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DRIP IRRIGATION AND MAIZE PRODUCTION IN CLAYEY SOIL

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ABSTRACT

A field trial under drip irrigation system, was carried out at Sakha Agricultural Research Station Farm, during 2003 and 2004 seasons. The study aimed to evaluate the irrigation time of 1 hr and 2 hrs. or treatments A and B respectively, under different irrigation intervals of 4, 6 and 8 days (subcripts 1, 2 and 3), respectively.

Results showed that the maximum grain yield was obtained from B_1 treatment, average value was 3650 kg/fed. (9052 kg/ha). Water requirement for maize was 2870 m^3/fed. or 68.3 cm resulted from B_1 .i.e. irrigation with 2 hrs every 4 days under drip irrigation system.

In general, the main results indicated that:

1. Grain yield was higher under 2 hrs. irrigation (Treat. B) as compared with 1 hr. irrigation (Treat. A). The average yields, resulted from the different applied water in the two seasons were, 3273 and 2715 kg/fed. for B and A treatments, respectively.
2. Ear length decreased with increasing irrigation intervals under both levels of irrigation.
3. Ear diameter was higher with B_1 as compared with the other amount of water regime.
4. The highest value of water use efficiency (W.Us.E.), was occurred with A_3 and the lowest was obtained under B_1.

INTRODUCTION

With increasing world food shortage problems and the limited situation of water resources, the evaluation of irrigation efficiencies becomes highly important. Since the overall surface irrigation efficiency is low, in the order of 50 percentage or less. Therefore, the irrigated acreage may be doubled, if only the application efficiency can be increased, to say 80% which can be done even under the existing water resources. The application efficiency (Ea) can be upgraded through several implementations such as proper field layout, water management, improve delivering systems, and/or by using the pressurized irrigation systems, such as drip irrigation under efficient management. Drip irrigation is the most efficient method of modern irrigation. While sprinkler irrigation has Ea in the range of 75-85%, drip system has a value of about 90% even more. Drip irrigation could be implemented by applying water slowly, directly to the soil, near by the roots of the growing plants. The high efficiency of drip irrigation results from two primary factors. The first, is that the water soaks into the soil before it can evaporate or run off. The second, is that the water is only applied where it is needed, (at the plant roots) rather than sprayed every where.

Goldberg and Shmueli (1970) stated that by using good trickle (drip) irrigation yield increased by 30% or more, over furrow or sprinkler irrigation. Hanson and Patterson (1974) studied the effects of trickle, furrow and sprinkler systems on water use efficiency, and yield of maize (*Zea mays* L.). Results showed that maize yields were the same of trickle and sprinkler system.

Some of the main benefits of drip irrigation which have been identified by researchers are:

1. Increased water use efficiency (W.Us.E.).
2. Minimizing water percolation through the root zone.
3. Minimizing run off from the tail end of the field.
4. Least evaporation from the soil surface.
5. Reduced energy usage.
6. Increased water distribution or uniformity efficiency throughout the irrigated field.
7. Reduction of moisture stress to plants, because of frequent irrigation which in turn resulting in good quality crop yield.

In a surface drip irrigation (SDI) study conducted on cotton, Phene *et al.* (1992) found that, out of eight irrigation methods, SDI had the highest WUE. Lamm *et al.* (1992) conducted SDI study on maize field and they found that maximum yields were achieved at 75 percent of evapotranspiration (ET).

Maize is one of the most important crops in world wide as in Egypt. The furrow irrigation methods, which are the common ones used for watering maize, are related with over irrigation, which associated with the traditional farmers. Such excess watering results in high water losses and low irrigation efficiencies, which in turn creates drainage and salinity problems.

Harder *et al.* (1982) showed that grain yield of maize was reduced by 33% due to the severity and duration of soil moisture stress. Ashoub *et al.* (1996) pointed out that decreasing irrigation intervals from 15 to 10 days caused significant increase in ear characters, 100-grain weight and grain yield.

Maize is a summer crop, which grows in Egypt under irrigation because there is no rainfall during summer months.

The objective of this work is, to report the results of the adaptation of the drip irrigation method, for irrigating maize in North Nile Delta. In addition, water use efficiency, water consumptive use and the response of maize yield to drip irrigation were investigated in a clayey slowly permeable soil in the region.

MATERIALS AND METHODS

The present study was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the two growing seasons 2003 and 2004, to study the effect of the drip irrigation on maize production and its water relations.

The soil physical and chemical characteristics are presented in Tables (1 & 2). The drip irrigation system consisted of a control unit and distribution lines. The control unit of the system contained a venture injector (25.4 mm), fertilizer tank, disk filter, control valves and a water flow meter. Distribution lines consisted of polyethylene (PE) pipe manifolds (display and discharge) for each plot. Irrigation laterals of 16 mm in diameter and 40 m in length had in-line emitters spaced 0.5 m part, each delivering 4 Lh^{-1} at a pressure of 1 bar. Drip irrigation lines were spaced 0.8 m apart, equally spaced between every other row of maize. Water was applied from a pressurized hydrant and filtered through gravel filters and refiltered through

screen filters. The texture of the experimental field soil is heavy clay. Water table level about 150 cm.

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

Depth cm	Particle size distribution			Texture	F.C. %	P.W.P %	Available % water	Bulk density g/cm^3
	Sand %	Silt %	Clay%					
0-15	16.0	18.0	66.0	Clayey	47.0	25.3	21.7	1.19
15-30	19.0	13.0	68.0	Clayey	39.0	21.8	17.2	1.16
30-45	16.5	16.0	67.5	Clayey	38.0	21.9	16.1	1.3
45-60	17.5	15.5	67.0	Clayey	38.5	20.8	17.7	1.2

Table (2):Some soil chemical analysis of experimental site.

Depth	EC	pH	Cation mmol/liter				Anion mmol/liter L.			
	dS/m		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO^{=}_3$	HCO^{-}_3	Cl^{-}	$SO^{=}_4$
0-15	1.50	8.15	0.3	0.10	0.76	0.02	-	0.55	0.21	0.42
15-30	1.57	8.0	0.31	0.10	0.79	0.02	-	0.57	0.22	0.43
30-45	1.65	8.0	0.34	0.10	0.89	0.02	-	0.65	0.23	0.47
45-60	2.78	7.9	0.84	0.27	1.25	0.03	-	0.45	0.23	1.71

The treatments were arranged in split plot design with four replicates as follows:

- The main treatments (irrigation time)
  A = 1 hr. B = 2 hrs.
- The sub treatments (irrigation intervals)
  1 = 4 days 2 = 6 days 3 = 8 days

Maize crop was sown on 1st and 5th June, and was harvested on 5th and 10th October in the 2003 and 2004 seasons respectively. Thinning process was undertaken 3 weeks after sowing leaving one plant per hill. Nitrogen was applied as urea (46% N) at the rate of 105 kg N/feddan (1 fed = 4200 m^2 = 0.42 ha) through the irrigation water using venture injection, in three equal doses and 100 kg P_2O_5/feddan (calcium super phosphate 15%) were applied before sowing.

1.Crop evapotranspiration (ETc):

To find out the crop evapotranspiration (consumptive use). The calculated reference evapotranspiration (ETc), was multiplied by the Kc values which quoted from FAO (Doorenbos, 1979) as follows:

$$Cu = ETo \times Kc$$

2.Irrigation water applied (IW):

The amount of applied water at each irrigation was measured by flow meter.

Water use efficiency (WUsE):

It was calculated according to the following equation (Michal, 1978)

$$WUsE = Y/Cu$$

Where:

Y= Grain yield kg/feddan

CU= Consumptive use m^3/feddan.

4.Water utilization efficiency (WUtE):

It was calculated using the following equation (Michal, 1978).

$$WUtE = Y/IW$$

Where:

Y= Grain yield

IW= The total amount of irrigation water applied.

Yield and its component:

- Grain yield (kg/fed.).
- Ear length (cm).
- Ear diameter (cm).
- Ear weight (gm).

Statistical analysis:

Data collected were subjected to the statistical analysis according to Snedecor and Cochran, 1967.

RESULTS AND DISCUSSION

1.Crop water consumptive use (Cu):

Values of reference evapotranspiration ETo for Sakha area were computed according to (Ibrahim *et al.*, 2005) and the crop coefficient (Kc) values for maize were quoted from the standard Tables of FAO, 1979, which are shown in Table (2).

Table(3):Monthly reference evapotranspiration (ETo) and crop coefficient (Kc) for the growing seasons.

	5th June	July	Aug.	Sept.	3rd Oct.	Seasonal
Eto, mm. day^{-1}	7.4	6.8	6.2	5.3	3.9	
Kc	0.47	0.90	1.1	1.0	0.85	
ETc mm/day	3.5	6.1	6.7	5.3	3.33	66.3
ETC/period/month	8.7	18.8	21.3	15.8	1.7	

Therefore, the monthly corresponding values of maize ETc are: 8.7 (for 25 days) of June, 18.8, 21.3, 15.8 and 1.7 cm for July through October. The seasonal value of ETc is 66.3 cm. It should be stated that the sowing date in average for the two season was 5th June and the harvesting date was 3rd Oct. with seasonal length of 120 days. Regarding rate of ETc, the corresponding values are: 3.5, 6.1, 6.9, 6.3 and 3.3 mm/day with season rate of ETo of 5.5 mm/day So, it could be stated the seasonal value of crop-water consumption by maize is 66.0 cm. with seasonal rate of 5.5 mm/day. The stated values are for the studied area of Sakha, that represents the middle north Nile Delta region.

2.Water applied:

Amounts of seasonal applied irrigation water (IW), for different treatments, are tabulated in Table (4) and illustrated in Figure (1). The amount of IW for the A (1 hr) treatment is the lowest, and the amount for the

B (2 hrs.) treatments was the highest. From the tabulated data, it is also revealed that with increasing irrigation intervals, the amount of irrigation applied (IW) decreased. Mean values of seasonal water applied under A treatments (1hr) are 1625, 1230 and 1040 m^3/fed, respectively. Corresponding values under B treatments (2 hrs.), are 2870, 2050 and 1635 m^3/fed.

Table (4):Seasonal amount of water applied for each treatment expressed in m^3/fed.

Interval / Trt.	Season 1			Season 2			Average		
	Irrig. 4 days (1)	Irrig. 6 days (2)	Irrig. 8 days (3)	Irrig. 4 days (1)	Irrig. 6 days (2)	Irrig. 8 days (3)	Irrig. 4 days (1)	Irrig. 6 days (2)	Irrig. 8 days (3)
A, m^3/fed.,	1650	1250	1030	1700	1210	1050	1625	1230	1040
B m^3/fed.	2840	2000	1600	2900	2100	1670	2870	2050	1635
	IW cm								
A cm.	39.3	29.8	24.5	40.4	28.8	25.0	38.7	29.3	24.8
B cm.	67.6	47.6	30.1	69.1	50.0	39.8	3650	48.8	38.9

A = 1 hr B = 2 hrs.

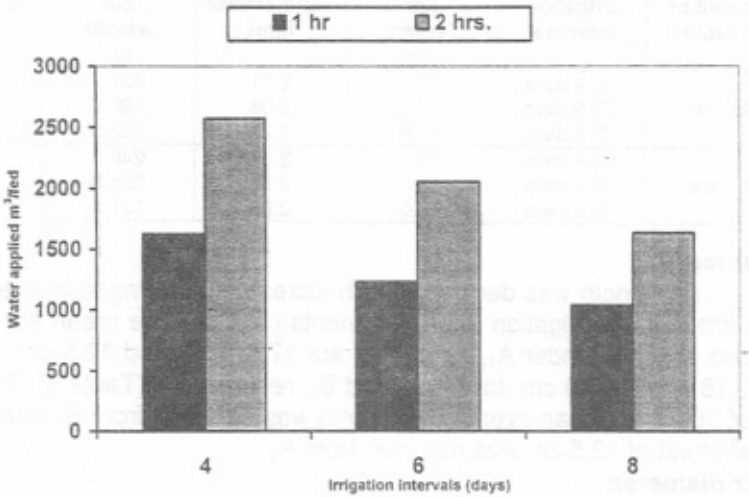

Fig. (1): Seasonal amount of water applied for each treatment expressed in m^3/fed.

3.Yield and its component

a.Grain yield:

One of the important parameters in the evaluation of any soil water-plant relationships is crop yield. Maize yield in kg/feddan is given in Table (5) and illustrated in Fig. (2) which shows that the yield significantly was affected by both irrigation amount, and its intervals. Grain yield was higher under B as compared with A treatment. This occurred in both seasons. The mean yields for the two seasons, due to the amount of water are 3373 and 2715 kg/fed. for B and A, respectively. The increase in grain yield under B in relation to A was 20.5%. The greatest yield is given by B_1 regime. With the B amount of

irrigation, yield of B_1, B_2 and B_3 (average of two seasons) were 3625, 3360 and 3273 kg/fed., respectively, indicating a superiority for the B_1 regime of yield components.

Table (5): Mean values of maize grain yield (kg/fed.) and its components as affected by the amount and interval of irrigations under drip irrigation.

Amount of irrigation	Irrigation interval	Season 1				Season (2)			
		Ear length (cm)	Ear diameter (cm)	Ear weight (g)	Grain yield, kg/fed.	Ear length (cm)	Ear diameter (cm)	Ear weight (g)	Grain yield. kg/fed.
A = 1 hr	(1) 4 days	16.8	2.28	206.7	3050.0	17.4	2.35	212.7	3150.0
	(2) 6 days	15.0	2.03	184.2	2720.0	15.5	2.13	195.0	2850.0
	(3) 8 days	12.19	1.70	149.8	2210.0	12.78	1.73	156.0	2310.0
B = 2 hrs.	(1) 4 days	20.00	2.72	243.8	3600.0	20.4	2.92	250.8	3650.0
	(2) 6 days	18.92	2.55	231.7	3420.0	18.5	2.45	225.8	3300.0
	(3) 8 days	15.80	2.09	180.7	2800.0	16.2	2.10	190.3	2870.0

Mean of the two seasons

Amount of irrigation	Irrigation intervals	Ear length (cm)	Ear diameter (cm)	Ear weight (g)	Grain yield kg/fed.
A, 1 hr	(1) 4 days	17.1	2.31	209.7	3100.0
	(2) 6 days	15.2	2.08	190.0	2785.0
	(3) 8 days	12.5	1.71	152.9	2260.0
B, 2 hrs.	(1) 4 days	20.2	2.82	246.5	3625.0
	(2) 6 days	18.7	2.50	228.0	3360.0
	(3) 8 days	16.0	2.09	185.1	2835.0

b.Ear length:

Ear length was decreased with increasing the irrigation interval under both amounts of irrigation main treatments (A & B). The mean ear length for the two seasons under A_1, A_2 and A_3 are 17.1, 15.2 and 12.5 cm. While it is 20.2, 18.7 and 16.0 cm. for B_1, B_2 and B_3, respectively (Table 5). The longest ear of 20.2 cm (mean over two seasons) was obtained from B_1 treatment and the shortest of 12.5 cm was obtained from A_3.

c.Ear diameter:

Ear diameter was the highest with B_1 and vise versa for A_3. This occurred in both seasons. The means of ear diameter for the two seasons due to A_1, A_2 and A_3 are 2.31, 2.08 and 1.71 cm, respectively. The corresponding values are 2.82, 2.50 and 2.09 for B_1, B_2 and B_3, respectively (Table 5).

d.Ear weight (gm):

The means of ear weights for the two seasons due to A_1, A_2 and A_3 are 209.7, 190 and 152.5 gm, while they are 246.5, 228.0 and 185.1 gm for B_1, B_2 and B_3, respectively. The greatest ear weight was given by B_1 over the other water regimes occurred with all treatments.

4.Field water use efficiency (WUsE):

Table (6) showed that the highest WUsE over the two seasons was occurred with A_3, and the lowest was resulted from B_1. The mean WUsE due to A_1, A_2 and A_3 were 1.85, 2.25 and 2.17 kg/m^3, respectively. While the

values are 1.25, 1.64 and 1.73 for B_1, B_2 and B_3, respectively. Concerning, the effect of irrigation intervals, WUsE was the greatest with A_2 followed by A_3 than A_1.

It might be stated that, under drip irrigation in the clayey soil of the north Nile Delta, irrigation every 4 days with duration of 2 hrs., discharge in average 4 L/h per nozzle, produced the highest WUsE of 2.25 kg/m^3 water applied.

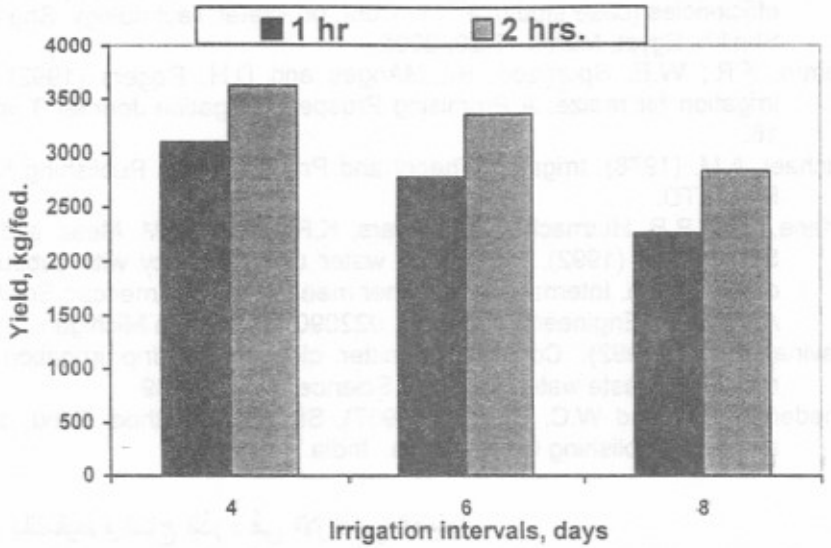

Fig. (2):Mean values of maize grain yield, (kg/fed.) as affected by the amount and intervals irrigations under drip irrigation.

Table (6):Field water use efficiency, WUsE in kg m^{-3} of maize as affected by the amount of irrigation and irrigation intervals during the two growing seasons under drip irrigation system.

	Season 1			Season 2			Average		
	4 days	6 days	8 days	4 days	6 days	8 days	4 days	6 days	8 days
A 1 hr.	1.84	2.17	2.14	1.86	2.35	2.2	1.85	2.25	2.17
B 2 hrs.	1.26	1.71	1.75	1.25	1.57	171	1.25	1.64	1.73

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الرى بالتنقيط وانتاج الذرة فى الاراضى الطينية

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا محافظة كفرالشيخ خلال موسمى ٢٠٠٣ ، ٢٠٠٤ وقد اشتملت الدراسة على الاثر المتبادل لكميات مياه الرى وكذا الفترة بين الريات حيث طبقت معاملات A (الرى بزمن ساعة) ، B (الرى بزمن ساعتين) فى حين أن الفترة بين الريات كانت ١ (كل ٤ أيام) ــ ٢ (كل ٦ أيام) ــ ٣ (كل ٨ ايام) زمن الرى ساعة وساعتين وفترة الرى كل ٤ ، ٦ ، ٨ أيام. **وقد أوضحت النتائج ما يلى:**

١- اعلى محصول للحبوب تم الحصول عليه من المعاملة B_1 اى الرى ساعتين كل اربعة ايام ، والتى حققت محصول ٣٦٥٠ كجم/فدان اى (٩٠٥٢ كجم/هكتار).

٢- المقنن المائى لمحصول الذرة فى منطقة شمال الدلتا وتحت الرى بالتنقيط ٢٨٧٠ م^3/فدان او ٦٦,٣ سم. وتم الحصول عليها من المعاملة B_2 اى رى ساعتين كل اربعة ايام.

٣- الكفاءة الاستعمالية لوحدة المياه كانت اعلى ما يمكن تحت المعاملة A_3 الرى لمدة ساعة كل ثمانية ايام ، بينما كانت اقل ما يمكن تحت المعاملة B_1 الرى لمدة ساعتين كل اربعة ايام.

٤- كما اوضحت النتائج ايضا أن:

أ- طول الكوز تناقص مع زيادة فترة الرى تحت كل من الرى كل ساعة وكل ساعتين.

ب- قطر الكوز كان اعلى ما يمكن تحت المعاملة B_1 اى الرى لمدة ساعتين كل اربعة ايام.