DEVELOPMENT OF PERFORATED PIPES TO IMPROVE SURFACE IRRIGATION PERFORMANCE

Abd El-Motaleb, I. A. * **M. A. El-Saadawy** ** **F. I. Hindy** *** **M. A. Mattar** ****

ABSTRACT

Surface irrigation is the oldest and widely used method of irrigation in Egypt. A major cost of surface irrigation may be due to labor requirements high percent of the applied water and improper management. It is caused deficiency of surface irrigation. The main goals of this study were improve surface irrigation performance and to minimize some undesirable consequences by using telescopic perforated pipes. Field experiments were conducted on soybean "Giza 111 variety" during the summer growing season of 2004 to achieve the qualification of the preceding developed technique. The developed (telescopic) perforated pipe (T.P.P.) was tested, however mean inflow rate was 0.83 l/s for each end closed furrow.

The results indicate that, the discontinuity in infiltration rate accounted for the accelerated advance rates that occurred in surge irrigation after one complete cycle. Surge flow treatments with telescopic perforated pipes (T.P.P.) had faster advance time, especially with longer off-time. Surge flow "15 min on - 45 min off" by using T.P.P. saved the amount of water by 46.63 % of the water applied for continuous irrigation with conventional perforated pipes (C.P.P.). Also, high water application efficiency (E_a) and water application efficiency of low quarter (E_{alq}), water distribution efficiency (E_d) and water distribution uniformity (D_u), and lower deep percolation percentage (D_{pp}) are observed for surge flow "15 min on - 45 min off" by using T.P.P. Generally, it can be concluded that surge flow with T.P.P. technique can not only save the water amount, but also enhance the soybean yield and therefore, the net income of the farmers.

***Keywords**:* Furrow irrigation, Continuous flow, Surge flow, Soybean yield, Economic returns.

INTRODUCTION

Surface irrigation is the introduction and distribution of water in a field by the gravity flow of water over the soil surface. **Lay and Leib (2001)** showed that Surface irrigation systems can be efficient, if a

* Prof. of Agric. Eng., Agric. Eng. Dept., Fac. of Agric., Kafr El-Sheikh Univ.
** Senior Res. of Agric. Eng. Res. Int., Agric. Res. Center, M.A.L.R., El-Dokki, Giza.
*** Associate Prof. of Agric. Eng., Agric. Eng. Dept., Fac. of Agric., Kafr El-Sheikh Univ.
**** Res. Assistant, Agric. Eng. Res. Int., Agric. Res. Center, M.A.L.R., El-Dokki, Giza.

proper management and water control had been applied. Knowing how much water is applied and scheduling aspects according to soil-water and crop relationships. These should be some means of controlling the direction of water flow.

Perforated pipe system is a simplified type of gated pipe system. Gated pipe irrigation is a type of furrow irrigation in which the conventional head ditch and siphons are replaced by an above-ground pipeline. Irrigation water flows from orifices (gates) which are regularly spaced along the pipeline. A gated pipeline is an example of divided manifold flow. As in any case of manifold flow, the flow in the pipeline is spatially varied and in this case the flow is also steady and reduces approximately to zero at the closed end of the pipeline (**Smith et al., 1986**). **Morcos et al. (1994)** stated that the use of perforated tubes is claimed to be one of the ways to improve the efficiency of surface irrigation methods (borders and furrows). The perforated pipe is mainly constructed of a portable line, which could be handled in the field. The pipeline usually has uniformly spaced outlets and usually of aluminum or P.V.C pipe.

Smith et al. (2005) reported that application efficiencies were shown to vary widely and on average to be much lower than is desirable, with a mean of 48% and range from 17 to 100%. Application efficiencies can be increased substantially, and deep drainage losses reduced equally substantially by the application of simple inexpensive irrigation management practices involving increased furrow flow rates and reduced irrigation times. Substantial reductions in deep drainage are possible by ensuring that irrigation applications do not exceed the soil moisture deficit. However, if maximum irrigation performance and minimal deep drainage are to be attained, then an accurate measure of the soil moisture deficit is required.

Krinner et al. (1994) stated that an automatic surface irrigation system with gated pipe can be a very efficient method of applying irrigation 91.9 % water application efficiency. **Omara (1997)** found that the irrigation application efficiency and irrigation distribution efficiency increased to 72.5 % and 92 % respectively by using gated pipe system through furrow irrigation. **El-Tantawy et al. (2000)** showed that perforated pipes have a positive effect on increasing agricultural production by increasing yield per unit area and through saving water in order to irrigate more area. **El-Yazal et al. (2002)** reported that perforated pipes is better to improve surface irrigation in old lands especially in maize crop under discharge 1.5 l/s/orifice/furrow with slope 0.1 %.

Walker (1989) indicated that under the surge flow regime, irrigation is accomplished through a series of individual pulses of water onto the field. Each surge is characterized by a cycle time and a cycle ratio. The cycle time is comprised of an on-time and an off-time related by the cycle ratio which is the ratio of on-time to the cycle time. The cycle time can range from as little as one minute to as much as several hours. Cycle ratios typically range from 0.25 to 0.75. **Osman et al. (1996)** concluded that all tested number of surge flow required less time to complete the advance phase and less amount of water than continuous irrigation and the 1:3 on to off cycle ratio treatment was the best treatment. **Kassem and El-Tantawy (2000)** reported that by increasing the off-time period from 10 min to 40 min, the irrigation efficiency increased and the water losses by deep percolation decreased compared with continuous irrigation method. **Evans and Leib (2001)** stated that the "surge" effect on surface irrigation is primarily due to reducing the soil intake rates and improving the hydraulic characteristics in the previously wetted portions of the furrows. This reduction occurs almost immediately after the initial dewatering of the soil surface. **Mattar (2001)** studied the effect of surge furrow irrigation comparing with continuous irrigation on water management at different ploughing methods. The results showed that, surge irrigation with 3 surges on-time (10 – 19 – 25 minutes) and off-time 20 minutes between the surges for rotary plough was the best treatment that used 74.64% of total amount of applied water for continuous irrigation. **Wang et al. (2005)** showed that surge irrigation with sediment-laden water can save irrigation water and improve irrigation quality. The analysis on water saving efficiencies indicated that while the intermittent surge flow and the sediment interact to achieve water saving efficiency, sediment plays a more important role.

The selected field crop for this study is soybean as a summer crop cultivated on furrows. Soybean is one of the most important oil crops, however, it ranked the third one among the world oils crop after cottonseed and sunflower. The increase in soybean production is considered a necessity in

Egypt because it can participate in solving food shortage production added to industrial scope, where, it serve as oil crop, artificial milk and source of protein for human feeding. More over its processing residues serve as animal feeding. So, the Egyptian government is interested in increasing the areas cultivated by soybean (**El-Saadawy et al., 2004**).

The main objective of this study was to improve surface irrigation system efficiency by using a developed (telescopic) perforated pipes technique. To achieve the qualification of the preceding system, the following work was carried out as follows:

1- Performance of telescopic perforated pipes through the estimation of water application efficiency, water distribution efficiency and field water use efficiency, under field conditions.
2- Determination of a seasonal cost and economic returns (productivity) analysis for telescopic perforated pipes.

MATERIALS AND METHODS

1. Telescopic perforated pipes:

This study is a continued one of using developed T.P.P. improving surface irrigation efficiency, that had been observed by a brief description of the system is shown in Fig. 1. The system consists of form of a T-section shape made of PVC, which is bound in support of a T-section shape. This form has two flange joints with faucet rubber ring to hold the inner PVC pipes, which have flange joints. The form was used for distributing irrigation water flow in both sides. Each side includes inner PVC perforated pipe of 110 mm in diameter (3.5 mm in thickness) and 6 m in length placed into outer PVC perforated pipe of 125 mm in diameter (3 mm in thickness).

The orifices are circular in shape of 38 mm in diameter and located along the two sides of the inner pipe at approximately 0.7 m spacing (the same spacing as the furrows being irrigated). Each side consists of eight orifices. These orifices diameter are reduced to 25.4 mm by rubber seals that are fixed in the edge of orifices. Portable plugs are installed the end of the inner perforated pipes.

Also, the circular orifices of 38 mm in diameter located along the two sides of the outer pipe at approximately 0.7 m spacing. But, the placing orifices in one side are located at the distance intervals 0.1 m to the placing orifices in the other.

Metallic clamps are fixed in both outer perforated pipes. Two pull bars are installed both metallic clamps to connect between the outer perforated pipes. One of metallic clamps has gear guide and gear that is geared the rack in the left side of the system for moving outer perforated pipes horizontally.

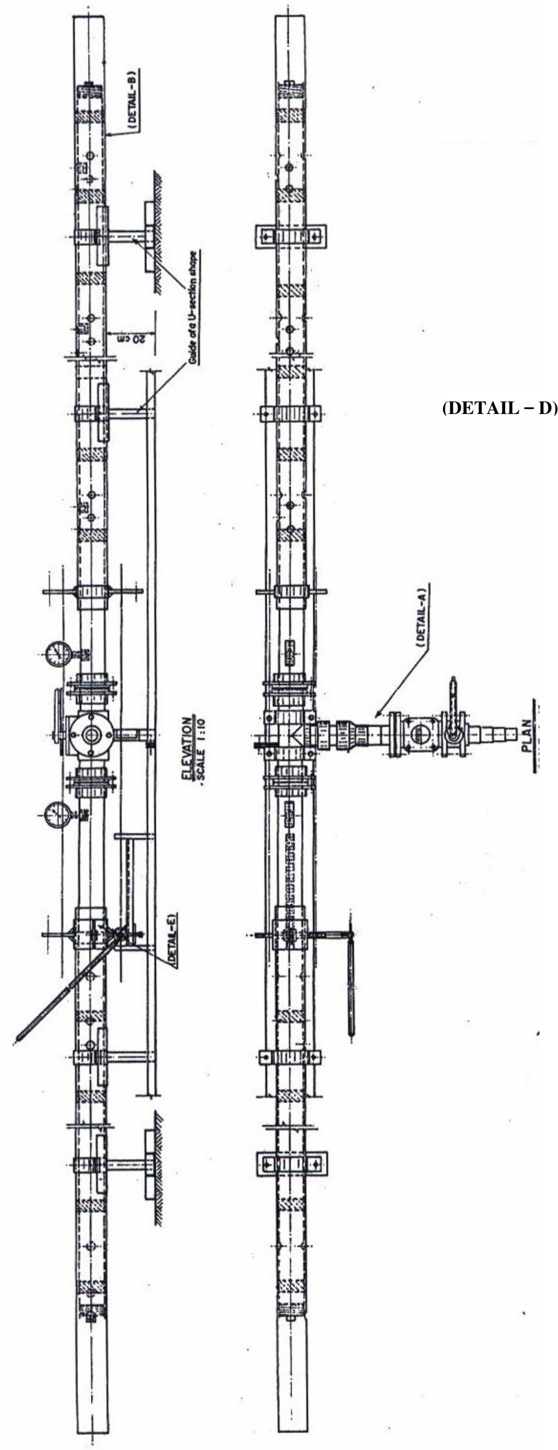

Fig. 1: The telescopic perforated pipes system.

2. The experimental pumping unit:

The pumping unit consists of one pump with a Diesel powered motor. The specifications of the pump and Diesel engine are shown in Table 1.

Table 1: The specifications of the pump.

Type of pump	Dry weight (kg)	Motor power (hp)	rpm	Suction pipe diameter (inch)	Delivery pipe diameter (inch)
Centrifugal	18	4	1500	3	3

The pump was connected through connecting tubes, spools, elbows, tees and other pipefitting in order to facilitate obtaining a variable range of discharge rates. The pump was equipped with an individual suction pipe and 3 inch hose ending with a trash screen and non- return valve. The discharge side of the pumping unit was connected to the inlet of tested perforated pipe through a discharge valve and flow meter.

3. Field performance:

Field experiments were carried out on soybean "Giza 111 variety" at Zarzora Agricultural Research Station, Etay El-Baroud, Beheira Governorate, Egypt during the summer growing season of 2004.

The experimental area was divided into three plots (replicates); each plot was 60 m wide and 94 m long. Each plot was divided into 5 strips (treatments). The area of each strip was 1053 m^2, which included 16 furrows. Stakes were placed at regular intervals along each furrow. The furrow has 94 m length, and 0.70 m width and zero% longitudinal slope. Random completed blocks design was used in this experimental. The soil type is clay. Some hydro-physical properties of the soil at the experimental site are shown in Table 2. The field experiment layout is shown in Fig. 2.

Five treatments were tested, however, it were applied after sowing and the post irrigation (El-Mohaya). These treatments are:

A: Continuous applied water flow in the upper end of the furrows run by using conventional perforated pipes (C.P.P.) (control).

B: Continuous applied water flow in the middle end of the furrows run by using telescopic perforated pipes (T.P.P.).

C: Surge flow with 5 min on - 15 min off with T.P.P.

D: Surge flow with 10 min on - 30 min off with T.P.P.

E: Surge flow with 15 min on - 45 min off with T.P.P.

Table 2: Some physical properties of the soil layers at the experimental site.

Soil depth, cm	Particle size distribution, %			Texture Soil	Bulk density, g/cm^3	Field capacity, %	Permanent wilting point, %	Available water, %
	Sand	Silt	Clay					
0 – 15	11.3	28.3	60.4	Clay	1.04	47.20	35.38	11.82
15 – 30	12.4	25.6	62.0	Clay	1.15	40.50	21.85	18.65
30 – 45	11.3	21.4	67.3	Clay	1.24	39.00	21.15	17.85
45 – 60	11.2	21.3	67.5	Clay	1.26	38.50	20.81	17.69

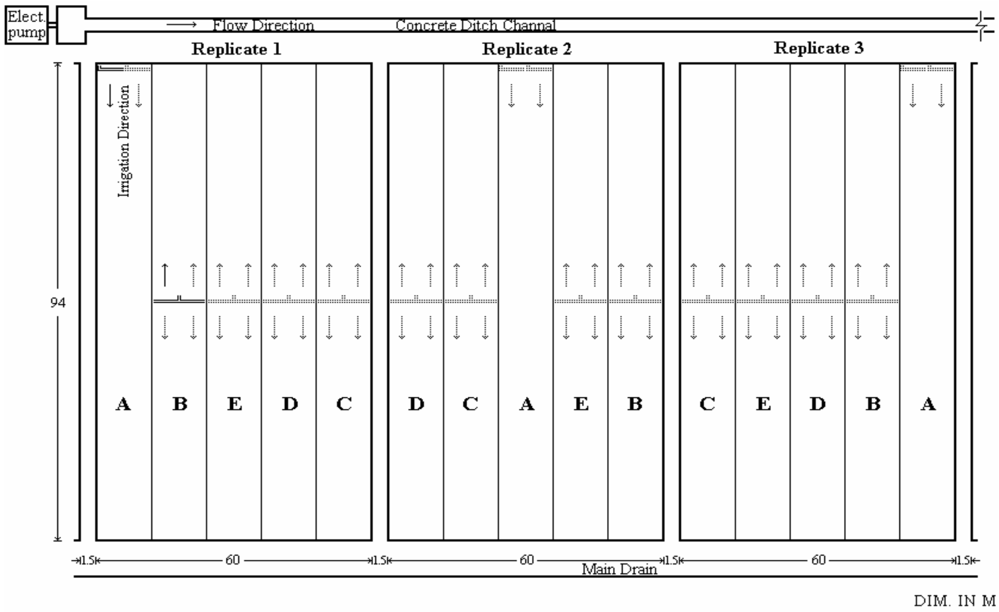

Fig. 2: Schematic diagram showing the layout of field experiment.

The mean inflow rate used in this test was 0.83 l/s each furrow which its end is closed. The inflow rate was constant over the irrigation period in all treatment.

Laboratory experiments were conducted to measure the water infiltration rates under continuous and surge application of water by the laboratory infiltrometer which consisted of: a glass cylinder, a control valve, a filter paper, two holders, a Mariotte tube, and a plastic hose. This method was presented and modified by **Abd El-Latif (1978)**, **Guirguis (1988)**, **Zein El-Abedin and Ismail (1998)** and **Mattar (2001)**.

The readings, which were recorded from the Mariotte tube against time, were used to calculate the constants of infiltration equations for each on-time for both continuous and surge application of water. This equation was the Kostiakov's infiltration equation as shown in the following equation (**ASAE, 2003**):

$$\mathbf{Z = k\,t^{a}} \quad \text{...} \mathbf{(1)}$$

Where:

Z = Cumulative infiltration (mm),
t = Elapsed time of infiltration (min) and
k, a = Constants which vary with the type of soil and its condition.

3.1. Infiltration equation for continuous flow:

Fig. 2 shows that infiltration starts with the greatest rate of increase when the soil was relatively dry, dropped to a much lower infiltration rate after a period of time and became lower and almost constant after a period of time, as the soil sample gets more saturated with water. Therefore, the parameters "k" and "a" of the Kostiakov empirical equation for the continuous flow were estimated as following: $Z = 7.2081\ t^{0.4905}$

Where:

Z = Cumulative infiltration (mm),
t = Elapsed time of infiltration (min) and

3.2. Infiltration equation for surge flow:

Fig. 2 appears that during the first surge for surge flow water with 5 min on-time and 15 min off-time treatment, the infiltration rate starts high 374.86 mm/h and drops to 147.42 mm/h in 5 min on-time. In other treatments, the corresponding values for surge flow water with 10 minutes on-time and 30 minutes off-time; and with 15 minutes on-time and 45 minutes off-time treatments, the infiltration rate starts high 358.01 and 347.48 mm/h and drops to 67.61 and 41.69 mm/h in 10 and 15 minutes on-time, respectively.

In Fig. 2, a rebound or jump phenomenon, where the initial infiltration rate following the off-time is higher than the infiltration rate measured at the end of the preceding surge. It is because of the negative pressure that developed at the soil surface during the off-time according to **Samani et al. (1985)**.

In all cases, since infiltration rates had become quasi-steady at tests end. The last or quasi-steady infiltration rates measured were lower with surge flow than with continuous flow, despite shorter opportunity times in the case of surge. This may be due to two reasons: 1) The redistribution and rate of development of negative pressure in the soil slows down as the off-time continues. 2) The soil surface sealing and then the consolidation of the previously wetted soil during the off-time. **(Blair and Smerdon, 1987; Bautista and Wallender, 1985;** and **Trout, 1991)**.

The typical empirical function that can be characterized by the Kostiakov relationship (parameters "k" and "a") were estimated as following:

- For surge flow "5 min on - 15 min off" treatment: $Z = 9.702\ t^{0.4288}$
- For surge flow "10 min on - 30 min off" treatment: $Z = 8.0462\ t^{0.4816}$
- For surge flow "15 min on - 45 min off" treatment: $Z = 7.0408\ t^{0.5094}$

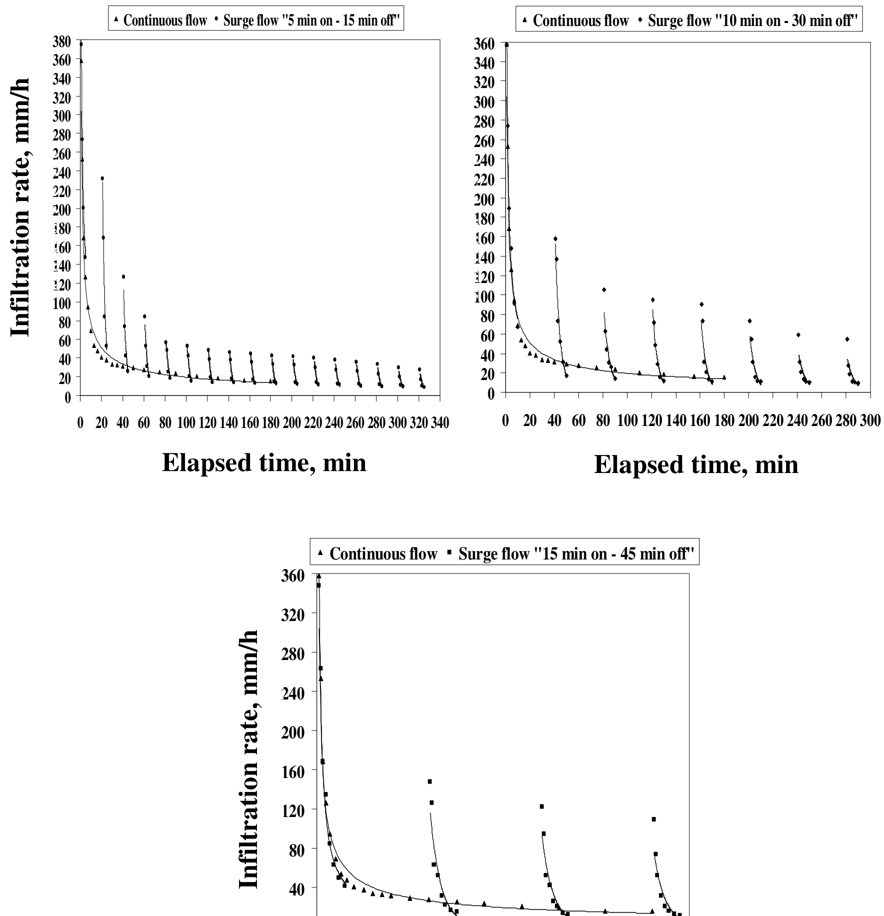

Fig. 2: Comparison of infiltration rates for surge flow and continuous flow treatments.

4. Measurements:

1) The water advance and recession times at stations along each dike downstream end furrow.
2) Total water on-time under various treatments.
3) Soybean crop yield at the beginning, middle, and end of the furrow.

5. Methods of calculation:

The parameters for different irrigation treatments were calculated according to **Micheal (1978), Kepner et al. (1982), Hunt (1983), James (1988), Walker (1989), Ismail (2002)** and **ASAE (2003)** as follows:

1- Amount of water applied to each irrigation treatment.
2- Water application efficiency (E_a).
3- Water application efficiency of low quarter (E_{alq}).
4- Deep percolation percentage (D_{pp}).
5- Water storage efficiency (E_s).
6- Water distribution uniformity (D_u).
7- Water distribution efficiency (E_d).
8- Water use efficiency (WUE).
9- The seasonal cost and economic returns of telescopic perforated pipes.

The income from produce was estimated using prevailing average market price as Egyptian 2500 L.E./Mg. One US dollar equals 5.87 L.E. (Egyptian pound) during experiment period.

RESULTS AND DISCUSSION

1. Effect of telescopic perforated pipes with continuous and surge flow irrigation on advance rate, total amount of applied water and infiltrated water distribution:

1.1. Advance rate:

Considerable attention has been given to the advance phase of surface irrigation because of its bearing on intake opportunity times between two ends of the irrigation run. The advance time data of the applied water at different stations along the furrow length were measured for each irrigation.

The average values of advance time for the five irrigations under continuous flow by using conventional perforated pipes (C.P.P.) (control treatment) were shown in Fig. 3. Also, the average values of advance time for the five irrigations under continuous flow; surge flow "5 min on - 15 min off"; surge flow "10 min on - 30 min off" and surge flow "15 min on - 45 min off" by using telescopic perforated pipes (T.P.P.) were illustrated in Fig.

3. The average time required for the water to advance to the end of the furrow for continuous flow by using C.P.P. was 224.83 min. The corresponding values for continuous flow; surge flow "5 min on - 15 min off"; surge flow "10 min on - 30 min off" and surge flow "15 min on - 45 min off" by using T.P.P. were 208.33, 185.33, 163.33 and 127.33 min, respectively.

So, the best results of water advance were obtained when using surge flow "15 min on - 45 min off" with T.P.P. This indicated that the surge furrow become more defined and smoother. Besides the soil infiltration rates gets usually lower with increasing the off-time, in accordance with **Kanber et al. (2001)** and **Mattar (2001)**.

Generally, decreasing advance time by using T.P.P. can be attributed to furrow being irrigated divided into two parts, therefore, decreasing furrow length lead to advance rate more rapid compared to conventional perforated pipes system according to **Morsi (2001)**. Furthermore, using surge flow with T.P.P. lead to more decrease advance time.

This may be due to the redistribution of the infiltrated water in the soil profile during the time that water is turned off and surface sealing and consolidation of the soil matrix near the soil surface in the bottom of the furrows during the interval between surges according to **Samani et al. (1985)** and **Izadi et al. (1990)**.

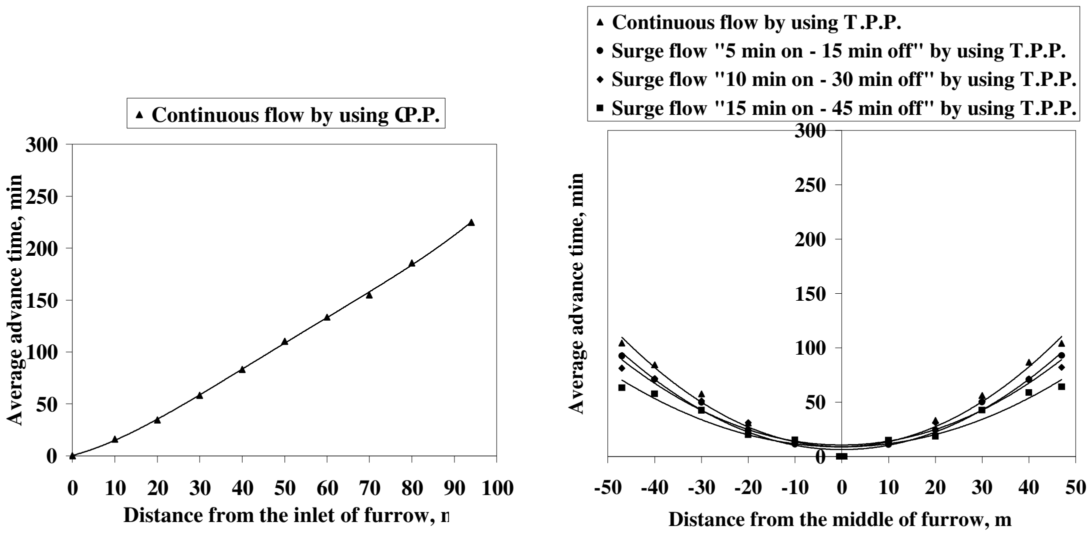

Fig. 3: Average advance time for continuous flow irrigation (control treatment) by using conventional perforated pipes, continuous flow and surge flow irrigation treatments by using telescopic perforated pipes.

1.2. Total amount of applied water:

During the growing season of soybean crop, there were five irrigation events. Total amounts of water applied for growing season varied with different irrigation treatments are shown in Fig. 4.

Total amounts of irrigation water were added to continuous flow by using C.P.P. (control treatment), and continuous flow; surge flow "5 min on - 15 min off"; surge flow "10 min on - 30 min off" and surge flow "15 min on - 45 min off" by using T.P.P. were 3558.14, 3297.01, 2848.62, 2532.11 and 1899.08 m^3/fed., respectively. Total amount of applied water by modified continuous flow, surge flow "5 min on - 15 min off", surge flow "10 min on - 30 mi f" and surge flow "15 min on - 45 min off" by using T.P.P. treatments were 92.66, 80.06, 71.16 and 53.37 % of the water applied by continuous by sing C.P.P., respectively.

These results showed that, the lowest total amount of water required to complete advance phase was surge flow "15 min on - 45 min off" by using T.P.P. This is due to great reduction in advance time compared to times used by other treatments.

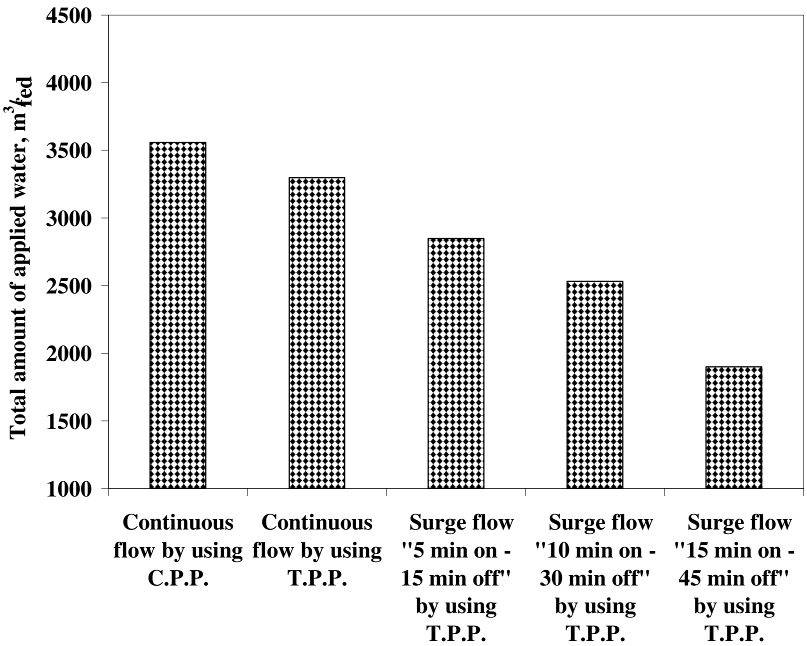

Fig. 4: Total amount of applied water (m^3/fed.) for different irrigation treatments through out the growing season.

1.3. Infiltrated water distribution:

The typical infiltrated water depths for each station is calculated by using the opportunity times with Kostiakov's equation for the cumulative infiltration depth. The infiltrated water depths for all treatments at each location along the furrow are plotted in Fig. 5.

In Fig. 5 shows that weighty difference between continuous flow by using C.P.P. and others treatment at head of the furrow but slight difference among them at lower end of the furrow. Decreasing infiltrated water depth was observed in the upper and lower ends of the furrow under surge flow "15 min on - 45 min off" by using T.P.P.

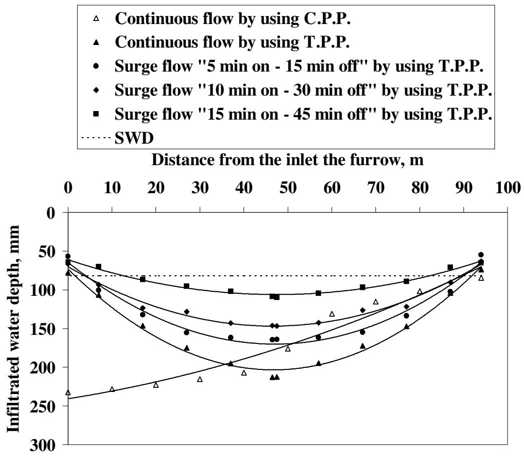

Fig. 5: Infiltrated water distribution curve for different irrigation treatments throughout the growing season.

On the other hand, the soil water deficit (SWD) was expressed numerically as a depth of water indicating the dryness of the root zone at the time of irrigation. This depth is the depth of water required to be replaced in root zone by irrigation, which was 82.07 mm.

Accordingly, slight differences at head and lower end of the furrow occurred between infiltrated water depths and soil water deficit for all treatments, except control treatment which showed a weighty weighty difference between infiltrated water depth and SWD at head of the furrow. The weighty differences exist between depths and SWD at middle of furrow for all treatments, except surge flow "15 min on - 45 min off" by using T.P.P.

Generally, using T.P.P. together with surge flow has off-time (surge flow "15 min on - 45 min off") increased, not only reduce water application depth but also reduce variability of water application depth along a furrow.

2. Performance parameters of furrow irrigation for telescopic perforated pipes with continuous and surge flow irrigation:

2.1. Water application efficiency (E_a) and water application efficiency of low quarter (E_{alq}):

The effectiveness of an irrigation water supply can be increased by improving the efficiency of water application. In Fig. 6, the results clear that, E_a and E_{alq} values were equivalent for continuous flow by using C.P.P. (control treatment) and difference increased between two values by increasing values of E_a and E_{alq}. This means that achievement of 100 % water storage efficiency and resulting D_{pp} higher (51.56 %) for continuous flow by using C.P.P. than other treatments. Therefore, the E_a and E_{alq} values increased whenever the D_{pp} value decreased. Accordingly, a high level of efficiency was readily attainable with only moderate losses in water storage efficiency as shown in Fig. 6. This is in accordance with **Clemmens (1991)**. There is no runoff where blocked furrows, but in this case, deep percolation is the only loss.

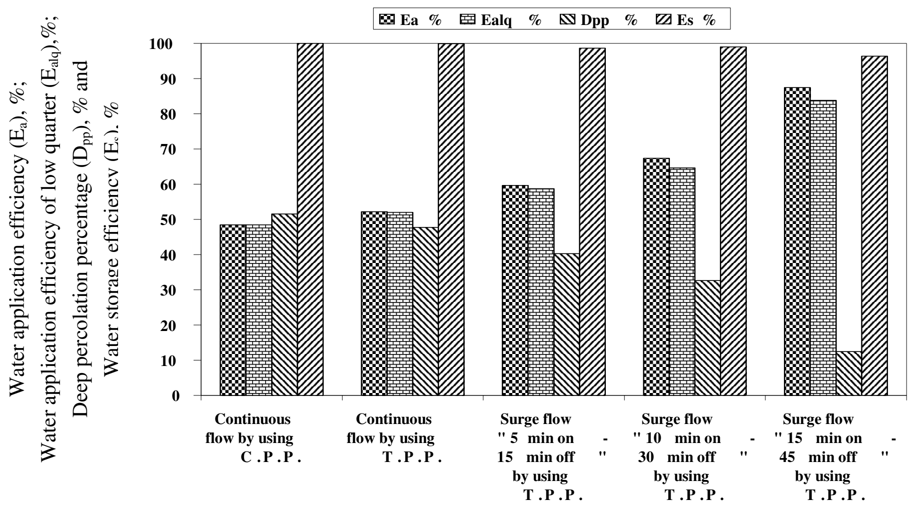

Fig. 6: Water application efficiency, water application efficiency of low quarter deep, percolation percentage and water storage efficiency for different treatments through out the growing season.

Generally, lower E_a and E_{alq}, and higher D_{pp} are observed for continuous flow by using C.P.P. This is due to the very long supply time required for the advance to be completed and hence, the amount of applied irrigation water increased. The case with lower D_{pp}, and high E_a and E_{alq} correspond to surge flow "15 min on - 45 min off" by using T.P.P. This may be due to the long off-time (45 min) which gave quite enough time to redistribute the infiltrated water in the soil profile associated with soil surface sealing and higher advance rate (15 min on-time). In addition to furrow being irrigated divided into two parts under telescopic perforated pipes system, thus, shortening the furrow length reduced the drainage below the root zone and took to water advance rate quickly. These results assure with those of **Morsi (2001)** and **Hanson (2003)**.

2.2. Water distribution efficiency (E_d) and water distribution uniformity (D_u):

The water distribution of the irrigation has an effect in the production of the crops, being considered as one of the most important factors in design and operation of irrigation systems. Fig. 7 illustrated that, the E_d and D_u values by using T.P.P. were increased by 2.43 to 13.61 % and 19.73 to 28.01 % compared with C.P.P., respectively, where the E_d and D_u values for continuous flow by using C.P.P. (control treatment) were 70.65 and 58.45 %, respectively.

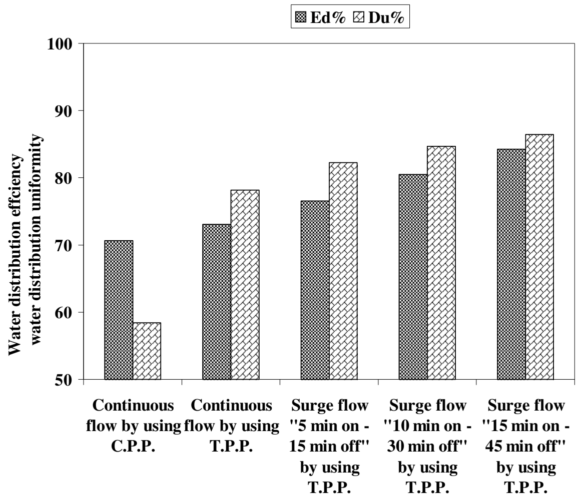

Fig. 7: Water distribution efficiency and water distribution uniformity for different irrigation treatments through out the growing season.

Finally, a trend is observed from Fig. 7 that is, the E_d and D_u values of surge flow "15 min on - 45 min off" by using T.P.P. were the highest. This is attributed to reducing the furrow length (using T.P.P.), which reduced deep percolation and irrigation set time. Also, converting to surge irrigation (15 min on – 45 min off) by increasing the on-time (15 min) or decreasing in total number of irrigation surges which lead to higher advance rate, where increasing pulses may not provide enough improvement in E_d and D_u. Besides, increasing the off-time (45 min) which gives reducing the infiltration rate of soil to the least values via redistribution of the infiltrated water in the soil profile associated with soil surface sealing during the interval time between surges and therefore, reducing differences in infiltration depths along the furrow.

2.3. Crop yield (Y):

The yield of soybean as related to irrigation technique (using continuously and surge applied by telescopic perforated pipes system and conventional perforated pipes system) is showed Fig. 8. The soybean yields for the continuous flow; surge flow "5 min on - 15 min off"; surge flow "10 min on - 30 min off" and surge flow "15 min on - 45 min off" by using T.P.P. were increased by 13.44, 17.31, 25.02 and 40.21 %, respectively, as compared with those under continuous flow by using C.P.P. (control treatment).

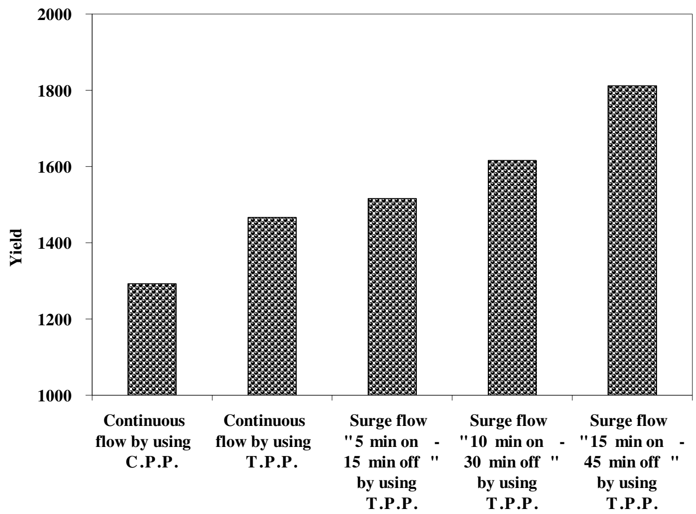

Fig. 8: Yield for different irrigation treatments through out the growing season

From these obtained data, the surge flow which had higher on/off-time "15 min on - 45 min off" by using T.P.P. treatment, recorded the highest yield (1812.16 kg/fed.) because of more uniformity water distribution along the furrow, the improvement of root soil aeration conditions correlated with the relatively less amounts of applied irrigation water and keeping of nutrients. On the contrary, the soybean yield decreased under continuous flow by using C.P.P. as a result of too much water applied during irrigation might have caused high water table depth, partially poor aeration of root and soil nutrients leaching.

2.4. Water use efficiency (WUE):

Water use efficiency (WUE) has reflected the performance of the irrigation system. Fig. 9 shows that higher WUE values were recorded by using T.P.P., especially with surging application. It increased from 22.22 to 163.89 % as compared with using T.P.P.

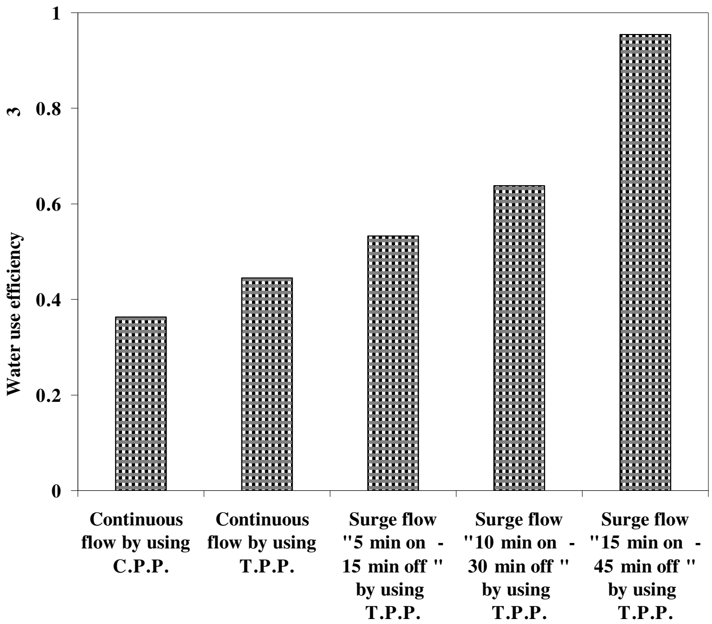

Fig. 9: Water use efficiency for different irrigation treatments through out the growing season.

Accordingly, the maximum WUE value was 0.95 kg/m^3 for surge flow "15 min on - 45 min off" by using T.P.P. The explanation of this result was that surge applied (higher on/off-time) by using developed pipes (T.P.P.) supplies water close to the root zone, so that the crops are able to take up water efficiently. Moreover, this system produces more water saved (less deep percolation) and then, reduced in the total amount of applied irrigation water and increased water distribution uniformity, which leads to achieved good production of grain yield. While continuous flow by using C.P.P. gave the lowest value (0.36 kg/m^3). This means that highest amount of applied water during the irrigation.

3. Economic analysis:

Table 3 indicates that the lowest production (seasonal total) cost was found under surge flow "15 min on - 45 min off" by using T.P.P., as the amount of labor required during irrigation was 50% less than the conventional practice (control treatment) plus minimum operating time and low fuel consumption for irrigation system. Conversely, the highest cost of production was observed under continuous flow by using C.P.P.

Table 3: Economic returns (productivity) analysis of soybean under various treatments.

Items	Continuous flow by using C.P.P. (control)	Continuous flow by using T.P.P.	Surge flow "5 min on - 15 min off" by using T.P.P.	Surge flow "10 min on - 30 min off" by using T.P.P.	Surge flow "15 min on - 45 min off" by using T.P.P.
1- Seasonal cost of irrigation system (L.E./ fed.)	1406.47	1063.82	972.63	910.03	784.84
2- Seasonal cost of cultivation (L.E./ fed.)	644.16	648.95	650.33	653.08	658.50
3- Seasonal total cost (L.E./ fed.) ***by (1+2)***	2050.63	1712.77	1622.96	1563.11	1443.34
4- Water used (mm)	847.10	784.93	678.18	602.83	452.12
5- Yield of production (Mg/fed.)	1.29	1.47	1.52	1.62	1.81
6- Income from produce (L.E./fed.)	3231.06	3665.33	3790.34	4039.46	4530.41
7- Net seasonal income (L.E./fed.) ***by (6-3)***	1180.43	1952.56	2167.38	2476.34	3087.07
8- Benefit-cost ratio ***by (7/3)***	0.58	1.14	1.34	1.58	2.14
9- Net profit per mm of water used (L.E.) ***by (7/4)***	1.39	2.49	3.20	4.11	6.83

C.P.P. = Conventional perforated pipes.
T.P.P. = Telescopic perforated pipes.

To show the economic returns to water management, In terms of net seasonal income and benefit-cost ratio, surge flow "15 min on - 45 min off" by using T.P.P. gave the highest return (3087.07 L.E./fed.) and ratio (2.14), because of it had the highest yield and lowest cost. Also, the net profit per mm of water used was obtained to be highest (6.83 L.E.) in case of surge flow "15 min on - 45 min off" by using T.P.P., by reason of decreasing amount of applied irrigation water as well as lessening water losses.

Finally, the overall observation is that depending on the availability of water and labor resources, one can decide to use either of the irrigation management options to obtain economically reasonable yield.

CONCLUSIONS

From the previously mentioned results in the study can be concluded in the following points:

1- Completion of the advance phase required less time (127.33 min) and lowest total amount of water (1899.08 m^3/fed.) in the surge flow "15 min on - 45 min off" by using T.P.P. than in those irrigated continuously by using C.P.P. (224.83 min and 3558.14 m^3/fed.).

2- The lowest deep percolation percentage (D_{pp}) (12.53 %), and highest water application efficiency (E_a) (87.47 %) and water application efficiency of low quarter (E_{alq}) (83.84 %) correspond to surge flow "15 min on - 45 min off" by using T.P.P. with only moderate losses in water storage efficiency (E_s).

3- The water distribution efficiency (E_d) (84.26 %) and water distribution uniformity (D_u) (86.46 %)values of surge flow "15 min on - 45 min off" by using T.P.P. were the highest.

4- The surge flow, which had higher on/off-time "15 on - 45 off" by using T.P.P., recorded the highest yield for soybean crop (1812.16 kg/fed.) and water use efficiency (WUE) (0.95 kg/m^3).

5- Surge flow "15 min on - 45 min off" by using T.P.P. gave the highest net seasonal income (3087.07 L.E./fed.) and benefit-cost ratio (2.14).

REFERENCES

Abd El-Latif, Z. Y. (1978). Evaluation of some of the surface irrigation methods. M. Sc. Thesis, Agric. Eng. Dep., Fac. of Agric., Al-Azhar Univ., Egypt.

ASAE (2003). Evaluation of irrigation furrows. ASAE, EP 419.1, pp. 883 – 888.

Bautista, E. and W. W. Wallender (1985). Spatial variability of infiltration in furrows. Transactions of the ASAE, 28 (6): 1846 – 1851, 1855.

Blair, A. W. and E. T. Smerdon (1987). Modeling surge irrigation infiltration. Journal of Irrigation and Drainage Engineering, ASCE, 113 (4): 497 – 515.

Clemmens, A. J. (1991). Irrigation uniformity relationships for irrigation system management. Journal of Irrigation and Drainage Engineering, ASCE, 117 (5): 682 – 699.

El-Saadawy, M. A; A. A. Mohamed and A.M. Bahnasy (2004). Effect of plowing depth on water requirement, draft force and soybean yield at Etay El Baroud region. 12th Annual conference of Misr J. of Agric. Eng., 21 (4): 285 – 296.

El-Tantawy, M. T.; H. E. Osman; S. S. Hassan and S. I. El-Khatib (2000). Evaluation of surface irrigation under perforated pipe on sugercane in old valley. 8th conference of Misr Socity, Agric. Eng. 25- 26 October 2000, pp. 23 – 33.

El-Yazal, M. N.; S. S. Hassan and M. T. El-Tantawy (2002). Effect of land leveling on maize crop under perforated irrigation pipes in old land. Misr J. Agric. Eng., 19 (2): 437 – 454.

Evans and Leib (2001). Surge flow surface irrigation. Washington State University Cooperative Extension and the U.S. Department, pp. 1.

Guirguis, A. K. (1988). Evaluation studies of surge flow furrow irrigation. M. Sc. Thesis, Agric. Eng. Dep., Fac. of Agric., Alex. Univ., Egypt.

Hanson, B. R. (2003). Options for reducing nonpoint pollution from surface irrigated fields though improved irrigation. Pp. 367-374 in Total Maximum Daily Load (TMDL) Environmental Regulations–II Proceedings of the 8–12 November 2003 Conference. ASAE Publication Number 701P1503.

Hunt, D. (1983). Farm power and machinery management. 8th Ed. Lowa State Univ. Press, Ames., USA, pp. 59 – 71.

James, L. G. (1988). Principle of farm irrigation system design. John Willey & Sons. Inc., Washington State University, pp. 100.

Kanber, R.; H. Köksal; S. Önder; S. Kapur and S. Sahan (2001). Comparison of surge and continuous furrow methods for cotton in the Harran plain. Agric. Water Manage., 47: 119 – 135.

Kassem, M. A. and M. T. El-Tantawy (2000). The effect of the off-time period in surge irrigation on the application efficiency and water distribution uniformity. Misr J. Agric. Eng.,17 (2):374 – 387.

Kepner, R. A.; R. Bainer and E. L. Barger (1982). Principle of farm machinery. The AVI publishing Co. Inc. West Port, Comecticut, pp. 392 – 431.

Krinner, W. A., A. Garcfa and F. Estrada (1994). Method for estimating efficiency in Spanish irrigation systems. J. of Irrig. and Drain. Eng. ASCE. 120 (5): 979 – 986.

Lay, T. W. and B. Leib (2001). Surface irrigation systems. Washington State University Cooperative Extension and the U.S. Department of Agriculture, pp. 1.

Mattar, M. A. (2001). Relationship between plough methods and surge irrigation and its effect on water rationalization M. Sc. Thesis, Fac. of Agric., Agric. Mech. Dept., Kafr El-Sheikh, Tanta Univ., Egypt.

Morcos, M. A.; A. F. El-Sahrigi; M. Hanafy and S. S. Hassan (1994). A mathematical approach to predict the pressure head inside the perforated tubes. Misr J. Agr. Eng. 11 (4): 1041 – 1065.

Morsi, T. M. (2001). Developing of furrow irrigation method for corn crop under local conditions. M. Sc. Thesis, Fac. of Agric., Agric. Mech. Dept., Kafr El-Sheikh, Tanta Univ., Egypt.

Omara, A. I. (1997). Implementation and evaluation of gated pipe for furrow irrigation system. M. Sc. Thesis, Fac. of Agric., Agric. Eng. Dept., Alex. Univ., Egypt.

Osman, A. M.; M. M. Attia; H. El-Zaher and M. A. Sayed (1996). Surge flow irrigation in calcareous soil, 1- Furrow advance time function and applied water. J. Agric. Sc. Mansoura Univ., 21 (10): 3671 –3678.

Samani, A. Z.; W. R. Walker and L. S. Willardson (1985). Infiltration under surge flow irrigation. Transactions of the ASAE, 28 (5): 1539 – 1542.

Smith, R. J., S. R. Raine and J. Minkevich (2005). Irrigation application efficiency and deep drainage potential under surface irrigated cotton. Agric. Water Manage., 71: 117 – 130.

Smith, R. J., P. J. Watts and S. J. Mulder (1986). Analysis and design of gated irrigation pipelines. Agric. Water Manage., 12: 99 – 115.

Trout, T. J. (1991). Surface seal influence on surge flow furrow infiltration. Transactions of the ASAE, 34 (1): 66 – 72.

Walker, W. R. (1989). Guidelines for designing and evaluating surface irrigation systems. Irrigation and Drainage paper 45. FAO, Rome, Italy.

Wang, W. Y.; W. Luo and Z.-R. Wang (2005). Surge flow irrigation with sediment-laden water in northwestern China. Agric. Water Manage., 75: 1 – 9.

Zein El-Abedin, T. K. and S. M. Ismail (1998). Infiltration rate under surge irrigation regime. Misr J. Agric. Eng., 15 (2): 413 – 430.

إسماعيل س. م. (٢٠٠٢). تصميم وإدارة نظم الري الحقلي. الطبعة الأولى ، منشأة المعارف بالأسكندرية ، ص ٦٣٤.

الملخص العربي

تطوير الأنابيب المثقبة لتحسين أداء الري السطحي

إسماعيل أحمد عبد المطلب* محمد عادل السعداوى فتحي إبراهيم هندي*** محمد عبد العزيز مطر******

الري السطحي من أقدم وأكثر طرق الري استعمالاً في مصر ، وتشكل متطلبات العمالة في الري السطحي التكلفة الباهظة بالإضافة إلى الإدارة غير الصحيحة ونسبة فقد عالية في المياه مما يؤدي إلى انخفاض كفاءة الري السطحي. الهدف الرئيسي من هذه الدراسة هو تحسين أداء الري السطحي والتقليل من بعض العواقب غير المرغوبة عن طريق تطوير نظام الري بالأنابيب المثقبة. تم إجراء التجارب الحقلية لتقييم النظام المطور على محصول فول الصويا "صنف جيزة ١١١" خلال موسم النمو الصيفي ٢٠٠٤ من خلال تقدير كفاءات الإضافة والتوزيع واستخدام المياه. وكان التصرف المستعمل في هذا الاختبار ٠,٨٣ لتر/ثانية لكل خط ري ذو النهاية المغلقة.

بينت النتائج إعطاء معاملات الري النبضي باستخدام نظام الري بالأنابيب المثقبة التلسكوبية أسرع زمن تقدم للمياه وخصوصاً مع أكبر أزمنة غلق. ووفر الري النبضي "١٥ دقيقة فتح – ٤٥ دقيقة غلق" باستخدام نظام الري بالأنابيب المثقبة التلسكوبية كمية المياه بحوالي ٤٦,٦٣ ٪ مقارنة بالكمية المضافة للري المستمر باستخدام نظام الري بالأنابيب المثقبة التقليدية. وأيضاً ، سجلت هذه المعاملة أقل نسبة تسرب عميق ، وأعلى كفاءة إضافة للمياه ، وإضافة لأقل ربع ، وكفاءة توزيع وانتظامية توزيع للمياه. وفي النهاية ، يمكن استعمال نظام الري بالأنابيب المثقبة التلسكوبية مع السريان النبضي لتوفير وحفظ المياه ، وزيادة قيمة إنتاجية محصول فول الصويا وصافي الدخل الموسمي للمزارعين.

---

* أستاذ الهندسة الزراعية – قسم الهندسة الزراعية – كلية الزراعة – جامعة كفر الشيخ.

** باحث أول – معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – وزارة الزراعة واستصلاح الأراضي.

*** أستاذ الهندسة الزراعية المساعد – قسم الهندسة الزراعية – كلية الزراعة – جامعة كفر الشيخ.

**** باحث مساعد – معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – وزارة الزراعة واستصلاح الأراضي.