J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 2 (8): 799 - 812, 2011

MAXIMIZING WATER AND N FERTILIZER USE EFFICIENCIES UNDER WHEAT CROP AT NORTH DELTA

Sonbol, H. A.* ; Z. M. El-Sirafy* ; E. A. E. Gazia ; H. A. Shams El-Din** and Sahar H. Rashed****

*** Fac. Agric., Mans. Univ.**

**** Soil, Water and Environment Research Institute**

ABSTRACT

Field experiment was conducted during 2007 cultivation season at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate. Split plot design was used; main plots were arranged for irrigation treatments (6 treatments), namely: surface irrigation (I_1) floppy sprinkler (I_2) , semipertable (I_3) , minisprinkler (I_4) ,surface drip (I_5) and subsurface drip (I_6). Sub plots were subjected for nitrogen fertilization treatments (5 levels), namely: 100% soil application (N1), 100% fertigation (N2), 75 % fertigation +25 % soil application (N3), 50% fertigation + 50% soil application (N4) and 25% fertigation + 75% soil application (N5). Results could be summarized as follows:

The lowest value of water applied to wheat (36.59 cm) was achieved under sub surface drip system. On the other side, the highest value of water applied to wheat (57.68 cm) is recorded with surface irrigation system. The highest amount of water stored under wheat crop was 43.68 cm for surface irrigation system and the lowest amount was (33.21 cm) for subsurface drip system. The actual water consumptive use increased with surface irrigation system to the maximum value (43.61 cm). while the minimum value was recorded with subsurface drip system (32.86 cm). The extraction of the soil moisture by wheat roots from the top layer with surface drip irrigation was higher than that with subsurface drip system, the highest irrigation application efficiency (90.75%) was achieved by subsurface drip system compared to the lowest value (74.79%) which obtained with the control (surface irrigation). The highest values of FWUE to wheat (2.05 kgm^{-3}) was recorded with minisprinkler and the lowest (1.39 kgm^{-3}) was achieved under floppy sprinkler system. The highest value of CWUE to wheat (2.30 kgm^{-3}) was resulted from minisprinkler system and the lowest (0.95 kg/m^3) was achieved under surface drip system. Subsurface drip system recorded the highest value of (WDE 90%). Also, The lowest value of WDE% (68 %) was recorded with flood irrigation system. Surface irrigation method gave the highest grain and straw yield (3894 and 4117 kg fed^{-1}). The lowest yield was obtained by surface drip. Increasing nitrogen addition N2(100% fertigation) produced the highest wheat grain and straw yield (3158.36 and 3445.44 kg fed^{-1}). There were high significant differences among irrigation systems on leaf area, spike length and number of kernels/spike.

The highest value of nitrogen use efficiency to wheat grain (45.55) was recorded under I_1 system and the lowest (25.67) was achieved under I_6 system. The highest value of N-recovery to grain wheat (68.76%) was recorded with I_3(minisprinkler) and the lowest (32.89%) was achieved under I_6. Increasing nitrogen units led to an increase in nitrogen use efficiency attributed to N_2 (100% fertigation) was higher than the same obtained in N_1 (100% soil application).The highest values of nitrogen use efficiency were obtained by I_3 N_2 (46.84%), and the lowest one was detected under I_6 N_1 (22.44%), N- recovery increased with increasing N level. The highest value of N recovery % was found under I_1 N_2 and the lowest one was found under I_6 N_1.

INTRODUCTION

Egypt is going to become more water poor country. The per capita share of water is now below the level of 1000 m^3 / person/year, which is just on, the border of what so called poverty line and expected to go further down with time.

The problem of surface irrigation system is that half of the irrigation water applied is lost. Soil fertility continues to decline because of agricultural intensification and cultivating crops more than time a year. Nitrogen which is an essential plant nutrient is the most commonly deficient and reduces yield throughout the world. There is a great gab between wheat consumption and production.

There are several methods for applying irrigation water; from which four methods were chosen namely: surface irrigation, sprinkler irrigation, drip irrigation and subsurface irrigation. Irrigation water application may be reduced by 21% with furrow irrigation. (Einsenhaver and Youth (1992)). Average water saving by furrow irrigation is about 32% as compared to border irrigation, Khan *et al* (1998). Water use efficiency was 30% higher in the drip irrigation treatments than that of furrow irrigation,(Matoes *et al,* (1991)). Drip irrigation achieved higher irrigation efficiency than surface irrigation (Omran, 2004).

The highest yield of wheat grain (2.25 tons fed^{-1}) was obtained with 120 kg N fed^{-1} (Faizy *et al*, 1986 b). The grain and straw yields of wheat, spike length, 1000 grain weight, number of grains $spike^{-1}$ were significantly increased with increasing N level up to 110 kg $feddan^{-1}$ (Mousa, 1995).

So, the objectives of this study are to evaluate the irrigation systems through their impacts on water use efficiencies, as well as determining nitrogen use efficiency with different irrigation systems for wheat crop at North Delta.

MATERIALS AND METHODS

Field experiment was conducted during 2007 cultivation season at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate. Soil samples were taken before planting from different depths namely; (0-15), (15-30), (30-45) and (45-60) cm, respectively, air dried, ground, sieved and stored for physical and chemical analysis. Mechanical analysis for soil was carried out using the pipette method as described by Dewis and Fartias (1970).

Split plot design was used; main plots were arranged for irrigation treatments namely: Surface irrigation (I_1), Semi portable sprinkler: (I_2), Minisprinkler (I_3), Floppy sprinkler (I_4), Surface drip (I_5) and Subsurface drip (I_6). Sub plots were subjectedto nitrogen fertilization treatments namely: 100 % soil application (N_1), 100 % fertigation (N_2), 75 % fertigation + 25% soil application (N_3), 50 % fertigation + 50% soil application (N_4) and 25 %

fertigation + 75% soil application (N_5). The seasonal prespitation at the research area was 70 mm.

Table (1): Chemical properties of the soil samples taken from Sakha Agricultural Research station farm, in the growing season 2007.

Depth (cm)	O.M. %	$CaCO_3$ %	C.E.C. meg/100 g soil	pH*	EC** dS/m²	Soluble cations, meg/l				Soluble cations, meg/l.				SAR
						Na^+	K^+	Ca^{++}	Mg^{++}	Co3-	HCo_3	Cl^-	SO_4	
0-15	1.48	2.13	48.5	8.08	1.68	11.4	0.16	3.53	2.01	0.0	3.0	8.0	6.1	6.9
15-30	1.23	2.05	45.0	8.16	1.73	11.9	0.17	3.68	2.1	0.0	3.5	8.3	6.1	7.0
30-45	1.05	1.86	44.0	8.21	1.92	13.1	0.19	4.03	2.3	0.0	4.0	9.1	6.5	7.4
45-60	0.95	1.71	42.5	8.29	2.01	13.8	0.20	4.22	2.41	0.0	4.5	9.6	6.5	7.6

*** pH was determined in soil suspension (1:2.5)**
**** EC was determined in saturated soil paste extract.**

Table (2): Particle size distribution and mean values of field capacity, permanent wilting point, available water and bulk density of the soil samples taken from Sakha Agricultural Station farm.

Depth cm	Particle size distribution				Field capacity %	Permanent wilting point %	Available water %	Bulk density, g cm³
	Sand %	Salt %	Clay %	Texture class				
0-15	21.59	35.76	42.65	Clay	43.70	23.96	19.74	1.24
15-30	21.10	32.15	46.75	Clay	39.00	21.20	17.80	1.36
30-45	20.61	29.71	49.68	Clay	37.10	20.11	16.99	1.39
45-60	18.13	30.50	51.37	Clay	36.20	19.67	16.53	1.47

Flag leaf area, FLA (cm^2), Plant height (cm), Spike length (cm), 1000-grain weight (g), Biological yield ($tonfed^{-1}$),Grain yield ($ardabfed^{-1}$) and Straw yield (ton/fed.) were determined

$$\text{Harvest index \% (HI)} = 100 \times \frac{\text{Grain yield}}{\text{Grain yield + Straw yield}}$$

Grain protein contentwas calculated according to A.O.A.C. (1980).

Recovering of N fertilizer was calculated according to Crasswell and Godwin, (1984).

$$\text{Recovery \% of N} = \frac{\text{N-uptake from treatment} - \text{N-uptake from control}}{\text{Fertilizer N applied}} \times 100$$

Irrigation water applied and irrigation time according to Phocaides (2001) as follows:

$$\text{Net depth of irrigation (DWs)} = F\,\frac{(Fe - Wp)}{100} \times Bd \times Ds \times P.$$

Where:
F = Permissible depletion, Fe = Field capacity (%),Wp = Wilting point (%) ,
Bd = Bulk density (g cm^{-3}), Ds = Soil layer depth(cm) and P = Ground cover
Irrigation application efficiency (Ea) is calculated according to Michael (1978).

Crop water use efficiency (kg m^{-3}) (CWUE) and field water use efficiency (kg yield/m^3 (FWUE) were calculated according to Doorenbos and Pruitt, (1977) as follows:

$$\text{CWUE} = \text{Yield}(\text{kgfed}^{-1})/\text{seasonal water consumptive use}(\text{m3fed}^{-1})$$

$$\text{FWUE} = \text{Yield}(\text{kgfed}^{-1})/\text{amount of water applied}(\text{m}^3\text{fed}^{-1}).$$

Water distribution efficiency was calculated according to James (1988) .

RESULTS AND DISCUSSION

Effect of irrigation systems on some water relations:

Amount of water applied to wheat:

Data inTable (3) show that the lowest value of water applied to wheat (36.59 cm) is achieved under subsurface drip system. On the other side, the highest value of water applied to wheat (57.68 cm) is recorded with surface irrigation system. The reduction in the amount of water applied may be due to decreasing deep percolation, evaporation and run off. The highest value of water saving to wheat (36.57%) is recorded with subsurface drip. On the other hand, the lowest value of water saving added to wheat (13.25%) is achieved under floppy sprinkler system. These results are in agreement with those obtained by El-Marazky (1996)

Water stored in soil:

The highest amount of water stored under wheat crop is 43.68 cm for surface irrigation system compared with the lowest amount (33.21 cm) for subsurface drip system.

Actual water consumptive use:

Table (3) shows that the water consumptive use increases with surface irrigation system to the maximum value (43.61 cm), while the minimum value is recorded with subsurface drip system (32.86 cm).

Table (3): Values of stored, applied irrigation water, irrigation application efficiency and actual water consumptive use as affected by different irrigation systems.

Irrigation system	Amount of water stored (m^3fed^{-1})	Applied irrigation (water m^3fed^{-1})	irrigation application efficiency %	Actual water consumptive use	
				cm	m^3fed^{-1}
Surface irrigation	1834.69	2422.80	74.79	43.61	1831.62
Floppy sprinkler	1813.74	2101.68	86.29	40.69	17.08.98
Semiportable sprinkler	1696.99	1826.16	88.37	38.17	1603.14
Minisprinkler	1565.36	1725.36	90.73	36.61	1537.62
Surface drip	1475.88	1643.90	89.78	34.68	1456.56
Subsurface drip	1394.67	1536.78	90.75	32.86	1380.12

Soil moisture extraction patterns (SMEP):

It could be concluded from the data in Table (4) that the extraction of the moisture by wheat roots from the top layer with surface drip irrigation is higher than that with subsurface drip system, while the moisture extraction from the deeper layer is higher with the subsurface drip irrigation than that with the surface drip irrigation system. This behavior may be due to that the moisture is more available in deeper layer with the subsurface drip irrigation than that with the surface drip irrigation system and vice versa in the upper layer. Also, it could be observed that the moisture extraction from the upper layers by wheat roots with the semiportable sprinkler system is slightly lower than that recorded with the minisprinkler system (50.64%). Meanwhile, in the deepest layer (40-60cm), the moisture extraction with surface irrigation system was higher than that with subsurface irrigation system (17.16%).These results are in good agreement with those obtained by Morsi (2005)

Table (4): Percentages of soil moisture extraction by wheat roots from soil layers under different irrigation systems.

Irrigation system	Soil layers (cm)		
	0 – 20	20 – 40	40 – 60
Surface irrigation	49.33	33.51	17.16
Floppy sprinkler	50.76	35.51	13.73
Semiportable sprinkler	50.64	33.05	16.31
Minisprinkler	51.05	36.03	12.92
Surface drip	52.55	34.56	12.89
Subsurface drip	53.57	34.11	12.32

Irrigation efficiencies:

Water application efficiency (WAE):

Data in Table (3) show that the highest irrigation application efficiency (90.75%) is achieved by subsurface drip system compared to the lowest value (74.79%) which obtained with the control (surface irrigation). These findings are in some harmony with those obtained by El-Mowelhi *et al*. (1999), and Hanson and May (2004).

Field water use efficiency: (FWUE)

Data in Table (5). Shows that the highest values of FWUE for wheat crop (2.05 k gm^{-3}) is obtained with minisprinkler. On the other side, the lowest values of FWUE for wheat (1.39 kgm^{-3}) is achieved under floppy sprinkler system. . These results are in agreement with those of Morsi (2005), Omar *et al*. (2008) and Saied *et al*. (2008).

Crop water use efficiency (CWUE):

Data in Table (5) show that the highest value of CWUE by wheat (2.30 kgm^{-3}) is recorded with minisprinkler system. On the other side, the lowest value of CWUE for wheat (0.95 kgm^{-3}) is achieved under surface drip system. It could be concluded that the crop water use efficiency increases with increasing the uniform distribution of irrigation water along border and furrow irrigation systems to obtain maximum wheat yield. These results are in good agreement with those obtained by Abo-Soliman *et al*. (2005) and Singh *et al*. (2009).

Water distribution efficiency (WDE%):

Values of WDE% for the different irrigation systems are shown in Table (5) indicated that subsurface drip system recorded the highest value of (WDE 90%). Also, the lowest value of WDE% (68 %) is recorded with surface irrigation system. The trend of these data is in agreement with those obtained by Morsi (2005)

Table (5): Values of FWUE, CWUE and (WDE%) under different irrigation systems

Irrigation system	FWUE (kgm^{-3})	CWUE (kgm^{-3})	WDE %
surface irrigation	1.59	2.13	68
Floppy sprinkler	1.39	1.72	77
Semiportable sprinkler	1.49	1.70	80
Minisprinkler	2.05	2.30	87
Surface drip	1.77	0.95	89
Subsurface drip	1.50	1.67	90

Effect of irrigation systems and nitrogen fertilization on wheat crop :

Table (6) shows the values of grain and straw yields (kg fed^{-1}) as affected by different irrigation systems. The obtained results show high significant effect of irrigation system on grain and straw wheat yield. Surface irrigation method gives the highest grain and straw yields (3894 and 4117 kg fed^{-1}). The lowest yield is obtained by surface drip irrigation system since it produces grain and straw yields lower than that produced by surface irrigation method by 40.73 and 45.56%, .

Finally, it could be abstracted that using of the surface irrigation achieves the highest values of yield and yield components of wheat followed by minisprinkler and surface drip irrigation systems, while the lowest values are recorded with semiportable and subsurface drip irrigation systems. This trend may be positively related to the water applied or stored in the effective root zone. In other words, more water applied with proper irrigation application efficiency, more yield and yield components values and vice versa. The tendency of these results is similar to those obtained by Omar *et. al.* (2008). El-Hendawy *et.al.* (2008), Abo Soliman *et. al* (2008) and Saied *et.al.* (2008).

Also it is shown in Table (6) that data revealed that nitrogen fertilization affected highly significant on wheat yield , where the highest grain and straw yield were accompanied with increasing nitrogen addition N2(100% fertigation) which produced the highest wheat grain and straw yield (3158.36 and 3445.44 kg fed^{-1}), while the lowest grain and straw yield (2699.66 and 2908.66 kg fed^{-1}) were achieved under the N5 (25% fertigation + 75 soil application).

It is known that the nitrogen is the most important elements for plant growth and development, and it is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes (MKhabela *et. al.*, 2001).It is also obvious that nitrogen influences yield largely because of its role in determining the amount of sunshine absorbed by crops and the efficiency of conversion of sunshine to biomass.

Nitrogen deficiency reduces leaf size, which reduces total crop leaf area and consequently the ability to absorb radiation, furthermore, nitrogen deficiency reduces the concentration of N in leaves which reduces their sunshine use efficiency or ability to photosynthesis Nitrogen deficiency also causes premature leaf death because crops are able to sense when leaf nitrogen concentration is getting too low to sustain adequate levels of sunshine use efficiency. To combat this problem crops sacrifice leaves so that N can be shifted to a smaller number.

Data presented in Table (6) indicated that the weight of 1000 kernel was affected highly significant by irrigation systems and nitrogen application. Results in Table (6) show highly significant differences existed due to irrigation systems. Where surface irrigation system (I_1) gave the highest weight of 1000 kernel (74.60 gm) as compared with subsurface drip irrigation system which recorded (65.40 gm).

Regarding the effect of nitrogen fertilizer rate on this trait, the results showed highly significant differences, where N_3 (75 % fertigation + 25% soil application) gave the highest 1000 kernel weight while N_5 (25% fertigation + 75% soil application) gave the lowest one. This may be attributed to more number of kernel weight and size. The effect of the interactions between all factors under study on 1000 kernels weight was highly significant.

Table (6): Effect of irrigation systems and nitrogen fertilization on wheat grain and straw yields (Kgfed^{-1}) and weight of 1000 kernels (gm).

Treatments	Grain yield (kg fed $^{-1}$)	Straw yield (kg fed $^{-1}$)	Weight of 1000 kernels (gm)
Irrigation system (I)			
I_1	3894.00 a	4117.00 a	74.60 a
I_2	2720.04 e	3299.40 d	65.48 d
I_3	3536.26 b	3368.40 c	69.98 b
I_4	2793.70 d	3450.00 b	67.34 c
I_5	2907.40 c	2873.00 e	65.60 d
I_6	2307.90 f	2241.20 f	65.40 d
F-test	**	**	**
LSD 0.05	7.04	9.60	1.51
0.01	10.02	13.65	2.16
Nitrogen fertilization (N)			
N_1	3127.66 c	3362.16 c	68.48 b
N_2	3158.36 a	3445.44 a	67.13 ab
N_3	3146.86 b	3413.66 b	69.40 a
N_4	3000.19 d	2994.22 d	67.37 c
N_5	2699.66 e	2908.66 e	65.95 d
F-test	**	**	**
LSD 0.05	9.90	9.72	0.89
0.01	13.21	12.96	1.19
Interaction			
IXN	**	**	**

On the other hand nitrogen mediates the utilization of other plant nutrients especially phosphorus and potassium, Brady (1984).

Growth parameters:

Leaf area (cm^2) :

Data presented in Table (7), indicated that there were highly significant differences of irrigation systems on leaf area. Surface irrigation method achieved the highest value (48.60 cm^2) and exceeded significantly the other irrigation systems. Subsurface drip irrigation system produced the lowest leaf area (30.28 cm) respectively.

Nitrogen fertilizer application had significant effect on leaf area. Results indicated that increasing nitrogen fertilizer application levels from $_{N1}$ to N_2, N_4, and N_5 increased leaf area . The highest nitrogen application rate (N_1) recorded 39.80 cm^2 while the lowest nitrogen fertilizer application rate (N_5) recorded 36.05 cm^2, respectively. Interaction effect between irrigation systems and nitrogen application fertilizer rate on leaf area was highly significant.

Spike length (cm):

The overall mean values of the spike length as affected by irrigation systems and nitrogen fertilizer application rate are presented in Table (7).

Results showed highly significant difference existed between irrigation systems Surface irrigation system gave the longest spike (14.50 cm) without significant differences with irrigation systems (I_2, I_3, I_4, I_5 and I_6). While subsurface drip irrigation system (I_6) recorded the shortest spike length (10.60 cm).

Concerning the effect of nitrogen fertilizer application rates on spike length, data indicated that N_3 achieved the longest spike length followed by N_4, while N_1 recorded the shortest one.

Number of kernels/spike:

Data presented in Table (7) indicated that the number of kernels per spike was affected highly significantly by irrigation systems and nitrogen fertilizer rates.

Results in Table (7) show high significant differences existed due to irrigation systems. Where flood irrigation system (I_1) gave the highest number of kernels/spike (85 kernels), as compared with subsurface drip irrigation system which recorded (64.4 kernels), respectively.

Regarding the effect of nitrogen application rate on this trait (Table 7), it was quite obvious that the number of kernels/spike was highly significantly affected by increasing rate of nitrogen fertilizer application. Generally, the trend was that increasing nitrogen fertilizer application rate increased number of kernels per spike. The highest number of kernels (76 kernels) was recorded by using N3 (75% fertigation +25% soil application) and the lowest number 74 kernels was recorded by using N_1 (100% soil application). The increase in number of kernels/spike might be due to the increase in spike length and availability of nutrition, which provided by higher rate of nitrogen fertilizer application. The effect of the interaction between all factors was high significant

Results showed highly significant differences between each of N_1 and N_2 and N_3 and N_4 and N_5. In general, N_1 and N_2 gave the longest spike (39.8 and 39.27 cm) compared with the lowest spikes recorded the N_5 (36.05 cm), respectively.

Data in Table (7) show that the interaction effect between irrigation systems and nitrogen fertilizer application rate was highly significant on spike length.

Table (7): Effect of irrigation systems and nitrogen fertilization on wheat leaf area, spike length, number of kernels / spike.

Treatments	Leaf area (cm^2)	Spike length (cm)	Number of kernels/spike
Irrigation systems (I)			
I_1	48.60 a	14.50 a	85.00 a
I_2	31.94 d	11.20 c	73.60 d
I_3	44.88 b	12.28 b	76.00 b
I_4	40.10 c	11.16 c	74.40 c
I_5	32.36 d	11.10 c	74.60 c
I_6	30.28 e	10.60 d	64.40 e
F-test	**	**	**
LSD 0.05	0.43	0.28	0.78
0.01	0.61	0.40	1.11
Nitrogen fertilization (N)			
N_1	39.80 a	11.33 b	74.00 b
N_2	39.27 a	11.33 b	75.61 a
N_3	37.97 b	12.58 a	76.00 a
N_4	37.03 c	12.16 a	73.72 b
N_5	63.05d	11.62 b	74.00 b
F-test	**	**	**
LSD 0.05	0.52	0.35	0.79
0.01	0.70	0.46	1.05
Interaction			
IXN	**	**	**

Effect of irrigation systems and nitrogen fertilizer on nitrogen concentration and its uptake by wheat crop:

Irrigation systems effect:

Data presented in Table (8) showed that the nitrogen uptake (kg fed -1) was affected by irrigation systems. The highest value of nitrogen uptake by grain wheat (62.09 kg fed^{-1}) is recorded under I_1 system. On the other side, the lowest value of nitrogen uptake by grain wheat (29.06 kg fed^{-1}) is achieved under I_6 system.

Concerning the relative changes (%) of wheat grain yield, the mean value of nitrogen concentration in grains was detected under I_1 followed by I_3, also the N concentration and its uptake in wheat straw took the same behavior of grains.

Nitrogen fertilizers rate effect:

Data obtained in Table (8) show that nitrogen concentration (%) and its uptake (Kg fed^{-1}) by both grain and straw increased with increasing nitrogen levels consequently as a result of increasing amounts of available nitrogen in the root zone.

The highest amount of nitrogen uptake by grain and straw were 67.13 and 18.22 kg N fed -1 were recorded under N_2 (100% fertigation) for minisprinkler system. The lowest ones were under N_1 (100% soil application) (24.33 and 8.67 kg N fed^{-1}) for grain and straw under surface drip system.

Table (8): Effect of irrigation systems and nitrogen fertilization on concentration (%) and nitrogen uptake (kg fed $^{-1}$) by wheat.

Treatments		Nitrogen concentration (%)		Nitrogen uptake (kg fed^{-1})		Relative change (%) of nitrogen	
Irrigation systems	**Nitrogen fertilizer**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Surface irrigation	**N1**	**1.854**	**0.383**	**62.09**	**14.03**	**0.0**	**0.0**
Semiportable sprinkler	N_1	1.490	0.320	31.21	8.61	0.0	0.0
	N_2	1.605	0.435	42.75	14.78	36.98	71.66
	N_3	1.637	0.426	42.13	13.25	34.98	53.89
	N_4	1.594	0.355	35.70	9.78	14.39	13.59
	N_5	1.583	0.327	34.02	8.92	9.00	3.60
Mean		1.582	0.373	37.16	11.07	23.84	42.74
Minisprinkler	N_1	1.811	0.420	40.85	9.58	00.0	00.0
	N_2	1.953	0.513	67.13	18.22	64.33	90.19
	N_3	1.942	0.509	62.96	17.12	54.12	78.70
	N_4	1.931	0.425	61.99	13.50	51.68	40.92
	N_5	1.825	0.421	55.87	11.02	36.76	15.03
Mean		1.892	0.458	57.76	13.89	51.73	56.21
Floppy sprinkler	N_1	1.534	0.385	27.33	9.21	00.0	00.0
	N_2	1.835	0.411	49.54	15.04	81.27	63.30
	N_3	1.710	0.392	43.85	14.80	60.45	60.69
	N_4	1.616	0.403	40.28	14.75	47.38	60.15
	N_5	1.526	0.395	37.76	11.81	38.16	28.23
Mean		1.664	0.397	39.75	13.12	56.82	53.09
Surface drip	N_1	1.534	0.380	24.33	8.67	00.0	00.0
	N_2	1.835	0.426	49.54	11.78	103.62	35.87
	N_3	1.710	0.415	43.85	11.17	80.23	28.84
	N_4	1.616	0.392	40.28	10.40	65.56	19.95
	N_5	1.526	0.390	37.76	9.33	55.19	7.61
Mean		1.644	0.400	39.15	10.27	76.15	23.08
Subsurface drip	N_1	1.516	0.370	26.66	6.50	00.0	00.0
	N_2	1.486	0.351	30.23	9.55	25.92	46.92
	N_3	1.410	0.360	29.92	6.90	12.22	6.15
	N_4	1.431	0.362	29.84	6.65	11.93	2.3
	N_5	1.490	0.375	28.66	6.52	7.50	0.31

Effect of irrigation systems and nitrogen fertilizers on nitrogen use efficiency and N-recovery:

Data in Table (9) indicated that the highest value of nitrogen use efficiency to wheat grain (45.55 kgunit^{-1}) is recorded under I_1 system. On the other side, the lowest value of nitrogen use efficiency to wheat grain (25.67 kgunit^{-1}) is achieved under I_6 system.

Concerning the nitrogen recovery (%) of wheat grain yield, the highest value of N-recovery to grain wheat (68.76%) is recorded with I_3(minisprinkler). While, the lowest value of N-recovery to grain wheat (32.89%) is achieved under I_6 system.

Data illustrated in Table (9) shows the effect of nitrogen fertilizer application rate on nitrogen use efficiency and N-recovery %. It is well known that increasing nitrogen units led to an increase in yield according to Mitscerlich theory, so we can observe that nitrogen use efficiency attributed by N_2 (100% fertigation) is higher than the same obtained in N_1 (100% soil application). Data clearly shows that the highest value of nitrogen use efficiency was obtained by I_3 N_2 (46.84%), and the lowest one was detected under I_6 N_1 (22.44%), these results were in accordance with that of Rashed (2005) and Mosa (2006).

Data in Table (9) show the total nitrogen recovery for wheat crop (grain and straw) at maturity stage. Data indicated that nitrogen recovery was increased with increasing N level. The highest value of N recovery % was found under I_1 N_2 , whereas, the lowest one was found under I_6 N_1, similar results were obtained by Rashed (2005).

Table (9): Effect of irrigation systems and nitrogen fertilization levels on nitrogen use efficiency and recovery % for wheat crop

Treatments		Nitrogen use efficiency (kg/N unit)		N-recovery %	
Irrigation systems	Nitrogen fertilization	Grain	Straw	Grain	Straw
Surface irrigation	N1	45.55	42.84	51.68	17.54
Semiportable sprinkler	N_1	27.33	28.43	35.58	10.76
	N_2	35.59	38.35	50.00	18.48
	N_3	34.28	34.30	49.23	16.56
	N_4	29.43	29.31	41.19	12.23
	N_5	28.11	28.95	39.09	11.15
Mean		30.98	31.87	43.02	13.84
Minisprinkler	N_1	29.66	22.65	47.63	11.98
	N_2	46.84	40.50	80.48	22.78
	N_3	44.00	37.88	75.26	21.40
	N_4	43.54	35.25	74.05	16.88
	N_5	41.38	27.38	66.40	13.78
Mean		41.08	32.73	68.76	17.36
Floppy sprinkler	N_1	22.78	24.23	30.73	11.51
	N_2	36.12	43.65	58.49	18.80
	N_3	34.15	42.03	51.38	18.50
	N_4	33.10	32.63	46.91	18.44
	N_5	32.84	26.23	43.76	14.76
Mean		31.79	33.75	46.25	16.40
Surface drip	N_1	31.51	22.66	26.98	10.84
	N_2	35.98	29.48	58.49	14.73
	N_3	33.63	28.43	51.38	13.96
	N_4	33.36	27.90	46.91	13.00
	N_5	31.60	24.23	043.76	11.66
Mean		33.22	26.54	45.50	12.84
Subsurface drip	N_1	22.44	15.06	29.89	8.13
	N_2	27.72	28.88	34.35	11.94
	N_3	27.19	17.55	33.96	8.63
	N_4	26.44	16.41	33.86	8.31
	N_5	24.83	15.30	32.39	8.15
mean		25.67	18.64	32.89	9.03

REFERENCES

A. O. A. C. (1980). Association of official Agriculture Chemists. (official methods of analysis), 13th Ed. Washington, D. C.

Abo Soliman, M. S.; H. E. Osman; M. M. Saied and E. H. Omar (2005). Maize, barley production and water use efficiency as influenced by different irrigation methods in Egyptian old land. Role and horizons of Agricultural Engineering in the Contemporary world. The 13th Conference of the Misr. Society of Agr. Eng., 14-15 December (2005).

Crasswell. E. T. and D. C. Godwin (1984). The efficiency of nitrogen fertilizers applied to cereals in different climates Adv. Plant Nutrition 1, 1-55.

Dewis, J. and F. Fertias (1970). Physical and Chemical Methods of Soil and Water Analysis. Soils Bulltien No. 10 FAO. Rome.

Doorenbos, J and W. D. Pruitt (1977). Guideline of predicting crop water requirements. Irrigation and Drainage paper (24). FAO, Rome.

Einsenhaver, D. E. and C. D. Youth (1992). Managing furrow irrigation system. Proc. Central Plains Irrigation. Feb. 5-6, Nebraska, USA.

El-Hendawy, S. E.; Abd El-Lattief, E. A.; Mohamed, S.Ahmed and U. Schmidhalter (2008). Irrigation rate and plant density effects on yield and water use efficiency of drip-irrigated corn, Agricultural water Management, 2008, Vol:95, issue 7, pages:836-844,

El-Marazky, M. S. A. (1996). Cotton production under trickle irrigation in comparison with traditional systems. Ph. D. Thesis, Fac. Agric. (Moshtohor), Zagazig Univ., (Benha Branch).

El-Mowelhi, N. M.; S. A. Abd El-Hafez; A. A. El-Sabagh and A. L. Abo-Ahmed (1999). Evaluation of drip irrigated maize in North Delta, Egypt. Third Conference of on-farm Irrigation And Agro Climatology. January, 25, 27, 1999,Vol. 1

Faizy, S. E. D. A.; T. M. El-Essawi; R. A. Ali and A. El-Shamly (1986b). Splitting nitrogen and the effect of potassium fertilizer on grain yield of wheat. J. Agric., Res., Tanta Univ., 12 (4): 1241-1247.

Hanson, B. And D. May (2004). Effect of subsurface drip irrigation on processing tomato yield, water table depth, soil salinity and profitability. Agricultural Water Management, 68: 1-17.

Israelsen, O. W. and V. E. Hansen (1962) . Irrigation principles and practices, 3rd Edit. John Willey &sons, Inc. New York.

James, L. G. (1988). Principles of farm irrigation system design. John Willey &Sons (ed), New York, pp.543.

Khan, K. H.; H. Amjad and A. M. Khan (1998). Effect of different irrigation techniques on seed cotton yield. Sci. Tech. Development, 17 (1): 39-42.

Matoes, L; J. Berengena; F. Orgaz; J. Diz and E. Ferers (1991). Comparison between drip and furrow irrigation in cotton at two levels of water supply. Agric. Water Mange., 19: 313-324.

Michael (1978). Irrigation theory and practices . Vikas publishing House, New Delhi.

Mkhabela, M. S.; M. S. Mkhabela and J. Pali-Shikhulu (2001). Response of maize (*Zea mays* L.) cultivars to different levels of nitrogen applications in Swaziland. Seventh Eastern and Southern Africa Regional Maize Conf., pp. 377-381.

Morsi, T. M. A. (2005). Development of farm irrigation, development of irrigation systems by adding fertilizer with irrigation water. Ph. D., Fac. Agric., (Kafr El-Sheikh), Tanta Univ.

Mosa, A. A. (2006) Water use efficiency and nutrients uptake as affected by alternate furrow irrigation technique and fertilization of maize . Ph. D. Thesis, Mansoura Univ. Fac. Of Agric. Egypt.

Mousa, A. M. M. (1995). Some agronomic treatments on growth and yield components of wheat. M. Sc. Thesis, Agronomy, Fac. Agric., Tanta Univ., Library CAT: 631.5: 633. 11.

Omar, E. H.; M. A. Abd El-Aziz; M. M. Ragab and M. M. Saied (2008). Response of chickpea and maize crops plants grown in a clayey soil to subsurface drip irrigation biosolids and mineral NPK fertilizers. J. Agric. Sci., Mansoura Univ., 33 (6): 465-468.

Omran, W. M. E. (2004). Soil Water Movement as influenced by soil properties and irrigation . Ph. D. Fac. Of Agric. Minufiya University.

Phocaides, A. (2001). Handbook on pressurized irrigation techniques. Food and agric. Organization of the United Nations, Rome.

Rashed, Sahar H. (2005) Effect of bio and organic fertilization on zea mays. M Sc. Thesis, Mansoura Univ. Fac. Of Agric, Egypt.

Saied, M. M.; M. M. Ragab; S. M. El-Barabary and El-Shahawy (2008). Effect of pressurized irrigation system on soybean and flax yields and some water relations in old lands. Misr J. Agric. Eng., 25 (1): 87-10.

Singh, R. B.; C. P. S. Chanhna and P. S. Minhas (2009). Water production functions of wheat irrigation with saline and alkali waters using double line source sprinkler system. Agric. water Management, 96 (5): 736-744.

تعظيم كفاءات استخدام مياه الري والتسميد الأزوتي لمحصول القمح في منطقة شمال الدلتا

حسين احمد سنبل* ، زكريا مسعد الصيرفي* ، السيد عامر السيد جازية ، حسن علي شمس الدين** و سحر حسن راشد****

*** كلية الزراعة – جامعة المنصورة**

**** معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية**

أقيمت تجربة في موسم 2007 علي محصول القمح بمزرعة محطة البحوث الزراعية بسخا كفر الشيخ استخدم التصميم القطع المنشقة وكانت القطع الرئيسية معاملات الري (6 معاملات) والقطع المنشقة مستويات النتروجين (5 مستويات)

ويمكن تلخيص أهم النتائج فيما يلي :

اقل قيمة لماء الري المضاف للقمح (36.59 سم) كانت في حالة الري بالتنقيط السطحي وعلي الجانب الآخر كانت اعلي قيمة (58.4 سم) في حالة الري بالغمر . اعلي قيمة لمياه الري المخزنة في القطاع الأرضي (43.68 سم) كانت للري السطحي واقل قيمة (33.21 سم) كانت

لنظام الري بالتنقيط تحت سطحي ز تزايد الاستهلاك المائي تحت نظام الري السطحي لأعلي قيمة (43.61 سم) بينما كانت اقل قيمة تحت نظام الري بالتنقيط تحت السطحي . كان أعلي استخلاص للرطوبة بواسطة جذور نبات القمح في الطبقات السطحية في وحالة الري بالتنقيط السطحي عنها في حالة الري بالتنقيط تحت سطحي . اعلي كفاءات للري كانت لنظام الري بالتنقيط تحت السطحي بينما كانت اقلها في حالة الري السطحي . اعلي قيمة لكفاءة استخدام المياه (2.05 كجم/م3) تحت نظام الميني رشاش واقلها في حالة الفلوبي رشاش . كانت اعلي قيمة لكفاءة استخدام المحصول (2.3 كجم/م3) في حالة آلميني رشاش واقلها كانت (0.95 كجم/م3) في حالة نظام الري بالتنقيط السطحي . اعلي قيمة لكفاءة التوزيع (90%) كانت لنظام الري بالتنقيط تحت السطحي واقلها (68 %) كانت للري السطحي.

تحصل علي اعلي محصول للقمح (حبوب وقش) في حالة الري نظام الري السطحي واقلها في نظام الري بالتنقيط السطحي, وسجل اعلي محصول للقمح (حبوب وقش) قد سجل عند مستوي التسميد (100% مع مياه الري) (3158.36 و 3445.44 كجم/فدان) وقد لوحظ تأثير عالي المعنوية علي كل من مساحة الورقة وطول السنبلة وعدد السنيبلات في السنبلة.

اعلي قيمة لكفاءة استخدام النتروجين (45.55 %) تحت نظام استخدام السماد مع مياه الري كاملا واقلها كانت تحت نظام الإضافة الأرضية (25.67 %) . اعلي قيمة لكفاءة الاستفادة (68.76 %) كانت تحت I3 واقلها كانت I6 (32.89 %) . أدت زيادة وحدات النتروجين مع مياه الري إلي زيادة كفاءة استخدام النتروجين وكانت اعلي كفاءة استخدام علي وجه العموم مع التفاعل بين I_3N_2 (46.84 %) واقلها مع التفاعل بين I_6 N_1 (22.44 %) . زادت كفاءة الاستفادة من النتروجين بزيادة مستويات السماد ألآزوتي وكانت اعلي قيمة I1 N2 واقلها كانت تحت I6 N1.

قام بتحكيم البحث

أ.د / السيد محمود الحديدى	**كلية الزراعة – جامعة المنصورة**
أ.د / محمود محمد سعيد	**مركز البحوث الزراعية**