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Management of Irrigation and Nitrogen Fertilization for Squash Grown at Different Plantation Seasons under Assiut Governorate Conditions

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ABSTRACT

Two field experiments were carried out during spring and autumn of 2017 and 2018 at the Experimental Farm of Agricultural Research Station, Arab El-awammer, Assiut Governorate, Egypt. The investigation amid to study the effect of irrigation regimes and partially substitution of inorganic-N fertilizer with biofertilizer on growth, flowering, yield and yield attributes as well as water productivity of squash under different plantation seasons using drip irrigation system. The treatments were three irrigation regimes (1.0, 0.8 and 0.6 IW: CPE) and four N fertilization application (P_1: 100% inorganic-N, P_2: 25% inorganic N+ Biogein, P_3: 50% inorganic N+ Biogein and P_4: 100% inorganic N+ Biogein). Squash (*Cucurbita pepo* L.) zucchini type cv "Eskandarany" seeds were sown in holes on 1st April at spring season and 1st September in autumn season. The results indicated that autumn sown surpassed spring sown in most studied traits, except growth traits, number of female flowers and fruit diameter. Irrigation squash plants at 1.0 IW: CPE and fertilized with 100% inorganic-N + biofertilizer (Biogein) recorded the highest values of growth traits such as plant hieght and number of leaves plant^{-1}. Applying 1.0 or 0.8 IW: CPE enhanced the response of squash plants to the Nitrogen fertilization treatments that containing 100% inorganic-N + biofertilizer (Biogein), consequently, increasing the yield of squash. 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). Physical irrigation water productivity values were ranged from 2.64 to 3.17 kg m^{-3} at spring season, whereas they ranged from 4.73 to 5.31 kg m^{-3} at autumn season under the same irrigation treatment. The same irrigation regime was surpassed the other irrigation regimes on EIWP values, where they were 8.99 and 10.76 L.E. m^{-3} at spring season; 16.08 and 18.06 L.E. m^{-3} at autumn season. It could be concluded that planting squash plants in autumn season saved 30.65 to 34.53% of irrigation water compared with spring season. Irrigating squash plants with 0.8 IW: CPE plus fertilizing with 100% inorganic-N+ biofertilizer (Biogein) to save about 20% of irrigation water and improve squash productivity.

Keywords: squash, plantation season, water productivity, actual evapotranspiration

Introduction

Summer squash (*Cucurbita pepo* L.) is one of the most important Cucurbits crops in Egypt. It is a summer crop, but can be grown over year. Squash fruits had high nutritional values due to their high contents of carbohydrates, amino acids, vitamins and minerals. The cultivated area of squash was 22761 ha on small fields which are less than 1 ha (Economic Affairs Sector, (EAS), 2016).

In the recent years, the safe agriculture is one of the main interests in the world; also there has been an increasing awareness of the undesirable impact of mineral fertilizers on the environment, as well as the potentially dangerous effect of chemical residues in plant tissues on the health of human and animal consumers. As a result of this awareness, strict regulations have been imposed in several countries (especially in the European markets) prohibiting the import of "chemically- grown" products. This has led growers of vegetable plants in many countries to adopt organic and biological agricultural methods (for fertilization, pest control, .etc).Bio-manure is a characteristic item conveying living microorganisms got from the root or developed soil. So they don't have any evil impact on soil wellbeing and condition. Other than their job in environmental nitrogen obsession and phosphorous solubilisation, these additionally help in animating the plant development hormones giving better supplement take-up and expanded resilience towards dry spell and dampness stress. A little portion of bio-compost is adequate to create alluring outcomes in light of the fact that every gram of bearer of

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bio-manures contains something like 10 million practical cells of a particular strain. Bio-manures implies the item containing bearer base (strong or fluid) living microbial arrangements which are agronomically valuable as far as nitrogen obsession, phosphorus solubilization or supplement assembly to expand the profitability of the dirt and additionally crop. Natural nitrogen obsession is one method for changing over essential nitrogen into plant usable structure (Gothwal *et al*., 2007). Nitrogen-fixing microorganisms (NFB) that work change latent air N2 to natural mixes (Bakulin *et al*., 2007). The capacity of these microorganisms to add to yields in harvests is just mostly a consequence of natural N2-obsession. The Mechanisms included have a critical plant-development advancement potential. In these connections the microorganisms get non-explicit photosynthetic carbon from the plant and, thusly, give the plant with fixed nitrogen, hormones, flag particles, nutrients, iron, and so forth (Kavadia *et al*., 2007; Mikhailouskaya and Bogdevitch, 2009). Past investigations demonstrated that the blend of biofertilizers with natural or compound composts additionally upgraded the biomass and grain yield of harvests (Azzan *et al*., 2009; Yasari *et al.,* 2008; Anjum *et al*., 2007). Therefore, partial replacement of inorganic-N by the use of more safe such as biofertilizers in producing squash crop is strongly recommended. Irrigation is one of the limiting agricultural managements in the production of the squash. Programming irrigation frequency and quantity to maximize water use without any decrement in yield is very important (Hassan, 2009). The present work investigates the response of squash to the mutual effects of irrigation regimes and N fertilization programs under different sown seasons.

Materials and Methods

Two field experiments were carried out during spring and autumn 2017 and 2018 at the Experimental Farm of Agricultural Research Station, Arab El-awammer, Assiut Governorate, Egypt. The investigation amid to study the effect of irrigation regimes and partially substitution of inorganic-N fertilizer with biofertilizer on growth, flowering, yield and yield attributes as well as water productivity of squash under different plantation seasons under drip irrigation. The treatments were three irrigation regimes (1.0, 0.8 and 0.6 IW: CPE) and four N fertilization treatments (P_1: 100% inorganic-N, P_2: 25% inorganic. N+ Biogein, P_3: 50% inorganic. N+ Biogein and P_4: 100% inorganic. N+ Biogein). The soil texture was sand; the characteristics of the soil were: average bulk density 1.58 g cm^{-3}, field capacity 11% (v v^{-1}), wilting point 4.5% (v v^{-1}), pH (1:1) 8.2, EC (1:1) 0.41 dS m^{-1}, organic matter 0.24%, available N, P and K 27, 7.32 and 150 ppm, respectively (averaged over of the 2016 and 2017 for 0-0.6 cm of soil depth). Data in Table (1) show the weather data of the experimental site according to Assiut agro-meteorological station as average of the 2017 and 2018 seasons.

The experiment was laid out in split plot design with four replications. The main plots were assigned for irrigation regimes; meanwhile sub plots were assigned for N fertilization programs. The drip system is set up of GR polyethylene pipe 16 mm in diameter auto emitter every 50 cm and 50 cm apart between drip lines with flow rate of 4 liter $hour^{-1}$ at 1.5 bars. The plot area was 15 m^2 (each plot consists of five raw 3 meters long and Squash was planted with 50 cm between plants and 100 cm between rows. There was 1.5 m separation between each treatment and plot to avoid the horizontal seepage. Biogein is a commercial biofertilizer produced by the General Organization for Agricultural Equalization Fund, Ministry of Agriculture and Land Reclamation, Egypt. It is contained nitrogen fixing bacterium namely, *Azotobacter chroccocum* Dutch; Beijerinck. Arabic gum was melted in amount of warm water and was added to the Biogen. Squash seeds were added to the mixture of Biogen and the gum with mixed carefully and spread over plastic sheet in shadowed place for a one hour before sowing. Squash (*Cucurbita pepo* L.) zucchini type cv "Eskandarany" seeds were sown in holes on 1st April at spring season and 1st September in autumn season; plants were terminated on 30 December and 15 June in both 2017 and 2018 at spring and autumn growing seasons, respectively. Nitrogen fertilizer was applied at a rate of 90 kg fed^{-1} as ammonium nitrate (33.5% N). Phosphorous and potassium fertilizers were applied at rates 30 kg P_2O_5 fed^{-1} and 24 kg K_2O fed^{-1} as phosphoric acid and potassium sulfate (50% K_2O). Inorganic-N, P and K levels for each treatment were splitted into 12 equal doses and injected through the irrigation water. The injection of N, P and K fertilizers through the irrigation water usually starts after 15 minutes from the beginning of the irrigation period and stops 15 minutes before the termination of irrigation to insure the washing of irrigation lines. The irrigation treatments started at 20 days after planting date. All experimental units received equal amounts of water during this period. The amount of irrigation water applied to each treatment during the irrigation regime was estimated by using the following equation according Vermeirem and Jobling (1980):

Table. 1. Meteorological average data at Assiut during the two growing 2017 and 2018 seasons.

Month	Temperature (°C)			RH%	Wind speed (ms^{-1})	Solar radiation (MJm^{-2} d^{-1})
	Max	Min	Mean			
				Spring 2017		
Mar	28.1	13.2	20.6	31.5	4.8	21.3
Apr.	35.1	17.1	26.2	27.7	4.7	26.9
May	36.1	20.0	28.3	28.0	5.6	27.2
June	40.7	24.6	33.0	37.9	5.4	27.8
Mean	35.0	18.7	27.0	31.3	5.1	25.8
				Autumn 2017		
Sept.	35.0	21.6	28.1	43.5	6.0	21.3
Oct.	32.8	17.7	24.8	49.5	5.3	19.1
Nov.	27.1	12.8	19.4	54.5	4.2	15.3
Dec.	19.9	6.3	12.8	59.3	4.6	13.5
Mean	28.7	14.6	21.3	51.7	5.0	17.3
				Spring 2018		
Mar	25.3	11.0	18.2	36.6	4.8	20.9
Apr.	31.3	15.5	23.5	31.4	4.8	25.2
May	36.3	20.0	28.4	34.6	4.5	27.4
June	37.4	23.4	30.7	32.7	5.8	25.9
Mean	32.6	17.5	25.2	33.8	5.0	24.9
				Autumn 2018		
Sept.	35.3	20.9	28.0	44.6	5.8	22
Oct.	30.3	16.5	23.2	47.0	4.8	18.2
Nov.	25.1	10.9	17.6	54.6	4.2	15.3
Dec.	23.0	9.0	15.5	58.8	4.0	13.7
Mean	28.4	14.3	21.1	51.2	4.7	17.3

$$IWA = \frac{A \times IW : CPE \times I_i \times K_r}{E_a \times 1000 \times (1 - LR)}$$

Where: IWA is the irrigation water applied (m^3), A is the (m^2), IW: CPE is the cumulative pan evaporation (mm day^{-1}), I_i is the irrigation intervals (day), Ea is the application efficiency (%) (Ea= 85), LR is leaching requirements (0.2), Kr covering factor and to calculate (Kr).

The daily pan evaporation data was used for scheduling irrigation. Irrigation treatments were given once in three days interval. The pan was located near the experimental research station field. The following equation (Doorenbos and Pruitt, 1977) was used to calculate the potential evapotranspiration (ETp):

$ET_p = E_{pan} \times K_{pan}$

where:

E_{pan} = pan evaporation (mm day^{-1})

K_{pan} = pan coefficient (0.7)

Actual crop evapotranspiration was measured directly by measuring changes in soil water content using Time Domain Reflectometry (TDR); model MP-917 at 0 to 0.6 m soil depth, according to Israelson and Hansen (1962) as follows:

$$ET_a = \sum_{i=1}^{n=4} (\theta_2 - \theta_1) \times d / 100$$

Where: ET_a, n, θ_1, θ_2 and d are actual crop evapotranspiration, number of layers, soil moisture % before irrigation (v v^{-1}), soil moisture % 24 h after irrigation (v v^{-1}) and soil depth (cm), respectively.

Crop coefficient (K_c) values were calculated using actual ET_a and ET_o estimates at different stages of plant growth under optimum soil moisture conditions (1.0 IW:CPE) during spring and autumn growing seasons. Reference evapotranspiration (ET_o) was determined from weather data collected at Assiut area using FAO56 Penman-Monteith (Allen *et al*., 1998) to calculate crop coefficient (K_C) under 1.0 IW:CPE regime as follows:

$$Kc = \frac{ET_a}{ET_o}$$

Where: ET_o and ET_a are reference and actual crop evapotranspiration.

All cultural practices were followed as recommended for squash crop through the two growing seasons under this region condition.

A random sample of ten plants from each treatment was used for measuring plant hieght(cm) 45 days after sowing, number of leaves plant^{-1}, number of produced female and male flowers, sex ration (male/female flowers), average fruit length and fruit diameter (cm) and average fruit weight (g). During the production season, fruits were harvested at two days intervals, counted and then weighted and number of fruits plant^{-1} was recorded. Early yield was determined from the early 4 harvests, whereas the average total yield was recorded during the whole harvesting period (ton fed^{-1}). As well as fruit set percentage was calculated based on the following equation:

$$Fruit\ set\ (\%) = \frac{Number\ of\ fruits\ per\ plant}{Total\ of\ number\ of\ female\ flowers\ per\ plant} \times 100$$

Irrigation water productivity (IWP) can be expressed as physical productivity (PIWP) and economical productivity (EIWP) according to Molden (1997). It was calculated as follows:

$$PIWP\,(kg\,m^{-3}) = \frac{Fruit\ yield\,(kg\ fed^{-1})}{Total\ amount\ of\ irrigation\ water\ applied\,(m^3\,fed^{-1})}$$

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

$$Water\ saving = 100 - \left(\frac{Water\ consumption\ of\ deficit\ treatment}{Water\ consumption\ of\ optimal\ treatment} \times 100\right)$$

Statistical analysis

The obtained data were subjected to standard analysis of variance and the means of treatments were tested for significant differences using the least significant difference method (LSD) at P = 0.05 probability. The MSTATC (version 2.10) computer program written by Freed *et al*. (1987) was used to perform all the analysis of variance. A combined analysis was performed for each trait over the two seasons.

Results and Discussion

1. Vegetative growth characters

Data presented in Table (2) show the effect of irrigation regimes and N fertilization programs on growth traits under spring and autumn growing seasons. Plant height and number of leaves plant^{-1} in the spring season were higher than autumn season under all tested treatments. Plant height increased by 3.29 and 2.51%, meanwhile number of leaves was enhanced by 24.42 and 24.56% in spring season compared with autumn season in 2017 and 2018, respectively.

It is quite clear that irrigation regimes had significant effects on plant height and number of leaves plant^{-1} of squash in spring season. Irrigation with 1.0 IW: CPE gave the tallest plants and highest number of leaves plant^{-1} under spring and autumn seasons compared with the other two irrigation regimes. However, increasing the irrigation water up to 1.0 IW: CPE had not significant effects on plant height compared with 0.8 IW: CPE at spring season only. Data also indicate that increasing the water deficit from 20% (0.8 IW: CPE) to 40% (0.6 IW: CPE) decreased significantly

Table. 2. Effect of irrigation regimes and N fertilization treatments on growth traits of squash during spring and autumn seasons in 2017 and 2018.

Treatments		Plant height(cm)				No. leaves plant^{-1}			
		2017		2018		2017		2018	
		Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Irrigation regimes									
1.0 IW:CPE		52.05	47.63	51.28	46.73	28.28	27.03	28.16	27.20
0.8 IW:CPE		50.83	40.15	50.34	39.73	25.43	25.08	25.40	25.03
0.6 IW:CPE		44.90	31.00	43.62	30.15	22.40	21.57	21.40	20.89
LSD 0.05		**3.41**	**0.66**	**3.37**	**1.70**	**1.93**	**0.23**	**1.82**	**0.63**
Fertilization program									
Inorganic-N (P_1)		54.20	43.50	53.40	42.53	27.07	26.13	26.87	26.27
25% Inorganic N+Biogein (P_2)		41.33	32.17	40.96	31.67	22.43	21.66	21.70	21.17
50% Inorganic. N+Biogein (P_3)		46.07	37.73	44.98	37.27	24.30	23.87	24.10	23.63
100% Inorganic. N+Biogein (P_4)		55.44	44.97	54.32	44.00	27.67	26.58	27.28	26.43
LSD 0.05		**2.38**	**1.41**	**2.90**	**1.56**	**1.34**	**0.23**	**1.41**	**0.69**
Interaction effect									
1.0 IW:CPE	**P1**	60.30	52.50	60.00	51.30	30.80	28.80	30.50	29.00
	P2	40.00	40.00	39.30	39.30	24.00	24.00	23.50	23.50
	P3	44.90	44.70	43.93	43.70	26.30	26.30	27.00	26.80
	P4	63.00	53.30	61.90	52.60	32.00	29.00	31.63	29.50
0.8 IW:CPE	**P1**	55.30	45.00	54.60	44.60	26.80	26.80	27.80	27.80
	P2	42.00	31.50	42.30	31.00	22.30	22.00	21.30	21.00
	P3	50.30	38.50	49.70	38.50	25.30	24.30	25.00	23.80
	P4	55.73	45.60	54.75	44.80	27.30	27.23	27.50	27.50
0.6 IW:CPE	**P1**	47.00	33.00	45.60	31.70	23.60	22.80	22.30	22.00
	P2	42.00	25.00	41.28	24.70	21.00	18.98	20.30	19.00
	P3	43.00	30.00	41.30	29.60	21.30	21.00	20.30	20.30
	P4	47.60	36.00	46.30	34.60	23.70	23.50	22.70	22.28
Mean		**49.26**	**39.59**	**48.41**	**38.87**	**25.37**	**24.56**	**24.99**	**24.37**
LSD 0.05		**4.13**	**2.44**	**5.02**	**2.70**	**2.32**	**0.39**	**2.44**	**1.19**

all growth traits in spring and autumn seasons. These results are in agreement with those of Amer (2011) and AbdEl-Mageed and Semida (2015) on squash.

The results show that the different N fertilization programs significantly affected on Plant height and number of leaves per plant. Application of 100% inorganic-N + biogein (P_4) gave the tallest plants and highest leaves number followed by 100% inorganic-N (P_1) without significant differences. Partial substitution of 50% of inorganic-N by Biogein (P_3) came in the third rank. The highest values of plant height and umber of leaves due to the combined application of inorganic-N with biofertilizer (Biogein) may be attributed to the continuous supply of nitrogen through all growth stages with beneficial association between chemical fertilizer and biofertilizer. Leaching losses of nitrogen must have been minimized by use of biofertilizer, which have ability to mobilize nutritionally important elements from non-usable form to usable forms (Yuvaraj, 2016).

The recorded data in Table (2) clearly indicated that, for all tested N fertilization programs, Plant height and number of leaves per plant was increased with increasing the amount of irrigation water delivered. The highest plant height and number of leaves were obtained using the N fertilization programs that 100% inorganic-N + Biogein. This means that applying 1.0 IW: CPE enhanced the response and the growth of squash plants to the N fertilization program that containing 100% inorganic-N + biofertilizer (Biogein).

2. Flowering characters

The influence of growing season on number of male and female flowers as well as sex ratio and fruit set is shown in Table (3). The number of male flowers, sex ratio and fruit set in autumn season were 3.56-6.66, 10.07-14.18 and 19.38-21.62% more than spring season. This trend was differed, where there are more female flowers during the spring season by 2.55-2.99% compared with autumn season in 2017 and 2018, respectively. This may be attributed to a strong female sex expression due to increase temperature and both high light intensity and long photoperiod tend to reduce female flower formation (Hassan, 1988; Mohamed *et al*., 2003).

Irrigation regimes had significant effects on number of male and female flowers per plant as well as sex ratio and fruit set of squash plants, except number of male flowers in spring season and fruit set in spring 2018. Increasing irrigation water deficit up to 0.6 IW: CPE decreased number of male and female flowers per plant in most cases. Meanwhile, irrigated squash plants with 0.6 IW: CPE gave the highest values of sex ratio. These increments of sex ratio associated with water deficit may be due to increase carbohydrate accumulation (Amer *et al*., 2009). However, irrigating squash plants with 0.8 IW: CPE gave the highest fruit set in spring season, while 0.6 IW: CPE regime recorded the greatest values of fruit set in autumn season.

Number of male flowers was extrusive significantly increased by increasing inorganic-N rate in N fertilization program from 25 to 100%. Similar results were reported by Kraup *et al*. (2002) and Refai *et al*. (2010), who reported that increasing N level encouraged male flowers rather than female flowers. On the other hand, fertilization programs that contained 100% inorganic-N+ biofertilizer (Biogein) enhanced number of female flowers of squash compared with other fertilization programs. Using fertilization program that contained 25% inorganic-N+ biofertilizer (P_2) gave the highest values of sex ration and fruit set. This positive impact may be due to improve soil biological properties, directly affecting root growth, production of phytohormones by bacteria, enhancement mineral uptake and transfer of nitrogen to the plant (Gharib *et al.,* 2008) as well as may be due to the role of nitrogen in building new merestemic cells, cell elongation and increasing photosynthesis activity which cause more florets fertility (Waly, 2008). In the same context, Abd El-Fattah and Sorial (2000) reported that biofertilizer treatments significantly enhanced the induction of female flowers and reduced male flowers in squash plant.

The effect of interaction effect among irrigation regimes and N fertilization programs on studies traits was significant in most cases. Irrigation squash plants at 1.0 or 0.8 IW:CPE and fertilized with 100% inorganic-N + bioferilizer or 50% inorganic-N + bioferilizer recorded the highest values of number of male and female flowers compared with other interaction treatments in spring and autumn seasons. Meanwhile, squash sex ratio exhibited the maximum values when applying the higher water stress (0.6 IW: CPE) with 25% inorganic-N + bioferilizer compared with other these interaction treatments in both seasons.

Table 3: Effect of irrigation regimes and N fertilization treatments on flowering traits of squash during spring and autumn seasons in 2017 and 2018.

Treatments		No. male flowers plant^{-1}				No. female flowers plant^{-1}				Sex Ratio				Fruit set%			
		2017		2018		2017		2018		2017		2018		2017		2018	
		Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Irrigation regimes																	
1.0 IW:CPE		14.63	14.95	13.80	15.13	11.38	12.78	11.44	12.78	1.31	1.23	1.23	1.25	44.82	44.56	43.69	43.47
0.8 IW:CPE		13.83	14.53	13.20	14.12	11.31	10.50	11.19	10.20	1.24	1.41	1.20	1.41	46.65	55.81	45.78	56.71
0.6 IW:CPE		13.63	14.13	13.10	13.55	8.63	7.25	8.38	7.10	1.60	1.96	1.58	1.92	42.74	59.86	42.88	60.80
LSD 0.05		**ns**	**0.63**	**ns**	**1.12**	**0.79**	**0.80**	**0.67**	**0.81**	**0.06**	**0.10**	**0.05**	**0.13**	**2.33**	**2.89**	**ns**	**3.39**
Fertilization program																	
Inorganic-N (P_1)		14.83	15.10	13.93	14.83	11.58	11.27	11.33	11.43	1.32	1.43	1.27	1.39	43.68	50.48	43.40	50.22
25% Inorganic. N+Biogein (P_2)		13.00	13.43	12.47	13.13	8.25	7.83	8.17	7.63	1.61	1.75	1.55	1.75	49.46	57.81	47.98	57.61
50% Inorganic. N+Biogein (P_3)		14.00	14.83	13.17	14.73	10.17	9.33	9.83	9.07	1.38	1.65	1.35	1.68	42.83	55.23	43.83	56.31
100% InorganicN+Biogein (P_4)		14.27	14.77	13.90	14.37	11.75	12.27	12.00	11.97	1.23	1.30	1.18	1.29	42.98	50.12	41.25	50.51
LSD 0.05		**0.74**	**0.82**	**0.70**	**0.85**	**0.75**	**0.79**	**0.53**	**0.83**	**0.06**	**0.10**	**0.03**	**0.10**	**2.43**	**2.70**	**2.43**	**2.98**
Interaction effect																	
1.0 IW:CPE	**P1**	15.00	15.30	14.00	16.00	13.25	14.30	13.00	15.00	1.13	1.11	1.08	1.09	42.04	44.38	42.61	42.58
	P2	14.00	14.00	13.00	14.00	9.00	9.00	8.75	8.80	1.58	1.56	1.49	1.59	45.71	49.05	44.67	47.84
	P3	15.00	15.00	14.00	15.20	11.25	11.50	10.75	11.30	1.34	1.30	1.30	1.35	42.92	45.38	44.14	43.91
	P4	14.50	15.50	14.20	15.30	12.00	16.30	13.25	16.00	1.21	0.95	1.07	0.96	48.60	39.40	43.32	39.56
0.8 IW:CPE	**P1**	15.00	15.00	14.00	14.00	12.50	11.50	12.50	11.50	1.20	1.30	1.12	1.22	46.80	54.02	45.18	53.30
	P2	12.00	12.30	11.80	12.08	8.75	8.00	8.75	7.80	1.39	1.54	1.35	1.55	50.09	61.70	48.06	62.14
	P3	14.00	16.50	13.00	16.40	10.50	10.00	10.50	9.50	1.33	1.65	1.24	1.73	44.95	56.59	44.05	59.12
	P4	14.30	14.30	14.00	14.00	13.50	12.50	13.00	12.00	1.06	1.14	1.08	1.17	44.78	50.93	45.82	52.30
0.6 IW:CPE	**P1**	14.50	15.00	13.80	14.50	9.00	8.00	8.50	7.80	1.61	1.88	1.62	1.86	42.20	53.05	42.42	54.77
	P2	13.00	14.00	12.60	13.30	7.00	6.50	7.00	6.30	1.86	2.15	1.80	2.11	52.57	62.67	51.21	62.86
	P3	13.00	13.00	12.50	12.60	8.75	6.50	8.25	6.40	1.49	2.00	1.52	1.97	40.62	63.72	43.29	65.91
	P4	14.00	14.50	13.50	13.80	9.75	8.00	9.75	7.90	1.44	1.81	1.38	1.75	35.55	60.01	34.60	59.67
Mean		**14.03**	**14.53**	**13.37**	**14.26**	**10.44**	**10.18**	**10.33**	**10.03**	**1.39**	**1.53**	**1.34**	**1.53**	**44.74**	**53.41**	**44.12**	**53.66**
LSD 0.05		**ns**	**1.42**	**ns**	**1.47**	**1.30**	**1.37**	**0.92**	**1.44**	**0.11**	**0.17**	**0.06**	**0.17**	**4.21**	**4.68**	**4.20**	**ns**

3. Fruit characteristics

Presented data in Table (4) show the effect of irrigation and N fertilization programs on fruit size (length and diameter) and weight under spring and autumn plantation. As shown autumn growing season was superior spring season for length and fruit weight, meanwhile the greatest fruit diameters were recorded in spring season compared autumn season. This may reflect the climatological change between the studied growing seasons, especially during fruiting stage, as it was in May for the spring season and November for autumn season.

Fruit length and diameter as well as fruit weight were significantly affected by irrigation regimes. The lengthiest, widest and heaviest fruits were obtained under non-stress water (1.0 IW: CPE). Fruit length and width reached to 10.42-10.47 and cm 3.37-3.40 cm at spring season; 11.28-11.35 and 2.98-3.03 cm at autumn season, respectively. Meanwhile, the heaviest fruits (100.16-100.63 g) were recorded at autumn under non-stress water compared those at spring season (97.39-98.18) under the same irrigation regime. These findings are in agreement with those of Ertek *et al*. (2004) and Ibrahim and Selim (2010).

Supplying the squash plants with different N fertilization application had significant effects on studied fruit characters in both spring and autumn seasons. It could be declared that plants received 100% inorganic-N+ biofertilizer (Biogein) recorded the highest values of fruit length, diameter and weight. The enhanced effects of using biofertilizer (Biogein) with high level of inorganic-N application on fruit traits might be due to the improvement of vegetative growth as well as plant hormones production like auxin, IAA and gibberellins in addition to the vitamins (Biotin, folic acid and vitamin B groups). Meanwhile, the N fertilization program that contained 100% inorganic-N only came in the second rank. These results are in good line with those reported by Habibi *et al*. (2011) on medicinal pumpkin on and Shafeek *et al.* (2016) on squash.

The interaction between irrigation regimes and N fertilization programs had significant effects on fruit length, diameter and weight. Plants watered with 1.0 or 0.8 IW:CPE and received 100% inorganic-N+ biofertilizer (Biogein) gave the highest values for these traits followed by 100% inorganic-N under the same irrigation regime, while the lowest values of these traits were noticed with 0.6 IW:CPE and 25% inorganic-N + biofertilizer (Biogein) in comparison with other treatments in both spring and autumn seasons. The increases in these traits might be resulted from high growth parameters at the same treatments (Table, 2) due to the enhancing in photosynthetic assimilation and absorption of various nutrients, and resulted in the increasing in yield and its components.

4. Yield and Its Components characteristics

The effect of plantation season on number of fruits per plant as well as early and total yields of squash is shown in Table (5). The autumn season produce more number of fruits, early and total yields than the spring season under all tested treatments. Planting squash at autumn season caused increases in total yield by 15.34 and 16.33% compared with spring season. These due to the reduction in weather elements such as air temperature and solar radiation at the end of the autumn growing season compared with spring growing season. The air temperature and solar radiation in the spring season were 30.1ºC and 27.1 MJm^{-2} d^{-1} versus 16.3 ºC and 14.5 MJm^{-2} d^{-1}, respectively, in the autumn season (Table 1), respectively. Similar results were obtained by Abd El-Mageed and Semida (2015) on squash.

Data also indicate that increasing irrigation water deficit from 1.0 up to 0.6 IW:CPE caused significant decreases in all studied traits in the two growing seasons, except number of fruits per plant; it was increased due to the increasing irrigation water deficit from 1.0 up to 0.8 IW:CPE. Irrigating squash plants with 1.0 IW: CPE gave the highest values of early and total yields followed by the medium irrigation regime (0.8 IW: CPE) without significant differences. This result may be due to the sufficient available water in the soil under this irrigation regimes (0.8 IW:CPE) which led to an increase in both water and nutrients' absorption and consequently an increase in the metabolic mechanisms in the plants leading to an increase in fruit weight, fruit length and no. of fruit $plant^{-1}$. Its means that can save 20% irrigation water, consequently decreasing water withdraw cost or using this saved quantity to cultivating other area. This result is in agreement with those of Amer *et al*. (2009), Amer (2011) and Salata and Stepaniuk (2012) who reported that yield was significantly affected by

Table. 4. Effect of irrigation regimes and N fertilization traetments on fruit characters of squash during spring and autumn seasons in 2017 and 2018.

Treatments		Fruit length (cm)				Fruit diameter (cm)				Fruit weight (g)			
		2017		2018		2017		2018		2017		2018	
		Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Irrigation regimes													
1.0 IW:CPE		10.47	11.35	10.42	11.28	3.40	3.03	3.37	2.98	98.18	100.63	97.39	100.16
0.8 IW:CPE		9.88	9.85	9.63	9.73	2.82	2.56	2.78	2.69	92.86	94.49	92.55	94.09
0.6 IW:CPE		7.67	8.50	7.85	8.20	2.23	2.02	2.15	2.00	80.00	87.25	78.98	85.63
LSD 0.05		**0.72**	**1.08**	**0.27**	**0.60**	**0.21**	**0.12**	**0.21**	**0.12**	**2.97**	**2.08**	**2.89**	**1.74**
Fertilization program													
Inorganic-N (P_1)		9.95	10.87	9.97	10.87	3.10	2.67	3.10	2.67	93.89	98.50	92.89	97.30
25% Inorg. N+Biogein (P_2)		7.99	8.53	7.93	8.17	2.30	2.22	2.23	2.16	81.73	86.83	81.50	86.73
50% Inorg. N+Biogein (P_3)		8.71	9.03	8.62	8.80	2.56	2.38	2.48	2.33	88.55	91.28	87.23	89.86
100% Inorg. N+Biogein (P_4)		10.70	11.17	10.67	11.10	3.30	2.88	3.27	3.06	97.22	99.87	96.94	99.28
LSD 0.05		**0.50**	**0.61**	**0.25**	**0.60**	**0.17**	**0.12**	**0.15**	**0.11**	**3.59**	**1.89**	**3.43**	**2.26**
Interaction effect													
1.0 IW:CPE	**P1**	11.00	13.00	10.90	13.00	3.90	3.02	3.90	3.00	102.40	106.00	99.78	105.60
	P2	9.08	9.10	9.00	9.00	2.70	2.70	2.68	2.60	93.45	93.50	93.30	93.30
	P3	9.50	9.60	9.46	9.50	2.90	2.80	2.80	2.76	93.95	94.50	93.80	94.30
	P4	12.30	13.70	12.30	13.60	4.10	3.60	4.10	3.55	102.90	108.50	102.70	107.45
0.8 IW:CPE	**P1**	11.00	10.80	10.71	10.80	3.00	2.99	3.00	3.00	96.90	97.00	96.60	96.60
	P2	8.40	8.30	8.00	8.00	2.20	2.16	2.10	2.08	85.50	87.50	85.20	87.30
	P3	8.90	9.30	8.90	9.20	2.78	2.40	2.73	2.40	90.20	94.45	90.00	94.08
	P4	11.20	11.00	10.90	10.90	3.30	2.70	3.30	3.27	98.85	99.00	98.40	98.40
0.6 IW:CPE	**P1**	7.85	8.80	8.30	8.80	2.40	2.00	2.40	2.00	82.38	92.50	82.30	89.70
	P2	6.50	8.20	6.80	7.50	2.00	1.80	1.90	1.81	66.23	79.50	66.00	79.60
	P3	7.72	8.20	7.50	7.70	2.00	1.94	1.90	1.84	81.50	84.90	77.90	81.20
	P4	8.60	8.80	8.80	8.80	2.50	2.35	2.40	2.36	89.90	92.10	89.73	92.00
Mean		**9.34**	**9.90**	**9.30**	**9.73**	**2.81**	**2.54**	**2.77**	**2.56**	**90.35**	**94.12**	**89.64**	**93.29**
LSD 0.05		**0.86**	**1.05**	**0.43**	**1.04**	**0.30**	**0.22**	**0.26**	**0.19**	**6.22**	**3.28**	**5.93**	**3.91**

Table 5: Effect of irrigation regimes and N fertilization treatments on yield and its components of squash during spring and autumn seasons in 2017 and 2018.

Treatments		No. fruits plant^{-1}				Early yield (ton) fed^{-1}				Total yield (ton) fed^{-1}			
		2017		2018		2017		2018		2017		2018	
		Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Irrigation regimes													
1.0 IW:CPE		5.07	5.56	4.96	5.41	2.18	2.36	2.12	2.32	7.03	7.86	6.84	7.64
0.8 IW:CPE		5.24	5.79	5.10	5.72	1.99	2.07	1.95	2.03	6.89	7.66	6.70	7.55
0.6 IW:CPE		3.62	4.31	3.53	4.29	0.96	1.23	0.94	1.21	4.11	5.28	3.95	5.17
LSD 0.05		**0.51**	**0.20**	**0.12**	**0.23**	**0.05**	**0.12**	**0.06**	**0.06**	**0.52**	**0.28**	**0.19**	**0.29**
Fertilization program													
Inorganic-N (P_1)		5.06	5.55	4.93	5.51	2.05	2.17	1.97	2.13	6.78	7.66	6.54	7.56
25% Inorganic N+Biogein (P_2)		4.03	4.47	3.89	4.34	1.05	1.32	1.04	1.31	4.69	5.45	4.52	5.28
50% Inorganic. N+Biogein (P_3)		4.37	5.01	4.30	4.93	1.47	1.71	1.45	1.66	5.50	6.41	5.35	6.25
100% Inorganic. N+Biogein (P_4)		5.11	5.86	5.01	5.78	2.26	2.35	2.22	2.30	7.08	8.21	6.92	8.05
LSD 0.05		**0.28**	**0.28**	**0.10**	**0.23**	**0.06**	**0.09**	**0.07**	**0.10**	**0.28**	**0.39**	**0.20**	**0.26**
Interaction effect													
1.0 IW:CPE	**P1**	5.55	6.18	5.54	6.14	2.55	2.65	2.42	2.62	7.97	9.11	7.76	9.05
	P2	4.07	4.41	3.88	4.21	1.45	1.45	1.44	1.44	5.37	5.77	5.12	5.50
	P3	4.84	5.22	4.72	4.96	1.90	2.25	1.88	2.21	6.38	6.87	6.24	6.55
	P4	5.83	6.42	5.72	6.33	2.80	3.10	2.73	3.00	8.43	9.69	8.26	9.46
0.8 IW:CPE	**P1**	5.84	6.21	5.64	6.13	2.45	2.45	2.38	2.39	7.95	8.39	7.67	8.26
	P2	4.35	4.94	4.20	4.85	1.40	1.50	1.39	1.47	5.25	6.03	5.06	5.92
	P3	4.73	5.66	4.62	5.62	1.50	1.72	1.48	1.69	6.00	7.45	5.86	7.38
	P4	6.03	6.37	5.94	6.28	2.60	2.60	2.56	2.55	8.38	8.77	8.22	8.63
0.6 IW:CPE	**P1**	3.79	4.24	3.59	4.27	1.15	1.40	1.10	1.38	4.42	5.48	4.20	5.37
	P2	3.68	4.07	3.58	3.96	0.30	1.02	0.30	1.02	3.47	4.54	3.38	4.43
	P3	3.55	4.14	3.56	4.22	1.00	1.15	1.00	1.09	4.11	4.91	3.95	4.81
	P4	3.46	4.80	3.37	4.71	1.38	1.35	1.38	1.34	4.42	6.18	4.29	6.07
Mean		**4.64**	**5.22**	**4.53**	**5.14**	**1.71**	**1.89**	**1.67**	**1.85**	**6.01**	**6.93**	**5.83**	**6.78**
LSD 0.05		**0.48**	**0.49**	**0.18**	**0.40**	**0.11**	**0.16**	**0.12**	**0.17**	**0.49**	**0.67**	**0.34**	**0.46**

IWA. Meanwhile, decreasing irrigation water by 40% for 60% ET_c reduced squash yield by 33-43% lower than the 100% ET_c regime, respectively. This may be due to the deficit of soil water greatly affects various biological processes in plant such as photosynthesis, assimilates translocation, biomass, dry weight as well as the contents of carbohydrate, sugar, starch, amino acids and protein etc. Drought stress also affects the cell membrane stability andgas exchange characteristics in plants (Abd El-Mageed and Semida, 2015).

Application of biofertilizer (Biogein) plus 100% inorganic-N (P_4) surpassed other fertilization treatments on studied characters. This program increased number of fruits per plant by 0.92-1.62% and 4.76-5.74%; early yield by 10.24-13.08% and 7.91-8.46%; total yield by 4.38-5.78% and 6.55-7.20% in spring and autumn seasons, respectively; compared to the application of 100% inorganic-N (P_1). The combined application of biofertilizer (Biogein) with inorganic-N might promote the crop growth by increasing root number and root length. Consequently, root system can absorb more water and nutrients from soil including the applied N. Thus, N lose hazards to the environment is reduce, especially, in sandy soil. These results were reported by Refai *et al*. (2010) and Shafeek *et al.* (2016).

The influence of irrigation and fertilization treatments reflected on the yield and its components of squash in both seasons. The maximum values of studied characters were recorded by irrigating squash plants with 1.0 IW: CPE plus fertilizing with 100% inorganic-N+ biofertilizer (Biogein) followed by irrigating with 0.8 IW: CPE with the same fertilization program. The results could be attributed to positive effect irrigation and N fertilization programs through application of water and N fertilization in the suitable quantities to plant required.

5. Water-Plant relations

5.1. Actual Evapotranspiration (ET_a)

Total amount of the actual evapotranspiration (ET_a) for spring growing season was higher than the autumn growing season under tested treatments (Table, 6). In general, averages of ET_a reached 2481 and 2078 m^3 fed^{-1} in the spring season; while was 1625 and 1440 m^3 fed^{-1} in autumn. So, it could be planted squash plants in the autumn season to save about 34.50 and 30.70% as compared with the spring seasons, respectively. This is expected due to the spring season is mostly warmer compared to autumn season as shown in Table (1). As well as, this result show the importance of plantation season on irrigation water saving. The obtained results show that seasonal ET_a values were greatly affected by deficit irrigation. Data indicate that ET_a values decreased with increasing the irrigation water deficit, where the consumptive use decreased as the available soil moisture decreased in the root zone. Data also reveal that the highest values of seasonal ET_a were recorded by 1.0 IW:CPE treatment in spring and autumn seasons. These values reached 3087 and 2673 m^3 fed^{-1} at spring season; 1987 and 1745 m^3 fed^{-1} at autumn season with significant differences as compared with the other irrigation regimes. The minimum values were observed under 0.6 IW:CPE treatment in both growing seasons. They reached 1744 and 1438 m^3 fed^{-1} at spring season; 1265 and 1149 m^3 fed^{-1} at autumn season. These results are in agreement with those obtained by Salah (2007). The differences in ET_a values at each stage depend on the plantation season, accordingly the climatic parameters exist. In the spring season, mid stage has higher ET_a values as compared to the development stage due to this stage has higher temperature. On the other hand, ET_a values at the development stage were relatively higher than the amounts needed at the mid stage in autumn season. This is expected due to the development stage has higher temperature compared with mid stage under autumn season. This trend was observed under different irrigation treatments.

5.2. Crop Coefficient (K_c)

The crop coefficient varied from growth stage to another in the two growing seasons. These values were low at the initial stage because the plant vegetation growth was not established yet and the loss of moisture is mostly by evaporation from soil surface. As the plant developed, a gradual increase was observed in crop coefficient. The crop coefficient reaches their peaks in medium growth stage (mid stage) at the time of maximum leave area index or maximum vegetation growth. Then, the crop coefficient was decreased during the late season of plants as leaves begin to age. Similar results were obtained by Abou El- Fotouh (2002) and Salah (2007).

Table. 6. Effect of irrigation regimes on actual evapotranspiration (m^3 fed^{-1}) at different growth stages of squash during spring and autumn seasons in 2017 and 2018.

Irrigation regimes	Initial stage	Develop. stage	Mid stage	End stage	Gross season
			Spring 2017		
1.0 IW:CPE	396	1064	1115	511	3087
0.8 IW:CPE	396	823	849	545	2613
0.6 IW:CPE	396	502	536	310	1744
Mean					2481
			Autumn 2018		
1.0 IW:CPE	385	897	467	238	1987
0.8 IW:CPE	385	688	349	201	1623
0.6 IW:CPE	385	497	262	120	1265
Mean					1625
			Spring 2017		
1.0 IW:CPE	317	921	955	480	2673
0.8 IW:CPE	317	679	686	439	2122
0.6 IW:CPE	317	451	419	251	1438
Mean					2078
			Autumn 2018		
1.0 IW:CPE	358	769	431	186	1745
0.8 IW:CPE	358	595	322	152	1427
0.6 IW:CPE	358	441	244	106	1149
Mean					1440

Table. 7: Effect of irrigation regimes on crop coefficient (K_C) at different growth stages of squash during spring and autumn seasons in 2017 and 2018.

Seasons	Initial stage	Develop. stage	Mid stage	End stage	Gross season
Spring 2017	0.66	0.96	1.11	0.80	0.92
Autumn 2017	0.60	0.94	1.01	0.81	0.85
Spring 2018	0.66	0.96	1.10	0.83	0.93
Autumn 2018	0.59	0.92	1.01	0.79	0.83

5.3. Irrigation Water Applied and Water Saving

As shown in Table (8), squash plants in the spring season consume more irrigation water as compared with the autumn season under tested treatments. Applied water amounts were 4136 and 3462 m^3 fed^{-1} in spring seasons; 2708 and 2401 m^3 fed^{-1} in autumn seasons. This means that planting squash plants in autumn season saved 30.65 to 34.53% of irrigation water compared with spring season.

Data indicate that increasing water stress tends to decrease the applied water under spring and autumn growing seasons. Under spring cultivation, irrigating squash plant at 0.8 IW: CPE treatment saved 15.36-20.61%, meanwhile 0.6 IW: CPE treatment saved 43.50-46.21% of irrigation water in spring season. These treatments saved 18.25-18.34% and 34.17-36.32% of irrigation water under autumn cultivation, respectively.

5.4. Water Productivity (IWP)

The highest values of physical irrigation water productivity (PIWP) and the economic irrigation water productivity (EIWP) were recorded at autumn season compared with that obtained at spring season (Table, 9). The PIWP at autumn season was increased by 76.86 and 67.3% than spring season. Meanwhile, EIWP at autumn season was increased by 76.63 and 67.40% compared with spring season.

Data also show that medium irrigation regime (0.8 IW: CPE) gave the maximum values of PIWP and EIWP. The PIWP values were ranged from 2.64 to 3.17 kg m^{-3} at spring season, whereas they ranged from 4.73 to 5.31 kg m^{-3} at autumn season under the same irrigation treatment. The same irrigation regime was surpassed the other irrigation regimes on EIWP values, where they were 8.99 and 10.76 L.E. m^{-3} at spring season; 16.08 and 18.06 L.E. m^{-3} at autumn season.

Table. 8. Effect of irrigation regimes on applied water and water saving of squash during spring and autumn seasons in 2017 and 2018.

Irrigation regimes	Spring 2017	Autumn 2017	Spring 2018	Autumn 2018
		Applied water (m^3 fed^{-1})		
1.0 IW:CPE	3632	2338	3144	2053
0.8 IW:CPE	3074	1909	2496	1678
0.6 IW:CPE	2052	1489	1691	1352
Mean	2920	1912	2444	1694
LSD 0.05	81.62	52.03	95.50	62.36
		Water saving (%)		
1.0 IW:CPE	-	-	-	-
0.8 IW:CPE	15.36	18.34	20.61	18.25
0.6 IW:CPE	43.50	36.32	46.21	34.17

Table. 9. Effect of irrigation regimes on applied water and water saving of squash during spring and autumn seasons in 2017 and 2018.

Irrigation regimes	Spring 2017	Autumn 2017	Spring 2018	Autumn 2018
		Physical water productivity (kg m^3)		
1.0 IW:CPE	2.27	3.95	2.56	4.38
0.8 IW:CPE	2.64	4.73	3.17	5.31
0.6 IW:CPE	2.35	4.17	2.75	4.50
Mean	2.42	4.28	2.82	4.73
LSD 0.05	0.13	0.21	0.02	0.20
		Economical water productivity (L.E. m^3)		
1.0 IW:CPE	7.72	13.42	8.69	14.89
0.8 IW:CPE	8.99	16.08	10.76	18.06
0.6 IW:CPE	8.00	14.17	9.35	15.30
Mean	8.24	14.56	9.60	16.08
LSD 0.05	0.44	0.72	0.06	0.67

*Average of price of 1 kg squash fruit= 4.00 LE

Conclusion

It could be concluded that planting squash plants in autumn season saved 30.65 to 34.53% of irrigation water compared with spring season. Irrigating squash plants with 0.8 IW: CPE plus fertilizing with 100% inorganic-N+ biofertilizer (Biogein) to save about 20% of irrigation water and improve squash productivity.

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