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Examining advance time of furrow irrigation at Koga irrigation scheme in Ethiopia

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Abstract: Koga irrigation scheme was developed to irrigate about 7004 ha. Furrow irrigation is the recommended method for the distribution of water. However, furrow irrigation has inherent inefficiencies due to deep percolation on the upper end and runoff at the lower end of the furrow. These losses depend on furrow length, furrow gradient, surface roughness, stream size and cutoff time. These factors play significant role to influence the advance time of irrigation and the operation rule of the scheme. This paper examines the advance time of furrow irrigation at Koga. The experiment was conducted during 2012 irrigation season in two periods (February and April). The advance time of irrigation was monitored at three discharge rates and four furrow gradients at 90–110 m furrow length. The required discharge was measured using RBC flume. The average advance time at respective discharge rates of 0.3, 0.6 and 0.8 litre/sec range from 290–460 min, 150–437 min and 100–294 min during 1st irrigation; and 115–370 min, 78–189 min and 43–217 min during 2nd irrigation. The advance time vary greatly among the discharge rates when the furrow length increases. The advance time of water at 0.5, 1.0, 2.0 and 2.5 % gradients was 236, 181, 197 and 398 min at 1st irrigation and 163, 175, 220 and 88 min at 2nd irrigation respectively. Furrow gradients and surface irregularities result in great variation of advance time. The advance time becomes shorter when the field gets smoother during 2nd irrigation. Under non-levelled and irregular field conditions, 0.6–0.8 litre/sec application rate can be suggested to irrigate 30–40 m furrow lengths in order to improve application efficiency above 60% and to optimize the daily operation rule of the overall scheme. The result of this study indicates the relevance of examining the furrow length, discharge and application time recommended in the feasibility study of irrigation schemes.

Key words: Koga, furrow length, advance time, discharge rate, furrow gradient

Media grab: Efficient operation and management of irrigation schemes can be enhanced when there is field testing and reexamining the irrigation design characteristics recommended during the feasibility study.

Introduction

Koga irrigation scheme was developed to irrigate about 7004 ha land. Given the wide range of slopes and the low degree of using advanced techniques in the area, furrow irrigation is the preferred method and recommended for the distribution of water to the fields. However, most surface irrigation systems have inherent inefficiencies due to deep percolation on the upper end and runoff at the lower end of the field. A well-designed and properly managed surface system can attain efficiencies of 60% or better (Waskom 1994). In a study conducted by Kassa (2003) at Melka Werer, Middle Awash Valley, with a furrow length of 200 m and different water inflow rates, the maximum attainable application efficiency of furrow irrigation is 62 to 64%.

The strategies to improve furrow irrigation efficiencies revolve around reducing runoff and deep percolation losses. These losses depend on furrow length, furrow gradient, discharge and cutoff time which in turn need to be optimized by irrigators to improve efficiency. These furrow design parameters should be chosen with analysis of local field conditions. Therefore, this paper presents the advance time of furrow irrigation based on field data from Koga under different discharge rates and slope gradients.

Methods

The advance time of irrigation was recorded at different furrow gradients and discharge rates. The Koga dam and irrigation project feasibility study was taken as the base to set up the experimental factors. Since levelling was not done for the whole scheme, the average slopes of the study sites were taken as furrow gradients. Accordingly, four furrow gradients (0.5, 1, 2 and 2.5 %) were chosen at different sites. The tested furrow discharges were purposively selected out of the recommended discharge sizes in the feasibility study. Three discharges (0.3 litre/sec, 0.6 litre/sec and 0.8 litre/sec) were considered. Three adjacent furrows of length 90–110 m are prepared.

The central furrow was used as an experimental furrow while the two adjacent furrows receiving equal discharge with the centre furrow were used as buffers. Two measuring RBC flumes were placed at the beginning and end of each centre furrow. The application was terminated when the stream flow through the outlet remains at steady flow. Wooden stakes were installed along each furrow at 10 m interval where advance time was recorded. The travel time of water advancing through the furrow (advance time) was recorded at each wooden mark of 10 m length using stopwatch. The advance time was recorded in two irrigation cycles, first irrigation period (February) and second irrigation period (April).

Results and discussion

Figures 1 to 3 present the advance time recorded at different discharge rates and furrow gradients with furrow spacing of 40 cm during first and second irrigation periods. It is clearly revealed that discharge played great role in the variation of the advance time. In fact, the advance time also varied from site to site. Regardless of differences in discharge rates, on average the advance time range from 180–400 min and 88–220 min between sites at first and second irrigation, respectively. This was attributed to differences in surface roughness, slope and field levelling or depressions. In the first irrigation, due to the confounding effect of high surface roughness, the effect of furrow gradient was not clearly observed.

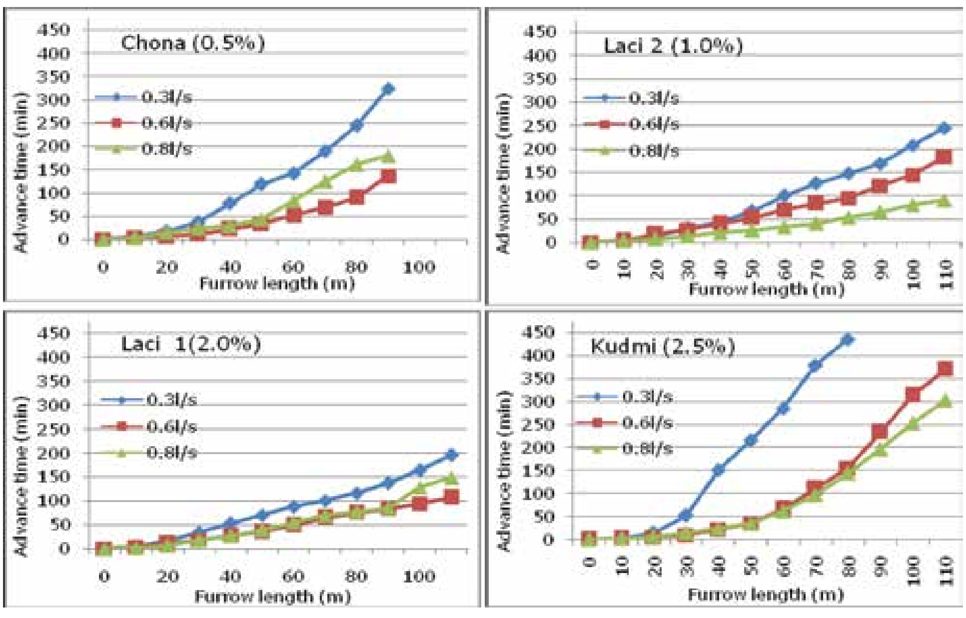

Figure 1. Illustration of advance time against furrow length, 1st irrigation.

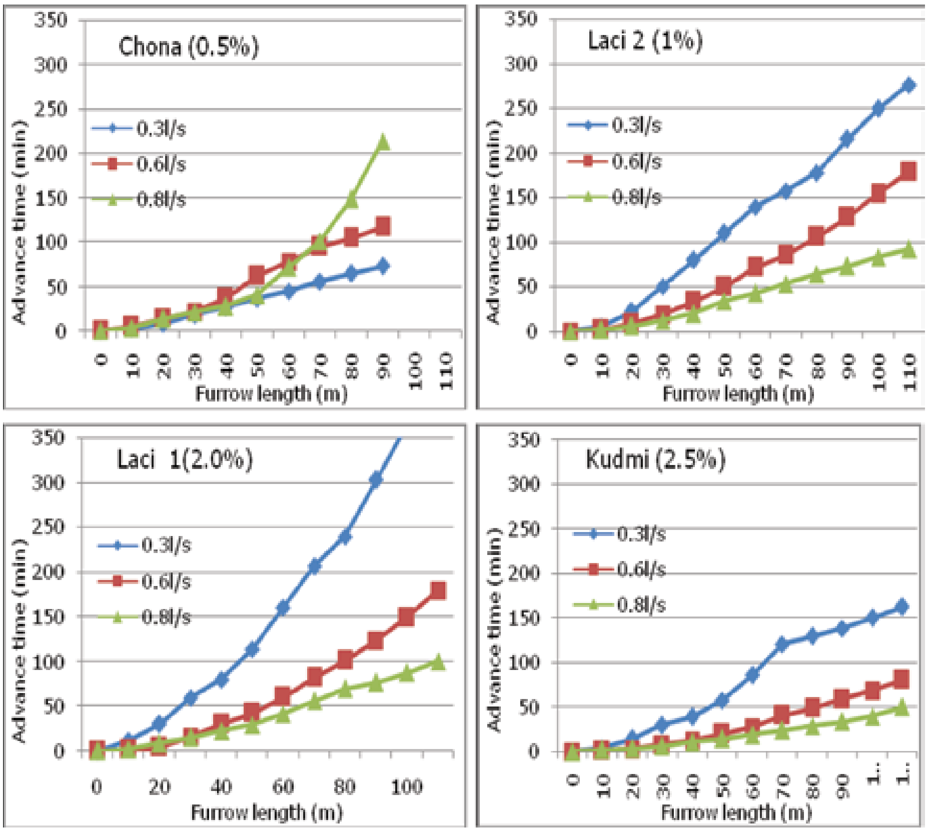

Figure 2. Illustration of advance time against furrow length, 2nd irrigation

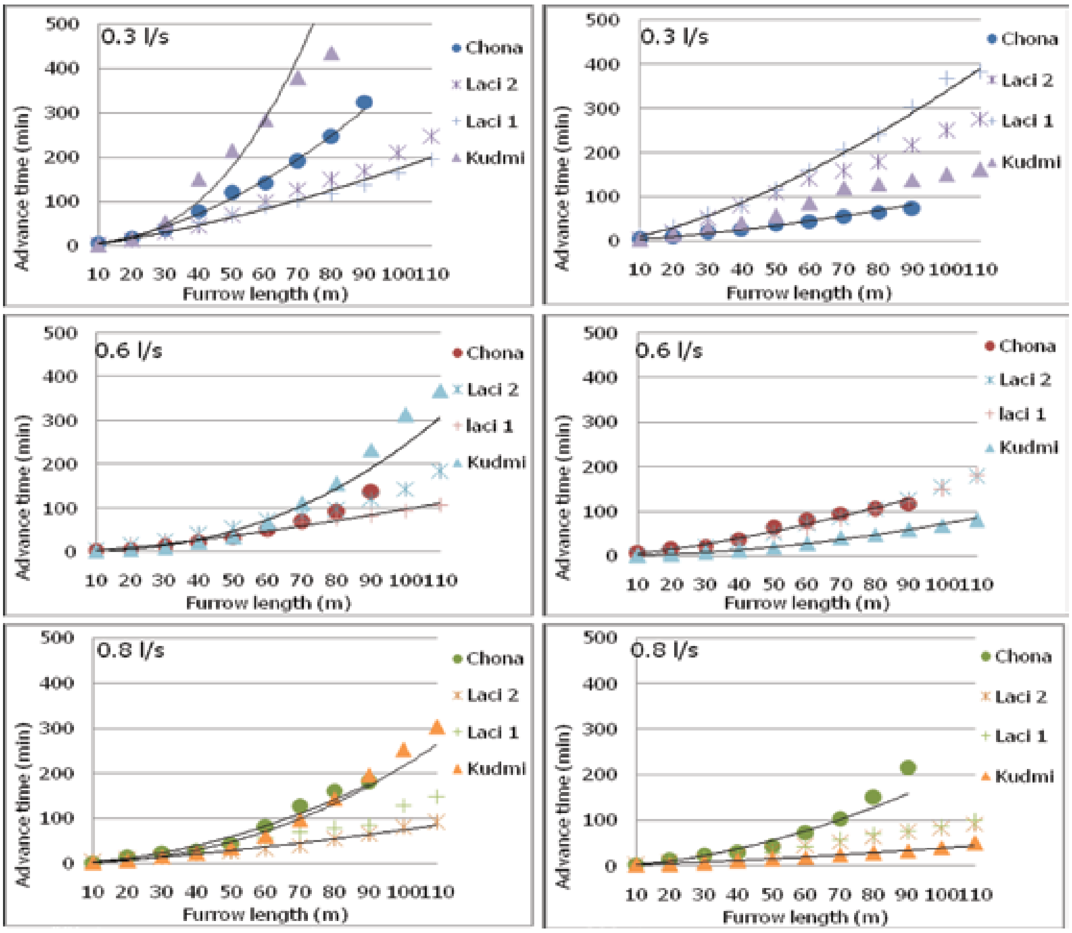

Figure 3. Illustration of advance time against length of irrigation at different slope conditions: 1st irrigation (left) and 2nd irrigation (right)

In the first irrigation, the average advance time to cover 110 m furrow length range from 195–435 min, 107–370 min and 90–300 min at 0.3, 0.6 and 0.8 litre/sec discharge rates, respectively (Table 1). However, in the second irrigation, the advance time was faster than the first irrigation most likely due to the relatively smoother surface and reduction of larger depressions. Results indicate that the advance time was approximately reduced by half compared to first irrigation. In the second irrigation cycle, the average time of advance to cover 110 m range from 70–380 min, 80–180 min and 50–213 min at discharge rates of 0.3, 0.6 and 0.8 litre/sec respectively (Table 1).

Table 1. Advance time (min) during first and second irrigations at 90–110 m furrow length

Site (gradient)	Qi (litre/sec)	First irrigation	Second irrigation
Chona (0.5%)	0.3	324.0	72.7
	0.6	136.4	116.8
	0.8	179.8	213.8
Laci 2 (1.0%)	0.3	244.8	276.0
	0.6	183.0	178.0
	0.8	90.5	92.0
Laci 1 (2.0%)	0.3	195.0	381.9
	0.6	107.0	179.8
	0.8	148.4	100.6
Kudmi (2.5%)	0.3	435.0	162.0
	0.6	369.0	80.4
	0.8	302.0	49.8

Even though the discharge at 0.3 litre/sec is non-erosive for all sites (slopes up to 2.3%), the application was very slow and become difficult to establish appropriate irrigation operation rule for the whole scheme. Discharge rates at 0.8 litre/sec and 0.6 litre/sec are erosive for slopes above 0.83 and 1.1%, respectively, but it is necessary to decide on the application rate and its advance time in relation to the operation rule. It is thus suggested to exclude very low discharge rates below 0.6 litre/sec as the application time is too long.

In the first irrigation, the advance time became very slow beyond 30–40 m furrow length (Figure 1). At 0.6 litre/sec discharge rate, the range of advance time to cover 30 and 40 m length was on average 17–28 min and 28–56 min per furrow, respectively. Similarly, at 0.8 litre/sec discharge rate, time needed to advance 30 and 40 m furrow length was on average 16–18 min and 25–30 min, respectively. Beyond 30 m the advance time for 0.6 litre/sec discharge became longer than 0.8 litre/sec. In the second irrigation (Figure 2), at 0.6 litre/sec discharge rate the advance time became short ranging from 14–18 min and 24–32 min for 30 and 40 m, respectively, whereas, at 0.8 litre/sec advance time ranges from 14–18 min and 20–28 min per furrow for 30 and 40 m length, respectively. Therefore the discharge rate that requires shorter application time is preferable as far as its erosive capacity is low. It is thus feasible to suggest 0.6–0.8 litre/sec application rate for slopes up to 2–2.5%.

The advance time of water at 0.5, 1.0, 2.0 and 2.5 % furrow gradients was 213, 173, 150 and 369 min at 1st irrigation and 134, 182, 221 and 97 min at 2nd irrigation respectively. Furrow gradients and surface irregularities result in such great variation of advance time. The effect of furrow gradient (Figure 3) shows that advance time increased when the slope decreases. Exceptional trends at first irrigation period was observed at Kudmi site this is most likely due to features of field irregularity and large size of surface roughness created at first tillage. In general, the inconsistency observed on the advance time is attributed to the non-uniformity or unlevelled fields.

Conclusion and recommendations

The existing operational furrow length at Koga is extremely long which lead to very low application efficiency. With the test furrow length of 90 to 110 m, it can be concluded that the irrigation application time per furrow was extremely long and difficult to establish appropriate irrigation operation rules among users for the whole scheme. The illustration of advance time by length graphs revealed that optimum furrow length at different sites can only be possible at short application time. In order to maximize application efficiency and minimize the losses, examining and determining an optimum furrow length before the operation of the whole scheme is essential by doing performance evaluation at different furrow lengths and application time. Moreover, the variable slopes and irregular surface shapes significantly affect the furrow length, optimum discharge, the application time and application efficiency. It implies that land levelling work needs due attention so as to improve the overall efficiency of the existing system.

Acknowledgement

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