

EVALUATION OF BEDDED BASIN IRRIGATION METHOD FOR FIELD CROP CULTIVATION ON A WELL DRAINED REDDISH BROWN EARTH SOIL

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ABSTRACT

Crop diversification is being implemented in most of the irrigation projects in the dry zone of Sri Lanka to alleviate water shortage. Eventually, there is a great necessity for convenient on-farm irrigation methods for such areas. A new on-farm irrigation method known as bedded basin irrigation method (BBIM) was evaluated in 1983 and 1984 at Kalankuttiya Block of Mahaweli H Project of Sri Lanka. The optimum bed width, stream size and the water application efficiencies of BBIM were studied. BBIM was compared with Farmers Irrigation Practice (FIP) and Flat Basin Irrigation Method (FBIM). The data revealed that the 90 cm bed width was the optimum among the tested bed sizes. Results indicated that 5.6 and 8.4 ls⁻¹ stream sizes were optimum for the basin sizes of 64 to 100 and 144 to 256 m², respectively. Results showed the application efficiency (E_a) and the storage efficiency (E_s) were more than 80 % with BBIM. The study showed that BBIM was superior to FIP and FBIM, because of lesser water duty, better surface drainage and water distribution.

KEY WORDS: Bedded basins, Irrigation, Reddish brown earths

INTRODUCTION

Cultivation of paddy in the well drained soils in the dry zone of Sri Lanka during *yala* seasons causes heavy water duty per hectare than that of other field crops (OFCs) (Goonasekara and Wickham, 1978). This resulted in water shortage and reduced cropping extent in many irrigation projects of Sri Lanka (S. Dimantha, 1982. Unpubl.). Hence, crop diversification had been introduced in a number of irrigation projects of the dry zone to alleviate the problem of water shortage. However, a challenge that farmers' face in crop diversification is to change the water application method that is appropriate to the crops without making major changes in the land layout. The soils of most of the lands where crop diversification is followed are the reddish brown earths (RBE).

Furrow irrigation (Lewis, 1973) and furrowed basin irrigation (Joshua, 1980) introduced for OFCs in the RBE soils, have little adaptability for level basins where paddy is cultivated. Both these irrigation methods require mild land slope, which does not exist in the level basins. On the other hand, a few farmers cultivate OFCs in the level basins during *yala* by forming beds of various sizes to improve surface drainage. This created problems in drainage and water distribution. However, there was no recommended stream sizes or bed sizes for such kind of bedded basin irrigation method (BBIM).

The objectives of this study was to determine the optimum bed width, stream sizes and application efficiency of BBIM and to compare BBIM with farmers' irrigation practice and flat basin irrigation method.

MATERIALS AND METHODS

The study was conducted during 1983 and 1984 in farmer's field of Kalankuttiya block in Mahaweli H project, where the soils are reddish brown earths (well drained) (RBE/WD). This study involved four steps as follows. Step 1 - selection of suitable bed width; Step 2 - selection of convenient stream sizes for different basin sizes; Step 3 - studying the irrigation efficiencies; Step 4 - comparing the bedded basin irrigation method (BBIM) with flat basin irrigation method (FBIM) and farmers' irrigation practice (FIP).

Step 1

Depth of root zone of well grown chilli and soybean crops was measured by cutting pits near the plants at five places and counting the root sections in the wall of the pits. Bulk density (BD) of the soil layers of 0-15, 15-30 and 30-60 cm was also measured at 10 places. Beds were formed by cutting parallel ditches (12 cm deep, 25-28 cm wide and 300 cm long) at a spacings of 60, 90, 120 and 150 cm (Fig.1). Beds were formed in a Latin square design with 3 replicates. The initial moisture content of the locations was estimated by gravimetric method and the amount of water needed to refill the moisture reservoir up to field capacity was poured into the ditches. The moisture content of the 90 cm deep soil profile of the bed cross section was estimated 1 to 1 1/2 days after watering (Fig.2).

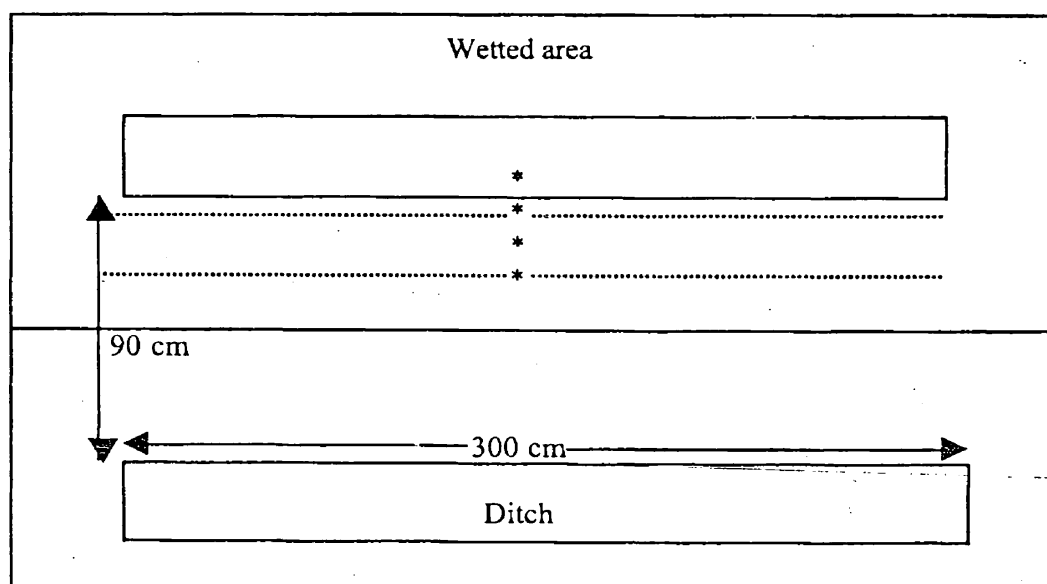


Fig. 1. Top view of the 90 cm wide bed, which was constructed to study the wetting pattern of 60 cm deep soil layer by irrigation. * Auger holes

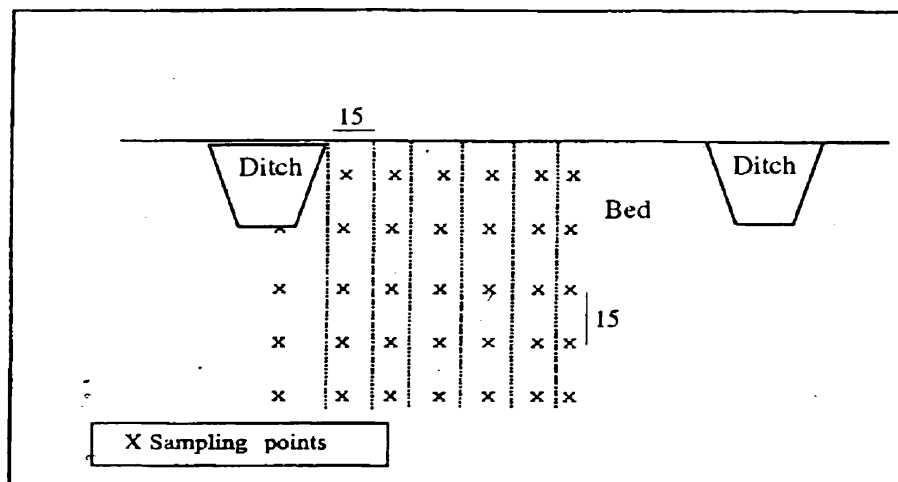


Fig. 2. Soil sampling points for gravimetric soil moisture measurements in the 120 cm wide bed cross section, to study the wetting pattern by irrigation

Step 2

To select suitable stream sizes for different basin sizes, five stream sizes (2.8, 5.6, 8.4, 11.2 and 14.1 $l s^{-1}$) and five basin sizes (64, 100, 144, 196 and 256 m^2) were selected. Five basins from each size were taken for the layout. Beds were formed with selected size at every basin as shown in Fig.3. Chilli was planted in the beds with spacing of 30cm x 60cm. Chemical fertilizer was applied at the rate of 120 kg N, 45 kg P_2O_5 and 60kg K_2O per hectare. Initial soil moisture content was measured and water deficit of root zone was calculated. This amount was provided to the basins by test irrigations. Five test irrigations were done at 10-12 day intervals. Observations such as advance time, manageability of stream, erosivity and opportunity time (time taken to infiltrate all the water in the ditches) were recorded.

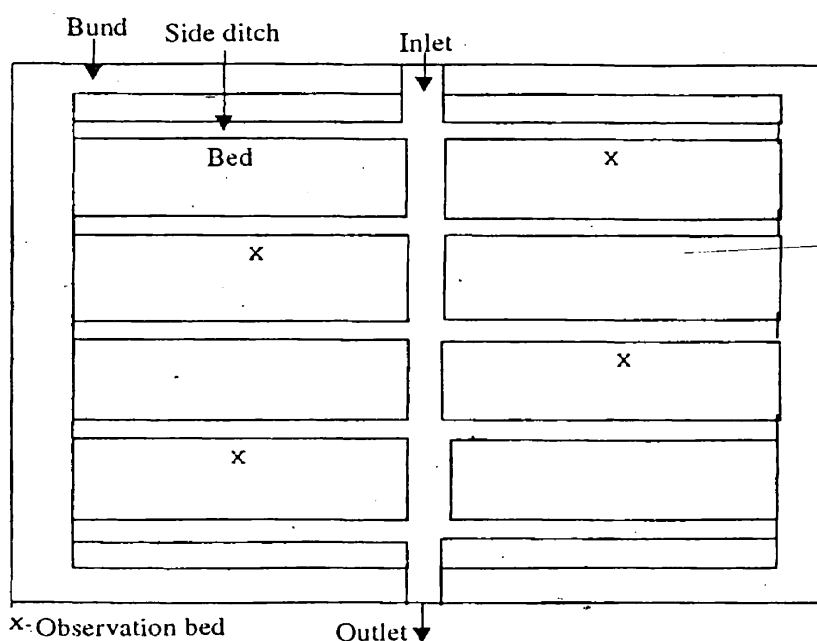


Fig. 3. Top view of basins which were developed in raised beds for the study of the selection of stream sizes for different basin sizes and irrigation efficiency

Step 3

To estimate irrigation efficiencies, all five basin sizes were tested in a RCB design with 3 replicates. Beds were constructed as shown in Fig.3 and chilli was planted. The amount of water deficit plus 5% more water (to compensate for deep percolation at central ditch) was applied to the basins. Moisture content of 4 beds (equally spaced in the basin) was measured 1 to 1 1/2 days after irrigation. This investigation was done for 2 irrigation cycles.

Step 4

BBIM (T1) was compared with FBIM (T2) and FIP (T3) in RCB design with 4 replicates. Basin sizes of 100 m² with selected stream size (5.6 ls⁻¹) and bed size (90 cm) was used in T1. The same basin size with few shallow ditches and bigger stream size (8.4 ls⁻¹) were used for T2 and T3. Irrigation was done at weekly intervals from 2 weeks after planting to end of the season for all 4 replicates. Four cm of water was applied to T1 and T2 and allowed to infiltrate into the soil profile. Four cm of water was allowed to infiltrate at the 4th quarter of the basin of T3 by keeping the water in the basins for the required time. After allowing 4 cm of water to infiltrate, the remaining water of T3 basins was drained out quickly. The outflow was measured by parshel flumes. Data collected were yield, irrigation input, depth to the water table and surface drainage conditions. Labour requirements for land preparation were also recorded.

RESULTS AND DISCUSSION

Selecting a suitable bed width

As shown in Table 1 the average water application efficiency (E_a = the percentage of applied water retained in the root zone - 60 cm deep soil layer) is highest for beds of 60 and 90 cm and those values were significantly different from the values of 150 cm beds. The analysis of replicated latin square design shows that there is no treatment-site interactions. Therefore, the most suitable bed widths were 60 and 90 cm.

Table 1. Water application efficiency (E_a) at four different bed sizes at three sites

Bed sizes (cm)	E_a (%)			
	Site 1	Site 2	Site 3	Average
60	87.4	87.2	90.3	88.5
90	85.0	88.3	88.1	87.5
120	76.3	80.3	74.7	76.8
150	69.7	62.7	68.6	65.9
LSD (0.05)	13.5	15.6	13.3	-

Fig. 4 shows that the 0-60 cm soil layer of 90,120 and 150 cm beds is evenly wetted from the ditch to 37.5 cm towards the centre of the beds. Moisture movement is low beyond 37.5 cm from the ditch, resulting in insufficient wetting at middle region of the bed sizes of 120 and 150 cm. Moisture movement of 60 cm bed is high

up to 22.5 cm from the ditch. Taking into account the cost of construction and adaptability to plant spacing, a bed size of 90 cm was better than a bed size of 60 cm. Considering all the above factors 90 cm bed size was selected as the best among the tested beds.

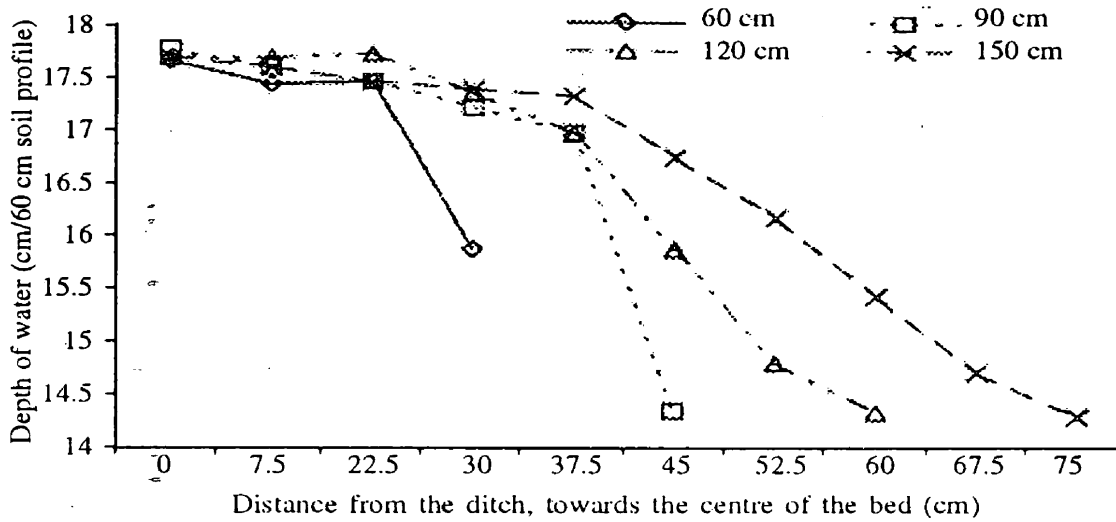


Fig.4. The pattern of water distribution across the beds of four different sizes, 1 to 1.5 days after irrigation

Selecting suitable stream size

Fig. 5 shows that advance time (AT) was higher with smaller stream sizes for the given basin sizes; and it was also higher with larger basin sizes for given stream sizes. According to Table 2, intake opportunity time (IOT) was more or less the same for all stream-basin size combinations. The ratio of AT/IOT increased with increasing basin size for same stream size (Table 3). However, all stream-basin size combinations had AT/IOT values less than 0.25, which means the distribution efficiency (Ed) was more than 91% for the all combinations.

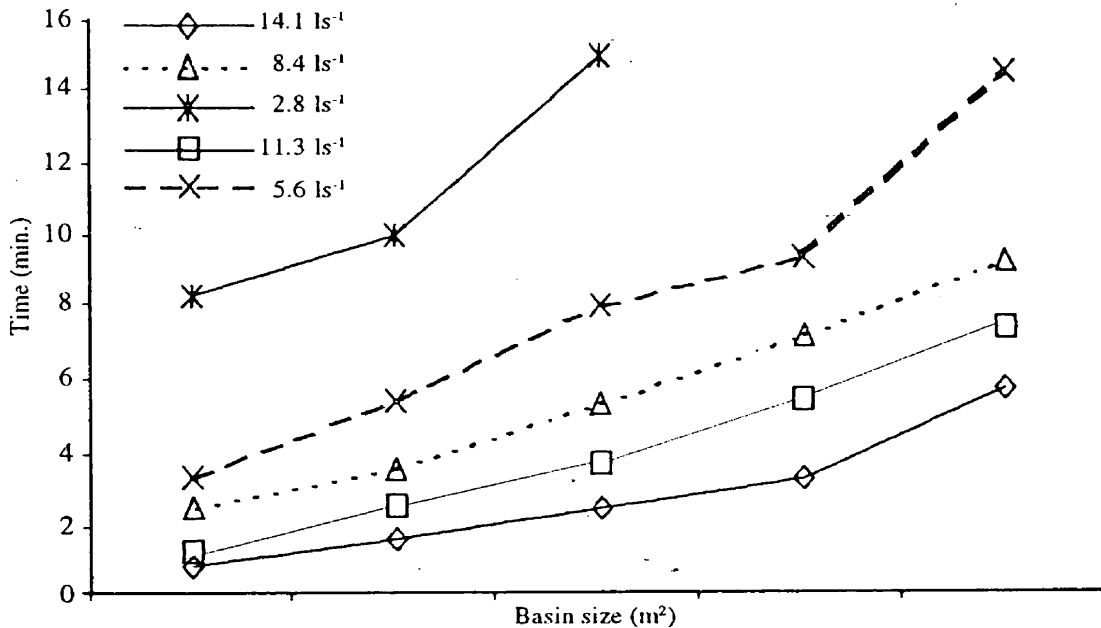


Fig.5. The variation of advance time (AT) for different basin size and stream size combinations

Table 2. Variation of intake opportunity time (IOT) for different basin size and stream size combinations

Stream size ($l s^{-1}$)	IOT				
	Basin size (m^2)				
	64	100	144	196	256
2.8	70.7	71.9	72.2	-	-
5.6	70.1	69.6	70.5	66.7	65.7
8.4	70.1	67.5	70.7	72.8	72.6
11.3	70.8	71.5	75.5	72.5	72.8
14.1	65.2	70.5	73.9	72.7	72.6

Table 3. The relationship of the ratio of advance time to intake opportunity time for different stream and basin sizes

Stream size ($l s^{-1}$)	AT/IOT				
	Basin size (m^2)				
	64	100	144	196	256
2.8	0.12	0.15	0.21	-	-
5.6	0.05	0.08	0.12	0.15	0.22
8.4	0.04	0.05	0.07	0.10	0.13
11.3	0.02	0.03	0.05	0.08	0.10
14.1	0.01	0.02	0.03	0.05	0.07

According to Table 4 stream size of $5.6 l s^{-1}$ is most suitable for the basin sizes of 64 and 100 m^2 , while stream size of $8.4 l s^{-1}$ is most suitable for the basin sizes of 144, 196 and 256 m^2 .

Table 4. The erosiveness and manageability of different stream sizes when applied to irrigate different bed sizes

Stream size ($l s^{-1}$)	Basin size (m^2)				
	64	100	144	196	256
2.8	AD	AD	AD	NS	NS
5.6	AD	AD	AD	AD	AD
8.4	BD	BD	AD	AD	AD
11.3	CE	CE	CE	CE	CE
14.1	CE	CE	CE	CE	CE

NS - not studied; A - stream is manageable; B - stream is moderately manageable; C - stream is unmanageable; D - stream is non-erosive; E - stream is erosive

Irrigation efficiencies

According to the Table 5, the value of application efficiency (E_a) varied from 83 to 84%. Storage efficiency (E_s) varied from 86 to 90%. The analysis revealed that there was no significant difference between E_a and E_s among the 5 different basin and stream size combinations.

Table 5. The irrigation efficiencies (%) in the different basin size treatments

Irrigation efficiency	Basin size (m ²)				
	64	100	144	196	256
Ea	83	83	84	84	84
Es	88	86	88	89	90

Ea- application efficiency; Es- storage efficiency

Comparison of BBIM with FBIM and FIP

There were 17 irrigation issues during the cropping period and 4 cm of water was applied for each irrigation issue. Hence, both BBIM and FBIM received only 68 cm of water whereas FIP received 89.6 cm of water (Table 6). There were two waterlogging periods with FBIM and five moderate waterlogging periods with FIP. However, there were only 3 moderate waterlogging periods with BBIM. This BBIM appears to be superior to the other 2 methods from the drainage point of view. Table 7 shows that dry chilli yield with BBIM was significantly higher than that with FBIM and FIP. Higher yield for BBIM may be due to better water distribution and surface drainage.

Table 6. Irrigation water use (cm) for the three different water application methods used on chilli crop

Replication	Irrigation treatment		
	Bedded basin irrigation (T1)	Flat basin irrigation (T2)	Farmers' practice (T3)
1st replicate	68	68	90.2
2nd replicate	68	68	87.6
3rd replicate	68	68	90.8
4th replicate	68	68	89.9
Average	68	68	89.6

Table 7. Yield of dry chilli (kg/ha) under 3 different water application methods

Replication	Irrigation treatment		
	Bedded basin irrigation (T1)	Flat basin irrigation (T2)	Farmers' practice (T3)
Average	1578	1188	1384
LSD (5%) =	179.1		
CV (%) =	7.48		

Economic feasibility

For all three irrigation methods, bund cleaning, harrowing by tractor and construction of farm ditches were same. However, construction of beds of width 90 cm was done for BBIM while beds of 225-275 cm width were done for FBIM and FIP. The average labour days used for preparation of beds and levelling of surface were 50, 20 and 20 per ha for BBIM, FBIM and FIP, respectively. The average yield increment for BBIM over FIP was 194 kg/ha of dry chilli. The extra expenditure and extra income of BBIM over FIP were Rs. 6000/ha and Rs. 17460/ha, respectively (Price of chilli is Rs. 90/kg and cost of labour is Rs. 200/day). Thus BBIM gave an extra income Rs. 11460/ha and a saving of 21.6 cm of water when compared to FIP.

CONCLUSIONS

Results show that 90 cm bed width is better than the bed widths of 60, 120 and 150 cm due to higher application efficiency, adaptability to crop spacing and lesser cost of construction. The suitable stream sizes were found to be 5.6 ls⁻¹ for the basin sizes of 64 and 100 m² and 8.4 ls⁻¹ for the basin sizes of 144, 196 and 256 m². High application efficiency and storage efficiency (more than 80%) can be obtained by practising bedded basin irrigation with the appropriate stream and basin size combinations with 90 cm wide beds. Bedded basin irrigation method is superior to the flat basin irrigation method and the farmers' irrigation method due to better surface drainage, lower water duty and higher yield.

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