Performance Evaluation Of Furrow Lengths And Field Application Techniques

Issaka, R. Z., Ibrahim. H., Issah, M.H.

Abstract: The study evaluated performance of furrow lengths and field application techniques. The experiment was conducted on 2000 m^2 field at Bontanga irrigation scheme. Randomized Complete Block Design (RCBD) was used with three replicates. The replicates include Blocks A, B and C of furrow lengths 100 m, 75 m and 50 m respectively. Each replicate had surge, cut-off, cut-back and bunds treatments. Water was introduced into the furrows and the advance distances and time were measured. Results of the study showed that at Block A, surge technique recorded the highest advance rate of 1.26 min/m and opportunity time of 11 min whilst bunds recorded the lowest advance rate of 0.92 min/m. Significant difference (3.32, $p \geq 0.05$) occurred between treatment means of field application techniques at Block A (100 m). Significant difference (2.71, $p \geq 0.05$) was also recorded between treatment means. At Block B (75 m) there was significant difference (2.71, $p \geq 0.05$) between treatment means. No significant difference (0.14, $p \leq 0.05$) was observed among surge, cut-back and bunds techniques. There was significant difference (2.60, $p \geq 0.05$) between treatment means, but no significant difference between cut-back and bunds techniques in Block C (50 m). Their performance was ranked in the order Surge > Cut-back > Cut-off > Bunds for furrow lengths 100 m, 75 m and 50 m respectively.

Keywords: Furrow, Surge, Bund, Cut-off, Cut back, Efficiency, Distribution

1.1 Introduction

Furrows are small charnels having a continuous nearly uniform slope and usually perpendicular to the field supply canal. Furrow irrigation is one of the most widely used surface irrigation technologies worldwide. Furrow Irrigation can be used for almost all crop and best suited for small-scale farmers. Furrow irrigation requires quite a lot of labour input but practically no investments. By adapting the furrow layout it can be used on different types of soils and slopes. Water under furrow irrigation can be used more efficiently compared to basin and border irrigation systems. Improving the performance of a furrow irrigation system requires more than achieving high distribution uniformity. The other primary measure of irrigation performance, application efficiency, is just as important. A uniform irrigation does not guarantee efficiency, and an efficient irrigation need not be uniform. The efficiency of furrow irrigation is about 60 %, which means that 40 % of the given water is lost due to run-off and percolation. Some of the negative side effects of irrigation decreasing yields, deterioration of soil structure and of soil fertility, and soil erosion - can be observed in many places and make the use of advanced furrow irrigation techniques necessary. There are many irrigation techniques which can be used to increase long furrow irrigation efficiency. These techniques include bunds, cut-back, cut-off and surge flow (Aberdeen, 1999). Bunds are strips made along the run or along the furrow so as to increase the duration between applying the water and infiltration, where as in cut-off irrigation technique the practice is to stop flow when the advance wetting front reached about 75% of the furrow. Surge flow was introduced by string ham under this method, irrigation is accomplished through series of individual pulses of water which is characterised by a cycle time and cycle ratio (Mohammed, 1982). The cycle time is comprised of an on time and off-time related by the cycle ratio. cut-back concept based upon applying a large initial non eroding stream size which can reach the lower end of the furrow in a short time, then the inflow stream should reduced as close as possible to a stream equal to the infiltration rate of the furrow

- *Issaka, R. Z1., Ibrahim. H2., Issah, M.H3.*
- *1-3. Agricultural Engineering Department, Tamale Polytechnic, Ghana.*
- *E-mail:iz.razak@gmail.com*
- *Cell phone: +233(0)206323080*

2.0 Methodology

2.1 Study area

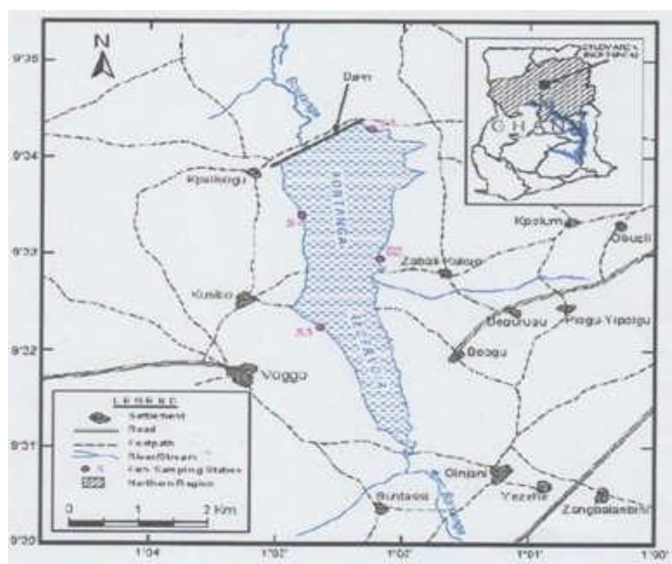

Figure 3.1: *Map of Bontanga area and its catchment (MiDA, 2011)*

Figure 3.1 above shows map of Bontanga Irrigation Scheme in the Kumbungu district, 34 km northwest of Tamale and lies between latitude 9^0 16” S and 9^0 32” N and longitude 0^0 46” E and 0^0 94” W (MoFA, 1998).

2.2 Field preparation

The land was cleared with cutlass and hoe. The boundaries of the land and Blocks were then demarcated with the measuring tape, line, and pegs. The field was divided into Block A, Block B and Block C.

2.3 Field layout

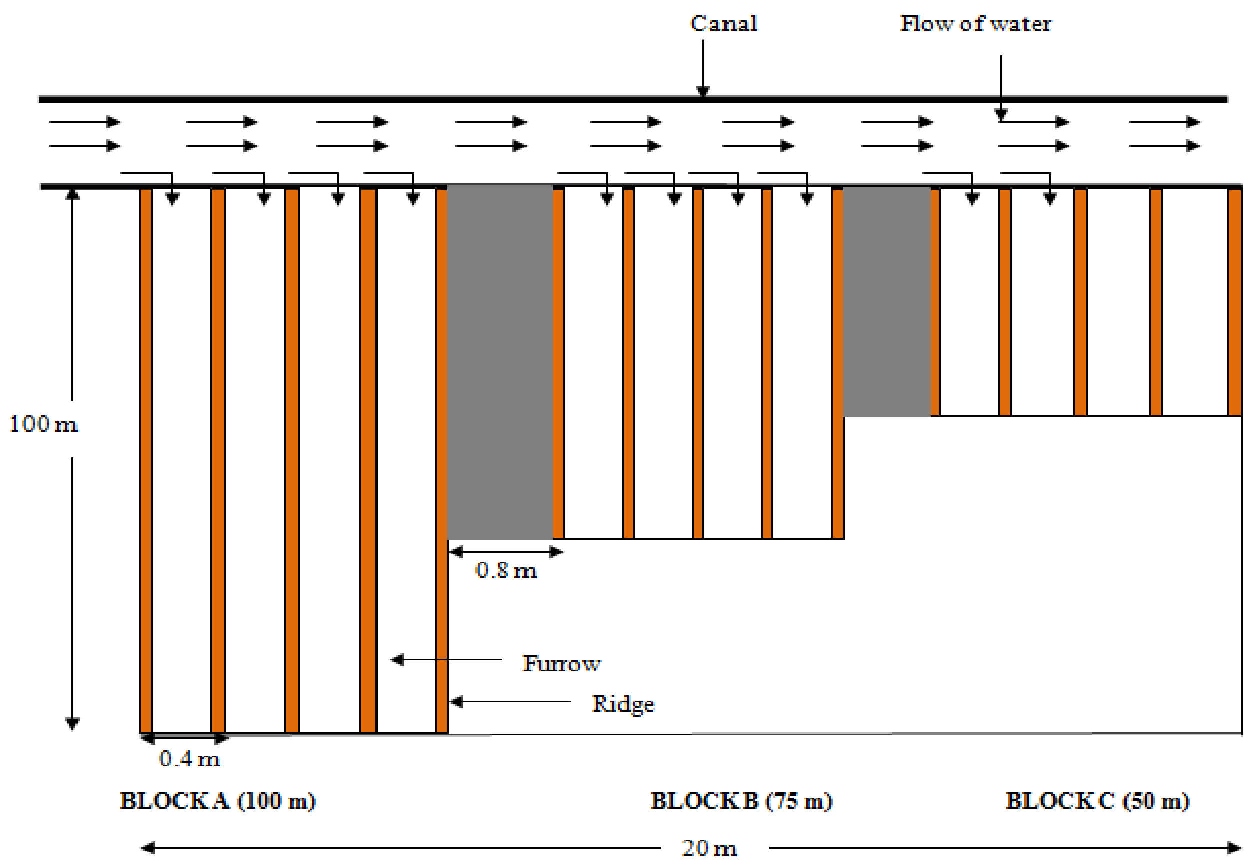

Figure 3.2: *Field layout*

Figure 3.3 shows field layout for the experiment. Block A was constructed with furrow length of 100 m. Block B and C were also constructed with furrow length of 75 m and 50 m respectively. A spacing of 0.8 m was maintained between the furrows in all the Blocks. Four water application techniques were applied to the furrows (Surge, Cut-back, Bunds and Cut-off).

2.4 Field application techniques

2.4.1 Surge

Water was introduced into the furrows by means of an open gate. The advancement of water was monitored, and after 5 minutes the gate was closed. The experiment was repeated and the advance and recession distances measured using pegs and measuring tape.

2.4.2 Cut-off

Water was delivered into the furrows until it reached the end of the furrow when the gate was closed. The advance and recession distances including the time the water reached the end of the furrow was measured.

2.4.3 Bund

Small bunds were constructed in between furrows with distance 20 cm in each furrow. Water was delivered in the furrow through the gate in the canal and a stop watch was set on simultaneously. Water flowed slowly across the bunds to the end of the furrow and advance and recession distance measured including the time.

2.4.4 Cut-back technique

Water was introduced into the furrow and allowed to flow towards the end of the furrow and the water diverted for reuse. The time was recorded and the advance and recession distances measured and recorded.

2.5 Performance criteria

2.5.1 Stream size

The cross-sectional area of the pipe was calculated using the formular below;

$$A = \pi r^2 \quad [3.3]$$

d=0.1 m
r=0.25 m
π=3.142
Area = 3.142 $(0.25)^2$ = 0.19638 m^2

The stream size was computed using the formula below;

$$q = 0.0215A \quad [3.4]$$

Where;
q: Stream size (m^3/s)

A: Cross-sectional area of PVC intake pipe (m^2)

3.7.2 Application efficiency
The field application efficiency was computed with formular.

$$A_e = \frac{W_{rz}}{W_q} \times 100\ \% \qquad [3.5]$$

Where,
A_e: water application efficiency
W_{rz}: water available in the root zone
W_q: discharge in the furrow (m^3/s)

3.7.3 Distribution efficiency
The distribution efficiency was computed with the formular below.

$$D_e = \frac{(1-y)}{d} \times 100\ \% \qquad [3.5]$$

Where,
D_e: Distribution efficiency (%)
y: Standard deviation
D: Volume of water stored along the furrow (m^3)

3.8 Data analysis
The distribution and application efficiencies of the treatments (Surge, Cut-back, Cut-off and Bunds) were separated using ANOVA at 5 % significance level.

3.0 Results and discussions

3.1 Advance rate and opportunity time

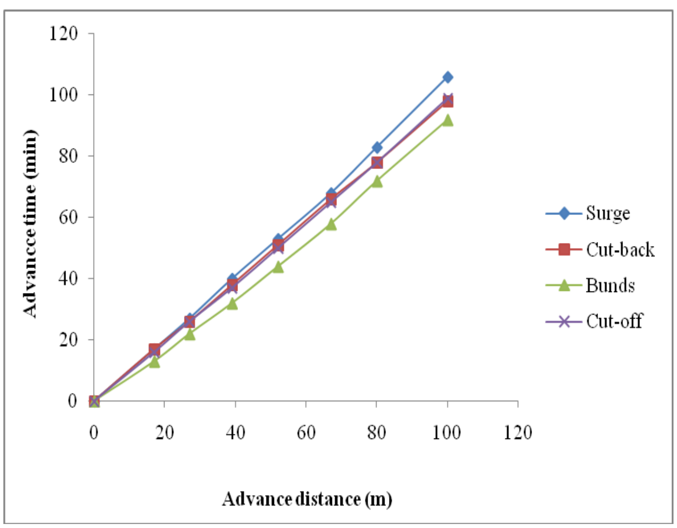

Fig. 4.1: *Advance curve at Block A (100 m)*

Results from Block A (100 m) showed that surge technique recorded the highest advance rate (1.26 min/m) and opportunity time (11 min). This may be due to the fact that surge flow has the potential to control both the time required for water to flow across the field (advance time) and infiltration rate, thereby reducing the amount of percolated water at furrow head and achieving better uniformity in soil moisture distribution. Podmore *et al*. (1983) reported that surge flow can provide a significant improvement in the efficiencies and uniformity of surface irrigation. Additionally, cut-back technique had a high advance rate (1 min/m) and opportunity time (8 min). However, cut-off technique had the lowest advance rate of (0.98 min/m) and opportunity time (7 min) whilst bunds technique recorded advance rate (0.92 min/m) and opportunity time (5 min) as shown Fig. 4.4 above.

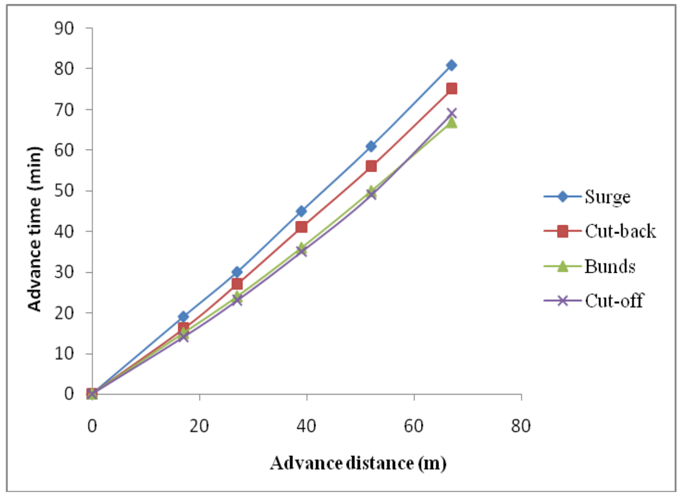

Fig. 4.2: *Advance curve at Block B (75 m)*

The highest advance rate (1 min/m) and opportunity time (9 min) was observed from surge technique at Block B (75 m). The higher advance rate and opportunity time recorded may be attributed to the fact that surge technique has the potential to control both the time required for water to flow across the field and infiltration rate (Podmore *et al*., 1983). Also, cut-back technique had a higher advance rate (0.91 min/m) and opportunity time (6 min). Bunds technique recorded lower advance rate (0.80 min/m) and opportunity time (3 min) whilst cut-off technique had lower advance rate of 0.72 min/m and opportunity time (5 min) as in Fig. 4.5

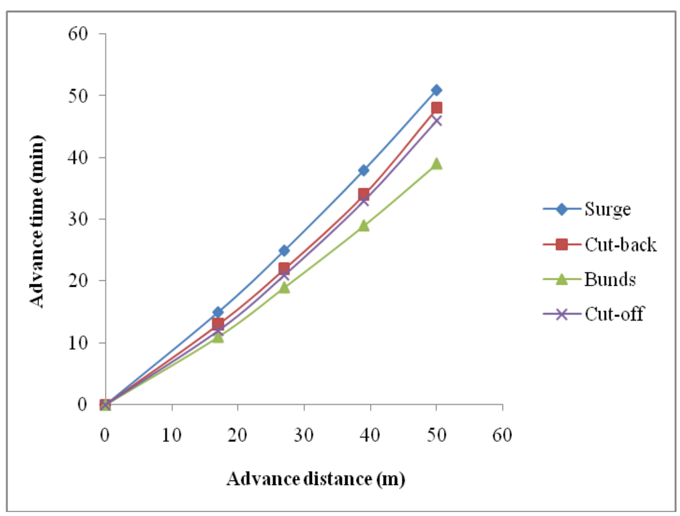

Fig. 4.3: *Advance curve at Block C (50 m)*

At Block C (50 m), surge technique had the highest advance rate (1 min/m) and opportunity time (6 min). Additionally, cut-back technique recorded a higher advance rate (0.91 min/m) and opportunity time (4 min). Bunds technique recorded the lower advance rate (0.80 min/m) and opportunity time (3 min), whilst cut-off technique which recorded advance rate of (0.72 min/m) and opportunity time (3 min) as shown in Fig.4.6.

4.3 Application efficiency

Results from the study showed that significant difference (3.32, $p \geq 0.05$) occurred between treatment means of the field application techniques at Block A (200 m). However, no significant difference (0.87, $p<0.05$) was established between cut-back and bunds application techniques. Additionally, the highest application efficiency was observed in surge techniques (90.4 %) whilst the lowest application efficiency was recorded in the cut-off technique (71 %). Surge application offered higher opportunity time for infiltration resulting in higher application efficiency. Evan *et al.* (1995) confirms the above finding that surge application techniques offers greater opportunity time for higher infiltration of water into the soil. At Block B (75 m), no significant difference (0.14, $p \leq 0.05$) was observed among surge, cut-back and bunds techniques. Surge recorded the highest application efficiency (85 %) whilst cut-off had the lowest (64 %). This could be attributed to the fact that surge techniques offered higher water-soil contact time as in Block A. Block C (100 m) had significant difference (2.60, $p \geq 0.05$) between treatment means. There was no significant difference between cut-back and bunds techniques. The results also showed that surge had the highest application (1985) efficiency (78 %) whilst bunds technique recorded the lowest (56 %). Elsheikh (2014) reported that the hydraulic characteristic of the cut-back flow reduce run-off losses and this leads to increase application efficiency.

4.4 Distribution efficiency

At Block A (100 m), significant difference (2.71, $p \geq 0.05$) was recorded between treatment means. Surge technique gave the highest distribution efficiency of (94 %) and cut-off technique had the lowest (75 %). This may be attributed to the fact that water progresses with higher advance rate allowing greater infiltration of water. Mustafa (1990) confirms the above finding that higher advance rate reduces the difference opportunity time between the head of the furrow and the lower end, resulting in uniform distribution of water along the furrow. Significant difference (2.71, $p \geq 0.05$) was observed between treatment means at Block B (75 m). However, a no significant difference (2.92, $p \leq 0.05$) was recorded between surge and cut-back techniques. Cut-off and bunds techniques recorded distribution efficiencies 79 % and 90 % respectively. This may have resulted from higher initial flow rates high initial flow rate of cut-off and bunds which resulted in high distribution efficiency. At Block C (50 m), no significant difference (0.93, $p \geq 0.05$) was observed between cut-back cut-off and bund techniques. Surge technique had 94 % distribution efficiency, where as cut-off recorded 89 %. The finding may be associated with reduction in deep percolation losses obtained when using surge flow as confirmed by Elsheikh (2014).

5.1 Conclusion

Results from the study showed that surge technique performed better in terms of advance rate, moisture content, and application and distribution efficiencies. Ranking their performance, surge emerge the highest application technique followed by cut-back, cut-off and bunds (Surge > Cut-back > Cut-off > Bunds) for Blocks 100 m, 75 m and 50 m respectively.

References

[1] Abdeen, N. O. (1999). Improvement of furrow efficiency using four technique. M.Sc. theses, Faculty of Agriculture, University of Khartoum.

[2] Mohamed, H. I. (1982). Hydraulic of long furrow irrigation. M.Sc. Theses, faculty of agriculture, university of Khartoum.

[3] Raine, SR and Walker, WR (1998). A decision support tool for the design, management and evaluation of surface irrigation systems, Irrigation Association of Australia National Conference 1998, Brisbane.

[4] Elsheikh, M. Abd E., Mohamed, Abd E. Elamin and Salah Abdelrahman Salih (2014). Effects of some techniques on long furrow efficiency. (BSc. Thesis) Department of Agricultural Engineering, University of Neelain. 216-217pp.

[5] Mustafa, Zadeh, B. (1990). Comparison of furrow irrigation advance under surface and continues how in three field at Isfahan. Iranian Journal of Agricultural Science. 21 (1, 2) 9 – 15pp

[6] Evan, R. G., Chenoweth, J. F. and Kroeger, M. W. (1995). Surge irrigation with residues to reduce soil erosion. Agricultural water management. 27 (3,4).283-297pp. [www.sciencedirect.com/science/article/pii/0377495011518], (May 6, 2015)

[7] Podmore, C.A., Lowdermilk, M.K., Clyma, W., Dunn., L.E., Haider, M.T. Laitos, W.R., Nelson, L.J., Sunada, T.H. (1983). Diagnostic analysis of irrigation systems, Vol. 1: Concepts and methodology. Water Management Synthesis Project, Colorado State University, Fort Collins, Colorado, USA. 22pp

[8] FAO-Food and Agriculture Organisation (2009). Nourishing the planet. South Africa. 3-7pp

[9] Mohamed, H. I. (1982). Hydraulic of long furrow irrigation. M. Sc. Thesis, Faculty of Agriculture, University of Khartoum.

[10] Aberdeen, N. O. (1999). Improvement of furrow efficiency using four technique. M.Sc. theses, Faculty of Agriculture, University of Khartoum.