.05			0.012	0.011	0.043	0.262	-----	-----
F test	I		***	***	***	***	-----	-----
	Q		**	***	***	**	-----	-----
	S		**	**	***	**	-----	-----
	I* Q		NS	NS	NS	NS	-----	-----
	I*S		NS	*	NS	NS	-----	-----
	Q *S		**	**	*	*	-----	-----
	I* Q *S		NS	NS	NS	NS	-----	-----



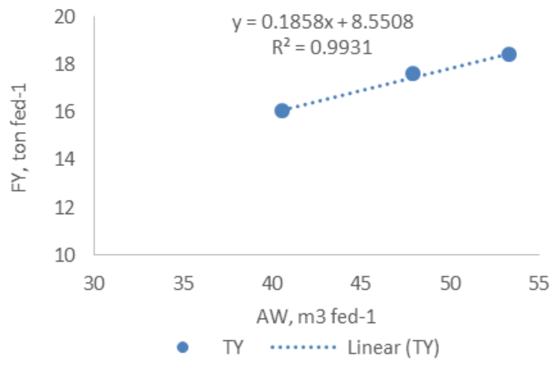


Fig. 3: Correlation between irrigation water applied, cm fed^{-1} and fruit yield ton fed^{-1} overall water quality and seed soaking in the two growing seasons.

On the other hand, for rate of decreasing yield %, irrigation every 4 days, water quality (irrigation water mixed with ozonated water + hydrogen peroxide) and soaking seeds (I1Q1S1) gave the highest yield Then there was a decrease in the crop with the highest rate recorded under water quality (Q4) and without soaking (S2) ≈ 25-30% of the fruit yield. These results may be due to the fact of irrigation every 4 days and irrigation water mixed with ozonated water + hydrogen peroxide with seed soaking seem to give the strongest impulse to when applied in the faster available of nutrients and strong plants due to increase effective roots and hence fresh vegetative cover and total yield. A positive linear relationship was obtained between applied water, cm and fruit yield, ton fed-1 (fig 2). They are highly significant with correlation coefficient values, r = 0.98 and 0.99 in the first and second seasons respectively. The positive relationship indicated that fruit yield, ton fed-1 increased with the applied water increased.

Fruit weight, g

A squash fresh fruit weight, gm related to its corresponding uniform irrigation water applied interval in the two growing seasons as shown in Table 5. It decreased as water applied decreased in deficit irrigation due to plant stress causing by drier soil. Irrigation with I1 maximized squash fruit weight with the highest (141.90 and 145.41 g) in both seasons respectively. On the other hand, the lowest values (118.47 and 119.64 g) in both seasons respectively which yielded from the irrigation water applied of I3 (longer interval, 8 days /interval). Fruit weight decreased by increasing irrigation interval, due to a reduction of the available water in the active root zone, which caused a disturbance in the physiological processes needed for plant growth then effect directly on fruit weight, g. These results are in agreement with Farag et al (2015) who reported that the highest fruit weight was achieved with highest irrigation quantity and fruit weight tended to decrease when irrigation water decreased. Also, data represented significant superiority of Q1 (irrigation water mixed with ozonated water + hydrogen peroxide) compared to Q2, Q3 and Q4 over all treatments. In addition, S1 had a clear effect on all treatments compared to S2. The results recorded the same trend for both seasons 2017 and 2018.

Table 5: Effect of irrigation interval, water quality and seed soaking on fruit weight (g), TSS (%) and Chlorophyll, (mgdm^{-2}) for squash crop in the two growing seasons.

Irrigation Interval (I)	Water quality (Q)	Seed Soaking (S)	Fruit Weight (g.)		TSS %		Chlorophyll, (mgdm^{-2})	
			1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	Q_1	S_1	163.66	171.80	4.94	5.07	46.51	47.28
		S_2	161.00	165.53	4.82	4.92	44.14	45.28
	Q_2	S_1	155.00	155.63	4.72	4.88	41.22	43.11
		S_2	123.33	146.96	4.21	4.55	37.00	38.53
	Q_3	S_1	142.36	142.33	4.61	4.79	30.75	32.70
		S_2	13883	131.83	4.45	4.66	38.22	39.51
	Q_4	S_1	134.17	130.10	4.47	4.46	34.60	34.53
		S_2	116.83	119.13	4.23	4.29	29.32	31.38
Mean I_1			141.90	145.41	4.56	4.70	37.72	39.04
I_2	Q_1	S_1	148.12	155.30	4.50	4.60	43.25	43.59
		S_2	145.27	149.64	4.39	4.46	41.04	41.75
	Q_2	S_1	140.27	140.69	4.30	4.43	38.33	39.75
		S_2	130.26	133.44	3.83	4.13	34.31	35.65
	Q_3	S_1	127.03	129.23	4.15	4.37	28.35	30.48
		S_2	12276	119.35	4.01	4.25	35.23	36.82
	Q_4	S_1	111.60	118.13	4.02	4.07	31.09	32.18
		S_2	105.73	108.17	3.81	3.92	27.03	29.24
Mean I_2			128.88	145.41	4.13	4.28	34.83	36.18
I_3	Q_1	S_1	137.48	138.96	4.06	4.11	39.81	40.95
		S_2	135.24	133.92	3.97	3.98	37.78	39.12
	Q_2	S_1	130.20	125.90	3.87	3.96	35.28	37.34
		S_2	117.60	120.65	3.44	3.67	31.36	33.08
	Q_3	S_1	114.67	116.85	3.75	3.83	26.29	27.60
		S_2	110.82	107.18	3.62	3.73	32.68	33.34
	Q_4	S_1	103.60	106.85	3.63	3.58	29.58	29.14
		S_2	98.14	106.81	3.44	3.44	25.07	26.48
Mean I_3			118.47	119.64	3.72	3.79	32.23	33.38
Mean I			129.75	132.27	4.30	4.26	34.93	36.20
LSD 0.05			3.976	3.606	5.316	5.937	0.090	0.123
F test		I	***	**	***	**	***	***
		Q	***	**	***	**	***	***
		S	***	**	**	**	***	***
		I* Q	NS	NS	NS	*	*	*
		I*S	NS	*	NS	NS	NS	NS
		Q *S	*	*	**	**	**	**
		I* Q *S	NS	NS	NS	NS	*	NS

*, **, *** and NS: significant at p ≤ 0.05, 0.01, 0.001or not significant, respectively. Means separated at P≤ 0.05, LSD test.

Total soluble solids content (TSS), %.

Data in the same previous Table indicated that TSS% was significantly influenced due to water applied interval, water quality and seed soaking in the two growing seasons. For water applied the highest TSS% were 4.56 and 4.70%, in 1st and 2nd seasons with irrigation every 4 days, respectively. Total soluble solids content, % tended to decrease when irrigation water decreased (increasing interval) and the data represented also significant superiority of Q1 (ozonated water + hydrogen peroxide) compared to Q2, Q3 and Q4 over all treatments. In addition, S1 had a clear effect on all treatments compared to S2. The results recorded the same trend for both seasons 2017 and 2018. These results were in harmony with Farag et al (2015) they revealed that the highest TSS% were obtained with traditional irrigation, respectively and total soluble solids% tended to decrease when irrigation water decreased.

Chlorophyll, mgdm-2

Data in Table 5 showed that chlorophyll content significantly affected due assessed irrigation intervals. The highest figures which amounted to 37.72 and 39.04 mgdm-2, in 1st and 2nd seasons, were attained with irrigation every 4 days interval, respectively. Leaves chlorophyll content seemed to decrease, gradually, with reducing the longest irrigation interval. In this sense, Lessani and Mojtahedi (2002) reported that water deficit can destroy the chlorophyll resulting in a lowered capacity for light harvesting. Moreover, Herbinger et al. 2002 stated that degradation of the absorbing pigments is negatively affected the production of reactive oxygen species which are mainly driven by excess energy absorption in the photosynthetic apparatus. Water quality exhibited higher chlorophyll content values reached to Q1(irrigation water mixed with ozonated water + hydrogen peroxide), in the two seasons. The values showed chlorophyll content significantly affected with seed soaking that seed soaking is higher than without soaking under overall irrigation interval and water quality

Effect of irrigation interval, water quality and seed soaking on summer squash vegetative component.

Data listed in Table 6 showed that irrigation water treatments caused significant effect on all vegetative growth parameters in both summer seasons; plant height, number of leaves and plant leaf area had the highest mean values under treatment I1 (irrigation every 4 days) in comparison with I2 and I3. The mean values were 62.15 and 62.93 cm for plant height, 20.14 and 20.45 for number of leaves/ plant and 2527.61 and 2533.69 cm2 for leaf area/ plant in the first and second seasons respectively. Also, increasing the mean values of the abovementioned studied parameters under irrigation treatments (I1) comparing with irrigation treatment (I2 and I3) which longer interval with water stress under different growth stages because of forming plants with thick vegetative cover by increasing amount of applied water, this encourages plants to grow well under easy obtaining their water needs and hence, increasing amount of nutrients uptake and content in plants. These results are agreement with Frag et al (2015) they concluded that all vegetable growth parameters were deceased when irrigation water requirements deceased.

Table 6: Effect of irrigation interval, water quality and seed soaking on Plant height (cm), No of leaves/ plant and Leaf area /plant(cm^2) for squash crop in the two growing seasons.

Irrigation Interval (I)	Water quality (Q)	Seed Soaking (S)	Plant height (cm)		No of leaves/ plant		Leaf area /plant(cm^2)	
			1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	Q_1	S_1	70.58	71.62	25.57	25.88	2993.3	2991.7
		S_2	69.60	69.45	23.23	23.80	2949.6	2944.0
	Q_2	S_1	64.83	66.62	21.50	21.83	2790.0	2762.0
		S_2	57.50	56.73	19.53	19.25	2465.5	2468.3
	Q_3	S_1	61.22	61.73	17.28	17.88	2391.2	2408.5
		S_2	61.60	63.58	19.55	20.00	2099.0	2132.5
	Q_4	S_1	59.16	59.98	18.25	18.23	2574.0	2599.7
		S_2	52.73	53.73	16.23	16.73	1958.3	1962.8
Mean I_1			62.15	62.93	20.14	20.45	2527.61	2533.69
I_2	Q_1	S_1	64.23	63.74	23.78	24.07	2694.0	2677.5
		S_2	63.34	61.81	21.61	22.13	2654.6	2634.9
	Q_2	S_1	59.00	59.30	19.99	20.31	2511.0	2471.9
		S_2	52.33	50.49	18.17	17.90	2218.9	2209.2
	Q_3	S_1	55.71	54.94	16.07	16.63	2152.1	2155.6
		S_2	56.06	56.58	18.18	18.60	1889.1	1908.6
	Q_4	S_1	53.84	53.38	16.97	16.96	2316.6	2326.7
		S_2	47.99	47.82	15.09	15.56	1762.5	1756.7
Mean I_2			56.56	56.01	18.73	19.02	2274.85	2267.64
I_3	Q_1	S_1	59.29	58.73	20.70	20.97	2394.7	2408.2
		S_2	58.46	56.94	18.81	19.28	2359.6	2369.9
	Q_2	S_1	54.46	54.93	17.42	17.69	2232.0	2223.4
		S_2	48.30	46.52	15.82	15.59	1972.4	1987.0
	Q_3	S_1	51.43	50.62	14.00	14.49	1912.9	1938.8
		S_2	51.74	52.14	15.83	16.20	1679.2	1716.7
	Q_4	S_1	49.69	49.18	14.78	14.77	2059.2	2092.7
		S_2	44.30	44.09	13.15	13.55	1566.7	1580.1
Mean I_3			52.21	51.64	16.31	16.57	2022.09	2039.60
Mean I			56.97	56.86	18.39	18.68	2274.85	2280.31
LSD 0.05			3.667	1.921	0.156	0.061	387.26	278.14
F test		I	***	**	***	***	***	***
		Q	***	**	**	***	***	***
		S	***	**	**	**	***	***
		I*Q	NS	NS	**	**	**	**
		I*S	NS	NS	NS	NS	**	**
		Q*S	*	*	**	**	**	**
		I*Q*S	NS	NS	NS	NS	NS	*

*, **, *** and NS: significant at p ≤ 0.05, 0.01, 0.001or not significant, respectively. Means separated at P≤ 0.05, LSD test.

Water quality caused significant effect on all vegetative growth parameters in both summer seasons; plant height, number of leaves and plant leaf area had the highest mean values under treatment Q1(irrigation water mixed with ozonated water + hydrogen peroxide), in the two seasons. The values showed all vegetative parameters significantly affected with soaking seeds that seed soaking is higher than without soaking under overall irrigation interval and water quality.

Effect of irrigation interval, water quality and seed soaking seeds on summer squash on N, P, K measured in squash leaves and portion, %: -

N, P and K % in squash leaves.

Presented data in Table (7) clearly illustrated that the mean values of nitrogen, phosphorus and potassium percentage in squash leaves were affected by both irrigation treatments, water quality and seed soaking in the two growing seasons. Concerning with, the effect of irrigation interval, the highest mean values for N, P and K percentage were recorded under irrigation treatment I1 (irrigation every 4 days) comparing with other irrigation stress treatments I2 and I4 (which exposed to water stress with longest interval) and the highest mean values are 3.40 and 3.17% for nitrogen and 0.40 and 0.40% for phosphorus and 3.33 and 3.27 for potassium in the first and second seasons, respectively. On the contrary, the lowest mean values were recorded under irrigation treatment I3 (high stress treatment, irrigation every 8 days) and the mean values are 3.04 and 2.28% for nitrogen and 0.36 and 0.38% for phosphorus and 3.00 and 2.97 for potassium in the first and second growing seasons, respectively. Increasing the mean values of nitrogen, phosphorus and potassium percentage under irrigation treatment (I1) in comparison with stressed treatments I2 and I3 might be attributed to increasing amount of water applied which leads to increasing availability of these nutrients. Consequently, increasing amount of nutrients percentage and hence increasing content in plant organs. These results are agreement with Martinez-Ballesta et al. (2010) who reported that one of the environmental stresses affecting mineral content is drought. Also, data in the same table clearly declared that the mean values of nitrogen, phosphorus and potassium percentage in squash leaves increased under irrigation water mixed with ozonated water + hydrogen peroxide (Q1) under overall irrigation interval and soaking treatments. Concerning with the effect of seed soaking (S1, S2) on nitrogen, phosphorus and potassium percentage in squash leaves, the presented data in the same table declared that the highest mean values for N, P and K percentage were recorded under S1 (seed soaking) under overall irrigation and water quality treatments

Protein, %.

Data listed in Table 7 shows that irrigation interval treatments, water quality and soaking seeds caused significant effect on protein content. Concerning the effect of irrigation interval, the highest mean values for protein content were recorded under irrigation treatment I1 (irrigation every 4 days) comparing with other irrigation treatments I2 and I3 (which exposed to water stress with longest interval) and the highest mean values are 20.49 and 19.37% for protein in the first and second seasons, respectively. Increasing the mean values of protein content under irrigation treatment (I1) in comparison with stressed treatments I2 and I3 might be attributed to increasing amount of water applied which leads to increasing availability of nutrients such as nitrogen. Consequently, increasing amount of nitrogen percentage and hence increasing nitrogen content in plant organs. Water quality caused significant effect on protein content in both summer seasons; the highest mean values were recorded under treatment Q1(irrigation water mixed with ozonated water + hydrogen peroxide), in the two seasons. The protein content significantly affected with seed soaking where, nitrogen content was higher with seed soaking under overall irrigation interval and water quality.

Table7: Effect of irrigation interval, water quality and seed soaking on N,P,K % in leaves and protein content % for squash crop in the two growing seasons.

Irrigation Interval (I)	Water quality (Q)	Seed Soaking (S)	N (%)		P (%)		K (%)		Protein (%)	
			1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
I_1	Q_1	S_1	3.83	3.66	0.44	0.48	3.66	3.55	23.00	21.95
		S_2	3.75	3.57	0.45	0.47	3.60	3.47	22.66	21.81
	Q_2	S_1	3.66	3.40	0.45	0.45	3.41	3.38	21.90	20.65
		S_2	3.43	3.09	0.41	0.42	3.28	3.27	20.57	18.53
	Q_3	S_1	2.97	2.79	0.35	0.36	3.11	3.08	18.05	17.25
		S_2	3.52	3.24	0.43	0.43	3.36	3.29	21.30	19.58
	Q_4	S_1	3.20	2.95	0.38	0.39	3.18	3.13	19.33	17.91
		S_2	2.81	2.68	0.32	0.36	3.01	2.99	17.13	17.28
Mean I_1			3.40	3.17	0.40	0.42	3.33	3.27	20.49	19.37
I_2	Q_1	S_1	3.69	3.46	0.41	0.44	3.45	3.21	20.85	20.26
		S_2	3.62	3.37	0.43	0.44	3.40	3.13	20.54	20.12
	Q_2	S_1	3.53	3.22	0.42	0.42	3.21	3.04	19.85	19.05
		S_2	3.28	2.92	0.39	0.40	3.09	3.08	18.71	17.05
	Q_3	S_1	2.81	2.64	0.33	0.35	2.93	2.91	16.55	15.75
		S_2	3.32	3.06	0.40	0.41	3.18	3.11	19.52	17.87
	Q_4	S_1	3.03	2.78	0.36	0.37	3.00	2.95	17.71	16.35
		S_2	2.66	2.53	0.30	0.34	2.85	2.82	15.71	15.63
Mean I_2			3.24	3.00	0.38	0.40	3.14	3.03	18.68	17.76
I_3	Q_1	S_1	3.44	3.25	0.39	0.43	3.31	3.24	19.08	18.21
		S_2	3.38	3.18	0.41	0.43	3.24	3.16	18.80	18.09
	Q_2	S_1	3.30	3.03	0.40	0.41	3.08	3.08	18.17	17.12
		S_2	3.07	2.75	0.37	0.38	2.96	2.97	17.02	15.47
	Q_3	S_1	2.64	2.48	0.32	0.32	2.81	2.80	14.84	14.55
		S_2	3.13	2.88	0.38	0.38	3.04	2.99	17.49	16.49
	Q_4	S_1	2.85	2.62	0.35	0.34	2.87	2.84	15.88	15.11
		S_2	2.51	2.38	0.29	0.32	2.72	2.71	14.09	14.58
Mean I_3			3.04	2.82	0.36	0.38	3.00	2.97	16.92	16.20
Mean I			3.23	3.00	0.38	0.40	3.16	3.09	18.70	17.78
LSD 0.05			0.047	0.032	0.005	0.004	0.033	0.030	0.326	0.345
F test	I		**	**	**	***	***	***	**	**
	Q		*	*	*	*	**	**	**	*
	S		*	*	*	*	**	**	*	*
	I*Q		*	*	NS	NS	*	*	*	*
	I*S		NS	NS	NS	NS	NS	*	NS	NS
	Q*S		*	*	NS	NS	*	*	*	*
	I*Q*S		NS	NS	NS	NS	NS	*	NS	NS

*, **, *** and NS: significant at $p \leq 0.05$, 0.01, 0.001or not significant, respectively. Means separated at $P \leq 0.05$, LSD test.

Conclusion and Recommendation

The practical conclusion to be drawn from the experiment is that, on the basis of the data, it should be producing squash fruits of more than adequate quality under North of Nile Delta conditions, it is advisable to irrigate squash crop under drip irrigation system every 4 days, water quality using oxygenated water; mixed water with ozonated water plus hydrogen peroxide and seed soaking in ozonated water in the two growing seasons. Investigation should focus on this issue and evaluates the efficiency of the irrigation water interval and water quality for squash production in North of Nile Delta region.

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