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IRRIGATION WATER USE EFFICIENCIES AS INFLUENCED BY IRRIGATION SYSTEM AND RATE OF APPLIED N FERTILIZER TO MAIZE PLANT

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ABSTRACT

Two field experiments were carried out during the two successive summer seasons of 2006 and 2007 at Bahteem, Water Requirements Research Station., El Kalyobia Governorate –National Water Research Center. Maize (Zea mays, single cross 10) was grown on the investigated soil under two irrigation systems i.e. surface irrigation (G1) and drip irrigation (G2) Nitrogen fertilizer was applied in the form of urea (46% N) at four rates N1 (0kg), N2 (90kg), N3 (120kg), and N4 (150 kg N /fed. Other cultural practices were done as recommended. The experiment was arranged in a split plot design.The irrigation systems were distributed uniformly in the main plots, while, the nitrogen treatments, were distributed randomly in the sub-plots.

Results showed that application of nitrogen regardless of its applied ratm could save 24.15 and 24.05% m^3/ fed within the first and second seasons, respectively under tie surface irrigation system. Under the drip"irrigation system the correspooding saved amount of the water requirement reached 37.93 and 38.03%, within the first and second seasons, respectively. Values of monthly and seasonal actual water consumptive use (Cu) were higher when irrigation water was applied by surface irrigation system than drip irrigation system. Values of (Cu) were decreased by i~creasing rate of the applied N. Thå highest attained values of irrigation water application effiãiency occurred under the drip irrigation system (G_2) end N_2 trmatments in the first and second growinw seasons. There was a decline yn crop water use efficienc} with!surface irrigation sysôem in both seisons/ as compared wéth the drip érriga|ion system® Xowever the miximum value of crop water use efficiency was obtáingd$under the drip irrigqtion system (G_2) and application of nitrogen fertilizer at a rate of 120 kg/fed. The field water use efficiency was highev under the drip irrigation system than under the surface irrigation one. Values of this parameter increased with increasing rate of the applied N up to 120 kg/fed beyond which it decreased obviously.

INTRODUCTION

Irrigation water ms gradually becoming scarce not only in árid and semi-arid regions but also in the regions where rainfall is abundant. Therefore. the wáter saving and conservation are essential to support agricultural activities, which account for 85% of the total water consumed

Maize is one of the major crops which require sufficient amount of irrigation water. It is very responsive to the amount of irrigation water applied: positive when irrigation is sufficient and negative when not. Rhoades and Bennett (1990) and Lamm *et al*. (1995) both reported that it is difficult to plan for deficit irrigation for maize without simultaneously causing yield reduction. However drip irrigation has become increasingly popular to reduce the amount of water and fertilizer that are applied to the crop, and also reduce the amount of labor (Hanson *et al*., 1997; Fekadu and Teshome, 1998). Because the drip irrigation is capable of applying small amounts of water where it is needed and to apply it with a high degree of uniformity and frequently, these features make it potentially much more efficient than other irrigation methods.

Since the study of de Wit (1958), different expressions (WUE, crop water productivity) have been proposed and discussed (Rijtema and Endrodi, 1970; Slabbers *et al*., 1979; Ritchie, 1983; Tanner and Sinclair, 1983; Feddes, 1985; Pereira *et al*., 2002; Zwart and Bastiaanssen, 2004; Turner, 2004b; Hsiao *et al*., 2007). In general, WUE can be written as follows:

$$WUE\,(kg\,m^{-3}) = \frac{yield(kg/fed.)}{water\,consumption(m3)}$$

The relationship fertilisation – WUE highlights the role of the fertilization technique in improving WUE.

The current study aimed at investigating the effect of different irrigation systems and rate of N applied to maize plants grown on a clay soil on irrigation water efficiencies.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive summer seasons of 2006 and 2007 at Bahteem, Water Requirements Research Station National Water Research Center.

Surface soil samples (0- 30 cm) were taken, before planting during the two seasons to determine some physical and chemical properties of the experimental soils.

Soil analyses:

Particle size distribution was carried out by using the international pipette method according to Klute (1986)

The bulk density was determined by using the undisturbed core sample according to Klute (1986).

Field capacity (F.C %) was determined according to Black (1965).

Permanent wilting point (P.W.P %) was determined by using a pressure membrane apparatus as outlined by Black (1965).

Available water (A.W) was calculated by subtracting value of P.W.P from value of F.C.

The electrical conductivity (E.C dS m^{-1}) and also soluble cations and anions ($mmol_c\ L^{-1}$) were determined in soil paste extract according to Page *et al*. (1982).

Soil pH was measured in 1:2.5 soil water suspension using pH meter (Model 315I/SET).

Total calcium carbonate was determined volumetrically by using Collin,s calcimeter according to Page *et al*. (1982).

Organic matter was determined by the modified Walkley and Black method, Jackson (1967).

Cation exchangeable capacity CEC was determined by using sodium and ammonium acetate as described by Jackson (1967).

Table (1): Some physical and chemical properties of the experimental soil

The soil properties	Value
Physical properties:	
Bulk density g /cm^3	1.61
Field capacity (%)	29
Permanent wilting point (%)	15.3
Available water (%)	13.7
Particle size distribution	
Coarse sand (%)	2.9
Fine sand (%)	18.6
Silt (%)	25.1
Clay (%)	53.4
Textural class	Clay
chemical properties	
pH	7.88
Organic matter (%)	3.46
$CaCO_3$ (%)	1
EC dSm^{-1}	0.61
Soluble cations	
Ca^{2+} m mol_c L^{-1}	4.1
Mg^{2+} m mol_c L^{-1}	0.6
Na^{2+} m mol_c L^{-1}	2.02
K^{+} m mol_c L^{-1}	0.34
Soluble anions	
CO_3^{2-} m mol_c L^{-1}	0
HCO_3^{-} m mol_c L^{-1}	4.8
Cl^{-} m mol_c L^{-1}	1.27
SO_4^{2-} m mol_c L^{-1}	0.99
Cation exchanig capacity $cmol_c kg^{-1}$	44

Basic treatments

. Irrigation systems:

The experiment included two irrigation systems as follows:

Surface irrigation (G1)

Drip irrigation (G2)

Fertilization treatments:

Nitrogen fertilizer was applied in the form of urea (46% N) at four rates N1 (0kg), N2 (90kg), N3 (120kg), and N4 (150 kg N) /fed.

Phosphorus was applied before cultivation during soil preparation, in the form of calcium super phosphate at a rate of 27 kg P/fed. The Potassium was applied before cultivation at a rate of 39.8 kg K/fed. Other cultural practices were done as recommended.

The experimental design included two irrigation systems i.e. surface irrigation (G1) and drip Irrigation (G2) and four rates of nitrogen fertilization with four replicates.The experiment was arranged in a split plot design.The irrigation systems were distributed uniformly in the main plots, while, the nitrogen treatments, were distributed randomly in the sub-plots.

Cultural practices:

Maize (Zea mays Single cross 10) was sown in 2006 and 2007 growing seasons, respectively.

Table (2) represents schedule of the applied irrigation water

All agricultural operations were performed according to the usual local agricultural management.

Maize grains were sown on 8 and 11 June and yield of maize grains crop were harvested on 25 and 20 September for the first and second growing seasons, respectively.

Numbers and dates of irrigation, in the two growing seasons are tabulated in Table (2).

Table (2): Irrigation water schedule in the two seasons(2006 and 2007)

Irrigation NO.	Growth Season			
	First season (2006)		Second season (2007)	
	G1	G2	G1	G2
1	8/7/2006	8/7/2006	4/7/2007	4/7/2007
2	22/7/2006	22/7/2006	18/7/2007	18/7/2007
3	5/8/2006	5/8/2006	1/8/2007	1/8/2007
4	19/8/2006	19/8/2006	15/8/2007	15/8/2007
5	2/9/2006	2/9/2006	30/8/2007	30/8/2007

G1: surface irrigation
G2: drip irrigation

RESULTS AND DISCUSSION

Values of the applied irrigation water (m^3/fed.) as well as the saved water amount (m^3/fed.) owing to the different irrigation system are shown in Table (3)

It is clear from obtained data that within the first season, the amount of irrigation water applied to maize plants were 1611 and 1450 (m^3/fed) for the surface (G1) and drip (G2) irrigation systems, respectively The corresponding amounts of the applied water were 1580, and 1420 m^3/fed respectively in the second season.

The comparison between the amounts of applied water under the two investigated irrigation systems and the common amount applied in the conventional irrigations i.e. 2000 and 1960 m^3/ fed within the first and second seasons, respectively indicates that application of nitrogen regardless of its applied rate could save 389 and 380 m^3/ fed within the first and second seasons, respectively under the surface irrigation system. Likewise, under the drip irrigation system the corresponding values were 550 and 540 m^3/ fed, respectively. Meanwhile, application of nitrogen fertilizer could, save about 24.15 and 24.05 % of irrigation requirements under surface irrigation. There values reached 37.93 and 38.03 %. under the drip irrigation system, within the first and second seasons, respectively.

Table (3): Values of applied irrigation wate (m^3/fed.), quantity of saved water (m^3/fed.) and percentage of saved wate under surface and drip irrigation systems within 2006 and 2007 seasons

Irrigation system	2006 season			2007 season		
	Water applied m^3/fed	Saved water, m^3/fed.	Saved water percentage %	Water applied m^3/fed	Saved water, m^3/fed.	Saved water percentage %
G_1	1611	389	24.15	1580	380	24.05
G_2	1450	550	37.93	1420	540	38.03

- **Quantities of total irrigation water applied (m3/fed.) for traditional irrigation were 2000 in 2006 and 1960 in 2007 growth season.**

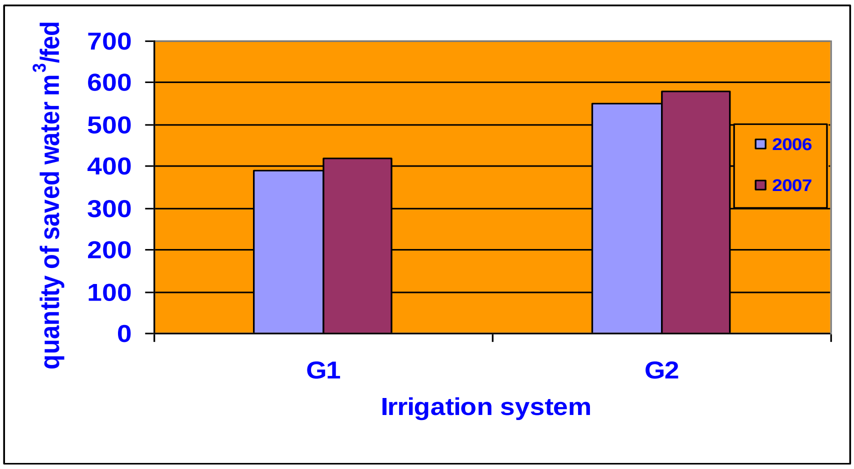

Figure (1): Amount of saved water (m3/fed.) under surface (G1) and drip (G2) irrigation systems during 2006 and 2007 seasons.

Monthly and seasonal actual water consumptive use:-

The consumptive use (CU) of water obtained by the difference between both soil moisture contents after irrigation and before the next one. In fact this amount was consumed by the plants as transpiration in addition to the quantity lost from the soil surface by evaporation. The quantities of water consumptive use were calculated for the 30 cm soil depth which was assumed to be the depth of the root zone as reported by many investigators. For an area of 4200 m^2 (one Fed.) Cu can be obtained by the following equation (Israelsen and Hansen, 1962):

$$Cu = \sum_{i=1}^{n=1} \frac{\Theta 2 - \Theta 1}{100} \times B.d \times \frac{30}{100} \times 4200\ m^2$$

Where :

Cu = Amount of water consumptive use, (m^3/fed.).

Θ2 = Soil moisture content in percent after irrigation.
Θ1 = Soil moisture content in percent before next irrigation.
B.d= Bulk density in g/cm^3
n = number of irrigations
i = number of soil layers

Data presented in Tables (4) and (5) showed that values of monthly and seasonal actual water consumptive use (Cu) were increased when irrigation water was applied by surface irrigation system. The highest values of water consumptive use (monthly and seasonal) were obtained from plants exposed to the highest levels of water supply. i.e., irrigation by surface irrigation system in both seasons. The increases of actual water consumptive use can be attributed to the increase of evaporation from the soil irrigated with surface irrigation system, The total values of seasonal water consumptive use were 571.87 and 542.27 m^3/fed for surface and drip irrigation systems, respectively in the first season. The corresponding values for the second season were 556.41 and 529.77 m^3/fed for the same systems, respectively.

Regarding the effect of nitrogen fertilizer, data in the same tables showed that application of N fertilizer caused decreases in both the monthly and seasonal actual consumptive use (Cu) where the lowest values of average water consumptive use were 501.62 m^3/fed in the first season and 489.11 m3/fed in the second season when nitrogen was applied at the highest rate (150 kg N /fed) under drip irrigation system. The reduction in the seasonal water consumptive use (Cu) owing to increasing nitrogen rate can be attributed to corresponding increase in K uptake (Ali *et al*., 2009).Such an increase in K uptake might caused a reduction in the amount of water lost by transpiration of the grown plants because the trudged cells of the stomata that are rich in K keep the stomata closed most of time. Therefore, there is no need for more water to be absorbed by plant roots which in turn, reduced the amount of absorbed water and consequently the Cu decreased. On the other hand, the highest average of water consumptive use (602.89m3/fed.) was obtained from G1 and N0 treatment during both seasons. It could be concluded that seasonal water consumptive use was reduced with increasing rate of the applied nitrogen fertilizer.

Irrigation Efficiency

Water Consumptive Use Efficiency:

Data in Table (6) show values of water consumptive use efficiency (which is calculated as $-\ \frac{\text{Water consumptive use (m3/fed.)}}{\text{water stord (m3/fed.)}}\times 100$) as affected by irrigation system and rate of the applied nitrogen fertilizer in the two growth seasons.

The results showed that the values of water consumptive use efficiency under the surface irrigation system (G1) varied from 81.27% to 96.11% for the growing season of 2006 while, the corresponding values ranged from 83.25% to 96.32% for the growing season of 2007.

Under the drip irrigation system the above mentioned values were relatively lower than under the surface irrigation one. There values varied from 80.96 % to 95.90 % and 81.94 % to 96.49 % in the growing seasons of 2006 and 2007, respectively.

Data presented in Table (6) and illustrated by figures (3 and 4) reveal that this efficiency value was decreased by increasing rate of the applied N. This finding was true within both the growing seasons. The reduction in the water consumptive use efficiency with the high rate of the applied nitrogen fertilizer can be attributed generally to the higher amounts of water stored by increasing rate of the applied nitrogen fertilizer compared to the corresponding ones which did not receive nitrogen fertilizer i.e.(without N) on one hand, and the reduction in the water lost by transpiration by leaves of the N treated plants on the other hand .

Table (4): Effect of system of irrigation and rate of the applied nitrogen fertilizer on monthly and seasonal actual water consumptive use (Cu) (cm/fed. and m3/fed.) during the growing season of 2006.

Treatment		Jun.		Jul.		Aug.		Sep.		Total season	
		cm/ fed.	m^3/ fed.	Cm /fed.	m^3/ fed.	cm/ fed.	m^3/ fed.	cm/ fed.	m^3/ fed.	Cm /fed.	m^3 /fed.
G1	N0	2.29	96.30	4.02	168.9	4.54	190.8	3.8	159.43	14.65	615.43
	N1	2.29	96.30	3.82	160.4	4.25	178.51	3.69	155	14.05	590.21
	N2	2.29	96.30	3.53	148.43	4.02	168.94	3.38	141.92	13.22	555.59
	N3	2.29	96.30	3.34	140.2	3.67	154.3	3.23	135.46	12.53	526.26
Average		2.29	96.30	3.68	154.48	4.12	173.14	3.53	147.95	13.61	571.87
G2	N0	2.29	96.30	3.68	154.45	4.26	178.9	3.59	150.8	13.82	580.45
	N1	2.29	96.30	3.59	150.71	4.09	171.89	3.5	146.89	13.47	566.79
	N2	2.29	96.30	3.29	138.11	3.7	155.42	3.1	130.38	12.38	520.21
	N3	2.29	96.30	3.15	132.34	3.51	147.62	2.98	125.36	11.93	501.62
Average		2.29	96.30	3.43	143.90	3.89	163.46	3.29	138.36	12.9	542.27

Table (5): Effect of system of irrigation and rate of the applied nitrogen fertilizer on monthly and seasonal actual water consumptive use (Cu) (cm/fed. and m3/fed.) during the growing season of 2007.

Treatments		Jun.		Jul.		Agu.		Sep.		Total season	
		Cm/fed.	m^3/fed.	cm/fed.	m^3/fed.	cm/fed.	m^3/fed.	cm/fed.	m^3/fed.	cm/fed.	m^3/fed.
G_1	N_0	1.92	80.7	4.04	169.84	4.3	180.5	3.79	159.3	14.05	590.34
	N_1	1.92	80.7	3.84	161.2	4.21	177	3.65	153.1	13.62	572.36
	N_2	1.92	80.7	3.59	150.6	3.92	164.7	3.44	144.59	12.87	540.59
	N_3	1.92	80.7	3.53	148.3	3.71	155.8	3.28	137.55	12.44	522.35
Average		1.92	80.7	3.75	157.49	4.03	169.5	3.54	148.64	13.26	556.41
G_2	N_0	1.92	80.7	3.9	164	4.04	169.7	3.61	151.49	13.47	565.89
	N_1	1.92	80.7	3.75	157.4	3.95	165.9	3.45	144.79	13.07	548.79
	N_2	1.92	80.7	3.51	147.59	3.67	154.3	3.16	132.7	12.26	515.29
	N_3	1.92	80.7	3.23	135.61	3.56	149.6	2.93	123.2	11.64	489.11
Average		1.92	80.7	3.6	151.15	3.81	159.88	3.28	138.05	12.61	529.77

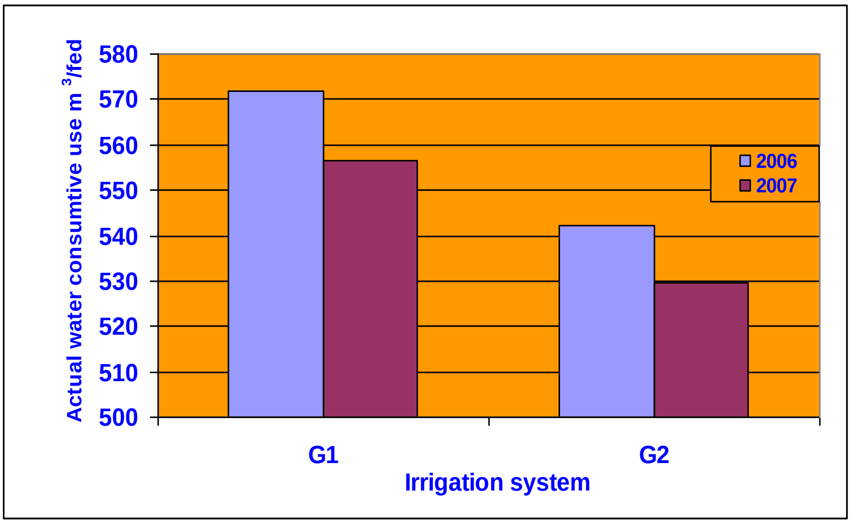

Figure (2): Average values of actual water consumptive use under surface(G1) and drip (G2) irrigation systems during 2006 and 2007 seasons.

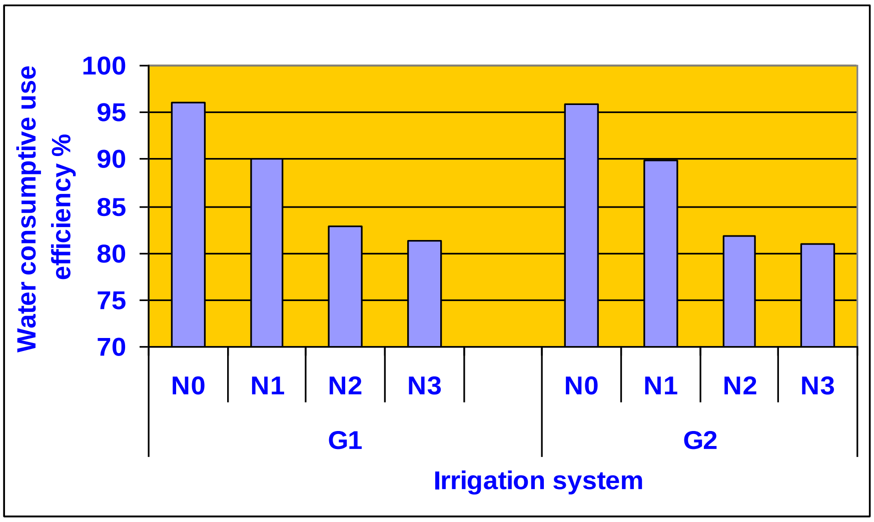

Figure (3): Values of water consumptive use efficiency under surface(G1) and drip (G2) irrigation systems during 2006 season.

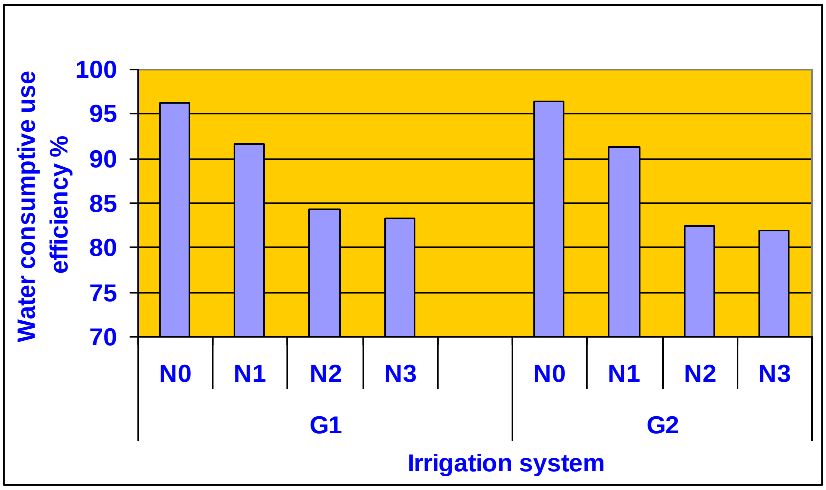

Figure (4): Values of water consumptive use efficiency under surface(G1) and drip (G2) irrigation systems during 2007 season

Table (6): Effect of system of irrigation and rate of the applied nitrogen fertilizer on values of water consumptive use, water stored and water conumptive use efficiency during 2006 and 2007 growing seasons.

Treatments		2006			2007		
		Water consumptive use (m^3/fed.)	Water stored (m^3/fed.)	Water consumptive use efficiency %	Water consumptive use (m^3/fed.)	Water stored (m^3/fed.)	Water consumptive use efficiency %
G_1	N_0	615.43	640.32	96.11	590.34	612.89	96.32
	N_1	590.21	655.46	90.05	572.36	624.75	91.61
	N_2	555.59	670.81	82.82	540.59	640.92	84.34
	N_3	526.26	647.54	81.27	522.35	627.38	83.25
Mean				**87.56**			**88.88**
G_2	N_0	580.45	605.24	95.90	565.89	586.47	96.49
	N_1	566.79	630.47	89.89	548.79	600.48	91.39
	N_2	520.21	635.58	81.84	515.29	624.59	82.5
	N_3	501.62	619.55	80.96	489.11	596.89	81.94
Mean				**87.14**			**88.08**

Irrigation Water Application Efficiency:-

Values of irrigation water application efficiency (Ea) in percent for each treatment were obtained by dividing the total water stored in the root zone by the applied irrigation water (Downy, 1970).

$$Ea = \frac{Ws}{Wd} \times 100 \quad \text{where:}$$

Ea = Water application efficiency
Ws= Water stored in the root zone
Wd = Water applied to the field plot.

Data presented in Tables (7) and (8) and illustrated by figures (5 and 6) represent effects of system of irrigation and rate of the applied nitrogen fertilizers on values of irrigation water application efficiency within the first and second growing seasons. The values of irrigation water application efficiency under the surface irrigation system varied from 39.75% to 41.64% for the growing season of 2006, The corresponding values in the next season ranged from 38.79% and 40.56%.

Under the drip irrigation system the above mentioned values ranged from 41.74 to 43.48 % in the first season and from 41.30 to 43.99 % in the second one, respectively. It is obvious from the of aforementioned results that although application of the nitrogen fertilizer could result in higher values of irrigation water application efficiency, yet no obvious or constant effect could be realized due to rate of the applied nitrogen fertilizer. Moreover, the used drip irrigation system was associated with relatively higher values of irrigation water application efficiency than the corresponding ones associated with the surface irrigation system in both seasons.

This is probably due to higher loss of the applied water through evapotranspiration and consequently the lower stored water as percentage of the applied water under surface irrigation system than under the drip irrigation one.

The highest attained values of irrigation water application efficiency i.e. 43.83% and 43.99% occurred under the drip irrigation system (G_2) when N was applied at rate of 120 kg N /fed. In both growing seasons On the other hand, the lowest values i.e. 39.75% and 38.79% were achieved under the surface irrigation system (G_1) when N was not applied (control) in both growing seasons.

Table (7): Effected of system of irrigation and rate of the applied nitrogen fertilizer on values of applied irrigation water, water stored, and irrigation water application efficiency during the growing season of 2006.

Treatments		Applied irrigation, m^3/fed.	Water stored, m^3/fed.	Irrigation water application efficiency %
	N_0	1611	640.32	39.75
G_1	**N_1**	1611	655.46	40.69
	N_2	1611	670.81	41.64
	N_3	1611	647.54	40.19
Mean				**40.57**
	N_0	1450	605.24	41.74
G_2	**N_1**	1450	630.47	43.48
	N_2	1450	635.58	43.83
	N_3	1450	619.55	42.73
Mean				**42.95**

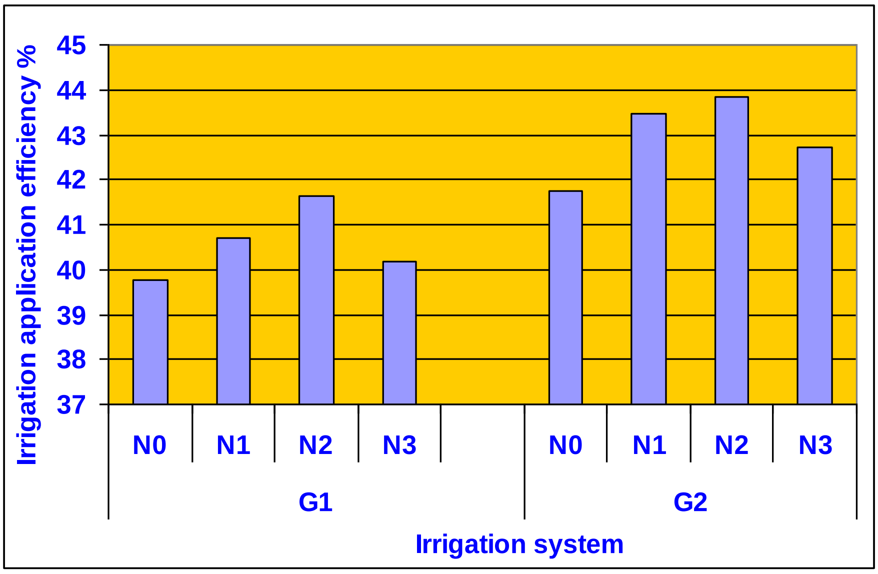

Figure (5): Values of irrigation water application efficiency under surface (G1) and drip (G2) irrigation systems during 2006 season.

Table (8): Effected of system of irrigation and rate the applied nitrogen fertilizer on values of applied irrigation water, water stored, and irrigation application efficiency during the growing season of 2007.

Treatments		Applied irrigation, m^3/fed.	Water stored, m^3/fed.	Irrigation water application efficiency %
	N_0	1580	612.89	38.79
G_1	N_1	1580	624.75	39.54
	N_2	1580	640.92	40.56
	N_3	1580	627.38	39.71
Mean				**39.65**
	N_0	1420	586.47	41.3
G_2	N_1	1420	600.48	42.29
	N_2	1420	624.59	43.99
	N_3	1420	596.89	42.03
Mean				**42.4**

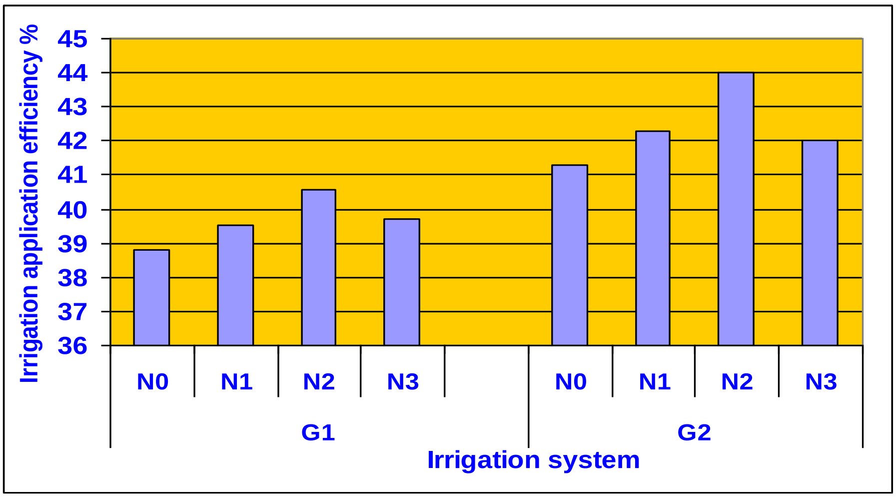

Figure (6): Values of irrigation water application efficiency under surface (G1) and drip (G2) irrigation systems during 2007 season.

Crop Water Use Efficiency:

The crop water use efficiency was computed for the different treatments by dividing the yield (kg/fed.) by units of evapotranspiration expressed as cubic meters of water/fed. (Abd El Rasool *et al.*, 1971). This value could be calculated by the following formula:

$$\text{C.W.U .E.} = \frac{\text{Yield (kg/fed.)}}{\text{Water consumptive use (m}^3\text{/fed.)}}$$

Data in Table (9) and figures (7 and 8) represent values of the crop water use efficiency as influenced by irrigation system and rate of the applied nitrogen fertilizer.

Data indicated values of crop water use efficiency averaged over all nitrogen doses were, generally, higher under the drip irrigation system than under the surface irrigation one. This value reached to 5.42 kg/m^3 for drip irrigation whereas the corresponding value in case of the surface irrigation system was only 4.93 kg/m^3. From these results it could be noticed that there was a decline in crop water use efficiency with surface irrigation system in both seasons. as compared with the drip one. The increases in crop water use efficiency attained, generally, due to applying nitrogen fertilizer might be mainly owing to the general increase in total yield of grains on one hand and the corresponding decrease in actual water consumptive use on the other one.

The highest value of crop water use efficiency was attained due to application of N at the rate of 120 kg /fed. This occurred under both the used irrigation systems and for both the two growing seasons. However, drip irrigation system achieved the highest values where percentage of 6.73 and 6.91 were recorded in the first season and second one, respectively.

Table (9): Effect of system of irrigation and rate of the applied nitrogen fertilizer on values of maize grain yield (kg/fed.) water consumptive use (m^3/fed.) and crop water use efficiency(m^3/fed.) within the growing seasons of 2006 and 2007.

Treatments		2006			2007		
		Total weight of grain in, kg/fed.	Water consumptive use (m^3/fed.)	Crop water use efficiency, kg/m^3	Total weight of grain in, kg/fed.	Water consumptive use (m^3/fed.)	Crop water use efficiency, kg/m^3
G_1	N_0	2408	615.43	3.9	2436	590.34	4.13
	N_1	2920	590.21	4.9	2960	572.36	5.17
	N_2	3332	555.59	5.99	3384	540.59	6.26
	N_3	2600	526.26	4.94	2628	522.35	5.03
Mean				4.93			**5.15**
G_2	N_0	2420	580.45	4.17	2484	565.89	4.39
	N_1	3148	566.79	5.55	3212	548.79	5.85
	N_2	3500	520.21	6.73	3560	515.29	6.91
	N_3	2612	501.62	5.21	2640	489.11	5.39
Mean				5.42			**5.64**

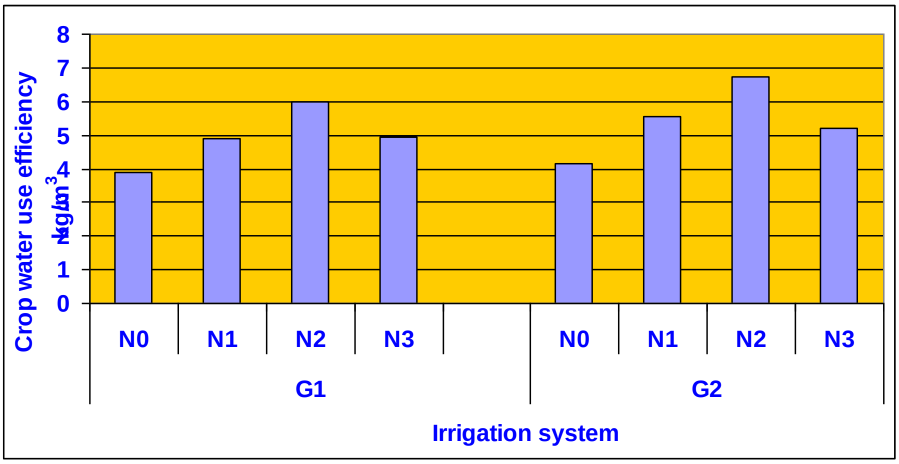

Figure (7): Values of crop water use efficiency under surface(G1) and drip (G2) irrigation systems during 2006 season.

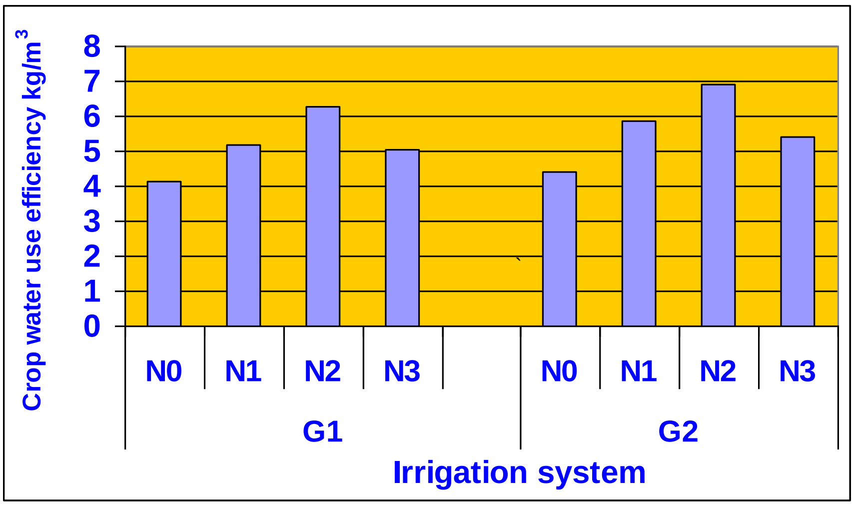

Figure (8): Values of crop water use efficiency under surface(G1) and drip (G2) irrigation systems during 2007 season.

Field Water Use Efficiency:

This value represent weight of marketable crop production per the volume unit of applied irrigation which expressed as cubic meter of water (Michael, 1978).

It was calculated by the following equation

$$F.W.U.E = \frac{\text{Yield (kg/fed.)}}{\text{Water applied (m}^3\text{/fed.)}}$$

The average values of field water use efficiency as affected by system of irrigation and rate of applied nitrogen fertilizer are presented in Table (10). These values varied between 1.75 and 2.01 kg/m^3 under the surface irrigation (G_1) and drip irrigation (G_2) systems, respectively during the first growing season. In the second season the corresponding values averaged 1.80 and 2.1 kg/m^3 , respectively.

It is obvious from the obtained data that, the field water use efficiency was higher under the drip irrigation system than under the surface irrigation one.

Data indicated that values of field water use efficiency, increased with increasing rate of the applied N up to 120 kg/fed beyond which it decreased obviously. This is probably attributed to the higher vegetative growth of maize at the expense of the grains yield upon application of the highest rate of the applied N i.e.150 kg/fed.

The highest value of field water use efficiency was obtained under the drip irrigation system (G_2) specially, and when N was applied at a rate of 120 kg/fed in both seasons of growth.

Table (10): Effect of system of irrigation and rate of the applied nitrogen on values of water applied (m^3/fed.), total grain yield (kg/fed.) of maize, and field water use efficiency(m^3/fed.) within the growing seasons of 2006 and 2007.

Treatments		2006			2007		
		Water applied, m^3/fed.	Total weight of grain in, kg/fed.	Field water use efficiency, kg/m^3	Water applied, m^3/fed.	Total weight of grain in, kg/fed..	Field water use efficiency, kg/m^3
G_1	N_0	1611	2408	1.49	1580	2436	1.54
	N_1	1611	2920	1.8	1580	2960	1.87
	N_2	1611	3332	2.1	1580	3384	2.14
	N_3	1611	2600	1.6	1580	2628	1.66
Mean				1.75			**1.80**
G_2	N_0	1450	2420	1.67	1420	2484	1.75
	N_1	1450	3148	2.17	1420	3212	2.26

	N_2	1450	3500	2.41	1420	3560	2.51
	N_3	1450	2612	1.8	1420	2640	1.86
Mean				**2.01**			**2.1**

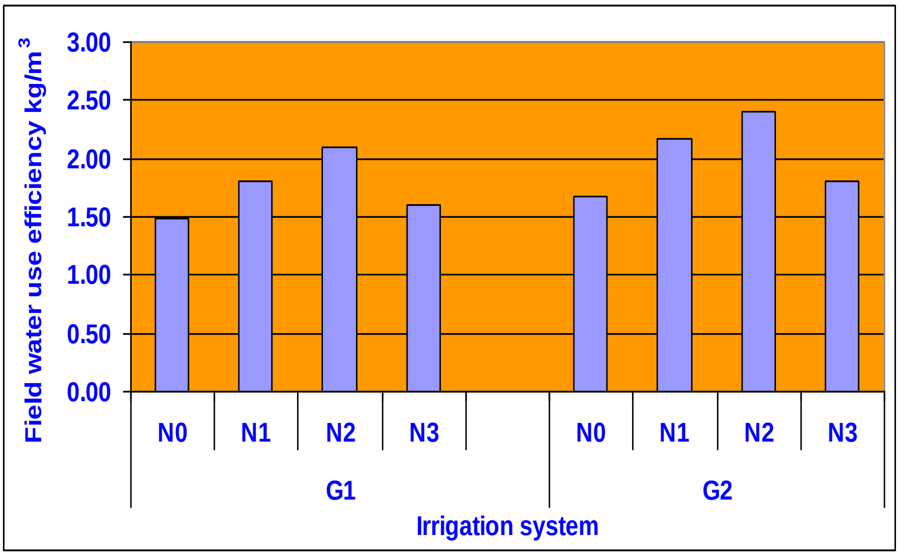

Figure (9): Values of field water use efficiency under surface (G1) and drip (G2) irrigation systems during 2006 season.

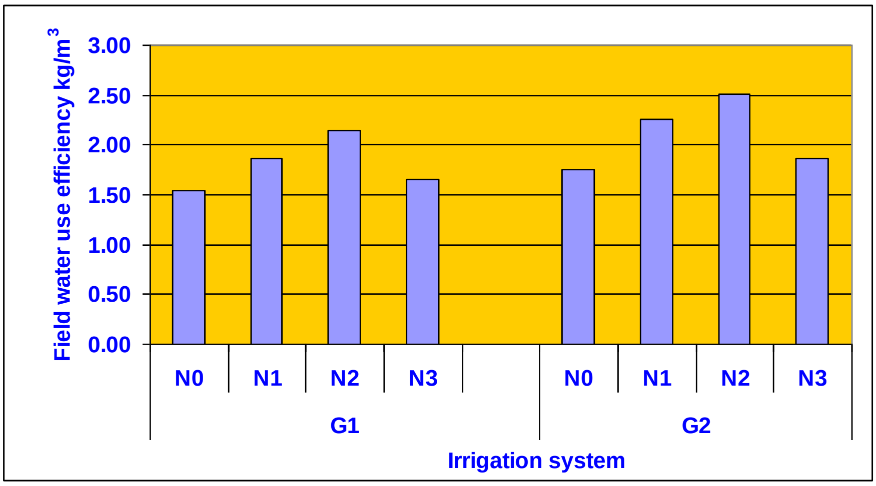

Figure (10): Values of field water use efficiency under surface (G1) and drip (G2) irrigation systems during 2007 season.

REFERENCES

Abdel-Rasool, S.F.; H.W.Tawodros; W.I Miseha,. and F.N Mahrous,.,1971. "Effect of irrigation and fertilization on water use efficiency by wheat" Conf., A. in Shams Univ. Egypt.

Ali, M.E., F.S El-Gamal, EH.A Noufal, W.F.,El-Bably, 2009. Effect of method of irrigation and rate of applied N fertilizer on yield and yield component of maize plants.Applied Sci., Zagazig Univ.,(under publication)..

Black, C. A.1965. "Methods of Soil Analysis". Amer. Soc. Agron. Inc., Madison, Wisconsin U. S. A.

Downy, L.A. 1970. "Water use by maize at three plant densities". Exper. Agr. (7): 161-169.

Feddes, R.A., 1985. Crop water use and dry matter production: State of the art. In: Les besoins en eau des cultures. Conference internationale, Paris, September 11-14, 1984, pp. 221-234.

Fekadu, Y. and T. Teshome, 1998. Effect of drip and furrow irrigation and plant spacing on yield of tomato at Dire Dawa, Ethiopia. Agric. Water Manage., 35: 201-207.

Hanson, B.R., L.J.Schwankl, , K.F Schulbach,., G.S Pettygrove,., 1997. A comparison of furrow, surface drip and subsurface drip irrigation on lettuce yield and applied water. Agric. Water Manage., 33: 139-157.

Hsiao, T., P. Steduto, E.Fereres, , 2007. A systematic and quantitative approach to improve water use efficiency in agriculture. Irrig. Sci., 25: 209-231.

Israelson, O.W. and V.E. Hansen. 1962. "Irrigation principles and practices". 3rd Edit. John Willey & Sons, New York.

Jackson, M.L. 1967. "Soil Chemical Analysis". Constable Co. Ltd. London.

Klutet A. (1986). "Methods of Soil Analysis". Part 1: Physical and Mechanical Methods, (2) ND-ED. Amer. Soc. Agron. Madison Wisconsin, U.S.A.

Lamm, F.R., H.L. Manges, L.R. Stone,., A.H. Khan, D.H. Rogers,., 1995.Water requirement of subsurface drip-irrigated corn in northwest Kansas. Trans. ASAE, 38 (2): 441-448.

Michael A.M. 1978. "Irrigation Theory and Practice". Vika Publishing House, New Delhi. 1978.

Page, A. L. 1982. "Methods of Soil Analysis". Part2. (2nd Ed.), Soil sci. Soc. of American Ine. Madison, Wisconsin, U.S.A.

Pereira, L. S., T. Oweis, A.Zairi, , 2002. Irrigation management under water scarcity. Agric. Water Manag., 57: 175-206.

Rijtema, P.E., G.Endrodi, , 1970. Calculation of production of potatoes. Neth. J. Agric. Sci., 18 (1): 26-36.

Ritchie, J. T., 1983. Efficient water use in crop production: Discussion on the generality of relations between biomass production and evapotranspiration. In: Taylor, H.M., Jordan, W.R., Sinclair, T.R.(Eds.), Limitations to Efficient Water Use in Crop Production. ASA- CSSA-SSSA, Madison, WI, pp.29-43.

Rhoades, F.M. and J.M.Bennett, 1990. Corn . In:Stewart, B.A., Nielsen, D.R., (Eds.), Irrigation of Agricultural Crops. Madison, WI, pp. 569-596.

Slabbers, P.J., V.Sorbello Herrendorf, and M.Stepper, 1979. Evaluation of simplified water-crop-yield models. Agric. Water Manag., 2: 95-129.

Tanner, C.B. and T.R. Sinclair, 1983. Efficient water use in crop production : research or re-search? In : Taylor, H.M., Jordan, W.R., Sinclair, T.R.(Eds.), Limitations to Efficient Water Use in Crop Production. Am. Soc. Agron., pp. 1-27.

Turner, N.C.,2004. Agronomic options for improving rainfall-use efficiency of crops in dryland farming systems. J.Exp. Bot., 55: 2413-2425.

de Wit, C.T., 1958. Transpiration and crop yields. Versl. Landbouwk. Onderz. 64.6, pudoc, Wageningen , 88 pp.

Zwart, S.J. and W.G.M. Bastiaanssen, 2004. Review of measured crop water productivity values for irrigated wheat, rice, cotton, and maize. Agric.Water Manag., 69: 115-133.

كفاءات استخدام مياه الري وتأثرها بنظام الري ومعدل السماد النيتروجيني المضاف إلى نبات الذرة

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**** المركز القومي لبحوث المياه- وزارة الموارد المائية والري**

أجريت تجربتين حقليتين خلال موسمين صيف متتاليين وهما ٢٠٠٦ – ٢٠٠٧ في محطة بحوث الإحتياجات المائية ببهتيم التابعة للمركز القومي لبحوث المياه.

قد نمى نبات الذرة على الأرض المذكورة تحت نظامي ري هما الري السطحى والري بالتنقيط وفي ظل إضافة السماد النيتروجيني على صورة يوريا (٤٦ % نيتروجين) بأربعة معدلات هي صفر، ٩٠ ،١٢٠ ، ١٥٠ كجم نيتروجين للفدان.

وقد أجريت العمليات الزراعية المعتادة وصممت التجربة بنظام القطع المنشقة حيث وزعت أنظمة الري بالقطع الرئيسية بينما وزعت المعاملات النيتروجينية عشوائيا فى القطع الشقية.

وقد اوضحت النتائج ان إضافة النيتروجين بغض النظر عن معدل الإضافة قد تسبب في توفير في كميات مياه الري بنسب ٢٤,١٥% ، ٢٤,٠٥% متر مكعب للفدان خلال موسمي النمو الأول والثاني على الترتيب تحت نظام الري السطحي بينما تحت نظام الري بالتنقيط كانت نسب

التوفير في مياه الري هي ٣٧,٩٣% ، ٣٨,٠٣% على الترتيب.كانت قيم الإستهلاك المائي الشهرية والموسمية أعلى عند إضافة مياه الري بنظام الري السطحي عنه بنظام الري بالتنقيط وكانت قيم الإستهلاك المائي تقل بوجه عام بزيادة معدل إضافة النيتروجين وكانت أعلى قيمة لكفاءة إضافة مياه الري تحت نظام الري بالتنقيط ومعدل إضافة من النيتروجين ١٢٠ كجم نيتروجين للفدان خلال موسمي النمو.

كان هناك نقص في كفاءة إستخدام المحصول للماء مع نظام الري السطحي في كلا موسمي النمو مقارنة بنظام الري بالتنقيط ومع ذلك فإن أعلى قيمة لكفاءة إستهلاك المحصول للمياه تحت نظام الري بالتنقيط وإضافة النيتروجين بمعدل ١٢٠ كجم نيتروجين للفدان.

كانت كفاءة إستخدام الحقل للمياه أعلى تحت نظام الري بالتنقيط عنه تحت نظام الري السطحي وقد زادت قيم هذا المؤشر بزيادة معدل إضافة النيتروجين حتى ١٢٠ كجم نيتروجين للفدان بعدها حدث نقصاً واضحاً.