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SURFACE ALTERNATIVE IRRIGATION AS AN EFFECTIVE TECHNIQUE FOR SAVING IRRIGATION WATER

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ABSTRACT

Two field experiments were carried out during summer seasons, of 2010 and 2011, at Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt. Maize (hybrid single cross 10) was evaluated in a split plot design with four replicates. Three treatments, of furrow length 30, 40 and 50 m, were studied under two surface irrigation methods; traditional and alternative. Data showed that, both water advance time and recession time were increased under traditional furrow irrigation, while opportunity time decreased under alternative irrigation.

The results also revealed that, the applied irrigation water amount was less under alternative method. Values of amount were 2673, 2727 and 2856 m^3/fed. for 30, 40 and 50 m furrow lengths, under alternate irrigation. While these values were 3177, 3282 and 3378, under traditional irrigation, for the studied lengths, respectively. Water application efficiency (Ea), was higher under the alternative technique. The average values of (Ea), for traditional irrigation method were 60.2, 64.3 and 59%. The corresponding values for alternate irrigation method were 77.5, 86.3 and 80.3% under furrow length of 30, 40 and 50 m respectively. Average values of water productivity (WP), for alternative irrigation method were 1.34, 1.40 and 1.3 kg/m^3 under 30, 40 a 50 m furrow length respectively. Meanwhile, corresponding values under traditional irrigation method were 1.06, 1.07 and 1.00 kg/m^3, respectively.
Keywords: Alternative irrigation, surface irrigation methods, maize

INTRODUCTION

Irrigation water is gradually becoming scarce, not only in arid and semi-arid regions but also, in the regions where rainfall is abundant. Therefore, water saving and conservation is essential to support agricultural activities, which account for 85% of the total water consumed In semiarid regions, Irrigation is one of the most important inputs to increase crop productivity. Sustainable water use is particularly relevant in areas where groundwater resources are used and crops with high water requirements, such as maize, are grown, because of the pumping energy costs (Ortega *et al*., 2004). El-sherbeny *et al* (1997) showed that, water use efficiency (W.U.E) increased with alternative irrigation . They also indicated that, water advance and recession time, increased for traditional furrow irrigation and opportunity time decreased under alternate irrigation technique.

In Egypt agricultural irrigation agriculture faces number of difficult problems, at parents and in furrow as well. One of the major concerns is the generally low efficiency, with which water resources have been used for irrigation. A relatively safe estimation is about 40 percent, or more of water diverted for irrigation, in wasted at the farm level. Through either deep percolation or surface run off, the principal objective of evaluating surface irrigation system is to identify management practices and system configurations, which can be feasibly and effectively implemented to improve the irrigation efficiency. Among the factors used to judge the performance of an irrigation system, or its management, the most common are efficiency and uniformity (Walker, 1989).

Mintesinot, *et al*., (2004) conducted a comparative study between the traditional irrigation management (every furrow-traditional scheduling)and alternative water management options on maize plots in northern Ethiopia. They found that the yield and economic productivity-based comparison has shown that every furrow-scientific scheduling generates the highest yield levels followed by alternate furrows-scientific scheduling. The yield increased (by every furrow-scientific scheduling) over the traditional management was found to be 54%, while the water productivity based comparisons have shown that alternate furrows-scientific scheduling generates the highest water productivity values followed by every furrow-scientific scheduling. The strategy of irrigation policy in Egypt aims at optimizing water use by better management, accurate estimation of crop water requirements and irrigation scheduling.

This paper aimed to; improve surface irrigation through, improving water productivity and saving water by implementing the alternate irrigation technique.

MATERIALS AND METHODS

Two field experiments were conducted during two growing seasons 2010 and 2011 at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate. The site represents the circumstances and conditions of Middle North Nile Delta region and allocated at 31-07' N Latitude, 30-57'E Longitude with an elevation of about 6 meters above mean sea level**.** Some physical and chemical properties of the experimental soils are presented in Table 1.

Table (1): Some physical analysis of soil samples for experiment site.

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

The field experiments included two factors:

1. Irrigation method (main treatments):
   A- Traditional irrigation (all furrows are irrigated).
   B. Alternate irrigation (one by one irrigated furrow).
2. Furrow length (sub treatment): 30 , 40 and 50 m.

It should be stated that, under the traditional method of irrigation, events were implemented at each of 15 days during the growing season, Maize (*Zea mays L.*) as summer crop was sown in June 29, 2010 and June, 30, 2011 and harvested on November, 5 and 9 in the first and second years respectively. All cultural practices were the same as recommended for the area, except the treatment under study. The experiment was arranged in split plot design with four replicates

Field measurements:

1. Soil moisture:

Soil moisture was determined gravimetrically, before and after each irrigation; samples were taken from different soil layers of 15cm thickness, down to 60 cm. depths, from three selected sites, along the furrow of two replicates.

2. Determination of advance and recession of irrigation water:

The irrigation run in each plot, was divided into equal distances "Stations" each 5 meters.

a) **Advance time (t_1):** The total elapsed time required for water, to **advance** from the upstream of an irrigation pathway, to the distal end of pathway.

b) **Recession time (t_2):** The time elapsed after water application cases, until the water recedes or disappeared, from the irrigation pathway.

c) **Opportunity time (t_0):** Opportunity time for each station was calculated according to $t_0 = t_2 - t_1$

Irrigation water applied (Wa) :

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

$$q = CA\sqrt{2gh}$$

Where

Q = Discharge through orifice, ($cm^3\ sec^{-1}$).

C = Coefficient of discharges (0. 61).

A = Cross sectional area of orifice, cm^2.

g = Acceleration due to gravity, cm/sec^2 ($980 cm\ sec^{-1}$).

h = Pressure head, over the orifice center, cm.

Irrigation water applied for each strip was calculated as follow

$$Q = q\,t\,n$$

Where: **Q** = Water volume $m^3\ strip^{-1}$

q = Discharge $m^3 min^{-1}$

t = Total time of irrigation and

n = Number of spiel

Water productivity (WP):

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

WP = GY/ET.

Where WP (kg/m^3), GY is grain yield (kg/fed).

And ET total water consumption of the growing season ($m^3 fed^{-1}$.)

Where I is irrigation water applied ($m^3 fed^{-1}$.).

Application efficiency (Ea):
This parameter is so-called consumptive use efficiency (Ecu) and Computed according to Doorenbos and Pruitt (1983) as:

$$Ecu = (CU/Wa)*100$$

Where:
Wa = Water applied, and
CU = Crop evapotranspiration or crop consumptive use.

Statistical analysis:
The obtained data were statistically analyzed by analysis of variance. The data of the two seasons showed nearly the same trend Thus, a combined analysis was done according to Gomez and Gomez (1984) .Means of the treatment were as compared by the least significant difference (LSD) at 5% level of significance which developed by Waller and Duncan (1969)

RESULTS AND DISCUSSION

Advance time (two seasons):
Data in Table 2 indicate, that the relationship between the advance time and distance from water inlet, for traditional and alternative irrigation methods. Data revealed that, the traditional irrigation required more time, to complete the advance phase, than the alternative irrigation method, for strips of 30, 40 and 50 m, the mean seasonal advance time, for traditional irrigation, was 43 min., 58 min. and 76 min.. While the corresponding values under alternative irrigation were, 24 min., 36 min. and 52 min. respectively.

It is obvious that, advance time decreased for alternating irrigation, this finding may be due to increase of flow rate, as a result of decreasing the number of furrows under such irrigation. These results are in agreement with El-Sherbeny *et al* (1997). Moreover results indicate that, the total irrigation time per fad. was decreased by about 20.5% under alternative irrigation method. The least advance time, was obtained by alternative irrigation method, with 40 m furrow length.

Opportunity time (two seasons):
Data of opportunity time in minutes are shown in Table 2. It has been noticed that the opportunity time increased for alternative irrigation method, the opportunity time decreased and vice versa, for the traditional method.

Applied irrigation water (two seasons) :
The number of irrigations during the growing seasons of corn were six for traditional irrigation, and eight for alternate irrigation, excluding the sowing and El-Mohaya (first after sowing) irrigations. Amount of irrigation water, which added to each treatment, during the season are illustrated in Fig 1 .

Data revealed that, alternative irrigation saved about 504, 555 and 522 m^3 /fed. for furrow length 30, 40 and 50 m., respectively. The saving amount of water is in average of about 500 m^3 fed^{-1} which equaled nearly 15%? This saving water was occurred under alternative irrigation, in spite of the high numbers of irrigation events under such irrigation, compared to the traditional surface one (10 and 8, respectively). On the other hand, the difference was found between treatments of furrow length, where the lowest amount of water irrigation was 504 m^3 fed^{-1} for 30 m furrow length. And the highest amount of irrigation water (555) m3 fed^{-1} $season^{-1}$, for 50 m furrow length. Regarding to increasing furrow length, the amount of water irrigation lightly increased. These results agree with Zangsou *et al* (1997) who studied the effect of controlled roots-divided alternative irrigation on water use efficiency in maize. They reported, as that in maize irrigation of roots to 60% of field water capacity, saved 35.6% of irrigation water while biomass yield decreased only by 9%.

Table 2: Advance time (t_1), Recession time (t_2) and Opportunity time (t_0) as affected by irrigation treatments

Irrigation method	Furrow length (m)	Time mints	Stations (m)									
			5	10	15	20	25	30	35	40	45	50
Alternative irrigation	30	AT	4	7	12	16	20	24				
		RT	118	123	128	133	136	140				
		OT	114	116	116	117	116	116				
	40	AT	4	8	13	17	22	28	34	36		
		RT	123	128	130	136	140	142	146	150		
		OT	119	120	117	118	118	114	112	114		
	50	AT	5	8	13	18	24	30	36	40	46	52
		RT	122	124	130	137	144	147	150	155	162	168
		OT	117	116	118	119	120	117	114	115	116	114
Traditional irrigation	30	AT	7	13	19	28	33	43				
		RT	243	255	266	219	280	286				
		OT	236	241	247	251	247	243				
	40	AT	8	13	18	23	33	42	50	58		
		RT	245	250	260	266	271	279	283	290		
		OT	247	237	242	243	234	237	233	232		
	50	AT	8	16	22	30	38	45	52	60	68	76
		RT	258	261	264	270	278	284	288	296	303	310
		OT	250	245	242	240	240	239	236	236	235	234

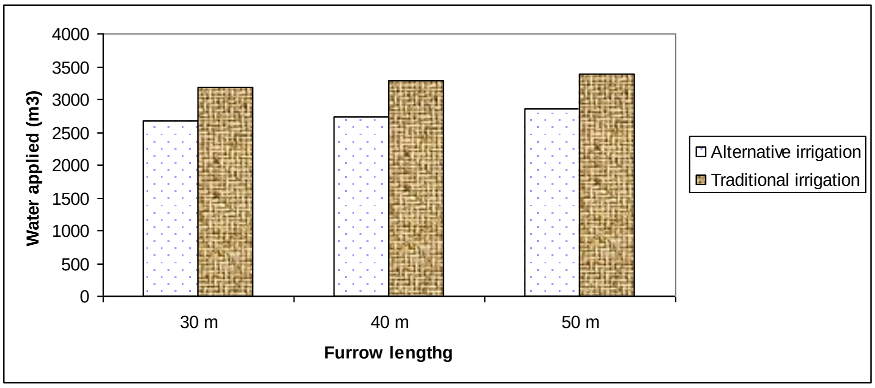

Fig (1): The overall values of water applied (m^3fed^{-1}) under different irrigation treatments for the furrow irrigation of corn during the tow seasons.

Water application efficiency (Ea of two season) :

Fig 2 show that, the alternate irrigation had developed the water application efficiency, compared with traditional method, due to the less applied irrigation water, under such method. Another reason for high Ea under alternate irrigation is due to its nature of high horizontal water movement from the irrigated furrow to driest one, which resulted in less one, stored deep percolation and therefore, high soil water which ultimately caused a higher Ea. The overall average of water application efficiency, during the two seasons are 77.5, 86.3and 80.3% for alternative irrigation under 30, 40 and 50 m furrow length respectively. The corresponding values for traditional irrigation, are 60.2, 64.3 and 59%. The highest Ea means that, less deep percolation below the crop root zone and less tail water of furrow (Samani *et al*., 1985)

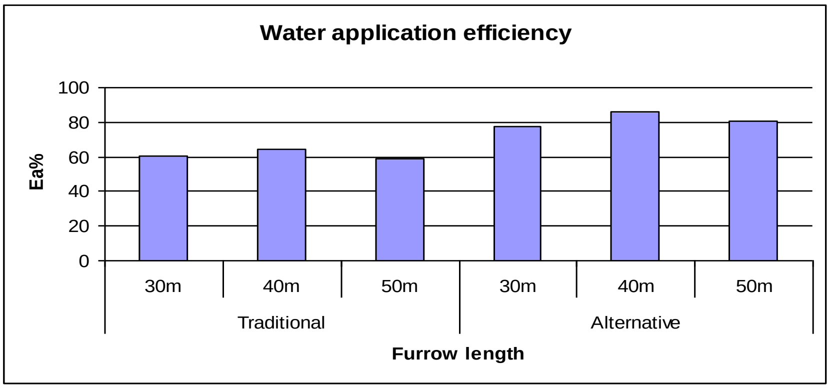

Fig (2): The overall values of water application efficiency under different irrigation treatments for the furrow irrigation of corn during the tow seasons.

Water productivity (WP):

Mean values of WP as affected by irrigation treatments, are shown in Table (3) and (Fig3). Data revealed that alternate irrigation method recorded the highest values of WP, compared with traditional irrigation method, under all furrow lengths. The overall average of WP values for alternate irrigation is; 1.34, 1.40 and 1.30 kg/m^3 for 30, 40 and 50 m furrow length respectively. While values under traditional irrigation are; 1.06, 1.07 and 1.00 kg/m^3 for the stated furrow length, respectively.

Table (3): Water productivity of maize in kg/m^3 under different irrigation treatments

Irrigation method	Furrow length	2010			2011			Average of two seasons
		Yield Kg fed^{-1}	Wa m^{3}fed^{-1}	WP	Yield Kg fed^{-1}	Wa m^{3}fed^{-1}	WP	
Traditional irrigation	30	3390.5	3162.0	1.07	3380.0	3182.0	1.06	1.06
	40	3540.5	3262.0	1.08	3560.0	3302.0	1.07	1.07
	50	3420.0	3370.0	1.01	3430.0	3386.0	0.99	1.00
Alternate irrigation	30	3604.3	2663.0	1.35	3590.0	2683.0	1.33	1.34
	40	3830.2	2700.0	1.41	3850.0	2754.0	1.39	1.40
	50	3720.2	2890.0	1.28	3760.0	2822.0	1.33	1.30

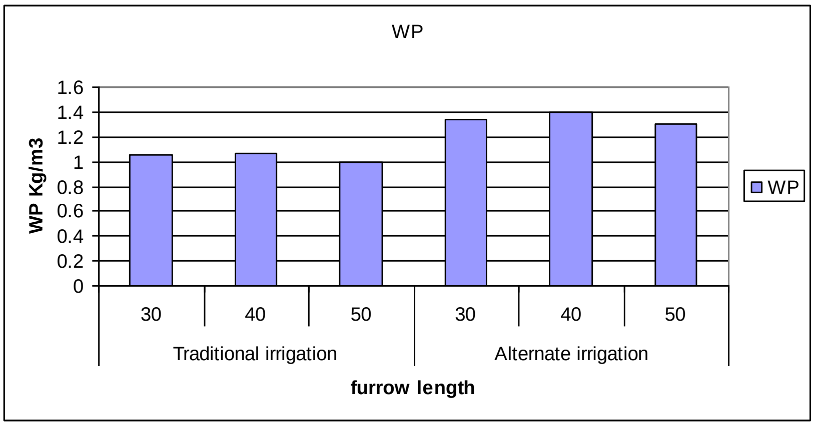

Fig 3 : The overall values of water productivity under different irrigation treatments for the furrow irrigation of corn during the tow seasons .

Conclusion:

The results of the current work indicated that the highest grain yield for maize planted in both growing seasons of 2010 and 2011 was obtained when the plants were irrigated using alternative irrigation technique and 40 m furrow length

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الري السطحي التبادلي كتقنية فعالة لتوفير مياه الري

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أقيمت تجربتان حقليتان خلال صيف موسمي 2010 و 2011فى محطة البحوث الزراعية بسخا- محافظة كفرا لشيخ – مصر . واستخدم الذرة الشامية هجين فردى 10 في تصميم احصائى القطع المنشقة مرة واحدة في أربعة مكررات . درست ثلاث معاملات لطول الخط (30 و 40 و 50 متر)تحت طريقتين للري السطحي (الري العادي والري التبادلي).أوضحت النتائج أن زمن تقدم وانحسار المياه أزداد تحت الري السطحي العادي والفرق بينهما قل تحت الري التبادلي .أوضحت النتائج أيضا أن كمية المياه المضافة كانت اقل في طريقة الري التبادلي وكانت كمية المياه المضافة 2673 و 2727 و 2856 م^3/للفدان لطول خط 30 و 40 و 50 متر تحت ظروف الري التبادلي بينما كانت 3177 و 3282 و 3378 م^3/للفدان لنفس طول الخط تحت الدراسة على الترتيب. كفاءة الري التطبيقية (Ea) لطريقة الري العادي كانت 60.2 و64.3 و 59 % فى المقابل كانت قيم الري التبادلي 77.5 و 86.3 و 80.3 % لطول خط 30 و 40 و 50 متر على الترتيب.متوسط قيم إنتاجية المياه (WP) للري التبادلي كانت 1.34 و1.40 و 1.3 كجم / م^3 لطول خط 30 و 40 و 50 متر على الترتيب. بينما كانت تحت الري العادي 1.06 و 1.07 و 1.00 كجم / م^3 على الترتيب

قام بتحكيم البحث

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