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MAXIMIZING WATER AND N FERTILIZER USE EFFICIENCIES UNDER MAIZE 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 at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate during the summer season of 2008, maize (zea mays) plants (variety mono parid 10) was cultivated. N-mineral fertilizer was applied as urea (46%). Split plot design was used; main plots were irrigation treatments namely: Surface irrigation (I_1), Semiportable sprinkler: (I_2), Minisprinkler (I_3), Floppy sprinkler (I_4), Surface drip (I_5) and Subsurface drip (I_6). Sub plots were 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 main résults could be sammarized as follows:

The lowest value of water applied under maize crop (48.06 cm) was achieved under subsurface drip system. and the highest value (63.03 cm) was recorded under surface irrigation system. While, the highest amounts of water stored under maize roots zone (49.08 cm) was obtained under floppy sprinkler system, and the lowest amount (45.31 cm) was found under subsurface drip system. The highest value of water consumptive use by maize crop was recorded under surface irrigation system (53.89 cm), and the lowest value was detected under subsurface drip system (38.17 cm). The most extracting portion of soil moisture by plant roots occurs in the upper 15 cm. The maximum value of water application efficiency (94.27%) was obtained from subsurface drip system, and the minimum (76.59%) was obtained from surface irrigation. The highest values of FWUE under maize crop (1.18 kg m^{-3}) was achieved under surface drip system. and the lowest value (0.79 kg/m^3) was recorded with semiportable sprinkler system The highest value of CWUE to maize crop (1.56 kg m^{-3}) was achieved under surface irrigation system., and the lowest value (0.97 kg m^{-3}) was recorded under semiportable sprinkler system. The longest plants were recorded with I_1 system, and the shortest plants were obtained with I_6 system. The longest plants (159.66 cm) were recorded with N_1 (surface irrigation), and the shortest plants (148.66 cm) were obtained under N_5 (subsurface irrigation system).Treatment I_5 obtained the highest value of leaf area (806.53 cm^2) and I_6 produced the lowest value (597.38 cm^2). Nitrogen application rate had significant effect on leaf area. The highest nitrogen application rate (N1) recorded 712.85 cm^2, while the lowest nitrogen fertilizer application rate (N_5) recorded 683.26 cm^2(LA).

The longest ear length (22.5 cm) was recorded from I_1 and the shortest ear length (11.58 cm) was recorded with (I_6). The effect of nitrogen fertilizer application rates, N_1 gave the longest ear length (19.09 cm) compared with the shortest ear length recorded with N_5 (17.58 cm).The interaction between irrigation systems and nitrogen application rates was highly significant effect on ear length.

There was high significant effect of irrigation systems on ear diameter. I_1 gave the highest ear diameter (9.4 cm). The lowest ear diameter was obtained by I_6 (5.92 cm). Ear diameter was highly significantly affected by changing the nitrogen fertilizer application rate. The highest ear diameter (8.35 cm) was recorded by using N_1 and the lowest and (7.23 cm) was recorded by using N_5 . Where I_1 gave the highest weight of 100 grain (50.18 g) as compared with (I_6) (34.12 g). N_1 gave the highest grain yield (2347.11 kg fed^{-1}). The lowest grain yield was recorded under N_5 (2053.83 kg fed $^{-1}$). Concerning the interaction effect between irrigation system and nitrogen application rate on grain and straw yield it was high significant.

The highest grain yield (2625.5 kg fed^{-1}) was recorded from I_1 while the lowest grain yield (1865 kg fed^{-1}) was recorded with I_2.

The highest values of N use efficiency to maize grain (20.21), was recorded with I_1. and the lowest values (13.87 kg/N unit) was achieved under I_2. Concerning the N-recovery (%) of maize grain yield, the highest value of N-recovery to maize grain (30.79%) is achieved with I_5 and the lowest value (19.19 %) was recorded under I_2. N-use efficiency and N-recovery % attributed to N_2 is higher than the same obtained by $N_{1.}$ The highest values of N-use efficiency were obtained by I_6 N_2 (21.78 kg/N) and the lowest one was detected under I_6 N_1 (10.35 kg/N unit).

Data indicated that N-recovery increased with increasing N level. The highest value of N-recovery % was found under I_5 and N_2 (35.40% grain and 18.16% straw), whereas, the lowest one was found under I_2 and N_1 (13 % grain and 10.49% straw)

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 one 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 maize consumption and production.

There are four methods for applying irrigation water namely: surface irrigation, sprinkler irrigation, drip irrigation and subsurface irrigation. Irrigation water application may be reduced by 21% with furrow irrigation. (Einsenhaver and Youth9 (1992). Average water saving by furrow irrigation is about 32% as compared to boarder irrigation. Khan *et al* (1998).reported that 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).

Application of 140 kg N fed^{-1} gave the highest maize grain yield. (El-Murshedy, 2002). The furrow irrigation method increased leaf area $plant^{-1}$ number of grains cob^{-1}, 100 grain weight and grain yield of maize (Riaz *et al*, 2002). Mkhabela *et al*, (2001) found that grain yield and total dry matter were increased with increasing nitrogen application rate up to 100 kg N ha^{-1}. Increasing N level from 60 to 120 kg fed^{-1} significantly increased plant height, ear height, ear length and diameter, number of rows, ear per plant, 100-kernel weight, yield per plant and per feddan in both seasons of the study (Griesh *et al*, 2001).

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 under different irrigation systems.

MATERIALS AND METHODS

Field experiment was conducted at Sakha Agriculture 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).

Table (1): Chemical properties of the soil samples taken from Sakha Agricultural Research station farm, in the growing season 2008.

Depth (cm)	O.M. %	$CaCo_3$ %	C.E.C. meq/100 g soil	pH*	EC** dS/m	Soluble cations meq/l				Soluble cations meq/l				SAR
						Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4	
0-15	1.22	2.46	41.20	7.89	1.46	9.93	0.14	3.7	1.75	0.0	3.0	6.9	4.9	6.4
15-30	0.98	2.28	39.50	7.96	1.62	11.02	0.16	3.40	1.94	0.0	3.5	7.7	5.3	6.7
30-45	0.75	2.10	37.80	8.05	1.82	12.38	0.18	3.82	2.18	0.0	4.0	8.7	5.9	7.1
45-60	0.65	1.95	35.90	8.11	1.95	13.26	0.19	4.10	2.34	0.0	4.5	9.3	6.1	7.4

*** pH was determined in soil suspension 1:2,5**
**** was determined in saturated soil paste extract.**

Table (2): Particle size distribution and mean values of bulk density, field capacity permanent wilting point and available water of the soil samples taken from Sakha, Agriculture Station farm in 2008 season.

Depth, cm	Particle size distribution							
	Sand %	Silt %	Clay %	Texture class	Field capacity %	Permanent wilting point %	Available water %	Bulk density G cm^{-3}
0-15	18.83	32.73	48.44	Clay	41.78	23.77	18.01	1.22
15-30	16.65	33.15	50.20	Clay	38.86	22.51	16.35	1.29
30-45	15.92	30.25	53.83	Clay	36.57	21.84	14.73	1.35
45-60	17.81	29.50	52.69	Clay	35.25	20.18	15.07	1.43

Split plot design was used; main plots were irrigation treatments namely: Surface irrigation (SI), Semi portable sprinkler: (SPS), Minisprinkler (MP), Floppy sprinkler (FS), Surface drip (SD) and Sub surface drip (SSD). Sub plots were nitrogen fertilization treatment 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).
Plant height leaf area: total yield: (ears + straw), grain yield: straw yield**:**. ear weight, ear diameter and 100 grain weight: were determined

$$\text{N use efficiency (NUE)} = 100 \times \frac{\text{(Grain yield of fertilizer level – grain yield of control)}}{\text{Fertilizer N applied}}$$

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

According to Grass well and Godwin, (1984).
CWUE and FWUE were calculated according to James (1988).

RESULTS AND DISCUSSION

Amount of water applied :

Data in Table 3 shows that the lowest values of water applied to maize (48.06 cm) is achieved under sub surface drip system, and the highest values of water applied to maize (63.03 cm) is recorded under surface irrigation system. The reduction in the amount of water applied may be due to decreasing deep percolation, evaporation and run off. The highest values of water saving to maize (23.79%) is recorded with subsurface drip. and the lowest values of water saving to maize (5.49%) is achieved under floppy sprinkler system. These results are in agreement with these obtained by El-Marazky (1996).

Table (3): Values of stored water, applied irrigation water and irrigation application efficiency and water consumptive use as affected by different irrigation systems during 2008 season.

Irrigation system	stored water, m^3/fed	applied irrigation water (m^3/fed)	irrigation application efficiency %	Water consumptive use (m^3/fed)
Surface irrigation	2027.86	2647.34	76.59	2263.38
Floppy sprinkler	2061.35	2501.94	82.39	2039.94
Semiportable sprinkler	1991.58	2366.70	84.08	1915.62
Minisprinkler	1989.95	2123.52	93.71	1811.46
Surface drip	1922.22	2052.12	93.37	1687.98
Subsurface drip	1902.86	2018.52	94.27	1603.14

Water stored in soil :

The highest amounts of water stored in maize (49.08 cm) is obtained with floppy sprinkler system, while the lowest amount of water stored under maize (45.31 cm) is found with subsurface drip system.

Actual water consumptive use :

Concerning the water consumed by maize crop the highest value of water consumptive use by maize is recorded with the traditional surface irrigation system (53.89 cm), while the lowest value is detected with subsurface drip system (38.17 cm).

Soil moisture extraction patterns (SMEP):

Data of soil moisture extraction from the effective root zone down to 60 cm by maize roots are shown in Table (4). The obtained results revealed that the most extracting portion of moisture by plant roots occurs in the upper 15 cm soil layer and then it decreased gradually in the other deeper layers to 60 cm depth. These results are in agood agreement with those obtained by Morsi (2005) .

Table (4): Percentage of soil moisture extraction by maize from soil layers during the growing season 2008.

Irrigation system	Soil layer cm		
	0 – 20	20 – 40	40 – 60
Surface irrigation	51.69	31.95	16.36
Floppy sprinkler	51.98	35.29	12.73
Semiportable sprinkler	53.25	33.35	13.40
Minisprinkler	51.40	34.68	13.92
Surface drip	51.49	33.12	15.39
Subsurface drip	51.29	34.79	13.92

Irrigation efficiencies:

Water application efficiency (WAE):

It is obvious from the data (table3) that the maximum value of water application efficiency (94.27%) was obtained from subsurface drip system, while the minimum application efficiency (76.59%) was obtained from surface irrigation system (control). 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):

The highest values of FWUE to maize (1.18 kg/m^3) was achieved under surface drip system. On the other hands the lowest value of FWUE to maize (0.79 kg/m^3) was recorded under semiportable sprinkler system (Table5). These results are in agreement with those of Morsi (2005), Omar *et al.* (2008) and Saied *et al.* (2008).

Crop water use efficiency (CWUE):

The highest value of CWUE to maize (1.56 kg/m^3) was achieved under surface irrigation system. The lowest value CWUE to maize (0.97 kg/m^3) was recorded under semiportable sprinkler system,(Table**5)**.

It can be concluded that the crop water use efficiency increases with increasing the uniform distribution of irrigation water along with boarder and furrow irrigation systems to obtain maximum maize yield. These results are in agood agreement with those obtained by Singh *et al.* (2009).

Water distribution efficiency (WDE):

The best treatment was that of subsurface drip irrigation system which had the highest value (91%) for maize crop. The lowest value of WDE for maize (72%) is recorded with surface irrigation system. The trend of these data is in agreement with those obtained by Morsi (2005)

Table (5): Field water use efficiency, crop water use efficiency and water distribution efficiency WDE under different irrigation systems for maize during 2008 season.

Irrigation system	Field use efficiency (kg/m^2)	Crop water use efficiency (kg/m^2)	WDE
Surface irrigation	0.99	1.56	72
Floppy sprinkler	0.89	1.09	80
Semiportable sprinkler	0.79	0.97	84
Minisprinkler	0.98	1.16	89
Surface drip	1.18	1.44	90
Subsurface drip	0.93	1.18	91

Effect of irrigation system and nitrogen fertilization rate on yield and yield components of maize crop.

Growth parameters and yield components:

Plant height (cm)

Data presented in Table (6) exhibited a significant influence of irrigation systems on maize plant growth. It is obvious that the longest plants were recorded under I_1 system, while the shortest plants were obtained with I_6 system. Also, data revealed highly significant effect due to nitrogen fertilizer application on maize plant height. The longest plants were recorded (159.66 cm) with N_1 (surface irrigation), while the shortest plants were obtained (148.66 cm) with N_5 (subsurface irrigation system). The effect of the interactions between irrigation systems and nitrogen fertilizer rate under plant height (cm) were highly significant.

Leaf area (cm^2):

Concerning the leaf area of maize plant as influenced by different irrigation systems, the data are presented in Table (6). The obtained results show highly significant effect of irrigation systems on the leaf area. I_5 (surface drip irrigation) obtained the highest value (806.53 cm^2) and exceeded significantly the other irrigation systems. I_6 (subsurface drip irrigation) produced the lowest leaf area (597.38 cm^2).

Nitrogen fertilizer application rate had significant effect on leaf area. The highest nitrogen application fertilizer rate (N_1) recorded 712.85 cm^2, while the lowest nitrogen fertilizer application rate (N_5) recorded 683.26 cm^2, respectively. Interaction between irrigation systems and nitrogen application fertilizer on leaf area was highly significant.

Ear length (cm):

The effect of irrigation systems on ear length (cm) is highly significant as shown in Table (6) The longest ear length (22.5 cm) recorded from I_1 (surface irrigation system), while the shortest ear length (11.58 cm) recorded with (I_6) subsurface drips system.

Concerning the effect of nitrogen fertilizer application rates, results showed highly significant 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 ear length (19.09 and 18.51 cm) compared with the shortest ear length which recorded the N_5 (17.58 cm).

Data in Table (6) show that the interaction between irrigation system and nitrogen fertilizer application rate was highly significant on ear length.

Ear diameter (cm):

Table (6) showed the values of ear diameter as affected by different irrigation systems. The obtained results show high significant effect of irrigation systems on ear diameter. I_1 (surface irrigation system) gave the highest ear diameter (9.4 cm). The lowest ear diameter (5.92 cm) was obtained by I_6 (subsurface drip system) .

Regarding the effect of nitrogen application rate on this trail (Table 6), it was quite obvious that ear diameter was highly significant affected by changing the nitrogen fertilizer application rate. The highest ear diameter (8.35 cm) was recorded by using N_1(100 % soil application) and the lowest ear diameter (7.23) was recorded by using N_5 (25% fertigation +75 % soil application). The effect of the interactions between all factors under ear diameter was highly significant.

100 grain weight (g):

Data in Table (6) indicated that the weight of 100 grain was highly significant affected by irrigation systems and nitrogen fertilizer application rate. Where I_1 (surface irrigation system) gave the highest weight of 100 grain (50.18 g) as compared with subsurface drip irrigation (I_6) which recorded (34.12 g).

Table (6): Effect of irrigation systems and nitrogen fertilization rates on maize plant height and leaf area, ear length , ear diameter and 100-grain weight .

Treatments	Plant height (cm)	Leaf area (cm2)	Ear length (cm)	Ear diameter (cm)	100-grain weight (g)
Irrigation system (I)					
I_1	174.00 a	802.50 a	22.50 a	9.40 a	50.18 a
I_2	157.60 c	642.54 c	18.40 c	7.64 d	43.26 c
I_3	142.20 e	594.66 d	14.32 d	6.48 e	42.22 d
I_4	150.80 d	709.38 b	20.08 b	8.10 c	41.82 d
I_5	169.00 b	806.53 a	22.26 a	8.52 b	44.66 b
I_6	131.00 f	597.38 d	11.58 e	5.82 f	34.12 e
F-test	**	**	**	**	**
LSD 0.05	1.63	6.47	0.284	0.133	0.52
0.01	2.33	9.20	0.400	0.189	0.69
Nitrogen fertilization (N)					
N_1	159.66 a	712.85 a	19.08 a	8.35 a	44.08 a
N_2	156.33 b	689.02 b	18.51 b	7.85 b	43.46 a
N_3	155.44 b	688.36 b	18.11 c	7.50 c	42.38 b
N_4	150.38 c	687.32 bc	17.65 d	7.37 cd	42.36 b
N_5	148.66 c	683.26 c	17.58 d	7.23 d	41.77 b
F-test	**	**	**	**	**
LSD 0.05	1.43	5.00	0.264	0.145	0.55
0.01	1.91	6.67	0.350	0.193	0.78
Interaction					
IXN	**	**	**	**	**

Regarding the effect of nitrogen application rate on this tralt, the results showed highly significant differences, where N_1 (100 % soil application) gave the highest 100 grain weight, while N_5 (25 % fertigation + 75 % soil application) gave the lowest ones. The effect of the interactions among all factors under study on 100 grain weight was highly significant.

Straw and grain yields:

Data in Table (7) showed highly significant effect of irrigation system on grain and straw yields. The highest grain yield (2625.5 kg fed^{-1}) was recorded from the I_1 (surface irrigation system), while the lowest grain yield (1865 kg fed^{-1}) was recorded with I_2 (semi portable sprinkler system)

Concerning the relative changes (%) of maize grain yield using semi portable sprinkler (I_2) and subsurface drip system (I_6) which recorded the highest reduction in grain yield (-28. 97% and -28.17 %) as compared to control treatment (I_1 surface irrigation system).

Concerning the effect of nitrogen application rates, results showed highly significant effect. N_1 (100 % fertigation) gave the highest grain yield (2347.11 kg fed-1) and relative of change grain yield 2.65 % compared with N_1 (100 % soil addition). The lowest grain yield was recorded under N_5 (2053.83 kg fed $^{-1}$). Concerning the interaction effect between irrigation system and nitrogen application rate on grain and straw yield, it was only highly significant .

Table (7): Effect of irrigation systems and nitrogen fertilization on maize grain and straw yields (kg fed -1) and their relative change (%).

Treatments	Grain yield (kg fed^{-1})	Relative change (± %)	Straw yield (kg fed -1)	Relative change (± %)
Irrigation system (I)				
I_1	2625.50 a	0.0	3111.00 e	00.0
I_2	1865.00 f	-28.97	2766.80 e	-11.06
I_3	2096.20 d	-20.16	3008.00 d	-3.31
I_4	2222.60 e	-15.35	3172.00 b	+1.96
I_5	2430.00 b	-7.45	3211.40 a	+3.23
I_6	1886.00 e	-28.17	2685.20 f	-13.69
F-test	**		**	
LSD 0.05	10.31		11.39	
0.01	17.08		16.20	
Nitrogen fertilization (N)				
N_1	2286.41 b	00.0	2953.16 e	+10.23
N_2	2347.11 a	+2.65	3255.16 a	+3.65
N_3	2165.50 e	-5.29	3061.00 b	-0.02
N_4	2084.88 d	-8.81	2952.66 e	-7.22
N_5	2053.83 e	-10.17	2740.00 d	
F-test	**		**	
LSD 0.05	10.61		12.08	
0.01	13.49		16.12	
Interaction				
IXN	**		**	

Effect of irrigation systems and nitrogen fertilization on nitrogen concentration and its uptake by maize crop.

Irrigation systems effect:

Data in Table (8) showed that the nitrogen concentration (%) and its uptake (kg/fed) by both grain and straw was affected by irrigation systems. The highest value of nitrogen concentration (%) in maize grain (1.86%) was recorded under I_5 system and the lowest value of nitrogen concentration (%) in maize grain (1.62 %) was achieved under I_2 system.

The highest value of nitrogen uptake of maize grain (37.67 kg fed-1) was achieved under I_1 system and the lowest value of nitrogen uptake of maize grain (28.28%) was recorded under I_6 system. The nitrogen concentration and uptake of maize straw took the same behavior of grains.

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

Treatments		Nitrogen concentration (%)		Nitrogen uptake (kg fed $^{-1}$)		Relative change of nitrogen %	
Irrigation systems	Nitrogen fertilizer rates	Grain	Straw	Grain	Straw	Grain	Straw
Surface irrigation I_1	N_1	1.75	0.71	37.67	18.77	0.0	0.0
Semi portable sprinkler I_2	N_1	1.63	0.63	15.80	12.59	0.0	0.0
	N_2	1.65	0.64	27.11	17.00	71.58	35.03
	N_3	1.64	0.65	26.01	15.61	64.62	23.99
	N_4	1.61	0.61	23.77	14.32	50.44	13.74
	N_5	1.59	0.59	22.46	13.90	42.15	1.04
Mean		1.62	0.62	23.03	14.68	57.19	18.45
Mini sprinkler I_3	N_1	1.66	0.60	26.34	13.39	0.0	0.0
	N_2	1.64	0.61	40.14	18.99	52.39	41.82
	N_3	1.66	0.66	37.98	16.43	44.19	22.70
	N_4	1.65	0.60	26.84	15.82	1.020	18.15
	N_5	1.67	0.64	26.73	13.74	1.01	1.03
Mean		1.67	0.62	31.81	15.67	24.65	20.93
Sloppy sprinkler I_4	N_1	1.72	0.70	27.81	16.78	0.0	0.0
	N_2	1.78	0.76	36.84	24.43	32.47	45.89
	N_3	1.79	0.76	34.96	20.81	25.71	24.02
	N_4	1.76	0.75	32.66	19.54	17.44	16.45
	N_5	1.74	0.71	28.14	17.94	1.01	6.91
Mean		1.76	0.74	32.08	19.90	19.16	23.31
Surface drip I_5	N_1	1.83	0.62	31.54	14.34	0.0	0.0
	N_2	1.89	0.73	42.48	22.35	34.69	55.86
	N_3	1.90	0.65	39.53	18.37	25.33	28.10
	N_4	1.82	0.64	35.91	17.57	13.86	26.78
	N_5	1.84	0.63	35.25	16.01	11.76	11.65
Mean		1.86	0.65	36.94	17.73	17.12	31.49
Subsurface drip I_6	N_1	1.86	0.60	21.49	10.27	0.0	0.0
	N_2	1.84	0.64	32.46	16.06	51.05	56.38
	N_3	1.80	0.65	26.66	15.86	24.06	54.43
	N_4	1.83	0.61	26.16	14.91	21.73	45.18
	N_5	1.85	0.61	24.65	14.07	14.70	37.00
mean		1.84	0.62	28.28	14.23	27.89	48.25

Nitrogen fertilization effect:

Data in Table (9**)** showed that nitrogen concentration (%) and its uptake(kg/fed) by both grain and straw increased with increasing nitrogen application levels as a result of increasing amounts of available nitrogen in the root zone. The highest values of nitrogen was found under N_2 (100% fertigation). Also, the lowest values of nitrogen were recorded under I_1 (100% soil application). The highest amount of nitrogen uptake by grains (42.48 kg fed^{-1}) was found under N_2 (100% fertigation) for surface drip irrigation system. Also, nitrogen uptake by straw (24.43 kg fed^{-1}) was found under N_2 for floppy sprinkler system. The lowest ones were under N (100% soil application) (21.49 and 10.27 kg fed^{-1}) for grain and straw under subsurface drip system, respectively.

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

Data in Table (9) showed that the nitrogen use efficiency (kg/ N unit) and nitrogen recovery (%) by both grain and straw was affected by irrigation systems. The highest values of nitrogen use efficiency to maize grain (20.21), was recorded under I_1 system. and the lowest values of nitrogen use efficiency to maize grain 13.87 (kg/N unit) was achieved under I_2 system.

Table (9): Effect of irrigation systems and nitrogen fertilization on nitrogen use efficiency and N-recovery % for maize.

Treatments		Nitrogen use efficiency (kg/N unit)		N-recovery %	
Irrigation systems	**Nitrogen fertilizer rate**	**Grain**	**Straw**	**Grain**	**Straw**
Surface irrigation I_1	N_1	20.21	21.76	16.84	15.64
Semiportable sprinkler I_2	N_1	12.69	15.42	13.17	10.49
	N_2	15.03	21.88	22.59	14.17
	N_3	14.45	19.38	21.68	13.00
	N_4	13.77	18.93	19.81	11.93
	N_5	13.43	18.85	18.72	11.58
Mean		13.87	18.89	19.19	12.23
Minisprinkler I_3	N_1	13.50	16.88	21.34	11.16
	N_2	21.58	26.35	33.45	15.83
	N_3	14.87	21.68	31.65	13.69
	N_4	14.60	20.24	22.37	13.18
	N_5	14.46	19.34	22.28	11.45
Mean		15.80	20.89	26.22	13.06
Floppy sprinkler I_4	N_1	14.77	19.34	23.18	13.98
	N_2	19.37	27.34	30.70	20.38
	N_3	18.18	22.68	29.13	17.34
	N_4	17.19	21.38	27.72	16.28
	N_5	14.77	20.60	23.45	14.95
Mean		16.86	22.27	26.84	16.59
Surface drip I_5	N_1	15.85	20.09	26.28	11.95
	N_2	21.18	25.85	35.40	18.63
	N_3	19.48	23.54	32.94	15.30
	N_4	18.62	22.54	29.93	14.64
	N_5	17.80	20.74	29.38	13.34
Mean		18.59	22.55	30.79	14.77
Subsurface drip I_6	N_1	10.35	12.62	17.91	8.56
	N_2	21.78	20.44	35.38	13.38
	N_3	13.38	19.79	22.22	13.22
	N_4	12.86	19.76	21.80	12.43
	N_5	11.88	18.44	20.54	11.73
mean		14.05	18.21	23.57	11.86

Concerning the nitrogen recovery (%) of maize grain yield, The highest value of N-recovery to grain maize (30.79%) was achieved under I_5 (surface drip irrigation). While, the lowest value of N-recovery to maize grain (19.19 %) is recorded with I_2 (semi portable sprinkler).

Data in Table (9) showed that nitrogen application rate on nitrogen use efficiency and N-recovery %. Nitrogen use efficiency attributed with N_2 (100% fertigation) was higher than the same obtained by N_1 (100% soil application). Data clearly show that the highest values of nitrogen use efficiency were obtained by I_6 N_2 (21.78 kg/N) and the lowest one was detected under I_6 N_1 (10.35 kg/N unit).

Also data in Table (9) show the total nitrogen recovery for maize yield (grain and straw) at maturity stage. Data indicated that nitrogen recovery increased with increasing N level. The highest value of N-recovery % was found under I_5 (30.79% grain) and I4 (16.59% straw), whereas, the lowest one was found under I_1 (16.84%) and N_1 (8.56%) under I_6 system.

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تعظيم كفاءات استخدام مياه الري والتسميد الأزوتي لمحصول الذرة الشامية 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 حقليه في موسم ٢٠٠٨ علي محصول الذرة الشامية بمزرعة محطة البحوث الزراعية بسخا، كفر الشيخ استخدم التصميم القطع المنشقة للقطع الرئيسية وهي معاملات الري (٦ معاملات) والقطع المنشقة مستويات النتروجين (٥ مستويات)

ويمكن تلخيص أهم النتائج فيما يلي :

كانت أقل قيم كمية مياة الري معطاه لمحصول الذرة (٤٨.٠٦ سم) مع الري بالتنقيط التحت سطحي وكانت أعلى قيمة (٦٣.٠٣ سم) للري السطحي التقليدي ، بينما كانت أعلى قيمة لكمية المياة المخزنه للذرة فى منطقة انتشار المجموع الجذرى (٤٩.٠٨سم) للفلوبي رشاش وكانت أقل قيمة لكمية الماء المخزن (٤٥.٣١سم) بالنسبة للري بالتنقيط التحت سطحي. كانت أعلى قيمة للاستهلاك المائي بواسطة محصول الذرة (٥٣.٨٩سم) للري السطحي التقليدي بينما كانت أقل قيمة (٣٨.١٧سم) للري بالتنقيط التحت سطحي. وقدر استخلاص الرطوبة الارضية بواسطة جذور النباتات وكانت أعلى قيمة في الطبقة السطحية (١٥سم). وكانت أعلى قيمة لكفاءة الري التطبيقية (٩٤.٢٧)فى معاملة الري بالتنقيط التحت سطحي بينما كانت أقل القيمة (٧٦.٥٩%) للري السطحى التقليدي. كما وجد أن أعلى قيمة لكفاءة استخدام مياة الري المضافة لمحصول

الذرة (١.١٨ كجم / م٣ مياة) كانت بالنسبة للري بالتنقيط السطحي بينما أقل قيمة (٠.٧٩ كجم /م٣مياة) للري بالرش نصف نقالى. وجد ايضا أن أعلى قيمة لكفاءة استخدام المياة المستهلكة تحصل عليها (١.٠٦ كجم/م٣مياة) من الري بالتنقيط السطحي بينما أقل قيمة (٠.٩٧ كجم/م٣ مياة) للري بالرش نصف نقالي من النتائج المتحصل عليها ايضاً بالنسبة لمحصول الذرة ومكوناته. وكان هناك تأثير عالى المعنوية بين نظم الري المختلفة ومعدل اضافة التسميد النتروجيني.

طول النبات :- كانت أحسن معاملة لطول النبات هي الري السطحي التقليدي (I_1) بينما كانت أقل معاملة هي الري بالتنقيط التحت سطحي (I_6). وكان أطول النباتات (١٥٩.٦٦ سم) مع اضافة (١٠٠ %مع أرضي)N_1بينما كانت أقصر النباتات مع N_5 (١٤٨.٦٦ سم).

مساحة الورق: أعطت المعاملة I_5 (الري بالتنقيط السطحي) أعلى قيمة لمساحة الورقة (٨٠٦.٥٣ سم٢) وأقل قيمة(٥٩٧.٣٨ سم٢) للمعاملة I_6 (الري بالتنقيط التحت سطحي) .وكان تأثير اضافة التسميد النتروجيني معنوياً على مساحة الورقة. وأعلى قيمة لمساحة الورقة كانت N_1 (٧١٢.٨٥سم٢) بينما أقل قيمة N_5 (٦٨٣.٢٦سم٢).

طول الكوز :- وجد أن تأثير نظم الري ومعدل اضافة النتروجين عالى المعنوية على طول الكوز. وكانت أعلى قيمة لطول الكوز ١٢.٥سم للمعاملة I_1 (الري السطحي التقليدي) بينما أقل قيمة ١٧.٥٨سم للمعاملة I_6 الري بالتنقيط التحت سطحي). بينما المعاملة N_1 أعطيت أعلى قيمة لطول الكوز (١٩.٥٩سم) بينما أقل قيمة N_5 (١٧.٥٨سم) والتفاعل بين نظم الري ومعدل اضافة النتروجين عالى المعنوية.

لوحظ تأثير عالي المعنوية علي قطر الكوز حيث أعطت المعاملة I_1 أكبر قطر للكوز (٩.٤ سم) بينما خصل علي أصغر قطر للكوز (٥.٩٢ سم) من المعاملة I_6 وبالنسبة للتسميد النيتروجيني أعطت المعاملة N_1 أكبر قطر للكوز (٨.٣٥ سم) وأعطت المعاملة N_5 أقل قطر للكوز (٧.٢٣ سم) . أعطت I_1 أعلي وزن ل ١٠٠ حبة (٥٠.١٨ جم) مقارنة بالمعاملة I_6 التي أعطت أقل وزن ل ١٠٠ حبة (٣٤.١٢ جم)

ووجد تأثير عالى المعنوية نتيجة تأثير نظم الري ومعدل اضافة تسميد النتروجين على كل من محصولي الحبوب والقش. وأعطيت المعاملة I_1 أعلى محصول للحبوب (٢٦٢٥.٥ كجم / فدان) بينما أقل قيمة لمحصول الحبوب (١٨٦٥ كجم / فدان) تحت I_2 . بالنسبة للتسميد النتروجيني أعطت N_1 أعلي محصول حبوب (٢٣٤٧.١١ كجم / فدان) بينما صجلت المعاملة N_5 أقل محصول حبوب (٢٠٥٣.٨٣ كجم/فدان). سجلت المعاملة I_1 أعلي قيمة لكفاءة استخدام النتروجين (٢٠.٢١) وأقلها (١٣.٨٧) تحت I_2 . وبالنسبة لاستعادة النتروجين سجلت أعلي قيمة (٣٠.٧٩%) تحت I5 وأقلها (١٩.١٩%) تحت I_2 . كانت قيم كفاءة استخدام واستعادة النتروجين التي سجلت مع المعاملة N_2 أعلي منها تحت المعتملة N_1 . وبالنسبة للتفاعل بين نظام الري والتسميد النتروجيني كان التاثير عالي المعنوية وسجلت المعاملة N_2 I_6 أعلي قيمة لكفاءة استخدام النتروجين وأقلها تحت المعاملة N_1 I_6 . وزادت قيم استعادة النتروجين بزيادة مستويات التسميد النتروجيني وكانت أعلي قيمة تحت N_2 I_5 وأقلها تحت المعاملة N_1 I_2 .

قام بتحكيم البحث

أ.د / السيد محمود الحديدى	**كلية الزراعة – جامعة المنصورة**
أ.د / محمد رضوان خليفه	**كلية الزراعة – جامعة كفر الشيخ**