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MECHANISM WATER SAVING UNDER SURGE FLOW IRRIGATION METHOD ITS EFFECT ON IRRIGATION EFFICIENCIES AND WATER USE EFFICIENCY BY COTTON

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ABSTRACT

Two field experiments were carried out at El-karada Experimental Research Station during 2006 and 2007 growing summer seasons, in Kafer El sheikh Governorate. The investigation aimed to save water in old cultivated land in Delta by using surge irrigation method in comparison with alternative and continuous Flow irrigation and its effect on water use efficiency of cotton crop.

Seven irrigation treatments were used, five treatments were surge irrigation (T_1) (5 min. on and 5 min off), surge irrigation (T_2) (10 min. on and 10 min. off)., surge irrigation (T_3) (10 min. on and 5 min of), surge irrigation (T_4) (20 min on and 10 min off) and surge irrigation (T_5) (15 min. on and 5 min. off).,the two remaining treatments were alternative furrow irrigation (T_6) and continues flow irrigation. (T_7) A complete randomized block design was used.

Results showed that the surge flow irrigation treatments significantly affected cotton seed yield in both seasons. Where as are average increment of the two seasons in seed cotton yield were 22.58% (1.75 kentar/fed.) and 21.81% (1.69 kentar/fed), respectively under surge irrigation 2 (10 min. on 10 min. off) , Also surge flow irrigation saved irrigation water by 16.32 (627.9 m^3/fed) and 21.27 % (841.64 m^3/fed) as an average in the first and second seasons, respectively. Compared by continues flow irrigation Increasing the off time in surge flow irrigation results in greater water saving.

Treatment surge (T_4) (20 min on and 10 min off) consumed the less amount of water whereas it saved irrigation water by about 22.6% (868.7 m^3/fed.) and 27.37% (1083 m^3/fed.) in both seasons respectively. The water application efficiency, water distribution efficiency, and water use efficiency were higher under surge flow irrigation than that under Alternative and continuous irrigation.

The maximum values of total income, net profit, water productivity and economic efficiency were achieved with surge irrigation 2 (10 min on and 10 min off).

Under the conditions of the current study we can concluded that, applying mechanism of surge irrigation method (T_4) (20 min. on and 20 min. off) could be saved 125.8 million m3 of irrigation water from cultivated area with cotton crop (116133 fed. Season 2007) in Kafer El sheikh Governorate.

INTRODUCTION

The water resources in Egypt are limited, therefore we are in need to keep these resources at high degree of quality and also to find other new resources. Another way to save more water for irrigating new reclaimed soils is using new methods such as surge irrigation method.

Looking at the problems of surface irrigation system, we find that they are in need to a comprehensive and radical change in traditional irrigation to a new system, which use the most modern techniques. Irrigation systems should be changed to obtain the aim of increasing production to go up with the constant increase in population and secure a large amount of water which

waste, in the old systems of irrigation. So reaching to these exact aims needs to put a plan for developing the irrigation system.

Surge flow irrigation is a method of applying water intermittently between two irrigation sets. Water usually advance faster in a furrow using surge flow irrigation than in a furrow using the conventional continuous flow irrigation method, and alternative furrow irrigation.

Abd El-Maksoud et al. (1999) revealed that surge irrigation with 0.5 and 0.3 cycle ratio resulted in a significant reduction in total volume of water applied by 9.12 and 12.26% less than continuous irrigation, respectively. Soil moisture distribution uniformity was improved under surge irrigation more than continuous irrigation. Water use efficiency (WUE) values were higher under surge techniques since the increase were 15.28 and 23.31 under surge irrigation with 0.5 and 0.3 cycle ratio, respectively compared to the continuous irrigation.

Dhanapal and Raiagopal. (2000) showed that the water front advance took more time for continuous irrigation compared to surge flow. Of the crop geometry, water front advance was faster under double row compared to single row. Out of three treatments on-off timings, there was no much difference in water front advance between 10 and 15 minutes. Water front advance was faster in 20 minutes. Surge irrigation in maize with single crop row geometry and T on-off timings of 10-15 with a flow rate of 1.5 LPS which was optimum from the point of view of water front advance.

Ibrahim and Eid (2001) the data obtained showed that all tested cycle ratios of surge flow irrigation gave lower water advance times, lower amounts of applied water, higher water application efficiency and higher water distribution efficiency than that continuous flow irrigation Advance inflow times were reduced in the case of surge flow to 21 and 20% of the time required for continuous flow under deal and traditional leveling, respectively. Amounts of applied water were reduced using surge flow irrigation by 19.1 and 16.5% of continuous flow irrigation under deal and traditional land leveling, respectively.

Aiad (2003). Stated that the surge flow and alternative irrigation saved irrigation water by about 17.6 and 22.5% and 26.6 and 31.8% as an average in the two growing seasons respectively.

The current study was carried out in order to manage surge flow irrigation and alternative furrow irrigation system by obtaining the following items:

1. Comparing surge and alternative with conventional continuous flow.
2. Studying the effect of on-off time on water application efficiency and distribution uniformity.
3. Evaluation of surge irrigation techniques and its effect on seed cotton yield and water relations in North of Nile Delta,

MATERIALS AND METHODS

Two field experiments were conducted at El Karada Research Station, Kafr El-Sheikh Governorate Water Management and Irrigation System Research Institute, National Water Research Center, Egypt. the aim

of the current work is to study the effect of surge irrigation, alternative and continuous flow irrigation on water saving and water use efficiency by cotton in North Delta during the two successive summer seasons of 2006 and 2007. Some physical and chemical properties of soil, for the two experiments were determined according to Black et al (1965). and presented in Tables (1&2) respectively.

A completely randomized block design with four replicates was used. The surge flow irrigation treatments were:

1- Surge irrigation with cycle ratio of 0.5 (5 min on and 5 min off)
2- Surge irrigation with cycle ratio of 0.5 (10 min on and 10 min off)
3- Surge irrigation with cycle ratio of 0.66 (10 min on and 5 min off)
4- Surge irrigation with cycle ratio of 0.66 (20 min on and 10 min off)
5- Surge irrigation with cycle ratio of 0.75 (15 min on and 5 min off)
6- Alternative furrow irrigation
7- Continuous flow irrigation (control).

Table (1): Some physical properties of the experimental soil site.

Depth	Particle size distribution,%				Soil texture class	Field capacity %	Wilting point %	Bulk density kg/m^3
	Coarse sand	Fine sand	Silt	Clay				
0-15	2.71	15.17	23.95	58.17	clayey	43.05	21.93	1.14
15-30	2.28	17.47	24.7	55.55	clayey	40.00	20.22	1.23
30-45	2.38	18.36	24.32	54.94	clayey	38.37	20.19	1.31
45-60	2.71	17.28	25.14	54.87	clayey	37.7	19.92	1.34

Table (2): Some Chemical Properties of The Experimental Soil Study.

Depth	Ec (ds/m)	pH (1:2.5)	Soluble cations meq/L				Soluble anions meq/L			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co^{--}_3	Hco^{-}_3	cl^{-}	So_4^{--}
0-15	2.22	8.77	5.0	1.5	17.6	0.3	-	3.0	7.1	14.3
15-30	2.63	8.69	7.6	5.3	16.0	0.6	-	5.0	8.2	20.9
30-45	2.96	8.64	8.4	4.3	24.4	0.2	-	3.0	13.3	21.0
45-60	3.70	7.96	3.0	2.1	33.8	0.2	-	7.0	11.2	20.9

The plot area was about (80 m length and 5 m width) 400 m^2 .Egyptian cotton (Gossypium barbadenese 1.), variety Giza 89, was planted on April 1st, 2006 and in April 2nd, 2007, respectively as will as harvesting date was September 25th (2006) and September 14th (2007) in both seasons, respectively . All agricultural operation were performed according to the usual local agricultural management.

FIELD MEASUREMENTS

Soil moisture

Soil moisture percentage was determined gravimetrically at three selected sites along the furrow of the two replicates, before and 2 days after each irrigation and immediately before harvesting. At each sampling date duplicate at soil samples were taken using auger method from the successive soil layers 0-15, 15-30, 30-45 and 45-60 cm depth. Moisture content in the soil samples was determined gravimetrically and calculated on the dry weight basis according to Garcia (1978).

Irrigation water measurement:

The volumes of water used for irrigation were calculated by measuring the discharge using rectangular sharp crested weir. The discharge was calculated using the following formula by Masoud (1967).

$Q = CLH^{3/2}$ (Massoud, 1967)

Where:

Q: The discharge in cubic meters per second.

L: The length of the crest in meters.

H: The head in meters.

C : An empirical coefficient that must be determined from discharge measurements.

The total on-time under continuous and surge flow irrigation was calculated using a stop watch.

Seed Cotton Yield:

Seed cotton yield obtained from each plot (area of 3 X 3.5m2 or 1/400 fed) was weighted. Seed cotton yield was calculated in kentar/fed (one kentar = 157.5 kg).

$$\text{Yield (Kentar/feddan)} = \frac{\text{Yield per plot in kg}}{157.5} \times 400$$

Actual Water Consumptive Use (CU).

The amount (Cu) is assumed to be equal to the difference between both soil moisture contents after irrigation and before the next one.

In fact, this amount is consumed by the plants through the transpiration in addition to the quantity which lost from the soil surface by evaporation. The quantities of water consumptive use were calculated for the 60 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.)

Calculation of Cu was reported for all irrigation until harvesting date using the following equation.(Israelsen and Hansen, 1962).

$$Cu = \sum_{i=1}^{n} \left(\frac{\theta_2 - \theta_1}{100}\right) Di \cdot Bd$$

Where :

CU = Amount of water consumptive use, cm

Di = depth of soil layer, cm

Bd = bulk density in gm/cm^3.

θ_1 = soil moisture content% before the next irrigation. (on dry weight basis)

θ_2 = soil moisture content %, two days after irrigation (on dry weight basis)

n = number of irrigations

l = number of soil layers

Water consumptive use (cm) as a depth of water was converted to m^3/fed. By multiple by 4200/100 for each irrigation treatment.

Soil Moisture Extraction Patterns

Soil moisture depletion patterns (S.M.D.P.) were calculated as follows:

$$S.M.D.P = \frac{\text{SME layer}}{\text{Total SME (seasonal)}}$$

Where:

SME layer = Seasonal soil moisture extracted water for specific layer.

SME (seasonal) = Seasonal soil moisture extracted water for the whole profiles (total consumptive use).

IRRIGATION EFFICIENCIES:

Irrigation application efficiency (Ea):

Values of Irrigation Application Efficiency (Ea) as percent for each treatment were obtained by dividing the total water stored on the irrigation water applied (Downy, 1970).

$$Ea = \frac{Ws}{Wd} X100$$

Where

Ea = Water application efficiency,%

Ws = Water stored in the effective root zone

Wd = Water applied to the field plot.

Crop water use efficiency (W.U.E.)

Crop water use efficiency is the weight of marketable crops produced per the volume unit of water consumed by plants or the evaportranspiration quantity. The crop water use efficiency was computed for the different treatments by dividing the yield (kg of cotton seed yield) on units of evaportranspiration expressed as cubic meters of water (Abd El-Rasool et al., 1971).The field water use efficiency as a measure to clarify variations in yield due to irrigation water applied was calculated according to Michael (1978) as follows:

$$CWUE = Y/Wa$$

Where:

CWUE = Crop Water Use Efficiency, kg/m^3

Y = Total Yield Produced, kg/fed

Wa = Total Applied Water, m^3/fed.

Water Distribution Efficiency (Ed):

It was calculated according to Jomes (1988) as follows:

$$Ed = \left(1 - \frac{y}{d}\right) x\ 100$$

Where:

Ed = Water distribution efficiency, %

d = Average depth of soil water stored along the furrow during Irrigation

Y = Average numerical deviation from d.

Statistical Analysis

All the collected data for the yield and yield component of cotton crop were subjected to the statistical analysis according to Snedecor and Cochran (1967) and the mean values were compared by L.S.D. test

Return per Unit Of Water:-

In Egypt, water is provided without charge to the farmer but estimation of return per unit of water can be taken as index to the relationship between water applied and the value of crop production (Division of Agricultural sciences irrigation costs, 1978).

Economic Efficiency:

Refers to the combinations of inputs that maximize individual or social objectives. Economic efficiency is defined in terms of two conditions necessary and sufficient. Necessary condition is met in production process when there is producing the same amount of product with fewer inputs or producing more products with the same amount of inputs. But the sufficient condition for efficiency encompasses individual or social goals and values (John and Frank, 1987).

RESULTS AND DISCUSSION

Seed cotton yield:

Results of seed cotton yield in kentar/feddan as affected by surge flow alternative and continuous furrow irrigation treatments in 2006 and 2007 growing seasons are presented in Table (3).

It was noticed that the surge flow irrigation treatments significantly affected cotton seed yield in both seasons. Surge irrigation (T_2) (10 min on and 10 min off) recorded the highest value of cotton seed yield and found to be, 9.50 and 9.40 kentar/feddan in the two growing seasons, respectively. While alternative furrow irrigation recorded the lowest value and found to be 6.66 and 6.85 kentar/feddan in both seasons respectively.

It is worthy to mention that surge irrigation (T_2) (10 min on and 10 min off) increased seed cotton yield by 22.58 and 21.81%.compared to continuous furrow irrigation in the first and second season respectively. On the other hand the alternative furrow irrigation resulted in decreasing the yield by 14.06 and 11.15% for both seasons respectively.

The obtained results are in harmony with those reported by Wanas et al., (2001) Abdel Maksoud etal,(1999) and Aiad (2003)

Table (3): Cotton seed yield (kentar/fed.) as affected by surge flow, alternative and continuous furrow irrigation treatments in the two growing seasons, 2006 and 2007.

Irrigation treatments	Cycle ratio	Cycle time (min)		Cotton seed yield kentar/fed	Relative yield %	Cotton seed yield kentar/fed	Relative yield %
		On	Off	2006		2007	
Surge 1	0.5	5	5	7.65	98.71	7.6	98.57
Surge 2	0.5	10	10	9.50	122.58	9.40	121.81
Surge 3	0.66	10	10	8.10	104.52	8.08	104.79
Surge 4	0.66	20	20	9.05	116.77	9.03	117.12
Surge 5	0.75	15	5	8.23	106.19	8.20	106.36
Alternative				6.66	85.94	6.85	88.85
Continuous				7.75	100.00	7.71	100.00
F. Test				**		**	
L.S.D. at 5%				1.1		0.9	
L.S.D. at 1%				1.5		1.2	

Relatively yield %: is the treatment yield as a ratio of continuous furrow irrigation (CFI = 100)

Applied irrigation water:

The amounts of the applied water for each treatment during the two growing seasons are given in Table (4) the total amount of applied water for each season of growth was varied according to the differences in irrigation treatments. As shown in Table (4), all tested cycle ratios of surge irrigation and alternative irrigation treatments used less amount of water than that for continuous one. Average volumes of applied water for continuous flow were 3843.7 and 3900.35 m^3/fed. for seasons 2006 and 2007, respectively. The average volumes of applied water for alternative treatments were 2852 and 2773 for seasons 2006 and 2007, respectively.

Also, the results indicated that surge flow irrigation saved irrigation water of 9.47, 16.38, 13.88, 22.60 , 19.34 and 25.80 % for the treatments of surge 1, surge 2, surge 3, surge 4, surge 5, and alternative furrow irrigation for season 2006. The corresponding values of water saving by surge flow for season 2007 were 14.76, 21.46, 18.60, 27.37, 24.16 and 31.92, respectively. In other words, surge flow irrigation method save irrigation water by about 16.33% and 21.27% as an average in the first and second seasons, respectively.

Table (4): Amount of irrigation water applied and water saving for cotton plant as affected by surge flow irrigation, alternative and continuous irrigation in the two growing seasons 2006 and 2007

Treatments	Cycle		Season 2006			Season 2007			Average of two seasons		
	On	Off	(M^3/fed.)	Water saving (M^3/fed.)	%	(M^3/fed.)	Water saving (M^3/fed.)	%	(M^3/fed.)	Water saving (M^3/fed.)	%
Surge 1	5	5	3479.7	364	9.47	3373	584	14.76	3426.35	474	12.12
Surge 2	10	10	3214	629.7	16.38	3107.8	849.2	21.46	3160.9	739.45	18.92
Surge 3	10	5	3310.1	533.6	13.88	3221	736	18.60	3265.55	634.8	16.24
Surge 4	20	10	2975	868.7	22.60	2874	1083	27.37	2924.5	975.85	24.99
Surge 5	15	5	3100.2	743.5	19.34	3001	956	24.16	3050.6	849.75	21.75
Alt.			2852	991.7	25.80	2694	1263	31.92	2773	1127.35	28.86
Con.			3843.7	-	-	3957		-	3900.35	-	-

It can be concluded that increasing the off-time in surge flow resulted in a greater water saving. The best treatment in saving water was that of alternative irrigation. The trend of the above mentioned results is in accordance with those obtained by Aiad (2003)

- Actual Water Consumptive Use (WCU)

Data in Table (5) showed the effect of surge flow irrigation on seasonal cotton water consumptive use. The highest amount of water consumed by cotton was 2664 m^3/fed as an average of the two seasons for continuous flow irrigation. While the lowest values were obtained with alternative irrigation treatment, 1981.5 m^3/fed. , as an average of the two seasons. Concerning the surge flow irrigation treatments data showed that surge 4 (20 min on and 10 min off) consumed the less amount of water (2198 m^3/fed.) The differences in WCU, between the two growing seasons of cotton

plants could be attributed to the variation of the climatic conditions and plant nature in the two seasons.

Table (5): Actual water consumptive use for cotton plant as affected by surge alternative and continuous irrigation, in the two growing seasons 2006 and 2007

Irrigation treatments	Cycle time min		season 2006	season 2007	Average of two seasons
	on	off	(m^3/fed.)	(m^3/fed.)	
Surge 1	5	5	2648	2540.9	2594.45
Surge 2	10	10	2437	2378.0	2407.50
Surge 3	10	5	2547	2450.0	2498.50
Surge 4	20	10	2252.4	2143.6	2198.0
Surge 5	15	5	2364.5	2302.0	233.23
Alternative			2039.9	1923.1	1981.50
Continuous			2690.5	2637.5	2664.00

Soil Moisture Extraction Patterns (SMEP)

Soil moisture extraction patterns cotton roots and Table (6) and fig (1) and fig. (2) almost had the same trend during the two growing seasons. Most of the water consumed by cotton was depleted from the surface soil layer (0-15cm), followed by the sub surface soil layer (15-30cm) and less water was extracted from the lower layers as shown in Figs. (1 and 2) this may be attributed to that 60% of heir roots distribution in the upper soil layer (0-15).

Table (6): Percentage of soil moisture extraction by cotton roots for different soil layers during the two growing seasons 2006/2007

Irrigation treatment	Cycle time min		Season 2006				Season 2007			
	on	off	soil layers (cm)				soil layers (cm)			
			0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
Surge1	5	5	45.90	27.0	18.30	8.80	46.91	25.96	19.67	7.46
Surge2	10	10	44.20	25.72	19.95	10.13	44.99	25.75	19.60	9.66
Surge3	10	5	45.19	25.82	17.42	11.57	45.66	27.41	18.72	8.21
Surge4	20	10	44.58	25.52	18.80	11.10	46.74	26.26	18.96	8.04
Surge5	15	5	46.82	25.98	17.73	9.47	46.30	26.47	19.30	7.93
Alternative			44.16	26.44	18.83	10.57	44.36	24.84	19.84	10.96
Continuous			49.48	24.43	17.56	8.53	48.60	25.71	17.50	8.19

With regard to the effect of surge flow irrigation on the SMEP, data indicated that the extraction from the upper 15-cm soil layer was relatively high under the continuous flow than that under surge flow irrigation and alternative irrigation. The opposite trend was true for the deeper layers (30-60 cm). These findings were more pronounced for the surge flow treatments surge 2 (10 min on and 10 min off) and alternative as compared to the continuous irrigation in season 2006. These results are in agreement with those of Ghalleb (1987).

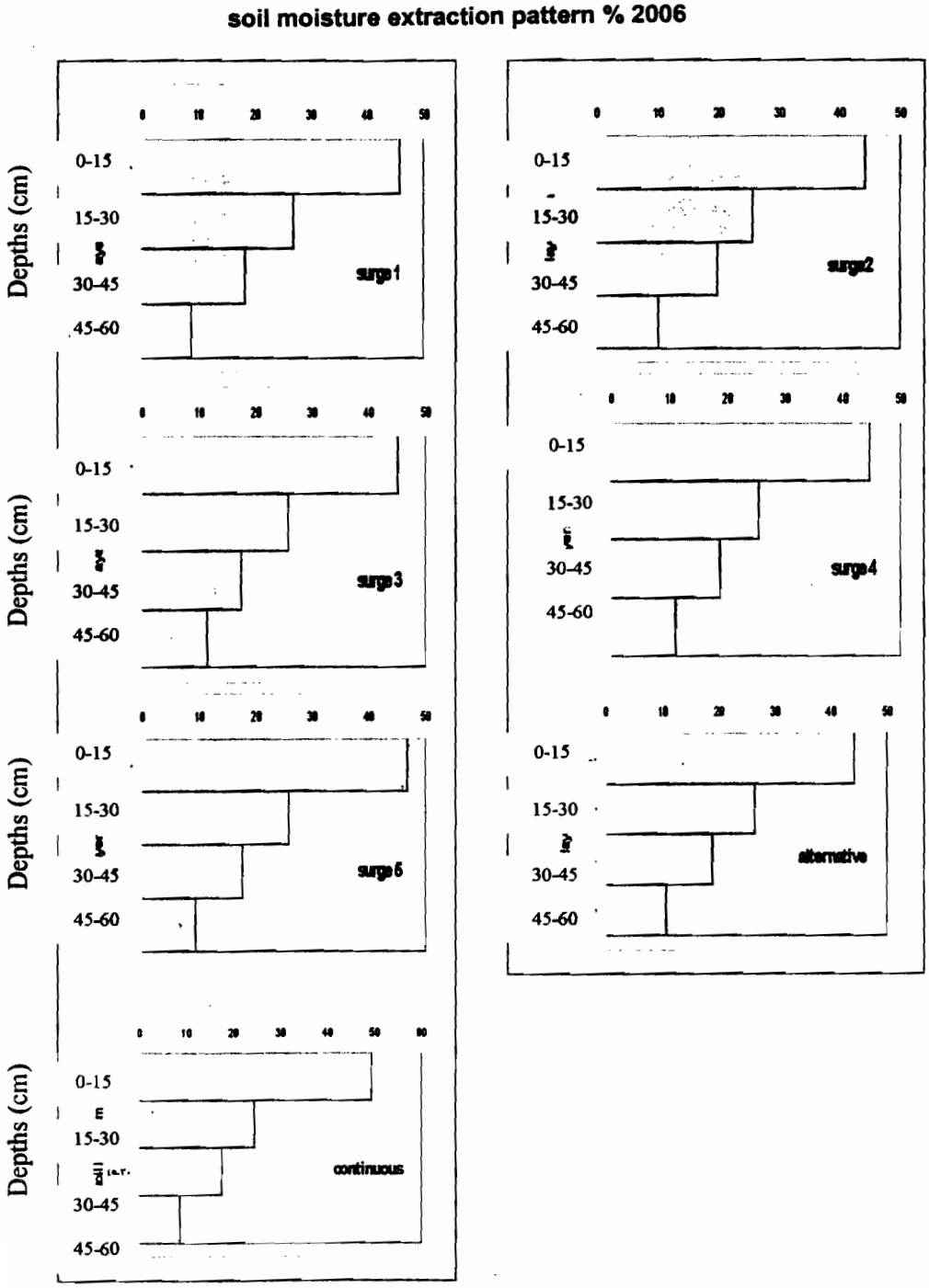

Fig. 1 : Average Percentage of Soil Moisture Depletion by Cotton Roots for Different Soil Layers during The First Growing Season, 2006

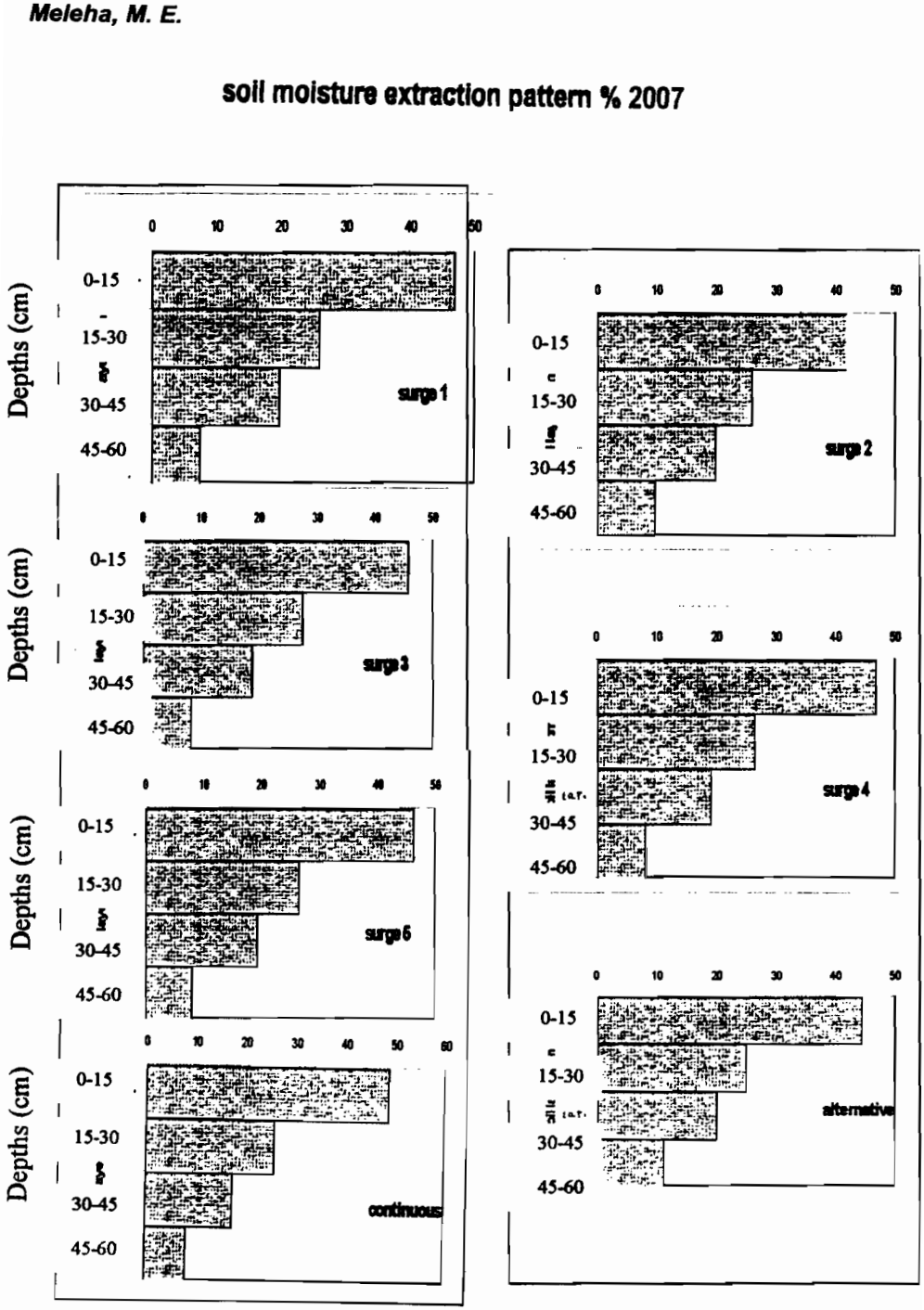

Fig. 2 : Average Percentage of Soil Moisture Depletion by Cotton Roots for Different Soil Layers during The Second Growing Season, 2007

Irrigation Efficiencies;

Water Application Efficiency (WAE):

Water application efficiency (WAE) is one of the most important criteria used to describe field irrigation efficiency, which represents the ratio between water stored in the effective root zone and total water applied. High WAE means less deep percolation below the crop root zone and less water at the tail of furrows.

Generally, WAE increases as the amount of water applied during each irrigation decreases.

However, the very small irrigation may not fill the root zone adequately and may reduce crop yields, and in the long run increase the salt problems due to inadequate leaching. The calculated WAE values for the different irrigation treatments are presented in Table (7). The overall average WAE values for continuous irrigation were 76.28 and 72,68% during the two growing seasons, respectively.

The corresponding values for surge flow irrigation treatments were 80.57, 79.75,80.60, 82.76 and 81.45% for surge 1 through surge 5 treatments during season 2006, respectively. Meanwhile for season 2007 it were 78.65, 78.42, 80.72, 80.55 and 78.81%. for the previous surge irrigation methods respectively the average WAE values for alternative irrigation were 77.59 and 78.14 during the two growing seasons. The higher efficiency of surge flow can be attributed to the surface soil that causing by the intermitted wetting and the surface hydraulic roughness of the wet advice. The best treatment was that of 0.75 cycle ratio (20 on min and 10 min off). It had the highest value of 82.76% and 80.55% as an average of the two seasons. The obtained results indicated that under WAE values were higher under surge flow irrigation than that under continuous irrigation and alternative irrigation. these results are in accordance with those obtained by Aiad (2003) on cotton.

Table (7): **Values Of Water Stored, Applied Irrigation Water And Irrigation Application Efficiency As Affected By Surge, Alternative And Continuous Irrigation In 2006 And 2007 Seasons**

Irrigation treatment	Cycle time		Water stored m^3/fed.	Applied irrigation water m^3/Fed.	Irrigation application efficiency %	Water stored m^3/Fed.	Applied irrigation water m^3/Fed..	Irrigation application efficiency %
	on	of						
Surge1	5	5	2803.6	3479.7	80.57	2653	3373	78.65
Surge2	10	10	253.2	3214	79.75	2437	3107.8	78.42
Surge3	10	5	2668	3310.1	80.60	2600	3221	80.72
Surge4	20	10	2462	2975	82.76	2315	2874	80.55
Surge5	15	5	2525	3100.2	81.45	2365	3001	78.81
Alternative			2214	2852	77.59	2105	2694	78.14
Continuous			2932	3843.7	76.28	2876	3957	72.68

Water Distribution Efficiency (WDE):

Values of WDE for the different irrigation treatments as shown in Table (8) surge flow technique recorded the highest values of WDE compared to continuous flow irrigation and alternative irrigation. The mean values for the surge flow irrigation treatments were 8230,796, 80.30, 82.25 and 84.0 % for surge 1, 2, 3, 4, and 5, in the growing season 2006, respectively. Where the corresponding of WDE values were 76.70 and 77.23% under alternative and continuous irrigation, respectively, The overall average of WDE values were 82.15, 80.3, 80.90 and 82.34 and 83.90 % for the surge (T_1), (T_2), (T_3), (T_4) and (T_5) respectively. The mean of WDE values were 75.50 and 75.66% under alternative and continuous irrigation treatments respectively. It was found that WDE value increased whenever the cycle ratio decreased or the off-time increase.

The best treatment was that of 0.75 cycle ratio (20 min on and 10 min off), that it had the highest values 84.0 and 83.56% with an average of 83.90% for the two growing seasons, respectively. The difference between WDE values of surge this maybe due to the nature of the clay soils that crack severely, however, the WDE depends on several factors such as cycle ratio (on and off time), in flow rate, and soil permeability. In addition, values of the WDE are relatively higher under surge flow, this maybe due to the faster water advance in the case of furrow surge flow, which results in more uniform water distribution,

Table (8): Average Values Of Water Distribution Efficiency under Surge Flow, Alteration and Continuous Irrigation Treatments in The Growing Seasons 2006 And 2007

Irrigation treatments	Water distribution efficiency %		Average %
	Season 2006	Season 2007	
Surge1	82.30	82.0	82.15
Surge2	79.60	81.00	80.30
Surge3	80.30	81.50	80.90
Surge4	82.25	82.80	82.34
Surge5	84.0	83.56	83.90
Alternative	76.70	75.50	76.10
Continuous	77.23	75.66	76.45

Water Use Efficiency:

Data in Table (9) illustrate the crop and Field water use efficiency values as influenced by the surge flow irrigation treatments. The highest value of crop and Field water use efficiency (0.63 and 0.47 kg/m^3) obtained with surge 4 (20 min on and 10 min off) in the first season and (0.66 and 0.49 kg/m^3) in the second season respectively. While the lowest values was obtained from surge 1 (5 min on and 5 min off) for both seasons. It can be concluded that the crop and water utilization efficiency increases with increasing the uniform distribution of irrigation water along furrows irrigation under surge flow irrigation for obtained maximum cotton yield the above mentioned results are similar to those obtained by Galled (1987) and Aaid (2003) on cotton.

Table (9): Values of Cotton Seed Yield, Water Consumptive Use, Water Applied, Crop Water Use Efficiency and Water Utilization Efficiency as Affected by Different Treatments during 2006 and 2007

Irrigation treatments	Cycle		Season 2006					Season 2007				
	On	Off	Cotton yield kg/fed	Water consumptive use m3/fed	Water applied m3/fed	Crop water use efficiency kg/m3	Water utilization efficiency kg/m3	Cotton yield kg/fed	Water consumptive use m3/fed	Water applied m3/fed	Crop water use efficiency kg/m3	Water utilization efficiency kg/m3
Surge 1	5	5	1204.87	2648	3479.7	0.46	0.35	1197	2540.90	3373	0.47	0.35
Surge 2	10	10	1496.25	2437	3214	0.61	0.47	1480.5	2378	3107.8	0.62	0.48
Surge 3	10	5	1275.75	2547	3310.1	0.50	0.39	1272.6	2450	3221	0.52	0.40
Surge 4	20	10	1425.37	2252.4	2975	0.63	0.47	1422.22	2143.6	2874	0.66	0.49
Surge 5	15	5	1296.22	2364.5	3100.2	0.55	0.42	1291.5	2302	3001	0.56	0.43
Alternative			1048.95	2039.4	2852	0.51	0.37	1078.87	1923.1	2694	0.56	0.40
Continuous			1220.63	2690.5	3843.7	0.45	0.32	1214.32	2637.5	3957	0.46	0.31

Economic evaluation

Data in Table (10) illustrated values of total costs, productivity, total income, net profit, water productivity and economic efficiency.

Results indicated that the maximum values of total income, net profit, water productivity and economic efficiency were obtained under surge 2 treatment, while the minimum value of total income, net profit, water productivity and economic efficiency. Were obtained under alternative irrigation treatment in the two seasons.

Table (10) Total Cost, Yield, Total Income, Net Profit and Water Productivity as affected by Different Treatments during 2006 and 2007.

Irrigation treatments	Season 2006						Seasons 2007					
	Total Cost L.E/Fe.	Yield Kentar/ Fed	Total Income L.E/M3	Net Profit L.E/Fed	Water Productivity/Y L.E/Fed	Economic Efficiency	Total Cost L.E/Fed.	Yield kentar/Fed	Total Income L.E/M3	Net Profit L.E/Fed	Water Produc./Y L.E/Fed	Economic Efficiency
Surge 1	2820	7.65	5737.5	2917.5	0.84	1.03	2850	7.6	5700	2850	0.84	1.00
Surge 2	2820	9.5	7125	4305	1.34	1.53	2850	9.4	7050	4200	1.35	1.47
Surge 3	2820	8.10	6075	3255	0.98	1.15	2850	8.08	6060	3210	1.00	1.13
Surge 4	2820	9.05	6787.5	3967.5	1.33	1.41	2850	9.03	6772.50	3922.50	1.36	1.38
Surge 5	2820	8.23	6172.5	3352.5	1.08	1.19	2850	8.20	6150	3300	1.10	1.16
Alternative	2820	6.66	4995	2175	0.76	0.77	2850	6.85	5137.50	2287.50	0.85	0.80
Continuous	2820	7.75	5812.5	2992.5	0.79	1.06	2850	7.71	5782.5	2932.50	0.74	1.03

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آلية توفير المياه باستخدام طريقةِ الرَيِّ النبضي وتأثيره على كفاءات الرى وكفاءة استخدام المياه لمحصول القطن

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تم تنفيذ تجربتين حقليتين في محطةِ بحوثِ القرضا التجريبية أثناء موسمي الزراعة الصيفيين ٢٠٠٦و ٢٠٠٧ في محافظةِ كفر الشيخ. ويهدَفَ البحث إلى توفير مياه الرى في الأرض المَزْرُوعةِ القديمةِ في الدلتا بإستعمال طريقةِ الرَيِّ النبضي مقارنة بالري بالغمر التبادلي والمستمر وتأثيره على كفاءات الرى وكفاءة استخدام المياه لمحصول القطن.

ولتنفيذ خطة البحث تم استخدام سبعة معاملات منها خمس معاملات رَيٍّ نبضي معاملة الرى النبضى (١) (٥ دقائق..فتح و٥ دقائق غلق) معاملة الرى النبضى (٢) (١٠ دقائق فتح و ١٠ دقائق غلق) معاملة الرى النبضى (٣) (١٠ دقائق.فتح و٥ دقائق غلق) معاملة الرى النبضى (٤) (٢٠ دقيقة فتح و١٠ دقائق غلق) معاملة الرى النبضى (٥) (١٥ دقيقة فتح.و٥ دقائق غلق)، المعاملتان الباقيتان كانتا رَيٍّ تبادلي في خطوطِ معاملة (٦) و رَيٍّ بالغَمْر مستمر معاملة (٧) وتم استخدام التصميم الإحصائى لها تصميمَ قطاعات كاملة العشوائية.

أوضحت النَتائِجَ المتحصل عليها بأنّ معاملة الرَيِّ النبضي أثّرتْ على محصول بذرةِ القطن بشكل معنوي في كلا من الموسمين حيث كان متوسط الزيادة فى محصول بذور القطن ٢٢,٥٨% (١,٧٥ قنطار للفدان) و٢١,٨١% (١,٦٩ قنطار للفدان)فى كلا الموسمين على الترتيب عند استخدام معاملة الرى النبضى (٢) (١٠ دقائق فتح و ١٠ دقائق غلق) وايضا ُالرَيُّ النبضي وقرَ ماءَ رَيٍّ بمقدار ١٦,٣٢% (٦٢٧,٩ متر مكعب للفدان) و ٢١,٢٧% (٨٤١,٦٤ متر مكعب للفدان) كمتوسط في الموسم الأول والثاني على التوالي مقارنة بالرى المستمر. وأن زيادة زمن الغلق في الرَيِّ النبضي يُؤدّي إلى توفير أكبر فى مياه الرى.

معاملة الري النبضي ٤ (٢٠ دقيقة فتح و١٠ دقائق غلق) أعطت اقل استهلاك مائي حيث كان التوفير فى مياه الرى حوالى ٢٢,٦% (٨٦٨,٧ متر مكعب للفدان) و ٢٧,٣٧% (١٠٨٣ متر مكعب للفدان) فى كلا الموسمين على الترتيب.

أشارت النتائج أيضا أن كفاءة تطبيق الماءَ، كفاءة توزيع الماء، و كفاءةُ استخدام المياه كانتْ أعلى تحت الري النبضي مِثْه الرَيِّ التبادلي والمستمر بالإضافى إلى ما سبق فإن الحَدّ الأقصى لقيم الدخل الكليِّ وصافي الربح ومعدل إنتاجية الماء والكفاءة الاقتصادية تم تحقيقها بالرَيِّ النبضي ٢ (١٠ دقيقة فتح و١٠ دقائق غلق).

تحت ظروف الدراسة الحالية نوصى بتطبيق استخدام الري النبضي معاملة (٤) (٢٠ دقيقة فتح و١٠ دقائق غلق) يؤدى إلى توفير مياه الرى بمقدار ١٢٥,٨ مليون متر مكعب فى الموسم من المياه المضافة فى رى محصول القطن (المساحة المنزرعه ١١٦١٣٣ فدان فى موسم ٢٠٠٧) فى محافظة كفر الشيخ.