J. Agric. Sci. Mansoura Univ., 29 (6): 3629 - 3638, 2004

SURGE IRRIGATION FOR SUNFLOWER UNDER DIFFERENT IRRIGATION INTERVALS IN CLAYEY SOIL

Eid, S.M.; M.M. Shahaine and M.A.M. Ibrahim
Soil Water and Environmental Research Institute, ARC

ABSTRACT

Two field experiments were carried out during 2001 and 2002 growing seasons, to study the effect of surge irrigation, under three different irrigation intervals 7, 14 and 21 days, on sunflower yield, advance time, water applied (WA), crop water consumptive use (CU), water application efficiency (WAE) and water utilization efficiency (WUtE), in clayey soil at North Nile Delta in Egypt. Four irrigation treatments were implemented, as follows: (1) continuous irrigation (control), (2) surge irrigation with cycle ratio of 0.5 (10 min., on-10 min. Off), (3) surge irrigation with cycle ratio of 0.4 (10 min. On-15. Off), (4) surge irrigation with cycle ratio of 0.33 (10 min. On-20 min. Off). Results indicated that, the advance tune rates for surge flow technique, were highly shorter i.e. faster than rates under continuous flow. Data revealed that surge irrigation with 0.33 cycle ratio resulted in a significant reduction in total applied irrigation water, with an average of 27.7, 38.3 and 38.0% less than continuos watering at irrigation intervals 7, 14 and 21 days respectively. Data also showed that, surge irrigation treatment with cycle ratio of 0.33 (10 min. On-20 min. Off) recorded the lowest values of C.U. 42.9, 37.75 and 31.05 cm for 7, 14 and 21 days intervals respectively. On the other hand, the highest WA values 45.5, 41.4 and 33.3 were resulted from the continuous irrigation (control) applied at 7, 14 and 21 days respectively. The results revealed that surge irrigation treatment with cycle ratio 0.33 (10 min. On-20 min. Off), recorded the highest values of (WAE) 84.2 and 91.6 for 7, 14 and 21 days respectively. In addition surge irrigation treatments recorded the highest values of WUtE.

INTRODUCTION

Surface irrigation is the application of a controlled stream of water, to an inlet of the field and its subsequent gravity distribution, over the field. Generally, surface irrigation efficiency is averaging 50 to 60% percent, developing surface irrigation aims to increase irrigation efficiencies, by the following means; improving water application efficiency, providing good water distribution uniformity, increase the rate of water advance time, and water saving by trying to use surge flow technique. Many authors and investigators, such as Stringham and Keller (1979), Bishop *et al.* (1981), Ismail *et al.* (1985), Ghalleb (1987), Osman *et al.* (1996), Osman (1991) and Varlev *et al.* (1995) found that surge irrigation required 20-25% less water than continuos irrigation. Deep percolation decreased from 12-15% to 6-8%, while run off losses reduced from 25-30% to 10-12%, by using surge irrigation. Osman *et al.* (1996) stated that, surge flow irrigation gave better results, regarding to water advance time, and amount of water applied, than in continuos one. Main objectives of the present study are:

1. To evaluate the furrow surge irrigation system of sunflower under different irrigation intervals.
2. To improve efficiency of the surface irrigation and water saving.
3. To define the best surge flow irrigation practices for sunflower crop owing to optimize the water utilization efficiency.

MATERIALS AND METHODS

Two field experiments were carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the two successive seasons 2001 and 2002. The station is situated at 31° N latitude, 30°-75° E longitude. It has elevation of about 6 meters above mean sea level (MSL). It represents the conditions and circumstances of the middle northern part of the Nile Delta.

Soil samples for different depths at the experimental site were collected; 15 cm for each, depth down to 60 cm, and analyzed for some chemical and physical properties.

a.Chemical properties:

Total soluble salts (EC), acidity reaction (pH) and soluble cations and anions were determined according to the methods described by Jakson (1962).

The results are given in Table (1) in general, soil is non-saline.

b.Physical properties:

1.Soil texture:

The particle size distribution was determined according to the international method, Klute (1982), to the soil texture. The obtained results indicate that the soil is clayey in texture and the soil profile is uniform without distinct change in texture.

2.Bulk density:

Bulk density was determined using cylindrical sharp edge samples Vomocil (1957). Each cylinder was pressed gently into the soil to the desired depth, to obtain a known volume of the undisturbed soil. Samples were oven dried at 105°C, and the bulk density was calculated as Mg/m^3. All values are presented in Table (1).

3.Field capacity (F.C.):

Field capacity was determined by the field method.

4.Permanent wilting point (P.W.P.):

Wilting point was calculated as field capacity/1.84 for the clayey soil textured, according to Garcia (1978).

5.Available water (AW):

The following equation is used to compute available water (James, 1988).

$AW = Dr_3 (F.C- P.W.P)/100$

Where:

AW	=	Available water (cm).
Dr_3	=	Depth of a soil layer that restricts water movement.
F.C.	=	field capacity in percent by volume.
P.W.P.	=	permanent wilting point in percent by volume.

II.Experimental layout:

Sunflower (*Helianthus annuus* L.) as summer crop, was sown on 1st July 2001 and 5th July 2002, harvesting took place on 1st November 2001 and 5th November 2002. All cultural practices were the same as recommended for

the area except, the irrigation treatments under study. Each plot was 3.5 x 80 m = 280 m^2 (1/15 feddan). Eight stations (S_1-S_8) were arranged every 10 m along the furrow, to measure the water flow advance pattern.

III.Statistical analysis:

The experiment was arranged in split plot design, with four replicates as follows:

Main treatment (irrigation intervals).

A Irrigation every 7 days
B Irrigation every 14 days.
C. Irrigation every 21 days.

Subtreatments: surface irrigation methods:

1. Continuos irrigation.
2. Surge irrigation with cycle ratio of 0-5 (10 min. On and 10 min. On and 10 min. Off).
3. Surge irrigation with cycle ratio of 0.4 (10 min. On and 15 min. Off).
4. Surge irrigation with cycle ratio of 0.33 (10 min. On and 20 min. Off).

V.Data collection:

1.The water from advance time:

The advance time of the water flow for each irrigation treatment was recorded, when the water front was reached each station along furrow. The numbers of surge were recorded, when the irrigation water reached at about 95% of the furrow length. To evaluate the flow advance rate for different treatments, the approach equation of Christiansen *et al.* (1966 was used as follows:

$L = at^b$

Where

L = Length of advance
t = Time of advance and
a, b = Empirical constants.

2.Applied irrigation water:

In each experiment, the volume of water applied for each plot was calculated, using the following equation:

$a = q \times T$

Where

a = Water volume L/plot
q = Irrigation flow rate per furrow, L/min., and
T = Total recorded time/min. of irrigation per furrow.

The irrigation flow rate per furrow was calculated according to Israelson and Hansen equation (1962).

$q = 0.0226\ D^2\ h^{1/2}$

Where:

q = Irrigation flow rat, cm^3.
h = Average effective head (the effective head of water above the center of irrigation). The water in the canal was controlled to maintain a constant head by means of fixed gate = 6 cm.
D = Inside diameter of the pipe, cm.

3.Water application efficiency (Ea): was calculated for the 60 cm soil depth, according to Michael (1978) and James (1988) as follow:

$$Ea = \frac{WS}{WF} \times 100$$

Where:

Ea = Water application efficiency, %
WS = Amount of water stored in the root zone m^3 and
WF = Amount of water added to each plot, m^3

4.Water utilization efficiency: WUtE:

The water utilization efficiency as a measure to clarify variations in yield, due to irrigation water, was calculated according to Michael (1978) as follows:

WUtE = Y/Wa

in which

WUtE = Water utilization efficiency kg/m^3
Y = Total yield produced kg/fed., and
Wa = Total applied water, m^3/fed.

RESULTS AND DISCUSSION

1.Advance time:

Data reveled (Table 2) that, the continuos flow A_1, B_1 and C_1 required more time, to complete the advance phase than surge flow, under different all studied irrigation intervals; 7, 14 and 21 days. Equations relating the average values of length of advance (L), time of advance (t) and values of constants a and b are shown in Table (2). Data showed that, both constant a and b have been affected by surge and continuous flow treatments, under different irrigation intervals. Under surge treatments, symbol (b) which reflects the slope, was increased with decreasing of cycle ratio (or with increasing off time) and in general it has relatively higher values under surge irrigation. These results indicated that surge flow has faster advance rate, with longer off time, due to the effect of wetting and drying cycles, on soil infiltration characteristics (Goldhamer *et al.*, 1987). Increasing the off time in surge flow reduces infiltration rate, and results in a greater advance on wetted area, (Guirguis, 1988). The same trend was obtained by Ghallab (1987), Osman *et al.* (1996), Moustafa (19992) and Ibrahim and Eid (1999).

2.Applied irrigation water: Wa:

The average amounts of water applied to different irrigation treatments, for the three stated irrigation intervals, during the two growing seasons are given in Table (2). The number of irrigations applied were 11, 6 and 5, during the growing season of sunflower, including the first two common irrigations of sowing and the recorded following one (El-Mohaiaa for watering each 1, 2 and 3 weeks respectively). It is obvious that, the amount of irrigation water applied, directly affected by cycle ratio. The total amount of applied water varied according to the differences in irrigation treatments. All tested cycle ratios of surge treatments, used less amount of water, than that continuos one. Average values of applied water, for the continuos flow

treatments, A_1, B_1 and C_1 (control), were 71.8, 68.0 and 58.0 cm, respectively While these values of surge flow treatment, (trt. 2 = 10 On-10 Off), A_2, B_2 and C_2 were 64.4, 55 and 40 cm respectively. In the same direction, values of trt. 3 (10 On-15 Off) A_3, B_3 and C_3 were 57.5, 45.8 and 38.0 cm and that of trt. 4 (10 On-20 Off) A_4, B_4 and C_4 were 51.9, 42.0 and 35 9 cm, respectively. The surge flow irrigation reduced the applied water by 27.7, 38.3 and 38.2%, for the treatments A_4, B_4 and C_4 respectively. In other words, surge flow irrigation saved water, for all treatments, by about 20%, 30% and 34%, compared with the continuos flow irrigation Under irrigation intervals 7, 14 and 21 days respectively.

These results indicate, that surge flow (10 min. On, and 20 min., Off) B_4 was the best treatments, and hence it could save water with an average of 38.3% (1092 m^3/fed.) of the applied water to sunflower crop, under irrigation intervals (14 days). Increasing the off time in surge flow irrigation, resulted in greater water saving. The trend of the above mentioned results is in accordance with those obtained by Eid *et al.* (1999), Osman *et al.* (1999), Ibrahim and Eid, 1999.

3.Water application efficiency (EA):

Water application efficiency values, for the different irrigation treatments, are presented in Table (3). Data revealed that, surge irrigation had the highest values of EA compared with the continuos irrigation. The overall average of EA values, for continuos irrigation A_1, B_1 and C_1, had the lowest values of 65.0, 61.7 and 59.6%, respectively. The surge treatments, with cycle ratio of 0.33 (10 min. On and 20 min. Off), recorded the highest values of EA 84.2, 91.6 and 86.6 for A_4, B_4 and C_4, respectively. These results indicate that EA under surge irrigation exceeded the continuos flow irrigation, with 19.2, 29.9 and 27.0%, under irrigation intervals of 7, 14 and 21 days, respectively. The higher water application efficiency values of surge irrigation, can be attributed to the surface hydraulic roughness of wetting advance, (Guirguis, 1988). These results are more or less in close agreement with the results of many workers, such as Eid *et al.* (1999), who stated that the EA were 64.8, 70.5, 74.6 and 83.3% for continuous irrigation and for surge irrigation 20/5, 20/10, 20/15 and 20/20 On/Off min., respectively. Osman (1991) found that the EA values were 60, 73.7, 74.4 and 77.7% for continuous flow and for surge flow of 5/5, 5/10 and 5/15 On/Off min., respectively at Sakha (Kafr El-Sheikh).

These results are in accordance with that of Zein El-Abedin (1988), who stated that EA was over 80% by surge irrigation, while it was about 40% for continuous irrigation. Also, Podmore *et al.* (1983), showed that surge irrigation had significant higher application efficiency than the continuous irrigation. Generally, it could be concluded that, surge irrigation techniques considered as a suitable method, to optimize water use, and increase the irrigation efficiency in soils at north Nile Delta.

4.Water utilization efficiency (WUtE):

Water utilization efficiency (WUtE) of sunflower seed yield, for the different irrigation treatments, under irrigation intervals of 7, 14 and 21 days are tabulated in Table (4).

Table (1): Some chemical and physical analysis of experimental site.

Soil depth	Particle size distribution %			Texture	Bulk density (mg/m^3)	FC W %	PWP W%	Available water w%	EC dS/m	Cation c mole/kg soil				Anion c mole/kg soil			pH
	Sand	Silt	Clay							Na^+	K^+	Ca^{++}	Mg^{++}	HCO^-_3	Cl^-	$SO^=_4$	
0-15	15.18	18.85	85.97	Clay	1.09	47.2	25.38	21.82	1.50	0.36	0.02	0.30	0.10	0.55	0.21	0.46	8.15
15-30	19.90	13.80	66.30	Clay	1.15	40.5	21.85	18.85	1.57	0.79	0.02	0.31	0.10	0.57	0.22	0.48	8.00
30-45	16.59	16.97	66.94	Clay	1.24	39.0	21.19	17.81	1.65	0.89	0.02	0.34	0.10	0.65	0.23	0.50	8.00
45-60	12.65	15.24	67.12	Clay	1.26	38.5	20.81	17.69	2.78	1.25	0.03	0.84	0.27	0.45	0.23	1.71	7.90

Table (2): Average of advance time, data equation and irrigation water applied to sunflower for all irrigation treatments during growing seasons 2001 and 2002.

Irrigation intervals	Irrigation treatments			Seasons 2001						Season 2002					Average of two season		
				Adv. time (min.)	Advance equation L = at^b			Applied water		Adv. time (min.)	Advance equation L = at^b			Applied water	Adv.	Applied water	
		On	Off		a	b	R^2	cm	% of T_1		a	b	rR^2	cm	Saved water %	time (min.)	cm	Saved water %
A (7 days)	1	Cont.	Cont.	56.5	0.831	0.935	0.999	72.0	10.0	57.3	0.725	1.012	0.998	71.6	0.0	56.9	71.8	0.0%
	2	10	10	53.4	0.785	0.964	1.00	68.0	5.5	48.6	0.529	1.099	0.991	60.8	15.0	51.0	64.4	10.3%
	3	10	15	44.1	0.632	1.041	0.996	56.2	21.9	47.1	0.485	1.128	0.969	58.8	17.8	45.6	57.5	19.9%
	4	10	20	39.3	0.560	1.111	0.998	50.0	30.5	43.1	0.449	1.032	0.886	53.8	24.8	41.2	51.9	27.7%
B (14 days)	1	Cont.	Cont.	96.3	0.660	0.984	0.999	67.0	0.0	99.2	0.565	1.053	0.998	69.0	0.0	97.7	68.0	0.0%
	2	10	10	78.3	0.521	1.057	0.998	54.4	18.8	79.1	0.509	1.108	0.994	55.0	20.2	78.7	55.0	19.1%
	3	10	15	65.6	0.604	1.049	0.998	45.6	31.9	66.2	0.488	1.113	0.997	46.0	33.3	65.9	45.8	32.6%
	4	10	20	63.3	0.484	1.127	0.986	44.0	34.3	60.4	0.429	1.143	0.984	40.0	42.0	61.8	42.0	38.2%
C (21 days)	1	Cont.	Cont.	96.6	0.691	0.999	1.000	56.2	0.0	100.2	0.645	1.094	0.992	59.8	0.0	98.4	58.0	0.0%
	2	10	10	65.6	0.531	1.072	0.999	38.9	30.7	69.1	0.520	1.079	0.997	41.1	31.1	67.4	40.0	31.0%
	3	10	15	65.2	0.496	1.142	0.986	37.8	32.7	65.6	0.493	1.143	0.954	38.2	36.1	65.4	38.0	34.4
	4	10	20	58.0	0.421	1.176	0.973	34.0	39.5	62.2	0.429	1.194	0.952	37.8	36.7	60.1	35.9	38.0

Table (3): Amount of water stored in the root zone (cm), WS, applied water (WA) in cm, and water application efficiency WAE %, in different irrigation treatments, for sunflower crop (2001 and 2002).

Irrigation inter.	Irrigation treatments			Season 2001			Season 2002			Average		
	No	On	Off	WS cm	WA cm	WAE %	WS cm	WA cm	WAE %	WS cm	WA cm	WAE %
A (7 days)	1	Cont.	Cont.	47.2	72.0	65.5	46.2	71.6	64.5	46.7	71.8	65.0
	2	10	10	46.0	68.0	67.6	45.2	60.8	74.3	45.6	64.4	70.8
	3	10	15	45.5	56.0	81.2	44.6	58.8	75.8	45.0	57.5	78.2
	4	10	20	44.3	50.0	88.6	43.2	53.8	80.2	43.7	51.9	84.2
B (14 days)	1	Cont.	Cont.	41.0	67.0	61.1	43.0	69.0	62.3	42.0	68.0	61.7
	2	10	10	40.3	54.4	74.0	41.4	55.0	75.2	40.8	55.0	74.1
	3	10	15	39.9	45.6	87.5	41.3	46.0	89.7	40.6	45.8	88.6
	4	10	20	39.2	44.0	89.0	37.8	40.0	94.5	38.5	42.0	91.6
C (21 days)	1	Cont.	Cont.	34.3	56.2	61.0	35.0	59.8	59.3	34.6	58.0	59.6
	2	10	10	33.2	38.9	85.3	33.0	41.1	80.2	33.1	40.0	82.7
	3	10	15	33.2	37.8	87.8	32.6	38.2	85.3	32.9	38.0	86.5
	4	10	20	30.2	34.0	88.8	32.0	37.8	86.4	31.1	35.9	86.6

Table (4):Water utilization efficiency (WUtE) of sunflower kg seed/m^3 water, for different irrigation treatments.

Irrigation inter.				First season			Second season			Average
	No	On	Off	Yield kg/fed.	WA m^3/fed.	WUtE	Yield, kg/fed.	WA, m^3/fed.	WUtE	
A (7 days)	1	Cont.	Cont.	1080	3864.0	0.279	1000	3864.0	0.258	0.268
	2	10	10	1090	3124.8	0.348	1.050	3007.2	0.349	0.348
	3	10	15	1110	2360.4	0.470	1150	2847.6	0.403	0.436
	4	10	20	1120	2100.0	0.533	1196	2940.0	0.397	0.465
B (14 days)	1	Cont.	Cont.	1200	3112.2	0.385	1120	3187.8	0.351	0.368
	2	10	10	1230	2284.8	0.538	1200	2335.2	0.513	0.525
	3	10	15	1290	1915.2	0.673	1340	1948.8	0.687	0.680
	4	10	20	1310	1848.0	0.708	1420	1680.0	0.845	0.778
C (21 days)	1	Cont.	Cont.	1150	2360.4	0.487	1100	2511.6	0.437	0.462
	2	10	10	1180	1633.8	0.722	1160	1726.2	0.671	0.696
	3	10	15	1220	1587.6	0.768	1200	1604.4	0.747	0.757
	4	10	20	1250	1437.2	0.869	1260	1587.6	0.793	0.831

Data revealed that, surge irrigation recorded the highest values of (WUtE), compared with continuous irrigation. Regarding irrigation intervals effect WUtE values were higher under irrigated every 21 days, than under both 7 or 14 days. The overall average of WUtE values, for continuous flow were ,0.268, 0.368 and 0.462 kg/m^3 for A_1, B_1 and C_1, respectively. The corresponding values of surge irrigation treatments, varied from 0.348 to 0.465, 0.525 to 0.776and 0.696 to 0.831 kg/m^3, for irrigation intervals 7, 14 and 21 days respectively. The best treatment was that of 0.33 cycle ratio (10 min. On-20 min. Off), which had the highest WUtE value of 0.465, 0.776 and 0.831 kg/m^3 for 7, 14 and 21 days respectively.

The explanation of these results is that, the surge irrigation leads to higher water distribution uniformity and less water losses by deep percolation, which resulted in less amount of applied water, during the irrigation. The above mentioned results are similar to those obtained by Osman (1991), who found that surge irrigation leads to increase water use efficiency by 0.69 kg/m^3 at Sakha farm, and by 0.9 kg/m^3 at Abies farm, than that water use efficiency for continuous irrigation. Ghalleb (1987) compared continuous irrigation, with three different surge irrigation treatments, having cycle ratios of 1/2, 1/3 and 1/4. He reported that WUtE was 0.58 kg/m^3 for continuous flow and varied between 0.79 and 1.0 kg/m^3 for surge irrigation treatments.

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الرى النبضى لعباد الشمس تحت فترات رى مختلفة فى الاراضى الطينية

صبحى محمد عيد ــ مجدى محمد شاهين ، محمد عبد الفتاح محمد ابراهيم
معهد بحوث الاراضى والمياه والبيئة ــ مركز البحوث الزراعية

أجريت تجربتان حقليتان فى مزرعة محطة البحوث الزراعية بسخا خلال موسمى ٢٠٠١ ، ٢٠٠٢ ، لدراسة اثر الرى النبضى (المتقطع) تحت ظروف فترات رى مختلفة ٧ ، ١٤ ، ٢١ يوم ، على إنتاجية محصول عباد الشمس وزمن تقدم المياه وكمية المياه المضافة للرى وكفاءة الرى الحقلى وكفاءة استخدام المياه وذلك فى الاراضى الطينية بالمزرعة البحثية بمحطة بحوث سخا ، التى تمثل منطقة شمال الدلتا ، حيث طبقت اربعة معاملات رى (ثلاثة للرى النبضى والرابعة للرى المستمر ، التى تمثل طريقة الرى التقليدية بالمنطقة ، وكانت المعاملات كالاتى:

١- الرى المستمر.
٢- اضافة المياه ١٠ دقائق ويغلق ١٠ دقائق.
٣- اضافة المياه ١٠ دقائق ويغلق ١٥ دقائق.
٤- اضافة المياه ١٠ دقائق ويغلق ٢٠ دقائق.

وذلك فى تصميم القطع المنشقة فى اربع مكررات ومساحة القطع التجريبية ٨٠ م × ٣,٥م = ٢٨٠م^{٢} = ١/١٥ من الفدان واهم النتائج المتحصل عليها:

١- قيم متوسط زمن مقدم جبهه المياه الى نهاية الخط ٨٠م لمعاملات الرى النبضى كانت اسرع من الرى المستمر تحت ظروف الرى كل ٧ ، ١٤ ، ٢١ يوم.
٢- معاملة الرى النبضى وفرت ٢٧,٧% ، ٣٨,٣% ، ٣٨,٢% من معاملة الرى المستمر (الرى التقليدى).
٣- حققت معاملة الرى النبضى بنسبة ٠,٣٣ (١٠ دقاق فتح و ٢٠ دقيقة غلق) اقل انخفاض فى الاستهلاك المائى فكانت ٤٢,٩ ، ٣٧,٧٥ ، ٣١,٠٥ تحت فترات رى ٧ ، ١٤ ، ٢١ يوم ، بينما كانت قيم الاستهلاك المائى تحت الرى المستمر ٤٥,٥ ، ٤١,٤ ، ٣٣,٣ لنفس فترات الرى.
٤- حققت معامل الرى النبضى ٠,٣٣ (١٠ دقائق فتح و ٢٠ دقيقة غلق) اعلى كفاءة رى ٨٢,٦% ، ٨٩,٨% ، ٨٦,٤% لفترات الرى ٧ ، ١٤ ، ٢١ يوم.
٥- حققت معاملة الرى ٠,٣٣ اعلى محصول خلال موسمى الدراسة فكانت ١,٠٩ ، ١,٢٦٥ ، ١,١٩٠ طن/فدان فترات الرى ٧ ، ١٤ ، ٢١ يوم.