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EFFECT OF SURFACE IRRIGATION TECHNIQUES AND NITROGEN, PHOSPHORUS AND POTASSIUM RATES ON MAIZE YIELD IN ALLUVIAL SOILS

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ABSTRACT

A field experiment was carried out at Batra village -Talkha district Dakahlia Governorate during two successive summer growing seasons 2010 and 2011 to study the effect of two surface irrigation systems (furrow and bed furrow irrigation systems) and four rates of NPK (0-0-0, 60-6.5-20, 90-10-30 and 120-13-40 kg N-P-K/fed, respectively) and their combinations on maize (c.v. single hybrid 30-K-8) yield, yield components, chemical composition, fertilization efficiency, soil fertility and some water relations. The most important results could be summarized as follows. Maize grain and stalk yields were insignificantly affected by irrigation systems in both seasons, but 1000-grain weight was significant. Addition of NPK levels significantly increased grain yield, stalk yield and 1000-grain weight. Interaction between irrigation systems and NPK levels increased grain and stalk yields, insignificantly. N % in stalk and grain was significantly affected by irrigation systems, but P % and K % were insignificantly affected. Addition NPK levels significantly increased N, P and K % in maize stalk and grain. Also, interaction between irrigation systems and NPK levels increased N, P and K concentrations in maize. The values of nitrogen use efficiency (NUE), phosphor use efficiency (PUE) and potassium use efficiency (KUE), were higher with furrow irrigation technique than bed furrow irrigation in two seasons. Also, addition of NPK levels increased NUE, PUE and KUE, respectively compared with control (zero level). The addition of NPK at 90-10-30 kg N-P-K/fed, respectively produced the highest values of NUE, PUE and KUE. Soil fertility were affected by irrigation techniques and NPK levels, where available N in soil increased insignificantly, but available P and K significantly increased with irrigation systems in both seasons. Application different levels of NPK increased significantly the availability of N, P, and K in soil. The average values of soil salinity were increased significantly with bed furrow irrigation methods and NPK levels as well as their interactions. The highest mean value of field water use efficiency in the two seasons (1.34 and 1.43 kg grain/m^3, respectively) was recorded with 120, 13 and 40 kg NPK/fed under bed furrow irrigation system.

Keywords: surface irrigation techniques, NPK rates and maize.

INTRODUCTION

Maize (*Zea mays L.*) is one of the most important cereal crops in Egypt for human consumption and animal feeding. Therefore, many studies were conducted to increase its yield and improve its quality through proper fertilization and good management as well as releasing new high varieties.

Egypt becomes in need to make good management for irrigation water and improve soil productivity to face water shortage as well as increasing of population. Water is a biotic for life in both the biochemical and biophysical synthesis and its influences are both internal and environmental. Water is often the primary limiting factor for maize production. The idea of applying too much irrigation water to achieve maximum crop yield is not always correct, where, it causes losses of water and fertilizers through leaching.

The salt content under furrow irrigation system generally increased by increasing distance from the furrow and with the depth, This indicates the effect of applied water in leaching soluble salts deep down the soil profile, Abd El-Razek *et al.,* (1992).

Eid (2004) found that values of water use efficiency were higher with alternative furrow irrigation comparing with traditional furrow irrigation in field experiments on corn. Water consumptive use by zea maize plants were increased with increasing available soil moisture, Abo-Omer(2006). Abdel-Aziz- El-Set and El-Bialy(2004) showed that the values of seasonal water consumptive use by maize ranged from 54.66 to 74.64 cm during the period of study. They added that water consumption increased with increasing soil moisture by frequent irrigations. Meleha (2006) found that water consumptive use increased due to increasing the amount of water applied.

Rafiee and Shakarami(2010), in field study on the effect of different surface irrigation methods {conventional furrow irrigation(CFI), fixed every other furrow irrigation(FFI), and alternate every other furrow irrigation(AFI)} on water use efficiency of corn yield. The results showed that there were no difference between both FFI and AFI, but the performance of them decreased the amount of irrigated water applied by 26.2% and 23%,respectively comparing with CFI. In this respect, FFI resulted in the highest water use efficiency for grain (1.91 kg/m^3).

Maize one of crops that need to high nitrogen fertilization, Nofal–Fatma, *et al.*,(2005) found that plant growth parameters, grain yield, 1000-grain weight and NPK contents of maize were gradually increased with increasing nitrogen fertilization levels up to 160 kg N/fed. El-Atawy,(2007) found that application of N fertilizer and organic manure increased water use efficiency.

Phosphorus is very important element to plant growth and plays a key role in metabolic processes such as cell divisions, conversion of sugar into starch and cellulose, transformation of starch, seed germination, synthesis of nucleoproteins and some other vital processes, Mengel and Kirkby(1987).

Potassium deficit decreased ATP, disturbed plant transfer system and decreased photosynthesis rate which led to unusual resources organization development, (Aziz, et al., 1999). Nesmith and Ritchie(1992) reported that potassium increased cell division, grains number per row, 1000 grain weight and grain yield. Marschner(1995) found that potassium has important role in water use efficiency and improves growth plant condition, cell division, formation of hydrocarbon and protein and quick transportation of these products toward grains.

In field clayey experiments aiming to evaluate the effect of furrow irrigation techniques(irrigation two furrows and let furrow, irrigation furrow and let furrow, and traditional furrow irrigation), N (0, 60 and 120kg N/fed) and K (0,10 and 20kg K/fed) fertilization levels, Abo El-Atta (2006) found that the amount of irrigation water applied was decreased with alternate furrow irrigation technique. Irrigation furrow and let furrow recorded the highest field water use efficiency. Also, he found that increasing fertilization levels of N and K had a positive impact on values of field water use efficiency. Conversely, grain and stalk yields were increased significantly with increasing N and K application rates, also N, P and K concentrations in grain and stalk were increased with increasing fertilization rates.

Asghar, et al., (2010) found that increase the application rate of NPK up to 250 – 110 – 85 kg/ha, respectively significantly increased grain yield and 1000-grain weight of maize. Among different treatment, NPK 250-110-85 kg/ha, respectively produced the highest grain yield (6.07t/ha) and the highest 1000-grain weight (255g).

In field study consisted four levels for irrigation (50, 90, 130, 170 mm after evaporation of A class pan) and five levels of potassium fertilizer (0, 50, 100, 150, 200 kg/ha), Tabatabaii Ebrahimi, et al.,(2011) found that potassium fertilizer in comparison with control increased grain yield as rate 49.96, 25.27, 36.08, 48.38%, respectively. Also, they found that the highest 1000 grain weight (330.74g) was recorded with 200 kg potassium/ha.

The objective of this research was to study the effect of different surface irrigation techniques, NPK levels and their interactions on yield and water use efficiency of corn.

MATERIALS AND METHODS

Two field experiments were carried out at Batra village -Talkha district Dakahlia Governorate during two successive summer growing seasons (2010 and 2011). The investigation was done to study the effect of irrigation techniques and different rates of NPK combinations on maize yield, yield components, nutrient contents in plant, fertilization efficiency, soil fertility and some water relations.

A split plot design with four replicates was used and plot area was $50m^2$(10m length x 5m width). Experimental treatments were carried out as follow:

1- The main plot: (Irrigation techniques)
   - $\mathbf{I_1}$= furrow irrigation
   - $\mathbf{I_2}$ = bed furrow irrigation
2- The sub plots: (Rates of NPK combinations).

NPK fertilizers were applied at four levels as follows (kg/fed):

	N	**P**	**K**
F0	0	0	0
F1	60	6.5	20
F2	90	10	30
F3	120	13	40

The soil experiment field was clay loam in texture, The water table depth was 110 cm. Data in table (1) show some soil properties of the experimental field, according to Jackson,(1967), Page(1982) and Garcia(1978).

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Maize (c.v. single hybrid 30-K-8) was planted on may 15^{th},2010 in first season, and may 20^{th}, 2011 on second season.

Phosphorus was added to the soil as super phosphate (6.75%P)at a one dose before planting. Nitrogen was applied as ammonia nitrate (33.5%N) at two doses equally with the second and third irrigations. Potassium was added as potassium sulphate (40% K) at two doses equally with the second and third irrigations.

Plant samples were taken at harvest stage, grain yield, stalk yield and 1000-grain weight were recorded. Nitrogen, phosphorus and potassium were determined according to Jackson, (1967). Nitrogen, phosphorus and potassium use efficiency (NUE, PUE and KUE**)** were calculated as grain yield (Kg) produced due to adding units of fertilizer, for example nitrogen use efficiency(NUE),

$$NUE = \frac{\text{Theoretical grain yield (Kg/fed)}}{\text{total N-applied (kg/fed)}} X100$$

Water relations:

amount of irrigation water applied (m^3/fed) was measured by using cut-throat flume (20x90cm) according to Early,(1975).

Determination of soil moisture percentage: soil moisture samples were taken before and after each irrigation from each plot with an auger at depths of 0-20, 20-40 and 40-60cm. These samples were immediately transported in tightly closed aluminum cans, where they weighed in the laboratory, then dried in oven at 105 c^0 for 24 hours and reweighed to calculate their moisture content as described by Garcia(1978).

Water consumptive use (WCU): was calculated according to the following equation (Israelsen and Hansen, 1962).

$$WCU = \sum_{i=I}^{i=n} \{ [(Ә_2 - Ә_1) \times D_{bi} \times D_i \times 4200]/100\}$$

Where: WCU = water consumptive use in m^3/fed.

$Ә_2$ = Soil moisture % after irrigation in the i^{th} layer.

$Ә_1$ = Soil moisture % before next irrigation in the i^{th} layer.

D_{bi} = Bulk density (g/cm^3)of the i^{th} layer.

Di = depth of the i^{th} layer, cm.

4200= feddan area in m^2

I = No. of soil layers

n = No. of irrigation

Water stored in the effective root zone (WS): Seasonal (WS) was calculated using the following equation:

$$WS = \sum_{i=I}^{i=n} \{ [(Ә_2 - Ә_1) \times D_{bi} \times D_i \times 4200]/100\}$$

Where: $Ә_2$ = Soil moisture % after irrigation in the i^{th} layer.

$Ә_1$ = Soil moisture % before irrigation in the i^{th} layer.

Irrigation application efficiency (Ea): It is defined as a ratio between the amount of stored water (m^3/fed), and the amount of the applied water (m^3/fed) as described by Downy(1970).

Ea= (Ws/Wa)x100

Where : Ws, Wa are the volumetric water stored and the volumetric water applied, respectively.

Field-water use efficiency (FWUE): it was calculated according to following formula:

FWUE= [Theoretical grain Yield(kg/fed)/ IWRa(m^3/fed)]

Crop-water use efficiency (CWUE): it was calculated according to following formula:

CWUE= [Theoretical grain Yield(kg/fed)/ WCUa(m^3/fed)]

Where, IWRa= actual irrigation water applied

WCUa= actual water consumptive use.

Water distribution efficiency (Ed): it was calculated according to James (1988) as follows: Ed=(1-y/d)x100

Where: d=average depth of soil water stored along the furrow during the irrigation, and Y= average numerical deviation from d.

The statistical analysis was estimated according to the method of Gomez and Gomez (1984) and treatment means values were compared against least significant differences test (L.S.D.) at 5% level.

RESULTS AND DISCUSSION

Yield and yield components

Data in table 2 show maize grain yield, stalk yield and 1000-grain weight. Grain yield was insignificantly affected by irrigation systems on both seasons. The values of grain yield slightly differ under furrow and bed furrow irrigation. Addition of different NPK rates up to F2 significantly increased grain yield in both seasons. The difference between F2 and F3 were insignificantly in both seasons. The interactions among irrigation and NPK levels were not affected significantly on grain yield.

Stalk yield was not affected significantly by irrigation systems (furrow and bed furrow) in 1st season, while application different rates of NPK increased stalk yield significantly in both seasons. The highest yield of stalk was 3.652 t/fed in 1st season at F2 and 3.948 t/fed in 2nd season at F3. While the differences between F2 and F3 were insignificant in both seasons. The interactions effects on stalk yield were insignificant in the 1st season and significant in the 2nd season.

The highest stalk yield was 3.743 t/fed at interaction between bed furrow irrigation technique and F2 in 1st season, and 3.954 t/fed at interaction between furrow irrigation technique with F3 in 2nd season. Where the differences between interactions (I_1xF2, I_1xF3, I_2xF2 and I_2xF3) were insignificant in both seasons.

Concerning the 1000-grain weight, data reveal that surface irrigation systems had significant effect on 1000-grain weight in the 1st season, but insignificant effect in 2nd season. Application NPK at different rates increased 1000-grain weight significantly in both seasons. The highest values of 1000-grain weight (414 and 402g in both seasons, respectively) were taken with F2 treatment. The interaction increased 1000-grain weight significantly in 2nd

season, but insignificantly in 1st season. The highest 1000-grain weight (403g) was the interaction between bed furrow irrigation technique and F2 (90-10-30 kg NPK) in 2nd season.

Table2: Effect of surface irrigation techniques, NPK levels and their interactions on maize yield

Treatments		First season			Second season		
		grain yield (t/fed)	stalks yield (t/fed)	1000 grain weight (g)	grain yield (t/fed)	stalks yield (t/fed)	1000 grain weight (g)
Irrigation							
I_1		3.613	3.315	404	3.775	3.363	384
I_2		3.549	3.382	395	3.777	3.571	394
LSD 5%		--	--	4.23	--	0.019	--
significance		ns	ns	*	ns	**	ns
NPK Levels							
F0		2.941	2.908	378	2.850	2.844	369
F1		3.619	3.190	397	3.733	3.308	383
F2		3.907	3.652	414	4.227	3.767	402
F3		3.856	3.644	408	4.293	3.948	402
LSD 5%		0.112	0.238	10.03	0.112	0.196	11.98
significance		**	**	**	**	**	**
Interaction effects							
I_1	F0	2.907	2.895	378	2.800	2.784	365
	F1	3.624	3.218	403	3.680	3.092	367
	F2	4.013	3.561	424	4.253	3.821	400
	F3	3.907	3.587	410	4.367	3.954	403
I_2	F0	2.976	2.921	378	2.900	2.905	373
	F1	3.613	3.163	390	3.787	3.524	400
	F2	3.800	3.743	403	4.200	3.913	403
	F3	3.805	3.700	407	4.220	3.942	400
LSD 5%		--	--	--	--	0.136	16.94
significance		ns	ns	ns	ns	**	*

In general, data reveal that irrigation techniques had insignificant effect on grain and stalk yields and 1000-grain weight. Where as, there were slightly differences between the values of corn yield and 1000 grain weight in both seasons. This results leads to superiority of bed-furrow irrigation technique than conventional furrow irrigation. Also, these superiority lead to decrease application irrigation water by 20% at means. Similar results were obtained by Abo El-Atta (2006). Also, addition of NPK levels significantly increased grain yield, stalk yield and 1000-grain weight in both seasons. These results were in agreement with that obtained by Asghar et al., (2010).

Chemical composition:

Data in table 3 reveal that the average values of N % in grain and stalk were significantly affected by irrigation systems, where furrow irrigation recorded the highest N %. Addition levels of NPK (F1, F2 and F3) increased significantly N % in maize grain and stalk. Also, interactions between irrigation techniques and NPK levels increased N % in maize significantly. The highest N % was recorded with interaction among furrow irrigation and NPK level F3 (120–13–40 kg NPK/fed).

Table3: Effect of surface irrigation techniques, NPK levels and their interactions on N, P and K % in corn.

Treatments		First season						Second season					
		N%		P%		K%		N%		P%		K%	
		grain	stalk	grain	stalk	grain	stalk	grain	stalk	grain	stalk	grain	stalk
Irrigation													
I_1		2.95	3.75	0.316	0.392	2.16	2.86	2.94	3.75	0.313	0.391	2.27	2.96
I_2		2.76	3.52	0.327	0.376	2.13	2.83	2.85	3.63	0.307	0.378	2.22	2.90
LSD 5%		0.106	0.187	--	0.016	0.014	--	--	0.086	--	--	--	--
significance		*	*	ns	*	*	ns	ns	*	ns	ns	ns	ns
NPK Levels													
F0		2.52	3.26	0.269	0.334	2.03	2.56	2.56	3.23	0.237	0.320	2.08	2.65
F1		2.72	3.45	0.311	0.378	2.16	2.79	2.86	3.57	0.303	0.373	2.20	2.87
F2		3.06	3.87	0.345	0.393	2.19	2.97	3.06	3.95	0.339	0.416	2.33	3.06
F3		3.11	3.96	0.361	0.432	2.22	3.07	3.10	4.03	0.361	0.427	2.36	3.14
LSD 5%		0.067	0.119	0.017	0.020	0.055	0.050	0.042	0.067	0.013	0.011	0.061	0.054
significance		**	**	**	**	**	**	**	**	**	**	**	**
Interaction effects													
I_1	F0	2.60	3.40	0.265	0.329	2.07	2.60	2.55	3.37	0.226	0.323	2.12	2.71
	F1	2.72	3.68	0.296	0.389	2.17	2.80	2.88	3.69	0.303	0.393	2.23	2.89
	F2	3.22	3.95	0.343	0.400	2.19	2.96	3.15	3.96	0.352	0.420	2.35	3.06
	F3	3.28	3.97	0.361	0.450	2.23	3.08	3.18	4.00	0.371	0.427	2.37	3.16
I_2	F0	2.45	3.11	0.273	0.338	1.99	2.51	2.58	3.09	0.247	0.317	2.03	2.59
	F1	2.73	3.23	0.327	0.367	2.15	2.78	2.83	3.45	0.302	0.353	2.18	2.86
	F2	2.90	3.80	0.347	0.386	2.19	2.99	2.97	3.93	0.325	0.413	2.31	3.05
	F3	2.94	3.94	0.362	0.413	2.20	3.06	3.02	4.05	0.352	0.428	2.35	3.11
LSD 5%		0.095	0.169	--	--	--	--	0.059	0.094	0.018	0.016	--	--
significance		**	*	ns	ns	ns	ns	**	**	**	**	ns	ns

The obtained results show that P % in grain was not affected significantly by irrigation systems. But, P % in maize stalk and grain was increased significantly by application of NPK levels in both seasons. The differences between NPK levels were significant. The highest concentration of P % in stalk and grain was obtained with F3 treatment. Interactions effect increased P % insignificantly in the 1st season, but significantly in 2nd season.

Changes in K % in grain and stalk due to irrigation systems were insignificant in both seasons except K % in grain in the 1st season that affected significantly. On the other hand, the values of K % were increased significantly by addition of different levels of NPK in two seasons. Among NPK levels the differences were significantly up to level F2. Interactions effect among irrigation techniques and NPK levels increased K % insignificantly in both seasons.

It is obvious from the results that the concentrations of N, P and K in grain and stalk were higher with furrow irrigation than bed furrow irrigation, also the differences between among NPK levels were significantly up to level F2 (90-10-30 kg NPK/fed). In this concern, Abo El-Atta (2006) found that N concentration in grain and stalk was higher with alternate furrow irrigation than traditional furrow irrigation, but P and K concentration were higher with traditional furrow than alternate furrow irrigation. While the increases in N, P and K concentrations with increasing NPK levels were in agreement with the finding of Sharer et al., (2003).

Fertilization efficiency:

Data in table 4 show the nitrogen use efficiency (NUE), phosphor use efficiency (PUE) and potassium use efficiency (KUE).

Furrow irrigation technique increased the efficiencies of NUE, PUE and KUE more than bed furrow irrigation technique in both seasons. The highest fertilization efficiency was achieved with furrow irrigation system. Also, addition of NPK fertilizers increased NUE, PUE and KUE compared with control. The treatment F1 produced the highest values of NUE, PUE and KUE in 1st season, but F2 recorded the highest efficiency in 2nd season.

Interaction among irrigation systems and NPK levels increased NUE, PUE and KUE values in both seasons. The highest values of NUE, PUE and KUE were 12.30, 49.19 and 30.74 in 1st season and 16.15, 64.59 and 40.37 in 2nd season, respectively were obtained with interaction between furrow irrigation system and F2 treatment.

Table4: Effect of surface irrigation techniques, NPK levels and their interactions on fertilization efficiency.

Treatments		First season			Second season		
		NUE	PUE	KUE	NUE	PUE	KUE
Irrigation							
I_1		8.15	32.59	20.37	10.97	43.87	27.42
I_2		6.67	26.69	16.68	10.06	40.22	25.14
NPK Levels							
F0		0.00	0.00	0.00	0.00	0.00	0.00
F1		11.29	45.16	28.22	14.72	58.89	36.81
F2		10.73	42.90	26.81	15.30	61.19	38.24
F3		7.62	30.49	19.06	12.03	48.11	30.07
Interaction effects							
I_1	F0	0.00	0.00	0.00	0.00	0.00	0.00
	F1	11.96	47.82	29.89	14.67	58.67	36.67
	F2	12.30	49.19	30.74	16.15	64.59	40.37
	F3	8.33	33.33	20.83	13.06	52.22	32.64
I_2	F0	0.00	0.00	0.00	0.00	0.00	0.00
	F1	10.62	42.49	26.56	14.78	59.11	36.94
	F2	9.16	36.62	22.89	14.44	57.78	36.11
	F3	6.91	27.64	17.28	11.00	44.00	27.50

Soil fertility

Surface soil samples (0-30cm) were taken after harvesting, air dried, ground and passed through 2.0mm sieve to analysis according to Jackson,(1967). Data in table 5 show the availability of nitrogen, phosphor and potassium, soil electrical conductivity (EC) and saturation percentage (SP).

Data reveal that N availability values were increased insignificantly, while the availability of P and K was significantly increased with irrigation techniques in both seasons. Application different levels of NPK significantly increased available concentration of N, P, and K. Also, interaction between irrigation systems and NPK levels increased significantly available NPK concentration in soil. These results are in harmony with those found by El-Nagar(2003) and Abo El-Atta(2006). They indicated that increasing soil moisture increases the mobility of N, P and K, where, the rate of solubility and extent of N, P and K migration increased with increasing soil moisture content.

The obtained results reveal that the average values of soil salinity (EC) were affected significantly with irrigation technique, NPK levels and their interactions. bed Furrow irrigation increased EC value by 29.31% compared with control, while it was decreased with irrigation in furrow irrigation technique.

Table 5: Effect of surface irrigation techniques, NPK levels and their interactions on soil fertility.

Treatments		First season					Second season				
		Available N (PPM)	Available P (PPM)	Available K (PPM)	EC (dsm^{-1})	SP	Available N (PPM)	Available P (PPM)	Available K (PPM)	EC (dsm^{-1})	SP
Irrigation											
I_1		63	9.4	565	2.81	54.67	66	11.8	589	2.81	55.18
I_2		57	10.8	615	3.75	54.67	61	11.2	641	3.74	55.31
LSD 5%		--	0.670	11.52	0.065	--	--	0.156	11.72	0.026	--
significance		Ns	**	**	**	ns	ns	**	**	**	ns
NPK Levels											
F0		41	6.8	439	2.96	54.33	37	7.0	415	3.06	55.10
F1		57	8.9	562	3.32	54.00	56	11.1	590	3.40	54.85
F2		59	10.2	608	3.35	55.17	67	11.9	641	3.33	55.38
F3		73	12.8	680	3.48	55.17	80	13.7	727	3.30	55.65
LSD 5%		1.069	0.618	7.32	0.088	0.94	2.706	0.603	8.93	0.123	--
significance		**	*	**	**	*	**	**	**	**	ns
Interaction effects											
I_1	F0	41	5.8	421	2.61	54.33	39	7.1	414	2.73	54.77
	F1	57	8.0	483	2.83	53.67	53	11.3	491	2.95	54.63
	F2	59	9.2	552	2.84	54.33	66	11.2	567	2.76	54.93
	F3	72	11.0	659	2.96	56.33	79	12.8	708	2.79	56.40
I_2	F0	40	7.7	456	3.32	54.33	35	6.9	415	3.40	55.43
	F1	56	9.8	641	3.81	54.33	60	10.8	688	3.85	55.07
	F2	58	11.1	663	3.86	56.00	69	12.6	715	3.89	55.83
	F3	74	14.5	702	3.99	54.00	80	14.6	745	3.81	54.89
LSD 5%		1.512	0.874	10.35	0.125	1.33	3.826	0.852	12.62	0.174	1.06
significance		*	**	**	**	**	**	**	**	**	*

The highest values of EC were 3.86 and 3.99 dSm^{-1} in 1st season and 3.89, 3.81 dSm^{-1} in 2nd season were recorded with the interaction among bed furrow irrigation and application NPK levels F2 and F3. These increases in EC values are expected and has been reported that furrow-bed irrigation technique caused a build up of soluble salts in the soil. These results were in agreement with results obtained by Helmy *et al.,* (2000) who found that soil salinity increased by increasing soil depth after irrigation but before the next irrigation, the soil salinity decreased by increasing depth under furrow irrigation system. Also, results show the insignificant effect of irrigation methods and NPK levels on SP in both seasons. Interaction effect increased SP significantly.

Soil water relations:

Amount of irrigation water applied: Amounts of irrigation water applied are shown in table(6). The obtained results indicate that the highest values of irrigation water applied in the 1st and 2nd season (3600 and 3500m^3/fed, respectively) were recorded with furrow irrigation system. The lowest values of applied water (2850 and 2950m^3/fed) were obtained with bed furrow irrigation in the 1st and 2nd season, respectively. Therefore, the amounts of water saved in 1st and 2nd season (20.83% and 15.71%, respectively) were achieved with bed furrow irrigation as compared to furrow irrigation system. These results agreed with Eid(2004), Meleha(2006) and Rafiee and Shakarami(2010).

Water consumptive use: Data in table (6) illustrate the values of water consumptive use by maize plants during the two growing seasons. It is clear from data that furrow irrigation system increased water consumptive use by maize plants compared with bed furrow irrigation. This is due to that more available soil moisture through increasing the irrigation water applied which gave a chance for more consumption of water.

Table 6: Effect of surface irrigation techniques on water applied and stored and some efficiencies.

Irrigation Techniques	First season				Second season			
	Water applied (m^3fed^{-1})	Water stored (m^3fed^{-1})	Water application Efficiency %	Water distribution efficiency %	Water applied (m^3fed^{-1})	Water stored (m^3fed^{-1})	Water application Efficiency %	Water distribution efficiency %
I_1	3600	2494.8	69.3	76.53	3500	2461.2	70.32	74.9
I_2	2850	2074.8	72.8	82.16	2950	2120	71.86	78.15

Water application efficiency: Values of water application efficiency are shown in table(6). The obtained results revealed that bed furrow irrigation system achieved the highest value of water application efficiency in both seasons (72.80 and 71.86%, respectively). The lowest values (69.3 and 70.32%) were recorded with furrow irrigation system in both seasons, respectively. These results are in agreement with findings of Meleha(2006).

Water distribution efficiency(Ed): Table (6) shows the water distribution efficiency . the highest values of distribution efficiency (82.16 and 78.15%) were obtained with furrow irrigation system in both growing seasons respectively, whereas, the lowest values of Ed (76.53 and 74.9%) were recorded with bed furrow irrigation in the two growing seasons, respectively.

Field water use efficiency (FWUE): The highest mean values of FWUE(1.34 and 1.43 kg grain/m^3) were recorded with F3 under bed furrow irrigation system in the two seasons, respectively. While, the lowest mean values (0.81 and 0.80 kg grain/m^3, respectively) were recorded with F0 (control) under furrow irrigation system.

Table7: Effect of surface irrigation techniques and NPK levels on field and crop water use efficiencies.

Treatments		First season				Second season			
Irrigation Techniques	NPK levels	Water applied ($m^3 fed^{-1}$)	Water consumptive use	FWUE	CWUE	Water applied ($m^3 fed^{-1}$)	Water consumptive use	FWUE	CWUE
I_1	F0	3600	2163	0.81	1.34	3500	2070.5	0.80	1.35
	F1			1.01	1.68			1.05	1.78
	F2			1.11	1.86			1.22	2.05
	F3			1.09	1.81			1.25	2.11
I_2	F0	2850	1956.6	1.04	1.52	2950	1995.0	.98	1.45
	F1			1.27	1.85			1.28	1.89
	F2			1.33	1.94			1.42	2.11
	F3			1.34	1.94			1.43	2.12

Crop water use efficiency (CWUE) showed the same tendency as FWUE in both seasons. The highest mean values were (1.94 and 2.12 kg m^3 were obtained with F3 under bed furrow irrigation in both seasons, respectively. While the lowest mean values (1.34 and 1.35 kg grain/m^3) were reported with F0 (control) under furrow irrigation system in both seasons, respectively.

RECOMMENDATION

Finally, it can be recommended that the application of 90 kg N + 10 kg P + 30 kg K/fed with bed furrow irrigation technique to obtain high grain yield, fertilization efficiency and water use efficiency of maize under the same experiment condition.

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تأثير نظم الري السطحي ومعدلات النتروجين والفوسفور والبوتاسيوم على إنتاجية الذرة فى الأراضي الرسوبية

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أقيمت تجربتان حقليتان بقرية بطره –مركز طلخا محافظة الدقهلية خلال موسمي 2010 و 2011 وذلك لدراسة تأثير نظامين مختلفين من الرى السطحى (الرى فى خطوط والري فى مصاطب) وأربع معدلات من النتروجين- والفوسفور-والبوتاسيوم (0-0-0 ، 60-6.5-20 ، 90-10-30 ، 120-13-40 كجم ن_ فو_ بو/فدان) على محصول الذرة الشامية(هجين فردى30ك8) ومكوناته والتركيب الكيماوي وكفاءة التسميد وخصوبة التربة وبعض العلاقات المائية وكانت أهم النتائج المتحصل عليها كما يلي:

أثرت نظم الري تأثيرا غير معنويا على محصولي الحبوب والحطب ومعنويا على وزن 1000 حبه، زاد محصول الحبوب والقش ووزن ألف حبة معنويا مع إضافة مستويات النتروجين والفوسفور والبوتاسيوم وكذلك غير معنويا مع التفاعل بينهم وبين الرى. تأثر تركيز النتروجين معنويا فى الحبوب والحطب والفوسفور والبوتاسيوم غير معنويا مع نظم الرى. زاد تركيز كل من النتروجين والفوسفور والبوتاسيوم معنويا فى الحبوب والحطب مع إضافة مستويات التسميد وكذلك مع التفاعل مع الرى، زاد كلا من تركيز الفوسفور والبوتاسيوم الميسر فى التربة معنويا والنتروجين غير معنويا مع الرى فى كلا الموسمين، زادت كفاءة استخدام كلا من النتروجين والفوسفور والبوتاسيوم مع الرى فى خطوط والتسميد بالمقارنة بالكنترول، وكانت أعلى كفاءة استخدام للنتروجين والفوسفور والبوتاسيوم مع التسميد بالمستوى 90-10-30 كجم ن_ فو_ بو/فدان. كذلك أدت إضافة مستويات مختلفة من النتروجين والفوسفور والبوتاسيوم إلى زيادة الصالح منهم فى التربة، فى حين زادت متوسطات قيم ملوحة التربة معنويا مع طريقة الرى فى مصاطب ومستويات النتروجين والفوسفور والبوتاسيوم والتفاعل بينهم، كانت كفاءة استخدام الماء أعلى مع نظام الرى فى مصاطب فى كلا الموسمين ومعدل التسميد 120- 13- 40 كجم ن. فو. بو/فدان.

قام بتحكيم البحث

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

Depth (cm)	Growing season	Mechanical analysis			Texture	SP	OM %	$CaCO_3$ %	* pH	** EC dSm^{-1}	Soluble Cations (meq/L)				Soluble Anions (meq/L)				Available NPK(ppm)		
		Sand %	Silt %	Clay %							Ca^{++}	Mg^{++}	K^{+}	Na^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
0-30	1st	39.65	28.22	32.13	Clay loam	53.50	3.14	2.85	7.6	2.92	9.2	10.9	4.8	4.9	0.0	8.2	11.3	9.7	60	18	540
0-30	2nd	39.59	28.97	31.44	Clay loam	54.20	3.28	2.77	7.6	3.05	9.5	11.7	5.2	4.5	0.0	8.0	11.2	11.3	64	20	420
mean		39.62	28.59	31.78	Clay loam	53.85	3.21	2.81	7.6	2.99	9.35	11.3	5.0	4.7	0.0	8.1	11.25	10.5	62	19	480

***pH in 1:2.5 soil : water suspension, ** EC in soil paste extract.**