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# EFFECTS OF TILLAGE DEPTH AND CYCLE RATIO ON PERFORMANCE OF SURGE IRRIGATION

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Performance of surge irrigation was analysed with special emphasis on the rate of water front advance for various cycle ratios and tillage depths. Water advance is slower in surge irrigated furrows than those with continuous irrigation. Reasons for the response have been explained. Smaller cycle ratio combined with larger tillage depth increased the rate of water front advance. A uniform distribution of water in the soil profile throughout the length of field encourages continued efforts to gain more information about surge irrigation.

## INTRODUCTION

A primary goal of surface irrigation is to complete the advance of water as quickly as possible in order to minimize infiltration. The advance time difference in the upper and lower ends of a field causes a non-uniformity in the depth of water infiltrated. This non-uniformity can be reduced by increasing stream discharge, reducing the length of field, introducing a slope in the field, etc. Each method has its limitations and a varying degree of success.

Another method for decreasing the non-uniformity of water distribution over the entire field is surge irrigation defined as, "Intermittent application of water in furrows or borders creating a series of on and off modes of constant or variable cycle time" (Bishop *et al.,* 1981). Various aspects of surge irrigation have been studied by previous investigators (Phillip *et al.,* 1982; Samani *et al.,* 1985; Evans *et al.,* 1987). They have investigated several parameters affecting surge irrigation performance, however, the effects of tillage depth on surge performance have not been studied. Tillage depth may possibly alter the advance rate of water front. Therefore, the present study was undertaken with the following specific objectives:

1. To compare the performance of surge and continuous flow irrigation methods in furrows under the typical soil and field conditions of this region.
2. To determine the effects of changes in tillage depth and cycle ratio on advance rate of the water front.
3. To investigate the interaction of tillage depth with surge and continuous irrigation and cycle ratio.

## MATERIALS AND METHODS

The experiment was conducted at the University of Agriculture, Faisalabad, on a sandy clay loam soil. The field was a corn stubble having little organic matter with nearly a flat slope and a length of 55 meters which is a typical field length in this region. The field was divided into three equal size blocks each designated for one tillage treatment. The following tillage treatments were used to investigate the effect of tillage depth on advance rate of water front in surge and continuous irrigation methods:

| Treatment | Implement | Depth of operation |
|---|---|---|
| A | Chisel plow | 10 cm |
| B | Chisel plow | 20 cm |
| C | Chisel plow | 40 cm |

In all the above plots, field chiseling was followed by two passes of rotavator at about 7-10 cm depth. Four furrows were manually prepared in each block. The furrows were 22 cm deep with a top width of 38 and spaced 75 cm apart. The furrows were randomly assigned to the cycle ratios of 1, 1/2, 1/3 and 1/6. The cycle ratio one implied continuous flow. The field data collection and procedure of analysis is given as follows:

**a. Management of surges:** The supply from a water course was diverted into a small reservoir especially constructed at the front side of the furrows (Fig. 1). The 75 cm deep reservoir helped maintain constant head of water during irrigation of furrows. Water was applied to the furrows using 3.2 cm dia hoses as siphons. A tapered wooden peg was used to open/close each siphon when desired. That is how on-off mechanism was operated in the experiment to generate surges.

**b. Timing the water front advance:** The stakes were placed in furrows at an interval of 5 m starting from the steam end. Times were recorded when the water front reached each stake. Only one furrow was irrigated at a time for convenience of operation and control. The cycle ratio of 1/2, 1/3 and 1/6 were arranged by selecting on-time to total cycle time ratios of 15-30, 10-30, and 05-30 minutes, respectively. However, on-time was progressively increased while keeping the cycle ratio constant urging later surges for all the furrows. Irrigation of a furrow was considered complete when advancing water front just reached the far end of the furrow. The surge advance times were then simply added in order to get the cumulative advance time data that were analysed (Mahmood, 1991).

## RESULTS AND DISCUSSION

### a. Advance Time

**i. Surge vs continuous flow:** Cumulative advance times of the water fronts in surge and continuous flows (Fig. 2) suggest that continuous irrigation was about 17% faster compared with surge method. This observation contradicts Bishop *et al.* (1981) who reported 3-4 times faster advance of water front in surge than continuous method of field irrigation. Their finding is more dramatic than those reported by others such as Phillip *et al.* (1982) and Evans *et al.* (1987). However, it was common in all the studies that the rate of water advance in surge irrigation was faster compared with continuous method. The results of the present experiment were contrary to those of the previous studies.

Most of the past research in surge irrigation was conducted on fine textured soils with slopes varying from 1-3%. On the contrary, in the present investigation, the field was nearly flat with a loam soil. This may partly explain the contradiction and also suggest surge irrigation as an inappropriate method for a level field and light soils. In addition, the unexpected performance of surge irrigation may be associated with a wrong selection of discharge and/or cycle ratios for the given soil type.

**ii. Cycle ratio:** Trajectories of cumulative advance times for various cycle ratios are given in Fig. 3. The cycle ratios of 1/3 and 1/6 required lesser time to complete the

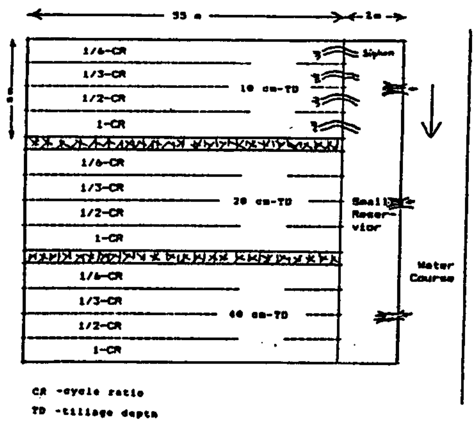


Fig.1.

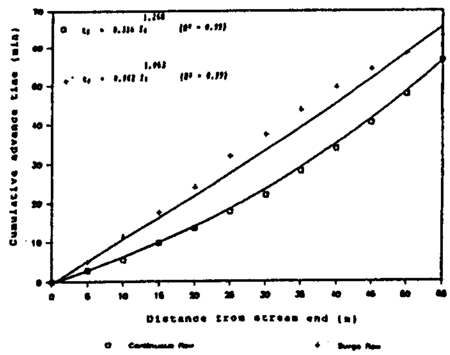


Fig. 2.

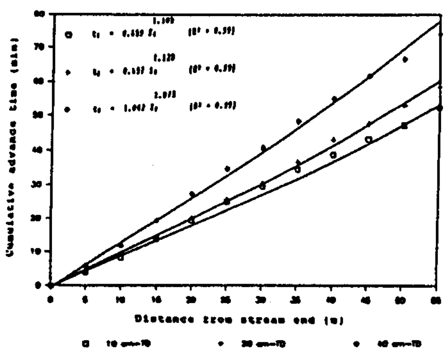


Fig. 3.

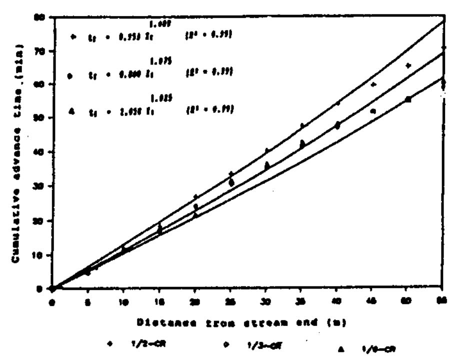


Fig. 4.

Fig. 1. Field layout.

Fig. 2. Effect of method of irrigation on cumulative advance time of water front.

Fig. 3. Effect of tillage depth on cumulative advance time of water front.

Fig. 4. Effect of cycle ratio on cumulative advance time of water front.

advance phase compared with cycle ratio of 1/2. A similar observation has been recorded by Izuno *et al.* (1985) who observed shorter time as the off-time increased or the cycle ratio decreased. In fact, during a longer off-time or smaller cycle ratio, finer soil fractions find enough time to move into soil pores and reduce infiltration capacity of soil in the subsequent surges. Thus a shorter cycle ratio appears beneficial. However, its interaction with soil type should be watched carefully.

**iii. Tillage depth:** Cumulative advance times for three levels of tillage depths averaged across the cycle ratios are presented in Fig. 4. The advance times for water front to reach the far end of the furrows were 52, 58 and 74 minutes in the plots tilled to 10, 20 and 40 cm soil depths, respectively. The increase in advance time with increasing tillage depth was expected as the soil was rather loose to a greater depth in deeply tilled plots. Obviously deep tillage associates with it a penalty in terms of additional water compared with shallow plowing even in surge method of irrigation.

**iv. Interaction of cycle ratio and tillage depth:** Of greater importance was the differential response of cycle ratio and tillage in this experiment. Analyses of the data revealed that generally smaller cycle ratio and larger tillage depth had desirable effects on cumulative advance time. In short, the smallest cycle ratio was the most efficient in the deepest tilled plots for surge irrigation under conditions of this experiment.

**b. Cristiansen's uniformity coefficients (UCC)**

The UCC is an index of water distribution pattern in soil profile over the entire length of field/furrow. The value of UCC for surge irrigated furrows was higher than continuously irrigated ones. The surge irrigation produced uniform distribution of water in the soil profile throughout the length of run. A better uniformity coefficient was, perhaps an advantage of surge irrigation that appeared from the present investigation and encouraged a continued effort to gain more information about surge irrigation before its application at farmer's level.

## CONCLUSIONS

1. Surge irrigation required 17% more time compared with continuous flow to complete the advance phase. This unexpected performance of surge was considered to be associated with nearly flat field, light soil and a small discharge incapable of modifying soil porosity before next surge. A very careful selection of discharge, field length, slope and furrow geometry may prove the worth of surge irrigation.
2. The advance of water front was faster in the plots with 1/3 and 1/6 cycle ratio than 1/2 cycle ratio.
3. Generally, a combination of a smaller cycle ratio and a larger depth had a desirable effect in completing the advance phase of irrigation.
4. The surge irrigation produced uniform distribution of water in the soil profile both at near and far ends of the field.

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