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YIELD AND SOME WATER RELATION OF MAIZE CROP AS INFLUENCED BY IRRIGATION SCHEDULING AND NITROGEN FERTILIZATION RATES AT MIDDLE NORTH NILE DELTA

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ABSTRACT

Two field experiments were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt during the two successive seasons of 2007 and 2008. The objectives of this research were: (i) to study the effect of irrigation scheduling using three different pan evaporation coefficients on maize yield; (ii) to evaluate the growth, yield and N use efficiency of maize as affected by different rates of N fertilization. The treatments were arranged in a split plot design with four replicates. The main plots were assigned with three irrigation regimes I_1, $I_2$and I_3 irrigated at 1.2 ,1.0 and 0.8 of accumulation of A.P.E. Five nitrogen rates i.e. zero,60, 90,120 and 150 kg N fed.$^{-1}$ in the sub plots namely N_1, N_2, N_3 , N_4 and N_5 .

Results showed that 1.2 of A.P.E significantly increased grain yield by 5.4, 8.9% and straw yield by 5.7 , 11.3% compared to irrigation at 1.0, 0.8 of A.P.E. respectively. Also irrigation at 1.2 of A.P.E resulted in higher amount of irrigation water applied to be 3150 m^3 /fed distributed on 7 irrigations , followed by irrigation at 1.0 to be 2830 m^3 /fed distributed on 6 irrigations , and irrigation at 0.8 of A.P.E. was 2370 m^3/fed distributed on 5 ones. The highest consumptive water used was obtained under irrigation with 1.2 pan evaporation coefficient i.e. 2386 m^3 .while the lowest 1998 m^3 obtained from irrigation at 0.8 of A.P.E.. Lower frequent irrigation due to irrigation at 0.8 of A.P.E. resulted in a significantly increased water productivity compared to the other two irrigation treatments it was 1.260, 1.903 and 1.957 kg/m^3 for I_1, I_2 and I_3 respectively

Increasing nitrogen rates up to 150 kg N fed.$^{-1}$ (N_5) significantly increased grain and straw yield by 69 , 50 ; 11.9 ,22.5 ; 4.7 , 4.7 % as compared to N_1 ; N_2 ; N_3 treatments respectively but not significant with N_4

Nitrogen use efficiency (NUE) increased with decreasing water applied .It was 77.47 , 79.25 and 80.07 % for I_1 , I_2 , I_3,respectively , and decreased with increasing N rate; 88.1 ,85.7 , 77.4 and 64.5 for N_2 ; N_3 ; N_4 and N_5 respectively.

Therefore, to increase water productivity and to save irrigation water, it could be recommended to irrigate maize at 1.0 of A.P.E in middle north Nile Delta soils to save water of about 320 m^3

Keywords: Irrigation scheduling, Nitrogen use efficiency, water consumptive use,maize yield

INTRODUCTION

Irrigation water is gradually becoming scarce not only in arid and semi-arid regions but also in the regions where rainfall is abundant. Therefore, water saving and conservation is essential to support agricultural activities, which account for 85% of the total water consumed In semiarid regions, Irrigation is one of the most important inputs to increase crop productivity. Sustainable water use is particularly relevant in areas where groundwater resources are used and crops with high water requirements, such as maize, are grown, because of the pumping energy costs (Ortega *et al*., 2004)

Irrigation scheduling is the decision of when and how much water to apply to a field,where,(i) its purpose is to maximize irrigation efficiencies by applying the exact amount of water needed to replenish the soil moisture to the desired level.(ii) Irrigation scheduling saves water and energy.(iii) All irrigation scheduling procedures consist of monitoring indicators that determine the need for irrigatio

The usefulness of evaporation pan to predict soil moisture deficit in field and to estimate the crop water requirement for weekly and long period is discussed in detail by Ashraf *et al*., (2002).

The knowledge of water requirement of maize is important for planning water management practices at farm . Norwood (2000) reported that irrigation, fertilizer, and plant density management systems substantially increased yields above those of dry land corn. A single irrigation at tassel combined with 112 kg ha^{-1} N, increased yield by an average of 1.76 Mg ha^{-1} (29%). On average, two (at tassel and dough stage of grain fill) and three (at the 9 to 10 leaf stage; and at tassel; and dough stage of grain fill) irrigations, in combination with N rates and plant density increased yields 11 and 13%, respectively.

Technique of pan evaporation for irrigation scheduling have been used by several researchers (Ashraf *et al.,* (2002); Khalil and Mohamed, (2006). El bably (2007)who studied the effect of 3 irrigation regime 0.8, 1.0 and 1.2 of accumulation pan evaporation (APE) on the productivity and soil water relationship of three maize cultivars. He showed that irrigation scheduling at 1.2 of APE significantly increased plant high by 4.4%,ear length by 4.6 %, number of rows by 16.7%,number of grains /row by 7.3 %, 100 grain yield weight by 6.6 %, yield of plant 17.1 % and grain yield /fed by 18.1 %.

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). Nitrogen fertilizer applied at rates higher than the optimum requirement for crop production may cause an increase in nitrate accumulation below the grain zone and leaching . (Norwood 2000) reported that irrigation, fertilizer, and plant density management systems substantially increased yields above those of dry land corn. A single irrigation at tassel combined with 112 kg ha-1 N, increased yield by an average of 1.76 Mg ha-1 (29%). On average, two (at tassel and dough stage of grain fill) and three (at the 9 to 10 leaf stage; and at tassel; and dough stage of grain fill) irrigations, in combination with N rates and plant density increased yields 11 and 13%, respectively.

Several studies have investigated the effect of interactions between irrigation and N on corn production, and water use efficiency. In general, increase in soil moisture enhances corn yield response to N fertilization, especially when high N rates are applied (Eck, 1984). In addition, N uptake was strongly influenced by water supply (Martin *et al*., 1982). Irrigation and N fertilization effects or their interactions are usually evaluated in terms of corn yield Norwood, (2000); El-sharkawy et al (2006).showed that increasing N-rate was accompanied with significant increase in maize grain yield values, in applied water and in water use efficiency (WUE) values. The increase in maize grain yield comprised 31.1 and 48.9 % and those of water applied reached 9.3 to 13.9, while with WUE the increases were 20.0 and 30.7% with 45 kg N/ fed. And 22.6 and 40.9 % with 90 kg/fed., compared to without N fertilization in the two seasons of study , respectively .Increasing irrigation intervals to 18 or 24 days resulted in reduction in applied water by 13.9 and 26.1 %in the first season and by 10.87-29.98 % in the 2nd one ,while the corresponding reduction in grain yield reached 5.2 and 16.8% ,; 6.1 and 18.42 % ., however WUE values were increased which reached 10.87-12.9 in the 1st season and 4.4 and 16.5 % in the 2nd one , compared with 12 days intervals.

Therefore the present study was conducted with the objective to (i) study the effect of scheduling irrigation using three different pan evaporation coefficients on maize grain and straw yield and water productivity .(ii) to evaluate the growth, yield and N use efficiency by maize as affected by different rates of N fertilization

MATERIALS AND METHODS

A field trial was conducted during the two successive growing seasons 2007 and 2008 at Sakha Agricultural Research Station, Kafr EL-Shiekh Governorate. The site represents the circumstances and conditions of Middle North Nile Delta region and allocated at 31-07' N Latitude, 30-57'E Longitude with an elevation of about 6 meters above mean sea level. Agrometeorological data of Sakha station , during the two season of study , are presented in table (1)

The experimental treatments were arranged in split plot design with four replicates. The main plot were devoted to irrigation treatment i.e 1.2,1.0 and 0.8 of accumulative pan evaporation (A.P.E), while sub plots were assigned to (nitrogen application) i.e 0,60,90,120 and 150 kg N/fed. Sub-plot area was 52 m^2 including 10 rows 7.5m long and 70 cm apart. Plots were isolated by ditches of 1.5 m in width to avoid lateral movement of water. Planting was in hill 30cm apart, seeding rate was 15 kg/fed. Maize hybrid single cross10 was used in the experiments. Maize seeds were sown in June 15th and 12th in both growing seasons. Plants were thinned to one plant per hill before the first irrigation the preceding crop was clover in both seasons. Nitrogen fertilizer was applied in the form of urea (46.5%N).All recommended agronomic practices for maize production in Sakha area were applied .The soil of the experimental site was clayey. The electrical conductivity (ECe) as well as of the irrigation water (ECw), and soil pH values were 2.o3dsm^{-1},0.48dsm^{-1} and 8.10 respectively , determined according to, page(1982). Water table level 150 cm as recorded by observation well.

Maize plants were harvested after 120 days from planting in both seasons.

Grain yield was obtained from the central area of each plot (1/80 fed.) to avoid eny border effect. Maize grain yield was adjusted to 15.5% moisture content. The flowing traits were measured i.e grain and straw yield in kg/fed.

Nitrogen content was determined by Kjeldahl method according to AOAC (1990)

Soil-water relation:

Soil moisture content was gravimetrically determine in soil samples taken from consecutive depth of 15 cm down to a depth of 60 cm. soil samples were also collected just before each irrigation, 48 hours after irrigation and at harvest time. Field capacity, permanent wilting point and bulk density were determined according to klute (1986) to depth 60 cm , Available moisture was calculated by subtracting wilting point from field capacity , (table 2)

Time of irrigation:

The available soil water has been converted to water depth in mm ,table (2), and it was 129.6 mm., at every irrigation the equivalent amount of evaporation that can occur was estimated, while amount of available soil water is being used. Scheduling of irrigation started after applying the first irrigation. Monthly accumulative pan evaporation (A.P.E), number and irrigation interval are presented in table (3)

Table (1): The average daily values of Sakha meteorological research station during 2007 and 2008 seasons

Season	2007					2008				
interval	Air temperature c^0		Relative humidity %		Pan evaporation (mm/day)	Air temperature c^0		Relative humidity %		Pan evaporation (mm/day)
	max	min	max	min		max	min	max	min	
1-10/6	31.0	15.0	81.3	59.2	7.01	32.6	14.7	82.0	46.0	8.51
11-20/6	32.0	16.0	81.4	56.0	7.90	32.0	14.0	80.0	51.0	7.17
21-30/6	35.0	19.5	84.4	52.7	8.82	34.0	16.0	85.5	54.0	7.67
1-10/7	32.8	17.0	83.5	56.2	7.07	33.3	16.4	82.5	57.2	7.74
11-20/7	33.2	17.7	90.2	56.5	6.91	32.8	16.2	80.8	57.1	7.09
21-31/7	35.2	19.0	83.3	54.5	7.08	32.8	16.0	77.7	58.5	6.21
1-10/8	33.0	17.7	82.1	59.0	6.58	33.0	16.2	82.6	58.3	7.5
11-20/8	33.5	17.5	85.3	58.0	6.71	34.4	16.6	85.3	57.1	6.22
21-31/8	34.5	17.5	90.3	58.0	6.55	34.6	16.5	90.0	57.0	6.91
1-10/9	33.0	16.5	80.5	52.7	5.95	33.5	15.4	82.0	52.0	6.5
11-20/9	31.5	13.0	71.0	53.2	5.82	34.0	14.6	80.0	47.0	6.35
21-30/9	33.0	12.5	74.5	61.2	4.92	33.6	15.0	68.0	44.0	5.85
1-10/10	31.2	13.0	76.0	58.0	4.65	32.5	13.0	73.0	47.5	5.09
11-20/10	29.4	12.2	74.6	55.0	4.67	28.0	11.0	72.0	53.6	3.42
21-31/10	30.0	11.0	81.3	56.5	4.37	26.5	10.0	72.0	54.5	3.29

Table (2): Some physical analysis of soil samples for experiment site.

Depth	Particle size distribution			Texture	F.C W%	PWP W%	Bulk density g/cm^3	Available water	
	Sand %	Silt %	Clay %					w%	mm
0- 15	15.28	18.80	65.92	Clay	47.2	25.65	1.14	21.55	36.8
15-30	19.90	13.80	66.30	Clay	40.5	22.01	1.15	18.45	31.8
30-45	16.59	16.92	66.49	Clay	37.0	20.10	1.24	16.91	31.4
45-60	17.65	15.24	67.12	Clay	34.5	18.79	1.26	15.71	29.6

Irrigation water applied (Wa)

Irrigation water was calculated by the summation of the daily records of class A pan evaporation.

Submerged flow orifice with fixed dimension was used to convey and measure the irrigation water applied, as the following equation (James,1988).

Q = CA $\sqrt{2gh}$

Where

Q = Discharge through orifice, (cm^3 sec^{-1}).
C = Coefficient of discharges (0. 61).
A = Cross sectional area of orifice, cm^2.
g = Acceleration due to gravity, cm/sec^2 (980cm/sec).
h = Pressure head, over the orifice center, cm.

Crop-water Relation Parameters:

Water Consumptive Use (CU)

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

Cu = $\sum_{i=1}^{1=4} D_1 \text{ x } D_{b1} \text{ x } \frac{PW_2 - PW_1}{100}$

CU = Water consumptive use (cm)
D_1 = Soil layer depth (15 cm each).
D_{b1} = Soil bulk density, (g/cm^3) for this depth.
PW_1= Soil moisture percentage before irrigation (on mass basis, %).
PW_1=Soil moisture percentage, 48 hours after irrigation (on mass basis, %).
I = Number of soil layers each (15 cm) depth.

Applied fertilizer nitrogen is partly taken up and used by the corn crop and partly “lost” to the environment.

Nitrogen Use Efficiency (NUE) is a term used to indicate the relative balance between the amount of fertilizer N taken up and used by the crop versus the amount of fertilizer N lost .

N use efficiency was calculated according to the formula Mosier et al. (2004)

N U E = (**TNF) - (TNU) / R *100**

Where:
TNF = Total nutrient uptake from fertilized plots
TNU = Total nutrient uptake from unfertilized plots
R = Rate of fertilizer nutrient applied

Water productivity (WP):

It was calculated according to (Ali *et al.,* 2007).

WP = GY/ET.

Where WP (kg/m^3), GY is grain yield (kg/fed). and ET total water consumption of the growing season (m^3/fed.)

Productivity of irrigation water (PIW)

Was calculated as (Ali *et al*., 2007)

PIW= GY/I

Where I is irrigation water applied (m^3/fed.).

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 compared by the least significant difference (LSD) at 5% level of significance which developed by Waller and Duncan (1969)

Table (3): Number and irrigation intervals as affected by irrigation treatments during the two growing seasons

Season	Season 2007				Season 2008			
		Irrigation at A.P.E of				Irrigation at A.P.E of		
Interval of A.P.E	A.P.E mm	1.2 (108 mm)	1.0 (129.6 mm)	0.8 (162 mm)	A.P.E mm	1.2 (108 mm)	1.0 (129.6 mm)	0.8 (162 mm)
1-10/6	70.1				85.1	12/6*	12/6*	12/6*
11-20/6	79.0	15/6*	15/6*	15/6*	71.7			
21-30/6	88.2				76.7	27/6 (15)	27/6 (15)	27/6 (15)
Total	237.3				233.5			
1-10/7	70.7	1/7 (15)	1/7 (15)	1/7 (15)	77.4	-	-	-
11-20/7	69.1	15/7 (14)	18/7 (17)	-	70.9	12/7 (14)	16/7 (19)	19/7 (22)
21-30/7	70.8	-	-	24/7 (23)	62.1	28/7 (16)	-	-
Total	210.6				210.4			
1-10/8	65.8	1/8 (16)	5/8 (18)	-	75.0	-	4/8 (19)	-
11-20/8	67.1	17/8 (16)	-	18/8 (24)	62.2	14/8 (16)	-	13/8 (24)
21-30/8	65.5	-	25/8 (20)		69.1	30/8 (16)	26/8 (22)	-
Total	198.4				206.3			
1-10/9	59.5	4/9 (17)	-	-	65.0	-	-	8/9 (25)
11-20/9	58.2	-	18/9 (23)	15/9 (28)	63.5	19/9 (19)	14/9 (19)	-
21-30/9	49.2	22/9 (19)	-	-	58.5	-	-	-
Total	166.9				187			
1-10/10	46.5	-	-	-	50.9	-	-	-
11-20/10	46.7	15/10 (23) harvesting	15/10 (27) harvesting	15/10 (30) harvesting	34.2	12/10 (23) harvesting	12/10 (28) harvesting	12/10 (33) harvesting
21-30/10	43.7				32.9			
Total	136.9				118			
No of irrigation		7	6	5		7	6	5

- **planting date**
- **Figures shown in between parenthesis indicate the irrigation intervals in days**

RESULTS AND DISCUSSION

Grain and straw yield

Effect of scheduling irrigation

The results in table (4) Indicate that irrigation by the highest rate .i.e., scheduling at 1.2 of accumulative pan evaporation (A.P.E) significantly increased grain yield by 5.1, 7.7% and straw yield by 5.7, 11.3% compared to irrigation at 1.0and 0.8 of A.P.E. respectively. These results are in agreement with those obtained by El-Bably (2007), Abd El-Hafez *et al*., (2001) , El-Tantawy *et al*., (2007) and Galbiatti *et al*., (2004) 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. The reduction in yield could be attributed to water shortage that causes the close of the stomata and reduce all metabolism process within plant tissues.

Effect of nitrogen level:

Increasing nitrogen levels from 0 to 60, 90,120 and 150 N/fed resulted in highly significant increase grain and straw yield in both seasons. Table (4). Significant increases were recorded for N_2, N_3, N_4 and N_5 compared with N1 treatment. The increase were 51.7, 62.1 , 68.8 and 69.8 % for grain yield and 19.0 ,42.9 , 47.6 and 49.7 % for straw yield respectively . This indicate that increasing N level up to 120 kg N/fed increased significantly the grain and straw yield, and that N applied over 120 kg/ fed., had no significant effect on the grain and straw yield. These results are in harmony with those of El Sharkawy(2006)

Interaction between irrigation treatment and nitrogen level

Data in table (5) show that the average values of grain and straw yield were significantly affected by the interaction between irrigation scheduling and nitrogen level in the combined analysis over both seasons. It is clear from table (5) that the highest mean values of grain and straw yields were 4779.3 and 2633 kg/fed respectively obtained from irrigation at 1.2 of A.P.E (I_1) with 150 kg nitrogen level (F_5). On the other hand, the lowest value of grain and straw yield were 2442 and 1546 kg/fed., obtained from irrigation at 0.8 of APE (I_3) using zero nitrogen level (N_1**).** However , there no significant differences between I_1N_4 and I_1N_5 treatments for grain and straw yield

N uptake

Effect of scheduling irrigation :

As shown in table (4) the effect **of** scheduling irrigation had no significant effect on both grain N uptake and straw N uptake .

Effect of nitrogen level:

Increasing nitrogen levels from 0 to 60, 90,120 and 150 N/fed resulted in highly significant increase grain and straw N-uptake in both seasons. table (4). Significant increases were recorded for N_2, N_3, N_4 and N_5 treatments compared with N_1 These increases were 106, 168, 168 and 190 % for grain N uptake and 43 ,70 , 57 and 101 % for straw N uptake respectively . This indicates that increasing N level up to 120 kg N/fed., increased significantly the grain and straw N uptake. However The N applied over 120 kg/ fed., had no significant effect on grain N uptake.

Nitrogen use efficiency (NUE):

NUE calculated for all treatments are given in table (4). The NUE were higher at low coefficients. results showed that the highest values were observed with irrigation at 0.8 of APE followed by irrigation at 1.0 of APE and the least ones were obtained with irrigation at 1.2 of APE . This mean that

NUE values increased with increasing the irrigation water applied . Values of the NUE due to I_1, I_2 and I_3 were 77,47 ,79.25 and 80.07 % , respectively.

Concerning the effect of the nitrogen rate applied , results showed that increasing the applied N-rate decrease the NUE , since highest value was obtained with N_2 and the lowest one obtained with N_5 .The values of NUE (over two seasons) due to N_2,N_3 ,N_4 and N_5 were 88.1 , 85.7 , 77.4 , and 64.5 % respectively.

Table (4): Mean values of grain yield (kg/fed), straw yield (kg/fed),grain N uptake, straw N uptake and Nitrogen use efficiency as affected by irrigation and nitrogen rates in the combined analysis over both seasons.

Irrigation treatments	Nitrogen treatments	Grain yield KG/FED	Straw Yield KG/FED	Grain N uptake KG	straw N uptake	Nitrogen use efficiency %
I_1	N_1	2876.0	1803.3			
	N_1	2798.9	1867.7	37.5	22.9	
	N_2	4148.7	2170.0	77.5	35.3	88.3
	N_3	4365.3	2523.3	100.6	36.9	86.2
	N_4	4740.0	2620.0	107.8	38.4	71.5
	N_5	4779. 0	2633.3	109.3	47.0	63.9
I_2	N_1	2683.3	1646.7	37.5	22.9	
	N_2	4021.3	2090.0	78.3	37.1	90.0
	N_3	4215.7	2373.3	102.1	37.0	86.6
	N_4	4404.3	2533.3	109.0	39.8	74.1
	N_5	4437.7	2533.3	110.2	49.7	66.3
I_3	N_1	2442.0	1546.7	38.0	23.0	
	N_2	4084.7	1999.7	79.0	36.0	86.0
	N_3	4265.7	2336.7	100.0	37.0	84.4
	N_4	4227.3	2386.7	110.0	39.0	86.6
	N_5	4239.7	2410.0	112.0	44.0	63.3
Mean of irrigation	I_1	4166 a	2363 a	86.433 a	36.1 a	77.47
	I_2	3952 b	2235 b	87.320 a	37.3 a	79.25
	I_3	3851 c	2123 c	87.800 a	33.8 a	80.07
LSD 5%		74.43	90.08	6.53	5.006	
Mean of Nitrogen treatments	N_1	2640 d	1687 d	37.5 d	22.9 e	
	N_2	4005 c	2008 c	77.47 c	32.8 d	88.1
	N_3	4282 b	2411 b	100.5 b	39.0 c	85.7
	N_4	4457 a	2491 a	107.6 a	36.1 b	77.4
	N_5	4485 a	2526 a	109.1 a	47.8 a	64.5
LSD 5 %		96.8	75.15	2.221	1.205	

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

Soil water relations

Irrigation water applied (IWA):

Amount of irrigation water applied was calculated by summation of daily evaporation records from class A pan evaporation for each treatments. Results in table (6) indicate that watering at 1.2 of A.P.E (I_1) resulted in higher amount of irrigation water applied to be 3150 m^3 /fed due to frequent irrigation, followed by watering at 1.0 and 0.8 of A.P.E (I_2) and (I_3) to be 2830 and 2370 m^3/fed respectively. Amount of irrigation water applied at 1.2, 1.0

and 0.8 of A.P.E was distributed on 7, 6 and 5 irrigation including seeding irrigation. It was also noticed that increasing N rate was accompanied with slightly increase in the applied water value, since the increase in applied water , due to increasing N rate up to 150 kg N/fed., reached 2.4% as compared with zero N rate . These results are in accordance with EL Sharkawy (2006) who stated that water applied for maize crop was increased as N rate increase.

As for irrigation interval, data showed that irrigation at 1.2 APE applied at 7 irrigation , i.e. , 15 days after seeding ,14 to 16 days after the 1st and 2nd irrigation according to growing season (see table 3) ,then 16 to 17 days after the 2nd as well as the 3rd irrigation , 18 to 20 days after the 4th as well as the 5th irrigation and 22 to 23 days after the 6th irrigation .

While irrigation at 0.8 APE applied at 5 irrigation , i.e.,15 days after seeding , 23 days after the 1st one , 25 days after 2nd irrigation , 28 days after 3rd irrigation and 30 days after the 4th irrigation .

The other treatment (I_2), irrigation at 1.0 APE , was in between (see table 3), Seeding and first irrigation were the same for all treatments.

Water consumptive use (CU):

Mean values of Water consumptive use for maize in 2007 and 2008 growing seasons are presented in Table (6). The highest and lowest values were obtained under irrigation with 1.2 and 0.8 pan evaporation coefficient , i.e. ,2386 and 1998 m^3/fed respectively(average of the two seasons). These results demonstrate that water consumption use increased as soil moisture was maintained high by frequent irrigations. The probable explanation of these results is that higher frequent irrigations provide chance for more consumption of water which ultimately resulted in increasing transpiration and evaporation from the soil surface. These results are in agreement with the data reported by Abd El-Hafez *et al*., (2001) ,Galbiatti *et al*., (2004) El-Tantawy *et al*., (2007) and El-Bably 2007

Water productivity (WP):

Water productivity expressed in kg of grain yield/m^3 of water consumed is present in table (6). The obtained results showed that WP increased as the irrigation water applied decreased. Maize irrigated at 0.8 of A.P.E had the highest value of WP to be 1.957 Kg of grain yield/ m^3 of water consumed, while the lowest one was 1.260 Kg of grain yield/ m^3 of water consumed, resulted from watering at 1.2 of A.P.E. These findings could be attributed to the highly significant differences among grain maize yield as well as differences between water consumed. The present results are in line with those reported by Ghadiri and Majidian (2003), Abdel Mawly and Zanouny (2005), Yang *et al*., (2005) El-Bably 2007 and El-Atawy (2007), Who mentioned that the efficiency of water use decreased as the soil moisture was maintained high by frequent irrigation. Data also showed that increasing N-rate resulted in gradual increase in WP values, since values of WP amounted 1.74 , 1.83 , and 1.94 kg of grain yield /m^3 of consumed water under 60 , 90 , and 120 kg N/fed., rates compared with zero N-rate . These results coincided with those of EL Sharkawy (2006) . The same trend was also observed with WP of straw yield as shown in table (6)

Table (5): Interaction between irrigation and nitrogen level on yields grain and straw (kg/fed.), over both growing seasons

Nitrogen treatment	Grain yield (kg/fed.)			Straw yield (kg/fed.)		
	1.2 of A.P.E (I_1)	**1.0 of A.P.E (I_2)**	**0.8 of A.P.E (I_3)**	**1.2 of A.P.E (I_1)**	**1.0 of A.P.E (I_2)**	**0.8 of A.P.E (I_3)**
F_1	2794.9 d	2683.1 d	2442.0 d	1867 d	1646 d	1546 d
F_2	4148.7 c	4021.1 c	4085.1 c	2170 c	2090 c	2002 c
F_3	4365.3 b	4215.6 b	4265.4 b	2523 b	2373 b	2335 b
F_4	4740.0 a	4404.3 a	4227.1 a	2620 a	2533 a	2420 a
F_5	4779.3 a	4437.5 a	4229.2 a	2633 a	2533 a	2410 a
LSD 5 %	96.8			30.0		

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

Productivity of irrigation water (PIW):

Mean values of PIW as affected by irrigation scheduling and rate of nitrogen fertilizer are shown in table (6). Results indicate that the highest values of PIW were recorded from the irrigation at 0.8 of A.P.E (I_3) whereas the lowest ones were obtained from irrigation at 1.2 of A.P.E (I_3). These results could be attributed to the significant differences among maize grain yield, evapotranspiration and water applied values. Results in table (6) cleared that with increasing the no of irrigation, both PIW of grain and straw yield increased. The highest average values of PIW 1.556 and 0.898 kg/m^3 for grain and straw yield , respectively , were obtained under treatment watering at 0.8 of A.P.E (I_3) , while the lowest ones 0.950 and 0.744 kg/m^3 , respectively were obtained under treatment watering at 1.2 of A.P.E (I_1). These results indicate that increasing irrigation at from (I_1) up to (I_3) increased the PIW of grain and straw yield by about 63% and 19.4% respectively.

This means that the effect of irrigation scheduling is more pronounced on yield of grains than that on the straw. The higher values of PIW of (I_3) than that of (I_1) is obviously due to the less amount of the applied water (W_a) under treatment (I_3), as shown in table (6). Average values of the W_a under (I_3) is less than that of (I_1) by about 32.5% .Thus ,the reduction of the W_a ,due to the irrigation regime of (I_3) ,is much lower than of the yield ,Therefore values of PIW were higher under (I_3) than (I_1) treatment .These finding is in harmony with those obtained by El-Bably(2007.)

Concerning the effect of N fertilizer on the PIW, as shown in table (6) results reveled that increasing N fertilizer significantly increased PIW values of grain and straw yield. This is due to the increased of grains and straw yield with increasing N fertilizer. The highest average values of PIW 1.510 and 0.912 kg/m^3 for grain and straw yield ,respectively ,were obtained under treatment (F_5).Whereas the lowest ones 0.88 and 0.60 kg/m^3 respectively, were obtained under treatment (F_1) .), These results are in agreement with those of Abdel Mawly and Zanouny (2005), Yang *et al*., (2005) El-Bably 2007 and El-Atawy (2007),

Table (6): Water productivity Kg/m (WP) and Productivity of irrigation water Kg/m^3 (PIW) in the combined analysis over both seasons.

Treatments		C.U, m^3/fed.	Water applied (m^3/fed)	WP Kg/m^3		PIW Kg/m^3	
				Grain	Straw	Grain	Straw
I_1	F_1	2320	3100	1.21	0.66	0.88	0.59
	F_2	2380	3100	1.74	0.91	1.32	0.68
	F_3	2390	3150	1.83	1.05	1.39	0.79
	F_4	2430	3200	1.94	1.07	1.51	0.83
	F_5	2460	3200	1.94	1.07	1.51	0.83
I_2	F_1	2120	2800	1.26	0.77	0.94	058
	F_2	2160	2810	1.86	0.96	1.42	0.73
	F_3	2190	2830	1.92	1.07	1.49	0.83
	F_4	2210	2850	1.99	1.14	1.55	0.89
	F_5	2250	2880	1.97	1.13	1.56	0.89
I_3	F_1	1860	2350	1.31	0.83	1.03	0.65
	F_2	1940	2360	2.11	1.03	1.72	0.84
	F_3	2010	2370	2.12	1.16	1.79	0.98
	F_4	2080	2380	2.03	1.14	1.78	1.01
	F_5	2100	2390	2.01	1.14	1.78	1.01
Mean of irrigation	I_1	2386 a	3150 a	1.260 b	0.753 c	0.950 c	0.744 b
	I_2	2186 b	2830 b	1.903 a	0.967 b	1.492 b	0.785 b
	I_3	1998 c	2370 c	1.957 a	1.093 a	1.556 a	0.898 a
LSD 5%		18.02	49.37	0.135	0.101	0.0282	0.0489
Mean of Nitrogen treatments	F_1	2100 e	2750 c	1.210 d	0.660 c	0.880 d	0.606 d
	F_2	2143 d	2770 bc	1.740 c	0.913 b	1.320 c	0.750 c
	F_3	2196 c	2783abc	1.830 b	1.050 a	1.390 b	0.867 b
	F_4	2240 b	2796 ab	1.940 a	1.070 a	1.510 a	0.912 a
	F_5	2270 a	2816 a	1.940 a	1.070 a	1.510 a	0.910 a
LSD 5%		6.454	33.45	0.1192	0.023	0.0337	0.023

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

Conclusion:

The results of our work indicated that the highest grain and straw yield for maize planted in both growing seasons of 2007 and 2008 was obtained when the plants were irrigated using 1.2 pan evaporation coefficient. However, the highest water productivity was obtained under irrigation with 1.0 pan evaporation coefficient in both growing season (320 m^3) saving in applied irrigation water). Therefore, it is recommended to apply irrigation water using 1.0 pan evaporation coefficient to save irrigation water and to increase water productivity under 120 kg N/fed .

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تأثيرجدولة الرى ومعدلات التسميد النتروجينى على الانتاج لمحصول الذره فى وسط شمال دلتا النيل وبعض العلاقات المائية

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اجريت هذه الدراسه بمزرعة محطة البحوث الزراعية بسخا – محافظة كفرالشيخ عامى 2007 و2008 بهدف (1) دراسة تأثير جدولة الرى باستخدام وعاء البخر القياسى على انتاج محصول الذره وكفاءة استخدام المياه (2) تقييم المحصول تحت مستويات مختلفة من النتروجين.

استخدم تصميم القطع المنشقه فى اربع مكررات حيث خصصت القطع الرئيسية لمعاملات جدولة الرى وهى الرى عند 1.2- 1.0- 0.8 (I1 – I2 –I3) من البخر التراكمى لوعاء البخر القياسى فى حين وزعت معدلات التسميد 0-60-90-120- 150 كجم للفدان ($N_5 – N_4 – N_3 – N_2 – N_1$) على القطع المنشقه

وعند الحصاد قدر انتاج المحصول من الحبوب والقش وكذا كفاءة استخدام المياه وكفاءة استخدام النتروجين تحت تأثير معاملات جدولة الرى والتسميد المختلفة وأوضحت النتائج أن :

1- الرى عند 1.2 من البخر التراكمى لوعاء البخر القياسى أدى الى زياده معنوية فى محصول الحبوب 5.1, 7.6% ومحصول القش 10.3% , 5.7 بالمقارنه لمعاملتى الرى الاخرى 1.0-8 .0

2- بلغت قيم الاحتياجات المائيه للذره الشاميه 3150 م^3 موزعه على 7 ريات و 2830 م^3 موزعه على 6 ريات و 2370 م^3 موزعه على 5 ريات وذلك للرى عند 1.2- 1.0- 0.8 على الترتيب

3-بلغت قيم الاستهلاك المائى الموسمى 2386 – 2186 - 1998 تحت معاملات الرى 1.2- 1.0- 0.8 من مجموع البخر التراكمى على التوالى

4- حققت المعامله 0.8 اعلى قيمة لل WP (1.957) الا انها غير معنوية مع المعامله 1.0 (1.903) كج للمتر المكعب

5- كفاءة استخدام النتروجين زادت بانخفاض كميات مياه الرى المضافة وانخفضت بزيادة معدلات التسميد

توصى الدراسه برى الذره عند معامل 1.0 من مجموع البخر التراكمى مع التسميد بمعدل 120 كجم N/فدان تحت ظروف منطقة الدراسة . حيث وفر320 متر مكعب مياه لكل فدان ذره مقابل انخفاض غير مؤكد فى الانتاج مقداره 5.4 %

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