J. Soil Sci. and Agric. Engineering, Mansoura Univ., Vol.1 (8): 775 - 787, 2010

INFLUENCE OF IRRIGATION WATER AMOUNTS AND NITROGEN RATES ON MAIZE PRODUCTIVITY AND SOME WATER RELATIONS IN WADI ELNATROON REGION,EGYPT

El-Atawy, Gh. Sh. and S. M. Eid.
Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt

ABSTRACT

Two field experiments were carried out at Wady Elnatroon, El-Behera governorate during 2008 and 2009 growing seasons to study the influence of irrigation water amounts and nitrogen fertilizer rates on maize yield and its components, and on some water relationships under drip irrigation method in the soil. The soil of the field experiments was sandy loam. The electrical conductivity of irrigation water was 1.1 dSm^{-1}. The treatments were arranged in a split plot design with four replicates. The main plots were assigned with four amounts of irrigation water of daily applied on a base of 100%, 90%, 80% and 70% of ETc with four nitrogen rates i.e. zero, 50, 100 and 150 kg N $fed.^{-1}$ in the sub plots.

The combined analysis over the two growing seasons showed that daily irrigation with applied water equals 100% of ETc increased plant height, ear length, number of grains row^{-1}, 100-grain weight and maize grain yield by 3.33, 7, 15.25, 6.19 and 37.25% as compared to daily irrigation with applied water equals 70% of ETc. Daily irrigation with applied water equals 100% of ETc, significantly increased N, P and K concentration in Zea maize plants and grains by (36.9, 21.2 and 9.8%) and (23.5, 21.2 and 18.5%) as compared to daily irrigation with applied water equals 70% of ETc, respectively.

Increasing nitrogen rates up to 150 kg N $fed.^{-1}$ significantly increased plant height by 5%, ear length by 5.9%, number of grains row^{-1} by 8.4%, 100-grain weight by 10.1% and maize grain yield by 47.25% as compared to the control treatment.

Seasonal water use values were 52.93, 47.93, 42.8 and 38.68cm for irrigated plants with 100%, 90%, 80% and 70% of ETc, respectively.

Daily irrigation with applied water equals 100% of ETc resulted in higher amount of irrigation water applied to be 59.5 cm, followed by daily irrigation with applied water equals 90%, 80%, and 70% of ETc to be 53.5 cm, 47.6 cm, and 41.6 cm, respectively.

Daily irrigation with 90% of ETc resulted in the highest value of water productivity as compared to 100%, 80% and 70% of ETc.

It could be concluded that for obtaining both high and good maize yield and facing the irrigation water shortage, daily irrigation with 90% of ETc must be added with 150 kg N fed^{-1} under the sand loam soil in Wady El-Natron region and in the same conditions.

Keywords: Maize, drip irrigation, N fertilization, water consumptive use, water productivity(PW).

INTRODUCTION

Maize (*Zea maize* L.) is considered one of the most important cereal crops in Egypt. Total annual area cultivated with maize varieties was estimated 1.5-2.0 million feddans. Total national production of maize is about 5.43 million tons, while the demand is for at least 7.0 million tons. This reflects the size of the problem and efforts that needed to increase maize production. This can be achieved by breeding high yielding varieties and by the application of improved agro-techniques. Irrigation is one of the most important factors contributing to increase maize production. Water resources in Egypt are limited. So, saving water is a vital demand to face the water gab problem. Crop water management and its yield in different environments are very important concern in irrigation planning and maximizing grain yield.

Drip irrigation is a highly efficient means of delivering water uniformly to crops. Because of the high cost of installing and maintaining a drip system beside its suitability to some soil properties than the others. It has been used primarily in areas of relatively high water costs where irrigation efficiency is an important economic consideration. Maize is one of the most efficient field crops in producing higher dry matter per unit quantity of water (Viswanatha *et al*., 2002). Maize cultivation requires large quantities of water seasonally to obtain a large crop (Filintas, 2003). Ayotamuno *et al*., (2007) reported that the maximum plant height and the other maize yield components increased with increasing irrigation water. Abd El-Hafez *et al*., (2008) reported that the highest values of grain yield were obtained with irrigation at 1.3 Etc as compared to 1 and 0.7 ETc. Abdel-Maksoud *et al*., (2008) reported that the highest (67.96 and 68.87cm) and lowest (56.45 and 57.13 cm) ETc values in both seasons were obtained with increasing irrigation intervals from 7 to 21 days intervals, respectively. El-Sabbagh *et al*., (1997) found that treatment which irrigated at 80% of the field capacity gave the highest values of ear length, ear weight, number of kernel row^{-1}, 100-kernel weight and grain yield $fed.^{-1}$. Also, they found that values of water consumptive use were 69.41, 58.30 and 46.68 cm for the treatments irrigated at 80% 65% and 50% of field capacity, respectively. El-Mowelhi *et al*., (1999) found that under drip irrigation increasing intervals from 4 to 7 days significantly decreased ear character and maize grain yield $fed.^{-1}$. Also, they found that furrow irrigation reduced water productivity (kg maize grain yield m^{-3} of water consumed or m^{-3} of water applied) by 15.89 and 30.61% respectively, as compared with drip irrigation system.

Fertilizer application, also, is the most important factor of increasing yield per unit area. Nitrogen is considered as one of major nutrients required by the plants for growth, development and yield (Singh *et al*., 2003). Abdel-Mawly and Zanouny (2005) reported that N and K fertilizer applications had significant effect on yield of Zea maize. Ma and Subedi (2005) found a positive effect of all N treatment over the control regarding yield in Zea maize. Wajid *et al*., (2007) reported that an increase in nitrogen application resulted in maximum stem length, 100-grain weight and grain yield of Zea maize..

The objectives of the present study were to investigate the effect of irrigation water amounts and nitrogen rates on maize yield, its components and some water relations such as water consumptive use, irrigation water applied, field and crop water use efficiencies under drip irrigation method in Northwest Delta.

MATERIALS AND METHODS

Two field experiments were carried out during 2008 and 2009 growing seasons at Wady Elnatroon, El-Behera governorate to study the effect of irrigation water amounts and nitrogen fertilizer rates on maize yield, its components and some water relations under drip irrigation system .

Surface drip irrigation system used was consisted of normal polyethylene pipes of 16 mm diameter as laterals with in line dripper of 4 l/h at 50 cm apart. The laterals were located 75 cm apart, one lateral for each plants row. Irrigation water was filtered through gravel filters and refiltered through screen filters. The soil of the experiments field was sandy loam and it contained 11.85% clay, 13.70% silt and 74.45% sand. The average of soil electrical conductivity (soil baste extract), over 0-60 cm depth, was 3.68 dSm^{-1}, pH of the soil (1: 2.5) was 7.5, EC of irrigation water was 1.1 dSm^{-1}. The treatments were arranged in a split plot design with four replicates. The main plots were assigned with four irrigation water amounts and the sub plots were randomly assigned with four N-fertilizer rates. The experiment size was 0.91 feddan included 128 rows with 75 cm apart and 40 m long.

The experimental field was fertilized with 10 m^3 of chicken manure as well as 15 kg P_2O_5 $fed.^{-1}$ under maize rows through soil preparation. The chicken manure contains 3.2% N, 2.1% P and 1.3% K.

Irrigation treatments were daily applied with amount of water equals to 100%, 90%, 80% and 70% of the crop evapotranspiration (ETc), while nitrogen was applied as ammonium nitrate (33.5%) at a rate of zero (control), 50, 100 and 150 kg N $fed.^{-1}$ through the irrigation water using venture injection in six equals doses, the first dose after thinning, while the later doses were applied on weekly basis.

Maize seeds (*cv. Single Hybrid 30K8*.) were manually planted in one row in dry soil on 25 and 20 of June during the two seasons, respectively. The distances between hills were 25 cm and one plant/hill was left after 3 weeks from planting. All field practices were done as usually recommended for maize cultivation. Harvesting was done after 120 days from planting. Central area of 45 m^2 in each plot was kept for determining maize yield to eliminate any border effect.

The following characters were studied:

Yield and yield attributes:

Plant height in cm, Ear length in cm. , No. of grains row^{-1}., 100-grain weight in gm and Grain yield in kg $fed.^{-1}$.

NPK concentration in maize ear leaf and grains.

Processing of samples: collected samples were analyzed for: (i)NPK by Kjeldahl method as reported in Standard Methods for Page (1984)(ii) P, by ascorbic acid method as described in the Standard Methods for Page (1984) .(iii) Total dissolved potassium by atomic absorption spectrophotometer.

Nitrogen use efficiency (NUE):

Nitrogen use efficiency by plants was calculated as kg of the grain yield produced by each unite of nitrogen fertilizer used

Soil water relations:

Soil moisture content was determined gravimetrically in soil samples at successive of 15 cm to a depth of 60 cm from three locations, under the emitter and between the emitters and the laterals. Soil samples were also collected just before irrigation and 6 hours after every irrigation as well as at harvesting to estimate evapotranspiration rates. Field capacity and the bulk density were determined up to a depth of 60 cm. The average values are presented in Table (1).

Table (1): Values of field capacity and bulk density for the two growing seasons.

Soil depth (cm)	2008		2009	
	Field capacity %	Bulk density g/cm^3	Field capacity %	Bulk density g/cm^3
0-15	12.9	1.37	12.9	1.37
15-30	12.9	1.37	12.9	1.37
30-45	13.0	1.38	13.0	1.38
45-60	13.0	1.38	13.0	1.38

1- Water consumptive use (Cu):

Water consumptive use was calculated using the following equation (Hansin *et al.,* 1979).

$$CU = \sum_{i=1}^{n=4} Di \times Bd \times (\theta_2 - \theta_1)/100$$

Where:

Cu = Water consumptive use (cm).

Di = Soil layer depth = 15 cm.

Bd = Soil bulk density, (g/cm^3) for this depth.

θ_1 = Soil moisture % before irrigation.

θ_2 = Soil moisture % 6 hours after irrigation.

n = Number of soil layers.

2. Irrigation water applied (IWA):

The amount of water applied at each irrigation was measured by flowmeter and calculated according to Keller and Karmeli (1974) as follows:

$$IWA = \frac{ETo \,.\, Kc \,.\, Kr.II}{Ea} + LR$$

Where:

IWA= irrigation water applied (mm).

ETo = reference evapotranspiration (mm/day).

Kc = crop coefficient.

Kr = reduction factor (Keller and Karmeli, 1974).

II = irrigation intervals (days).

Ea = irrigation efficiency % = $K_1 \times K_2$ = 0.85.

K_1 = emitter uniformity coefficient = 0.95.

K_2 = drip irrigation efficiency coefficient = 0.90.

LR = leaching requirements (10% of Etc).

Reference evapotranspiration (ETo) were estimated using penman-Monteith, as calculated by Allen et al. (FAO, 1998) and crop coefficient (Kc) values for maize were taken as calculated by (El-Sabbagh *et al*., 1997). Values are shown in Table (2).

Table (2): Monthly potential evapotranspiration (ETo) and crop coefficient (Kc) used with maize in this study.

Months	June	July	August	September	October
ETo mm/day	6.31	6.17	6.05	5.37	4.42
Crop coefficient (Kc)	0.47	0.92	1.13	1.00	0.88

3-Water productivity:

was determined by dividing grain yield by evapotranspiration as follows (Ali *et al*., 2007):

$$WP = GY \ /ET$$

Where WP is water productivity (kg m^{-3}), GY is grain yield (kg fed^{-1}) and ET is maize total water consumption of the growing season (m^3 fed^{-1}).

Statistical analysis:

The obtained data were statically analyzed by analysis of variance. The data of the two seasons showed nearly the same trend Thus, a combined analysis was done according to Gomez and Gomez (1984) .Means of the treatment were as as compared by the least significant difference (LSD) at 5% level of significance which developed by Waller and Duncan (1969)

RESULTS AND DISCUSSION

Yield and yield attributes:

Combined analysis of variance over the two growing seasons indicated that all studied characters were significantly affected by irrigation treatments as shown in Table (3).

Daily irrigation with applied water equals 100% of ETc significantly increased plant height, ear length, number of grains row^{-1}, 100-grain weight and maize grain yield by 3.33%, 7%, 15.25%, 6.19% and 37.25% as compared to daily irrigation with applied water equals 70% of ETc. A higher grain yield for irrigated maize with applied water equals 100% of ETc might be due to the large wet area at the root zone, enhanced root distribution, increased root surface area and encouraged nutrients uptake which reflected on the higher yield components such as ear length, number of grains row^{-1} and 100-grain weight, as shown in Table 3. These results are in agreement with those obtained by Abd El-Hafez *et al*., (2001), Abdel Aziz and El-Bialy (2004), Galbiatti *et al*., (2004) and Omran (2005), who concluded that yield and its attributes of maize plants were gradually increased as a result of increasing in the availability of soil moisture content because the availability of water is an important factor in the growth of maize plants which increase grain yield. Maize is one of the most efficient field crops in producing higher dry matter per unit quantity of water (Viswanatha *et al*., 2002 and Megyes *et* *al*., 2005). Meleha (2006) reported that growth of maize is highly related to irrigation depth and it increases with increasing irrigation water. These results are in harmony with those obtained by Abd El-Hafez *et al*., (2008), Abdel-Maksoud *et al*., (2008) and Kara and Biber (2008).

Regarding the effect of nitrogen fertilizer, Table (3) indicate that increasing nitrogen levels caused a significant increase in plant height, ear length, number of grains row^{-1}, 100-grain weight and maize grain yield due to inorganic N ions which affect plant growth and its development. Ammonium has been recently shown to be an important factor regulating plant adaptation to environmental changes through its effect on the balance of growth promoting and growth restraining Mo-enzymes in plant roots. The obtained results are in conformity with those of Megyes *et al*., (2005) and Wajid *et al*., (2007).

The data in Table (3) show that increasing nitrogen level gradually increased all plant growth characters, so the most vigorous growth was obtained in plants received N at 150 kg fed.$^{-1}$. The previous studies indicated that abundant nitrogen encouraged cell division and elongation increased leaves number which consequently enhanced plant growth, and this may explain the favorite effect of increasing N rate on plant growth (Abdel-Mawly and Zanouny, 2005 and El-Hamdi *et al*., 2008).

Insignificant effect of irrigation treatments and season's interaction was obtained on all traits (Table 3). Such result indicates that irrigation treatments showed similar effect from year to the other.

Table (3): Mean values of maize grain yield/feddan and its components as influenced by irrigation treatments under drip irrigation method in combined analysis of 2008 and 2009 seasons.

Treatments	Plant height (cm)	Ear length (cm)	No. of grains row^{-1}	100-grain weight (gm)	Grain yield (kg fed^{-1})
Irrigation:					
100% of ETc	248 a	21.4 a	40.8 a	41.2 a	3828 a
90% of ETc	247 b	20.8 b	39.2 b	39.6 b	3549 b
80% of ETc	243 c	20.3 c	37.7 c	39.1 c	3119 c
70% of ETc	240 d	20.0 d	35.4 d	38.8 d	2789 d
N-rates:					
Zero N (control)	238 d	20.2 a	36.9 c	37.6 d	2639 d
50 kg N/fed.	244 c	20.5 b	37.7 c	38.4 c	3243 c
100 kg N/fed.	246 b	20.9 c	38.5 b	39.6 b	3636 b
150 kg N/fed.	250 a	21.4 d	40.0 a	41.4 a	3886 a
Interactions:					
Irrig. x season	N.S.	N.S.	N.S.	N.S.	N.S.
Irrig. x N rates	**	N.S.	N.S.	**	**
Irrig. N rates x season	N.S.	N.S.	N.S.	N.S.	N.S.

Means designated by the same letter at each cell are not significant at the 5% level according to Duncan's multiple range test.
N.S: Indicate not significant

Interaction between irrigation treatments and nitrogen rates:

It is clear from Table 4 that the highest mean values of grain yield obtained with daily irrigation with applied water equals 100% of ETc, 150 kg N fed.$^{-1}$.

On the other hand, the lowest value of grain yield obtained from irrigation with applied water equals 70% of ETc without fertilization. Similar results were reported by El-Atawy (2007) and Ibrahim and Hala, Kandil (2007). who concluded that low available soil water content resulted in a significant reduction in grain yield due to disparity in flowering and the frequency of sterile plants. The availability of nutrients and their uptake are higher when soil water is adequate and available at low tension.

Table (4): Interaction between irrigation and nitrogen fertilizer levels on grain yield of Zea maize, over both growing seasons.

Variables	Irrigation treatments			
	100% of ETc	90% of ETc	80% of ETc	70% of ETc
N-rates:				
Zero N (control)	3100 gh	2899 g	2448 i	2108 j
50 kg N fed $^{-1}$	3752 cd	3544 f	3015 g	2624 h
100 kg N fed $^{-1}$	4156 b	3837 cd	3414 ef	3137 f
150 kg N fed $^{-1}$	4304 a	3914 c	3598 d	3288 d

Means designated by the same letter at each cell are not significant at the 5% level according to Duncan's multiple range test

NPK concentration in maize plants (ear leaf) and grains.

Data in Table 5 reveal that N, P and K concentration in Zea maize plants were significantly affected by irrigation water amounts and high significantly affected by nitrogen fertilizer levels in combined analysis of variance over the two growing seasons.

The highest values of N, P and K concentration in Zea maize plants and its grains were obtained from irrigation at 100% of ETc.

Daily irrigation with applied water equals 100% of ETc, significantly increased N, P and K concentration in Zea maize plants by 36.9%, 21.2% and 9.8% as compared to daily irrigation with applied water equals 70% of ETc, while it increased N, P and K concentration in Zea maize grains by 23.5%, 21.2% and 18.5% as compared to daily irrigation with applied water equals 70% of ETc.

From the previous results it could be mentioned that the increase of N,P and K% in Zea maize plants and grains may be attributed to increasing of soil moisture. As soil moisture content increased solubility and mobility of N, P and K are increased,. These results are in agreement with those obtained by El-Nagar (2003), Othman, Sanaa *et al*., (2005), and Ibrahim and Hala, Kandil (2007).

Increasing N fertilization up to 150 kg N fed.$^{-1}$ increased N, P and K concentration in maize plants by 111.1%, 46.6% and 31.7%, while, N, P and K concentration in maize grains increased by 121.1%, 38.7% and 38.5% as compared to the control treatments. The increment of NPK concentration in maize plants and grains might be due to higher availability of the nutrients with increasing the N fertilizer levels which finally resulted in better root growth and more physiological activities for nutrients absorbance. These results are in accordance with those obtained by Ibrahim and Hala, Kandil (2007) and El-Hamdi *et al*., (2008).

Nitrogen use efficiency (NUE):

Nitrogen use efficiency (NUE) is one of the principal factors for saving fertilizer .There are many factors affecting NUE The data presented in table (6) show the effect of irrigation regimes, nitrogen fertilizer levels and their interactions on nitrogen use efficiency in kg grain yield kg^{-1} N fertilizer applied.

Table (5): Mean values of N, P and K concentrations as influenced by irrigation water amounts and nitrogen rates under drip irrigation method in combined analysis of 2008 and 2009 seasons.

Variables	N%		P%		K%	
	Plant	Grains	Plant	Grains	Plant	Grains
Irrigation treatments						
100% of ETc	1.52a	1.05a	0.079a	0.40a	1.23a	0.32a
90% of ETc	1.42b	0.97b	0.073b	0.38b	1.20b	0.31b
80%of ETc	1.22c	0.91c	0.067c	0.36c	1.17c	0.29c
70% of ETc	1.11d	0.85d	0.062d	0.33d	1.12d	0.27d
N-rates in Kg /fed.						
Zero N (control)	0.81d	0.57d	0.058d	0.31d	1.01d	0.26d
50 kg N $fed.^{-1}$	1.27c	0.87c	0.065c	0.35c	1.14c	0.28c
100 kg N $fed.^{-1}$	1.49b	1.07b	0.074b	0.38b	1.24b	0.31b
150 kg N $fed.^{-1}$	1.71a	1.26a	0.085a	0.43a	1.33a	0.33a

***Mean designated by the same letter is not significantly different at the 5% level according to Duncan's multiple range tests.**

Table (6): mean values of nitrogen use efficiency (NUE) in kg grain yield kg applied nitrogen N fed^{-1} as influenced by irrigation treatment and nitrogen rates under drip irrigation in combined analysis of 2008 and 2009 seasons

Variables	Irrigation treatments				Mean
	100% of ETc	90% of ETc	80% of ETc	70% of ETc	
N-rates:					
Zero N (control)	**13.03 a**	**12.90 a**	**11.34 a**	**10.32 a**	**11.89**
50 kg N fed^{-1}	**10.56 b**	**9.38 b**	**9.30 b**	**10.29 b**	**9.88**
100 kg N fed^{-1}	**8.02** c	**6.70** c	**7.66** c	**7.86** c	**7.56**
150 kg N fed^{-1}					
Mean	**10.53**	**9.66**	**9.43**	**9.49**	

Means designated by the same letter at each cell are not significant at the 5% level according to Duncan's multiple range test.

LSD at 5 %　In row　1.293
In column　0.2137

There were no significant between amount of irrigation water, values of NUE (over two seasons) were 10.53 , 9.66 , 9.43 and 9.49 due to irrigation at 100% of Etc , 90% of Etc , 80% of Etc ,and 70% of Etc respectively

Concerning the effect of the nitrogen rates applied , results showed that increasing the applied N-rate decrease the NUE , since highest value was obtained with 50 kg N fed^{-1} and the lowest one obtained with 150 kg N fed^{-1} .The values of NUE (over two seasons) due to 50 kg N fed^{-1}, 100 kg N fed^{-1}, and 150 kg N fed^{-1} were 11.89, 9.88, and 7.56 kg grain yield/kg N respectively.

III- Soil water relations:

1- Water consumptive use (Cu):

The values of water consumptive use as affected by irrigation treatments are presented in Table (6).

Data presented in Table (6) show that water consumption increased as soil moisture was maintained high. Monthly values of evapotranspiration were lower at the beginning of the growing season, and then increased as the plants grow up till it reached its peak in August. At the end of the season the rates declined as the crop matured. These results indicated that the increase in evapotranspiration rates goes parallel to the increase in the vegetative growth of maize plants. These findings agreed with El-Mowelhi *et al*., (1999), Oktem *et al*., (2003), Ayotamuno *et al*., (2007) and El-Bably (2007), who reported that the increment in water consumption depends on the availability of soil moisture in the root zone and plant growth stage

2- Irrigation water applied (IWA):

The amounts of irrigation water throughout the two growing seasons under drip irrigation are showed in Table (7). Results in Table 6 indicated that daily irrigation with applied water equals 100% of crop evapotranspiration resulted in higher amount of irrigation water applied due to the application of 100% of ETc, followed by daily irrigation with applied water equals 90%, 80%, and 70% of ETc, respectively.

Table (7): Monthly and seasonal evapotranspiration rates and water applied as affected by irrigation treatments and nitrogen rates for maize over both growing seasons under drip irrigation.

Irrigation treatments at	Nitrogen rates fed.$^{-1}$	Months					Seasonal water consumption (cm)	Water applied (cm)
		june	july	August	sept.	oct.		
100%of ET_c	Zero	0.19	1.25	9.53	6.12	0.57	52.66	59.5
	50 Kg N	0.19	1.40	9.56	6.14	0.60	52.89	
	100 Kg N	0.19	1.42	9.61	6.19	0.62	53.03	
	150 Kg N	0.19	1.44	9.64	6.22	0.62	53.11	
Mean		0.19	1.38	9.59	6.17	0.60	52.93	
90% of ET_c	Zero	0.19	0.20	7.74	4.42	0.27	47.82	53.5
	50 Kg N	0.19	0.24	7.78	4.46	0.30	47.97	
	100 Kg N	0.19	0.31	7.60	4.48	0.31	47.89	
	150 Kg N	0.19	0.38	7.63	4.52	0.33	48.05	
Mean		0.19	0.28	7.69	4.47	0.30	47.93	
80% of ET_c	Zero	0.19	.02	5.68	2.72	0.79	42.40	47.6
	50 Kg N	0.19	.03	5.71	2.84	0.92	42.69	
	100 Kg N	0.19	.06	5.78	2.93	0.97	42.93	
	150 Kg N	0.19	.08	5.81	3.08	0.99	43.15	
Mean		0.19	.05	5.75	2.89	0.92	42.80	
70% of ET_c	Zero	0.19	.03	4.33	1.38	0.55	38.48	41.6
	50 Kg N	0.19	.06	4.35	1.41	0.57	38.58	
	100 Kg N	0.19	.08	4.40	1.47	0.59	38.73	
	150 Kg N	0.19	.14	4.43	1.54	0.61	38.91	
Mean		0.19	.08	4.38	1.45	0.58	38.68	

3- Water productivity (WP)

WP calculated for all treatments are given in Table 8. The values of WP ranged from 1.4 to 2.0 kg m^{-3} depending on the treatments .The WP was higher at increasing N applied . The mean values (over 2 seasons) due to Zero N, 50 kg N, 100 kg N and 150 kg N were 1.4 , 1.7 , 1.9 and 1.9 kg seed m^{-3}

Results showed that maize plants irrigated daily with 90% of ETc had the highest value of WP(1.8 kg m^{-3}), while the lowest one resulted with 70% of Etc. These findings could be attributed to the highly significant differences among grain maize yield as well as differences between water consumptive uses. The present results are in line with those reported by Ghadiri and Majidian (2003), Abdel Mawly and Zanouny (2005), Yang *et al*., (2005) and Abo-Omer (2006) who mentioned that the water productivity decreased as the soil moisture was maintained high.

Table (8): Interaction between irrigation and nitrogen fertilizer levels on Water productivity (WP) of maize, over both growing seasons

	100% of ET_c	90% of ET_c	80% of ET_c	70% of ET_c	Mean
Zero N	1.4 c	1.4 c	1.4 c	1.4 c	1.4 c
50 kg N	1.7 b	1.8 b	1.7 b	1.6 b	1.7 b
100 kg N	1.9 a	1.9 a	1.9 a	1.9 a	1.9 a
150 kg N	1.9 a	1.9 a	2.0 a	2.0 a	1.9 a
Mean	1.725	1.750	1.750	1.725	

Comparison	LSD (5%)
In row	0.2629
In column	0.1032

CONCLUSION

Irrigation water and nitrogen had a positive effect on growth and yield of Zea maize as it enhanced Zea maize production. According to the results, we can recommend that under shortage of irrigation water, daily irrigation with 90% of ETc and fertilization with 150 kg N per feddan are the best conditions for producing a good and high maize grain yield in sandy loam soils of Wady Elnatroon region, Egypt and the same conditions.

REFERENCES

Abd El-Hafez S. A.; Meshref H. A.; El-Hamdi Kh. H. and El-Atawy Gh. Sh. I. (2008). Effect of irrigation, nitrogen and organic fertilization on soil water relationships of Zea maize crop. J. Agric. Sci. Mansoura Univ., 33 (7): 5409-5418.

Abd El-Hafez, S.A.; El-Sabbagh A.A.; El-Bably, A.Z. and Abo-Ahmed, E.I. (2001). Response of maize crop to drip irrigation in clay soils. Alex. J. Agric. Res. Egypt, 46(2): 153-159.

Abdel-Aziz, A. and El-Bialy, U.S. (2004). Response of maize plant to soil moisture stress and foliar spray with potassium. J. Agric. Sci. Mansoura Univ., Egypt, 29(6): 3599-3619.

Abdel-Maksoud, H. H.; M. R. K. Ashry and K. M. R. Youssef (2008). Maize yield and water relations under different irrigation and plant density treatments. J. Agric. Sci. Mansoura Univ., 33 (5): 3881- 3893.

Abdel-Mawly, S.E. and I. Zanouny (2005). Irrigation and Fertilization management for maximizing crop-water Effeciencies of Maize. Minia J. Agric. Res. And Develop., 25 (1):125-146

Abo-Omer, E. A. E. (2006). Effect of water level at different growth stages on growth and yield of maize and water productivity. M. Sc. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt.

Ali, M. H.; M. R. Hoque; A. A. Hassan and A. Khair (2007). Effects of deficit irrigation on yield, water productivity, and economic returns of wheat. Agricultural Water Management 92(3): 151-161.

Allen, R. G.; L. S. Pereirs; D. Raes and M. Smith (1998). Crop evapotranspiration. Guidelines for computing crop water requirements. FAO irrigation and drainage, paper No. 56, FAO, Rome.

Ayotamuno, J. M.; K. Zuofa; O. A.Sunday and B. R. Kogbara (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. African Journal of Biotechnology Vol. 6 (5), pp. 509-515.)

El-Atawy, Gh. Sh. (2007). Irrigation and fertilization management under the conditions of Kafr El-Sheikh Governorate soil. Ph.D. Thesis, Soil Dept. Fac. of Agric., Mansoura Univ., Egypt.

El-Bably A. Z. (2007). Irrigation scheduling of some maize cultivars using class A pan evaporation in north delta Egypt. Bull. Fac., Agric., Cairo Univ., 58 (3): 222-232.

El-Hamdi Kh. H.; Meshref H. A.; Abd El-Hafez S. A. and El-Atawy Gh. Sh. (2008). Effect of irrigation, nitrogen and organic fertilization on yield and nutrient contents of Zea maize crop. J. Agric. Sci. Mansoura Univ., 33 (7): 5419- 5428.

El-Mowelhi, N. M.; S. A. Abd El-Hafez; A. A. El-Sabbagh and El-Sh. I. Abou-Ahmed (1999). Evaluation of drip irrigated maize in North Delta, Egypt. 3rd Conf. of on farm irrigation and agroclimatology. Vol. (1). p. 223-231, January 25-27, 1999, Egypt.

El-Nagar, G.R. (2003). Integrating of mineral and Bio-fixed nitrogen fertilization in maize production under different irrigation regimes. Assiut J. Agric. sci.,34 (5) : 53-76.

El-Sabbagh, A. A.; S.A. Abd El-Hafez and El-Sh. I. Abou-Ahmed (1997). Response of some maize cultivars to water regime. Menofiya J. Agric. Res., 22(5): 1431-1440.

Filintas, T. Ag., (2003) Cultivation of maize in Greece: Increase and growth, management, output yield and environmental sequences, Univ. of Aegean, Fac. of Environment, Depart. Of Environmental Studies, Mitilini, Greece (In Greek with English abstract).

Galbiatti, J. A.; Borges, M. J.; Bueno, L. F.; Garcia, A. and Vieira, R. D. (2004). Effect of different irrigation periods in the development, yield and seedling quality in the maize (*Zea mays* L.) crop. Engenharia Agricola 24(2): 301-308.

Ghadiri, H. and Majidian, M. (2003). Effect of different nitrogen fertilizer levels and moisture stress during milky and dough stages on grain yield, yield components and water productivity of corn (*Zea mays* L.). Journal of Science and Technology of Agriculture and Natural resources. 7(2):103-113.

Gomez, K.A and A. Gomez(1984) Statistical procedures for agricultural research . 1st ed. John Wiley & Sons, New York
Hansin, U. W.; O. W. Israelsen and Q. E. Stringharm (1979). Irrigation Principles and Practices. 4th (ed.). John Willey and Sons
Ibrahim, S. A and Hala, Kandil (2007). Growth, Yield and Chemical Constituents of corn (*Zea maize* L.) as affected by nitrogen and phosphors fertilization under different irrigation intervals. Journal of Applied Sciences Research, 3(10): 1112-1120,
Kara, T. and C. Biber (2008). Irrigation frequencies and corn (*Zea mays* L.) yield relation in Northern Turkey. Pak. J. Sci., 11(1): 123-126.
Keller, J. and Karmeli (1974). Trickle irrigation design parameters. Transaction of the Amer. Soc. agric. Eng., 177(4): 678-684.
Ma, B. L. and Subedi, K.D.; (2005). Development, yield, grain moisture and nitrogen uptake of Bt corn hybrids and their conventional near-isolines. Field-Crops-Res. 93(2/3): 199-211.
Megyes, A.; J. Nagy; T. Rátonyi and L. Huzsvai (2005). Irrigation of maize (*Zea mays* L.) in relation to fertilization in a long-term field experiment. Acta Agron. Hungaria Vol. 53 (1): 41-46
Meleha, M. I. (2006). Water management of maize crop on North Delta. J. Agric. Sci. Mansoura Univ., 31(2): 1185-1199.
Oktem, A.; M. Simsek and A. G. Oktem (2003). Deficit irrigation effects on sweet corn (Zea mays sccharata Sturt) with drip irrigation system in a semi-arid region I. Water-yield relationship. Agric. Water Manage., 61: 63-74.
Omran W. M.(2005). Maize yield response to available soil moisture. Monofiya J. Agric. Res. 30 (4): 1257-1268.
Othman-Sanaa A.; A. M. M. Shehata and I. M. El-Naggar (2005). Effect of rice straw compost and N-fertilization on maize production and some soil physical properties. Minufiya J. Agric. Res. 30 (6): 1853-1863.
Page, A. L.; R. H. Miller and D. R. Keeny (1984). "Methods of Soil Analysis." Madison, Wisconsin, USA, Part 2.
Singh, S. S., P. Gupta and A. K. Gupta (2003). Handbook of Agricultural Sciences. Kalyani Publishers, New Delhi, India. pp. 184- 185..
Viswanatha, G.B.; B.K. Ramachandrappa and H.V. Nanjappa, 2002. Soil-plant water status and yield of sweet corn (*Zea mays* L. cv. Saccharata) as influenced by drip irrigation and planting methods. Agric. Water Manage. 55: 85-91.
Wajid, A.; A. Ghaffar; M. Maqsood; Kh. Hussain and W. Nasim (2007).Yield response of maize hybrids to varying nitrogen rates. Pak. J. Agri. Sci., Vol. 44(2): 217-220.
Waller, R.A. and D.B.Duncan. (1969). Symmetric multiple Comparison Problem. Amer. Stat. Assoc. Jour. December, 1485-1503.
Yang, T.; Liang, Z.S.; Xue, J. and Kang, S. (2005). Diversity of water productivity in various maize varieties. Transaction of the Chinese Society of Agricultural Engineering. 21(10): 21-25.

تأثير كميات مياه الري والتسميد النتروجيني على إنتاجية محصول الذرة الشامية وبعض العلاقات المائية في الأراضي الرملية بوادي النطرون, محافظة البحيرة, مصر

الغباشي الشرنوبي العطوي و صبحي محمد عيد
معهد بحوث الأراضي والمياه والبيئة، مركز البحوث الزراعية، الجيزة, مصر

أجريت هذه الدراسة بمنطقة وادي النطرون محافظة البحيرة خلال موسمي 2008 ، 2009 بهدف دراسة تأثير كميات مياه الري المضافة تحت نظام الري بالتنقيط السطحي ومعدلات التسميد النتروجيني على المحصول ومكوناته والعلاقات المائية لمحصول الذرة الشامية.

واستخدم تصميم القطع المنشقة حيث كانت معاملات الري بالقطع الرئيسية والتسميد النيتروجيني بالقطع المنشقة في أربع مكررات وكانت المعاملات تحت الدراسة:

*** أولاً: معاملات الري:**

أ : تروى يومياً وبكمية مياه تعادل 100% من البخر نتح اليومي للمحصول.
ب: تروى يومياً وبكمية مياه تعادل 90 % من البخر نتح اليومي للمحصول.
ج: تروى يومياً وبكمية مياه تعادل 80 % من البخر نتح اليومي للمحصول.
د : تروى يومياً وبكمية مياه تعادل 70 % من البخر نتح اليومي للمحصول.

*** ثانياً: معاملات التسميد:**

الكنترول (بدون تسميد) ، 50 ، 100 و 150 كيلو جرام نيتروجين للفدان.
وتم إضافة 10م^3 سماد دواجن + 15 كجم فو$_2$ ا$_5$ للفدان قبل الزراعة.

وكانت أهم النتائج التى تم الحصول عليها كما يلي:

1) أدى الري اليومي بكمية مياه تعادل 100% من جهد البخر نتح إلى زيادة معنوية لصفة ارتفاع النبات بنسبة 3.33% وطول الكوز بنسبة 7%، عدد الحبوب في السطر الواحد بنسبة 15.25%، وزن 100 حبة بنسبة 6.19% ومحصول الحبوب للفدان بنسبة 37.25%, مقارنة بالري اليومي بكمية مياه تعادل 70% من جهد البخر نتح اليومي للمحصول.
2) أدت إضافة السماد النيتروجيني بمعدل 150 كجم للفدان إلى زيادة معنوية لصفة ارتفاع النبات, طول الكوز، عدد الحبوب في السطر الواحد ، وزن 100 حبة ومحصول الحبوب للفدان بنسبة 5% , 5.9% , 8.4% ,10.1% و 47.25% مقارنة بالكنترول (بدون تسميد نيتروجيني معدني).
3) أدى الري اليومي بكمية مياه تعادل 100% من البخر نتح اليومي إلى زيادة معنوية من عناصر النيتروجين والفوسفور والبوتاسيوم بنسبة (36.9%, 21.2% , 9.8%) و(23.5% ,21.2% و18.5%) من المحتوى الكيماوي لنباتات الذرة والحبوب على الترتيب, كما أدت إضافة السماد النيتروجيني بمعدل 150 كجم للفدان إلى زيادة معنوية من عناصر النيتروجين والفوسفور والبوتاسيوم بنسبة (111.1%, 46.6%, 31.7%) و(121.1%, 38.7 % و 26.9%) من المحتوى الكيماوي لنباتات الذرة والحبوب على الترتيب مقارنة بالكنترول.
4) وجد أن متوسط قيم الاستهلاك المائي الموسمي بلغ 52.93 ، 47.93 ، 42.8 و 38.68 سم لمعاملات الري اليومي وبكمية مياه تعادل 100% , 90% , 80% , 70% من جهد البخر نتح اليومي في المنطقة على الترتيب, بينما كانت قيم الاحتياجات المائية المضافة لنفس المعاملات هي 59.5سم , 53.5 سم , 47.6 سم و41.65 سم على الترتيب.
5) أدى الري اليومي للذرة وبكمية مياه تعادل 90% من جهد البخر نتح اليومي في المنطقة إلى زيادة كفاءة استخدام المياه (كجم حبوب/ م^3 ماء مضاف أو لكل م^3 ماء مستهلك) مقارنة بالري اليومي وبكمية مياه تعادل 100% , 80% , 70% من جهد البخر نتح اليومي في المنطقة.

يمكن التوصية للحصول على محصول جيد للذرة الشامية في حالة ندرة المياه فيمكن الري بكميات مياه تعادل 90% من البخر نتح اليومي للمحصول مع التسميد النيتروجيني بمعدل 150كجم نيتروجين للفدان وذلك في الأراضي ذات القوام الرملي السلتي بمنطقة وادي النطرون والظروف المشابهة لها.

قام بتحكيم البحث

أ.د / سامى عبد الحميد حماد	**كلية الزراعة – جامعة المنصورة**
أ.د / محمد محى الدين صفان	**كلية الزراعة – جامعة كفر الشيخ**