

Effect of Tillage on Water Advancing and Distribution Under Surge and Continuous Furrow Irrigation for Cotton in Egypt

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Abstract

The experiment was conducted in the clay soil of the Agriculture Experimental Station, Assiut University, Assiut, Egypt. The furrows with blocked ends were 76 cm long and 0.70 m width with 0.0024 m/m of slope. To monitor the advance time, six points were established along the furrows at 9, 18, 27, 36, 45 and 76 m from the inlet. Soil moisture content was measured with gravimetric method at 0-0.25 m and 0.25-0.50 m depths at the beginning, middle and end of the furrows. Hand hoeing tillage system (HH) was compared with weed control tillage system (WC) under continuous flow (CF) and surge flow irrigation (SF). HH decreased the water advance time compared to WC either under continuous or surge flow irrigation. SF also decreased the advance time compared to CF. The greatest effect on the advance time reduction resulted from the combined effect SFHH treatment, which reduced the total supplied water by 22.4 % and 25.7 % during first and second irrigation, respectively compared to the other treatments. Combining surge irrigation and tillage could be an efficient method to use irrigation water efficiently and ensure uniform distribution of soil water.

Résumé

L'essai a été mené dans la station expérimentale de l'Université d'Assiut en Egypte sur un sol de type argileux. Les raies d'irrigation, fermées à leurs extrémités, mesuraient 76 m de long et 0.70 m de large avec une pente de 0.0024 m/m. Six points de mesure choisis le long de chaque raie (9, 18, 27, 36, 45 et 76 m) ont servi pour mesurer le temps de progression de la lame d'eau. L'humidité du sol a été mesurée par la méthode gravimétrique aux profondeurs 0-0.25 m et 0.25-0.50 m au début, milieu et fin des raies. Le grattage à la daba était comparé au désherbage mécanique en conditions d'irrigation en continue et par intermittence. Le grattage à la daba a réduit le temps de progression en comparaison au désherbage mécanique aussi bien en irrigation continue que par intermittence. L'irrigation par intermittence a réduit la vitesse de progression de la lame comparée à l'irrigation en continue. Le plus grand impact de la réduction du temps de progression de la lame a été le résultat de l'effet combiné de la lame d'eau par intermittence et du travail du sol, ce qui a réduit l'apport en eau respectivement de 22.4% et 25.7% au cours de la première et seconde irrigations. La combinaison « travail du sol et irrigation par intermittence » pourrait être une méthode efficace d'utilisation de l'eau d'irrigation et pourrait assurer une distribution uniforme de l'eau dans le sol.

1. Introduction

Surge flow irrigation improve the application efficiency by advancing the water rapidly along the furrows, which lead to reduce deep percolation and runoff losses, also to obtain a uniform wetting of the root zone, with minor differences in the infiltration depth at the beginning and at the end of a furrow. Surge flow irrigation has its maximum effect during first irrigation in the season but by introducing tillage, the surge effects can be extended for second and sub-subsequent irrigations during the season. The presence of cracks during irrigation leads to increases infiltration rates and decrease run-off in fine-textured soil (Novak et al., 2000). Tillage re-shapes the furrow beds and decrease furrow roughness which lead to faster advance for water along the furrows. Some packing of the soil surface in addition to destroying the cracks will occur during the re-shaping process that lead to reduce infiltration of the irrigation water. Kanber et al (2001) found that surge flow irrigation reduced the water

intake of a surface soil loosened by tillage by 13-23% as compared to continuous flow, thus manifesting an incomparable advantage to the level furrow systems. The objective of this study was to investigate the effect of the tillage system on the water movement in clay soil under surge flow irrigation and compare it with continuous flow.

2. Materials and methods

The experiment was carried out at the Agriculture Experimental Station, Assiut University, Assiut, Egypt. The soil was classified as a clay soil. The blocked end furrow length was 76 m and the width was 0.70 m, the slope was 0.0024 m/m. To monitor the advance time, six points were established along the furrows at 9, 18, 27, 36, 45 and 76 m from the inlet. Water content was measured in two different depths (0 – 0.25 and 0.25 – 0.50 m) at the beginning, middle and end of the furrows by gravimetric method. The samples were collected before and after 24 h of irrigation for measuring the soil water content. Two tillage systems were studied; hand hoeing system (HH) to loosen the soil surface, reshape furrow bed and destroying the cracks and weed control (WC) system to get rid of weed without disturbing the soil surface. Four treatments were followed, continuous flow with weed control system (CFWC), continuous flow with hand hoeing system (CFHH), surge flow with weed control system (SFWC) and surge flow with hand hoeing system (SFHH). The recommended discharge to use in the experimental station is 0.8 /s with 30 minutes cycle time and 0.5 cycle ratio (Ismail et al 2004). Cotton seeds were cultivated on March 22, 2004 with an intense continuous irrigation set. After germination and before starting first irrigation the tillage treatments were applied. The irrigation performance parameters such as application efficiency (E_r), distribution uniformity (DU) and deep percolation (DP) were used to compare the irrigation methods performance.

3. Results and discussion

3.1. Advance time

The results revealed that the advance time required to reach the water to the end of the furrows was less in HH furrows than in WC furrows either under continuous or surge flow irrigation (Fig. 1). The reduction in advance time was almost the same in both irrigation methods as affected by tillage. Moreover, the reduction in advance time in second irrigation was smaller than in first irrigation.

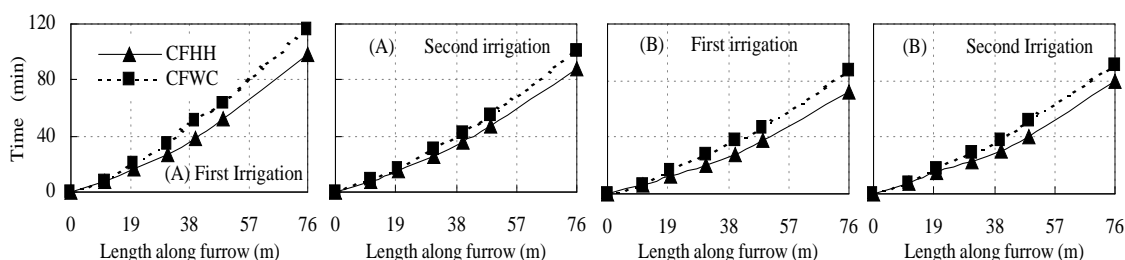


Figure 1 Effect of tillage on water advance in continuous and surge flow, (A and B, respectively) during first and second irrigation.

The advance trajectories presented in figure 2 show the combined effect of surge and tillage on water advance compared to continuous flow for first and second irrigation. Surge flow irrigation tends to decrease the advance time compared to continuous flow for the same tillage system under first and second irrigation and resulted in a remarkable reduction in water supply which was gradually varied among the treatments as follows: the greatest reduction in water supply resulted from the combined effect of surge SFHH. The reduction was 22.4% and 25.7% for first and second irrigation, respectively followed by CFHH, which reduced the water supply by 15.5 and 12.9 for first and second irrigation, respectively. The reduction in water supply for the SFWC was 9.5 for first irrigation and 10.9 for second irrigation (table 1).

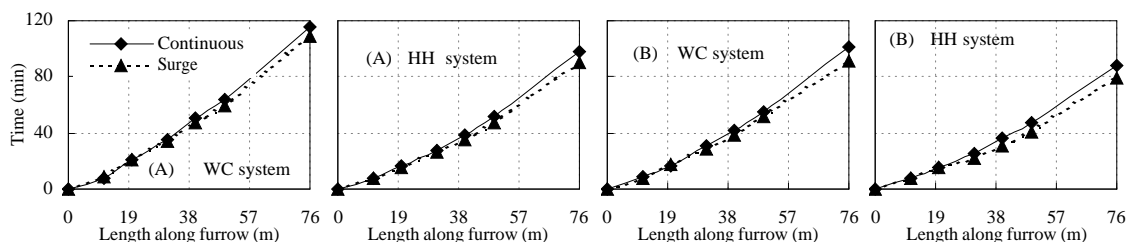


Figure 2 Effect of surge flow irrigation on water advance along the furrows for first and second irrigation (A and B respectively) under both tillage systems.

The reduction of the advance time and infiltration rate for CFHH compared to CFWC was due to cracks refilling. The presence of cracks in CFWC increase infiltration rate and advance time because of the large surface area of the cracks, which involved in the infiltration process. While, tillage practice in CFHH decreased the infiltration rate and consequently advance time because the furrow beds were re-shaped and the large surface area of cracks were removed as a result of cracks break down by tillage. The improvements in SFHH treatment resulted from several reasons beside cracks refilling such as: a) surface sealing, as water infiltrates after the first pulse, lubricated particles in the surface soil may be reoriented horizontally and in a plate fashion that would greatly reduce infiltration in the wetted section of the furrow; b) deposition of suspended sediment, when the supply is interrupted before the water reaches the end of the furrows, the suspended sediment is deposited on the furrow bed leads to reduce the intake rate up to 50%. Consolidation, redistribution of infiltrated water and entrapped air were also involved in the reduction of water advance and infiltration (Samani et al 1985; Novak et al., 2000).

3.2. Water content distribution

The results presented in figure 3 indicated that both tillage systems under surge flow irrigation distributed the water uniformly along the furrow in the first and the second irrigation compared to continuous flow. The infiltration profile for SFHH and SFWC was straight lines with minor differences between beginning and end of the furrow, while the infiltration profile for CFWC and CFHH was curved line with large differences between beginning, middle and end of the furrow. The best distribution resulted from the treatment of SFHH in both irrigation events. When water contacts the soil for the first time in a furrow, the infiltration rate is high. As the water flow continues the infiltration rate at a certain point in the furrow is reduced to a near constant rate. When the water is shut off and allowed to infiltrate as in surge flow, the surface soil particles consolidate and form a seal in the furrow.

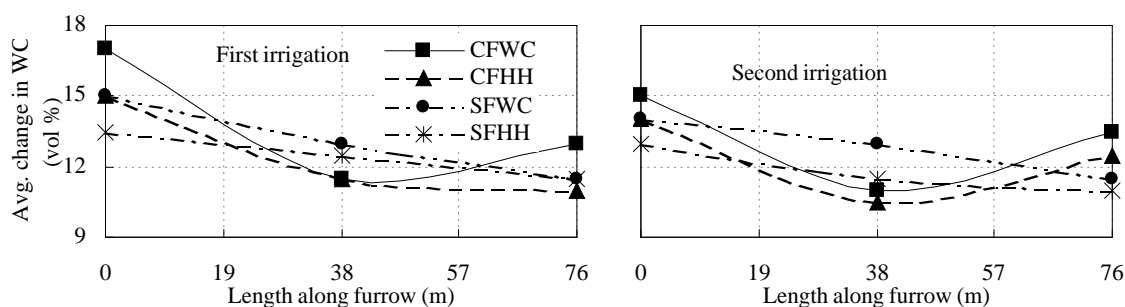


Figure 3 Average change in soil water content for continuous and surge flow irrigation under both tillage systems.

When the water is reintroduced to the furrow, the intake rate can be reduced resulting in more water movement down the furrow and rapid advance of the wetting front than with continuous and resulted in a more uniform distribution of water intake over the length of the furrow. In continuous flow the water was stayed on the soil at the beginning longer than on

the soil at the end resulted in more water infiltrated at the beginning and less water infiltrated at the end of furrows, which lead to low distribution uniformity along the furrows. The furrow slope with the blocked end lead to water accumulation at the lower end of the furrows resulting in more water infiltrated and retained at the end than at the middle of the furrows consequently, curved distribution was expected (Fig. 3).

3.3. Irrigation performances

The deep percolation losses were calculated by deducting the total water stored in the upper 0.5 m of soil surface from the total water supply (table 1). The results indicated that the highest application efficiency and distribution uniformity as well as the lowest deep percolation were obtained from SFHH treatment, (E_r , 77%- DU, 92% and DP, 23%) for first irrigation and (E_r , 87% - DU, 94% and DP, 13%) for second irrigation. During the first irrigation, the performance parameters (E_r , DU, and DP,) of SFWC were less than in CFHH, while these performance parameters were higher in the treatments of surge flow than in continuous flow during second irrigation (table 1). In short furrows, it is easy to control the flow of the water especially with siphons and constant head channel resulting in high irrigation performance parameters. The lower values of performance parameters for SFWC compared to CFHH were due to the presence of cracks. Under surge flow irrigation in fine-textured soil with cracks the infiltration may further increase because cracks reverse the effect of soil consolidation to reduce the soil intake rate (Samani et al 1985).

Table 1 Evaluation of continuous and surge flow irrigation under both tillage systems

Irrigation Event	Treat.	Inflow time min	Water supply mm	Stored water at 0.5 m depth in mm	Reduction in water sup. (%)	(DP %)	(E_r %)	(DU %)
First irrigation	CFWC	116	105	69	0.0	34	66	86.8
	CFHH	98	88	63	15.5	29	71	89.8
	SFWC	105	95	66	9.5	31	69	87.6
	SFHH	90	81	63	22.4	23	77	92.0
Second irrigation	CFWC	101	91	66	0.0	28	72	87.1
	CFHH	88	79	62	12.9	22	78	88.4
	SFWC	90	81	64	10.9	21	79	89.3
	SFHH	75	68	59	25.7	13	87	93.6

4. Conclusions

Surge flow irrigation decreased the advance time compared to continuous flow. Hand hoeing tillage system led to decrease the advance time compared with weed control tillage either under continuous or surge flow irrigation. The SFHH reduced the total water supply by 22.4% and 25.7% during first and second irrigation compared to the other treatments. Tillage and surge effects distributed the irrigation water uniformly along the furrow length compared with continuous flow treatments. Application efficiency and distribution uniformity increased under the combined effect of surge with tillage. Tillage with surge flow decreased the advance time, decreased total water supply, increase the efficient water use and distributed the water uniformly along the furrows.

5. References

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