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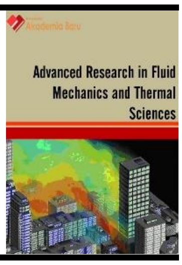

The Dimensions Effect of Border Irrigation Basins on Irrigation Efficiency, Distribution and Uniformity Coefficient

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ABSTRACT

The surface irrigation model with mathematical expression in stream flow was applied in a border irrigation system for an agricultural area in Al-Mussaib city north of the Babylon governorate in central of Iraq in which divided into basins of different dimensions. This study aims to select the optimum area for basins (dimensions) and their relationship into soil type to show the ability of fully submerged basins in standard time with high irrigation efficiency and uniform distribution along the border. The improvement of field irrigation efficiency was done by studying the relationship between soil type, flow rate, slope, and basin area. Geographic Information System (GIS) and Remote Sensing were used to analyze satellite imagery, identify the topography and inclinations of the area, as well as the possibility of classifying the soil by collecting field data for the study area and measuring the discharge on-site with calculation of irrigation efficiency, distribution efficiency, uniformity, progression and infiltration time. After analyzing the results and graphically, it was concluded for the case of providing a large basin of silty soil with high discharge, the infiltration time is long with increase in losses, the value of irrigation efficiency was 63%. For small basins with dimensions (20 * 120) m and flow rate, 0.04 m 3 / s, the irrigation efficiency was approximately 77% due to the convergence and parallelization of the infiltration time with advance time of irrigation, which requires making the land basin small. According to the results, when the soil type is clay, the results showed that basin can be small or large with making leveling of the land in a slope of not more than 3%, but when the soil is silty, the basin designed in small dimensions to obtain highest uniformity and minimum time required.

Keywords:
Surface irrigation model; border irrigation; GIS; remote sensing; irrigation efficiency

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1. Introduction

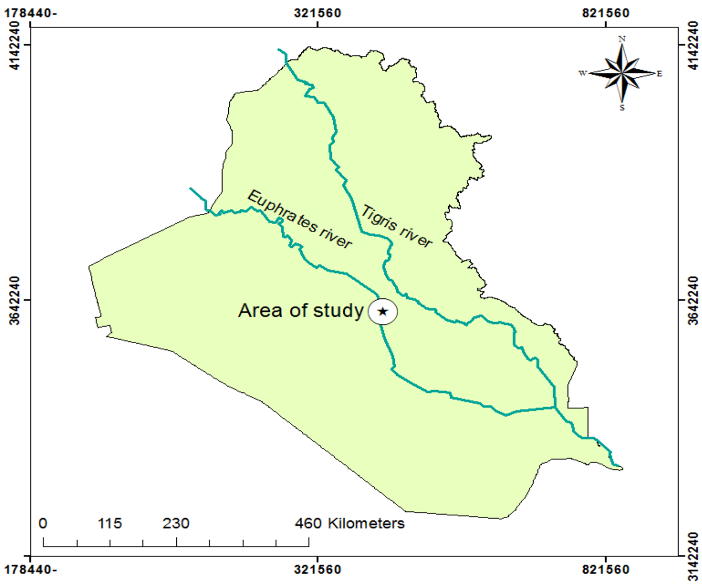
Irrigation is the process of artificially supplying crops with water. The irrigation technology is used in agriculture to make plants able to grow when there is not enough rain, especially in arid areas, and in less dry areas to supply crops with the water they need when planting seeds [1].It is, therefore, necessary to develop a carefully designed irrigation technique that optimizes agricultural production while preserving this resource. The amount of irrigation water depends on the number of waters needs that change over time and depending on the type of soil and plant [2]. It is important to select the right type of irrigation technique to suit the particular crop arid soil. The predict runoff hydrographs from graded border and furrow irrigation systems by using two procedure, the results of the two procedure were compared with actual measured field data in different location and good agreement has been noticed measured and predicted runoff discharge [3]. One of these applications in surface irrigation is border irrigation, which is mostly used for the irrigation of close-growing crops and the pasture in the world [4].In border irrigation, the field divided into strips, which can be design and management with apply irrigation water at high-efficiency levels and uniformity [5]. The overall efficiency in irrigation covers many concepts such as conveyance, application, storage, consumptive use, distribution and uniformity efficiencies, the application efficiency also means the ratio of the water stored in the root zone to the applied irrigation water [6].In this study an irrigation efficiency and coefficient of uniformity were evaluated. The slops in border must be uniform with rang 0.05% at minimum and 2% at maximum to provide adequate drainage and to limit the soil erosion problems [7]. Dimensions and shape of the border are influenced by soil type, size with the slope of stream, the depth of irrigation and the farm size [8]. The inflow to the border can be stopped according to soil type. When the soil is clay, the inflow is stopped when the irrigation water fill 60% of the border, in loamy soil when fill (70 - 80) % but in sandy soil, the irrigation water must fill the entire border before the flow is stopped When the size of stream is large [9],the water will flow fast down the border and the point where the water flow must be stopped is reached before sufficient water has been applied to fill the root zone, but when the stream size is small will result deep percolation losses near the farm channel especially on sandy soil [10].

2. Material and Methods

2.1 Area Under Consideration

The area being considered is located in the middle of Iraq, north of the city of Babylon. It lies (44° 18' 12" to 44° 18' 29.5") E and (32° 43' 51" to 32° 43' 44") N along Land sat 8 track (36, 37) path and (168) row (USGS). The area is about (6.25 * 10^4 m^2). The location illustrated in Figure 1.

This region is irrigated from a small river called Juda river; this river takes water from the left Euphrates River. The system of irrigation in this region depends mainly on the surface irrigation using border strips. Soil samples were analyzed at different locations of the studied area to find their type, classification, and shows that on the satellite image according to their geographical location and the spatial distribution of them was analyzed using geographic information system (GIS) supervisor classification , it was found that 44% clayey and 56% silty as shown in Figure 2.



(a)

(b)

Fig. 1. (a and b) Area of case study (area under consideration)

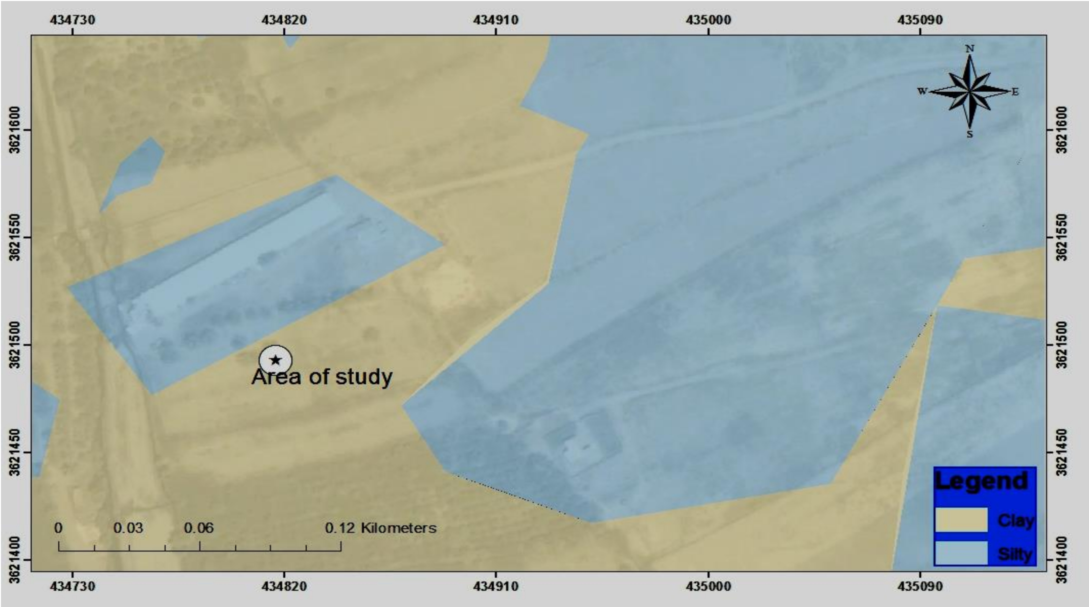


Fig. 2. Soil classification of study area

2.2 Mathematical Modals

Many factors contribute to determining the discharge in the field that irrigates by border method. In the case of border irrigation, such a field divided into strips at rang number about (5-15) m in width and (75 - 300) m in length, which separated by low dikes or small border ridges about 15 cm. Each strip irrigated by water which connects directly to the channel situated in u / s end of border strip, the sheet of water advances towards the d / s. For one strip and after applied the sufficient water, the stream is turned to another strip. In border irrigation, the specific requirement is uniformity in the longitudinal slope and transverse slope equal to or less than zero [11]. It is suitable for irrigating the crops of close-growing such as groundnut, berseem and bajra [12]. Different models have been developed to simulate water on the soil surface while different models have been used the mass conservation [13]. The continuity and momentum equations describe the surface irrigation hydraulic. These equations are known as the St.Venant equation [14].In general, the continuity equation is express mass conservation which can be written as the equation of momentum express the flow process in dynamic equilibrium [15].The assumption in design border irrigation is that the infiltration time at the start of the border (Ti) equal time require to observation net depth by soil (Ta).

$$T_i = T_a + T_L \quad (1)$$

$$T_L = \frac{d^2}{1200} * S_i * Q_u \quad (2)$$

where T_i: infiltration time at the beginning of the border, T_a: time require to observation net depth by soil, *d*: depth of irrigation water, *S*: the border slope and *Q*: discharge of irrigation water.

By assuming the depth of water at the beginning of the border is equal to the normal depth and calculation by using manning formula [16].

$$T_L = (n^{1.5} * Q_u^{0.5})/3795 * \left[S_i + \{(0.0028 * n * Q^{0.175})/T_n^{0.88} * S_i^{0.5}\}\right] \quad (3)$$

where n: Manning roughness.

$$CU = (1 - y/R) * 100\% \quad (4)$$

where y: average absolute division to irrigation depth and R: average irrigation depth inters the soil.

2.3 Data Requirements

A selection of multi-dimension field area (case study) was done with two cases, case one uses slope (0.005) to agriculture wheat crop that requires depth about 80 mm with discharge 40 L/sec when the flow resistance of the soil nearly 0.15. Case two, applying surface irrigation model with variable discharge (50, 40, 35) L/sec with depth 80 mm.

3. Results and Discussion

The results show that the maximum uniform efficiency of 92% achieved when designing border dimension (80*20) m whereas the minimum of 66 % was achieved when using dimension (150,20) m. This means that the efficiency of irrigation increases with increasing border dimension while the uniform efficiency has an inverse tend, as shown in Table 1 and Figure 3.With different values of discharge max. and min. irrigation efficiency when discharge equal (35 and 50) L / sec respectively, max. and min. uniformly efficiency when discharge equal (50 and 35) L / sec respectively as shown in Table 2 and Figure 4. Figure 5 shows the relationship between border length with a variation of time (advance - recession - cutoff), and irrigation water depth (infiltration profile). Table 3 shows values of depth requirement and depth measurement in which plotted in Figure 6.

Table 1
Values of IE and CU for multi border dimension

Field Dimension (m)	80*20	100*20	120*20	150*20
Irrigation Efficiency %	53	66	77	91
Uniformly Coefficient%	92	88	82	66
Advance Time (min)	35	49	66	98
Appointed Time (min)	105	97	85	57

Table 2
Values of IE and CU for multi discharges with border dimension (120*20)

Discharge L / sec	35	40	50
Irrigation Efficiency %	85	77	63
Uniformly Coefficient %	75	82	90
Advance Time	79	66	50
Appointed Time	70	84	100

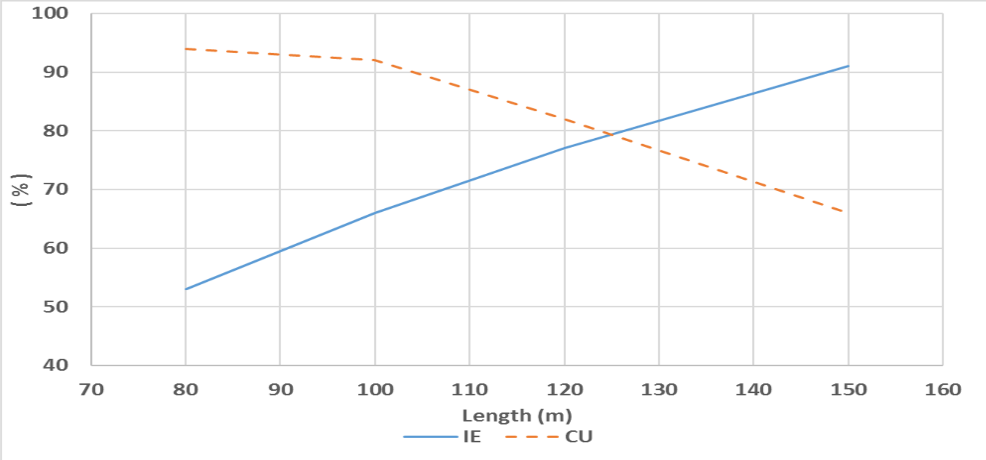


Fig. 3. Relationship between variation of length with irrigation efficiency and uniformly coefficient

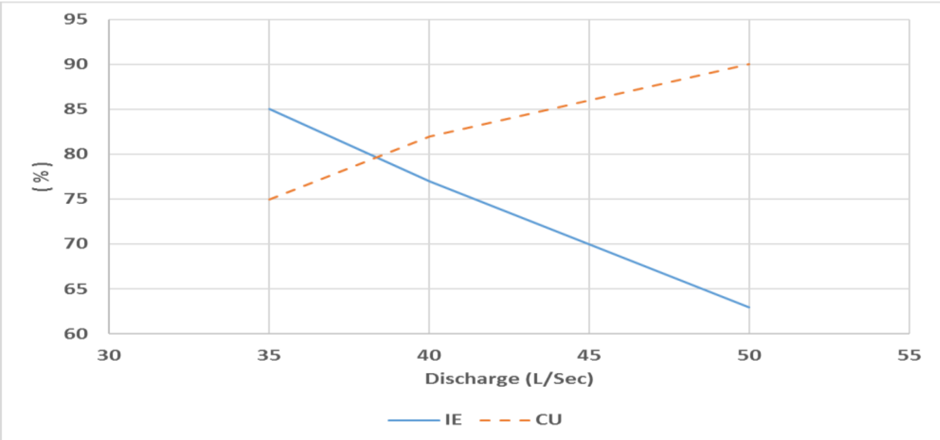
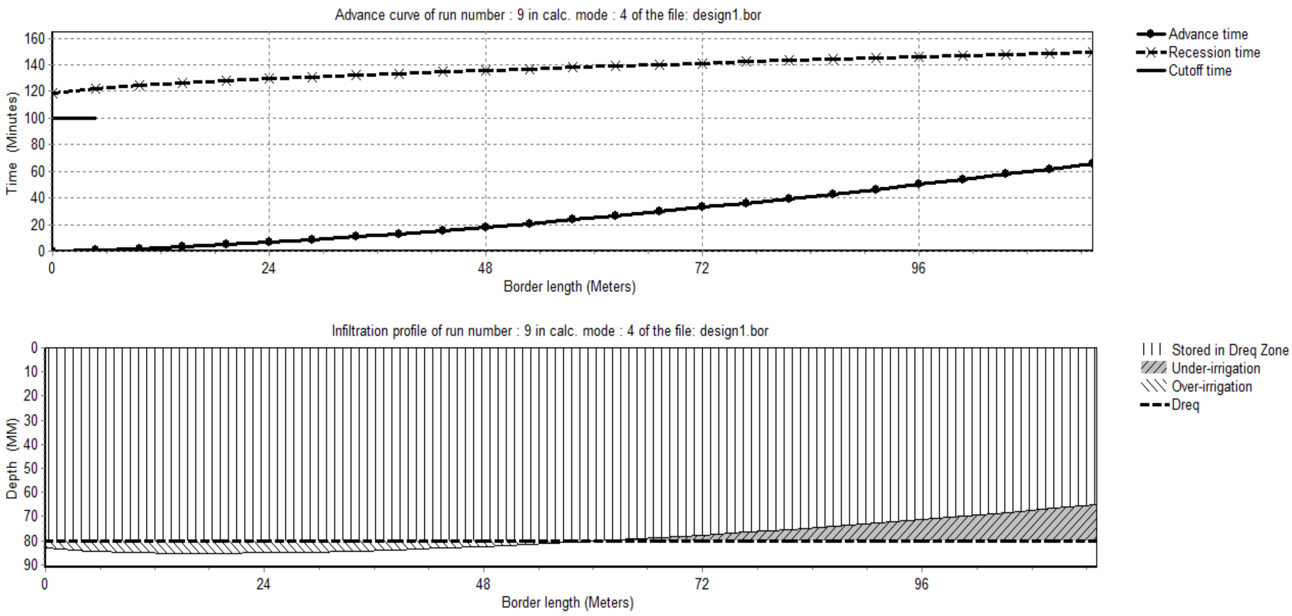
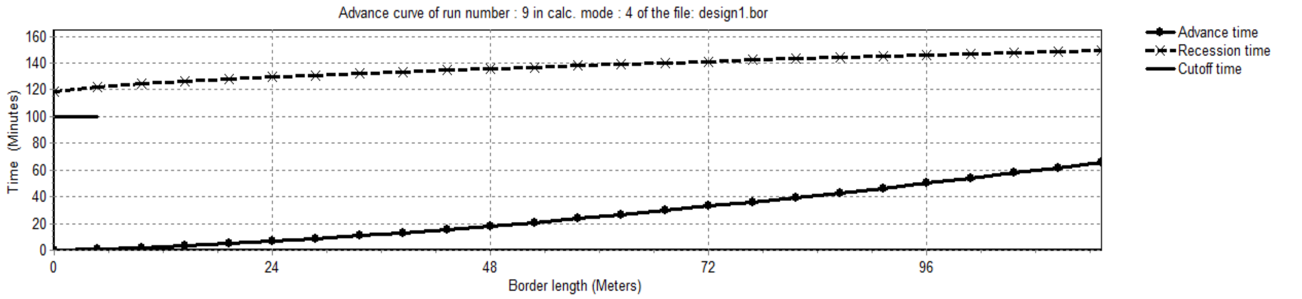
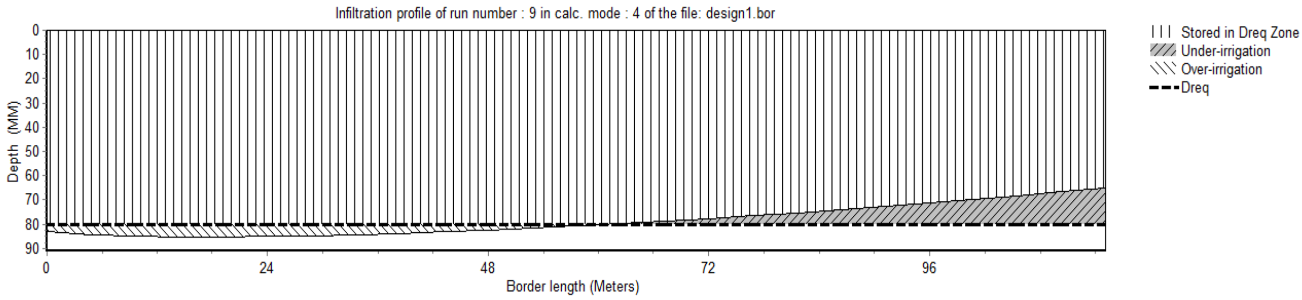


Fig. 4. Relationship between variation of discharge with irrigation efficiency and uniformly coefficient




Advance curve of run number : 9 in calc. mode : 4 of the file: design1.bor
Time (Minutes)
Border length (Meters)
Advance time
Recession time
Cutoff time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Depth (MM)
Border length (Meters)
Stored in Dreq Zone
Under-irrigation
Over-irrigation
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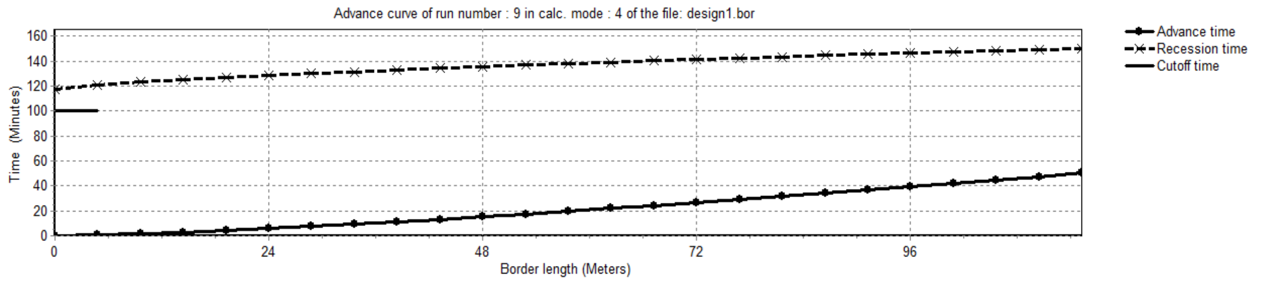
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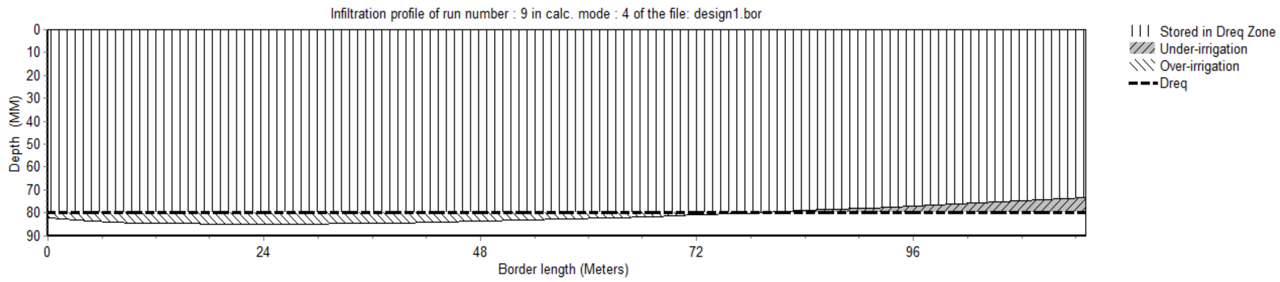
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Under-irrigation
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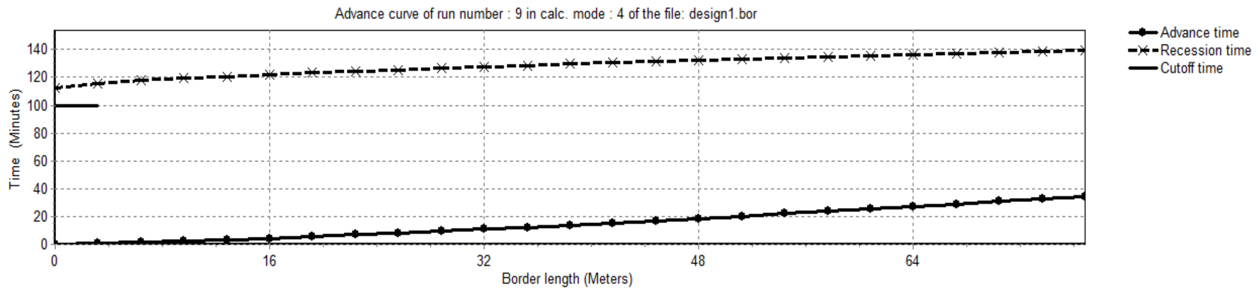
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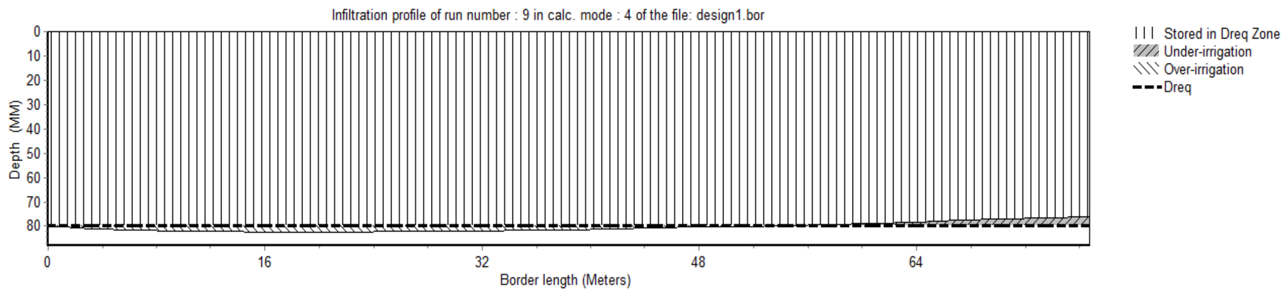
Infiltration profile of run number : 9 in calc. mode : 4 of the file: design1.bor
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Stored in Dreq Zone
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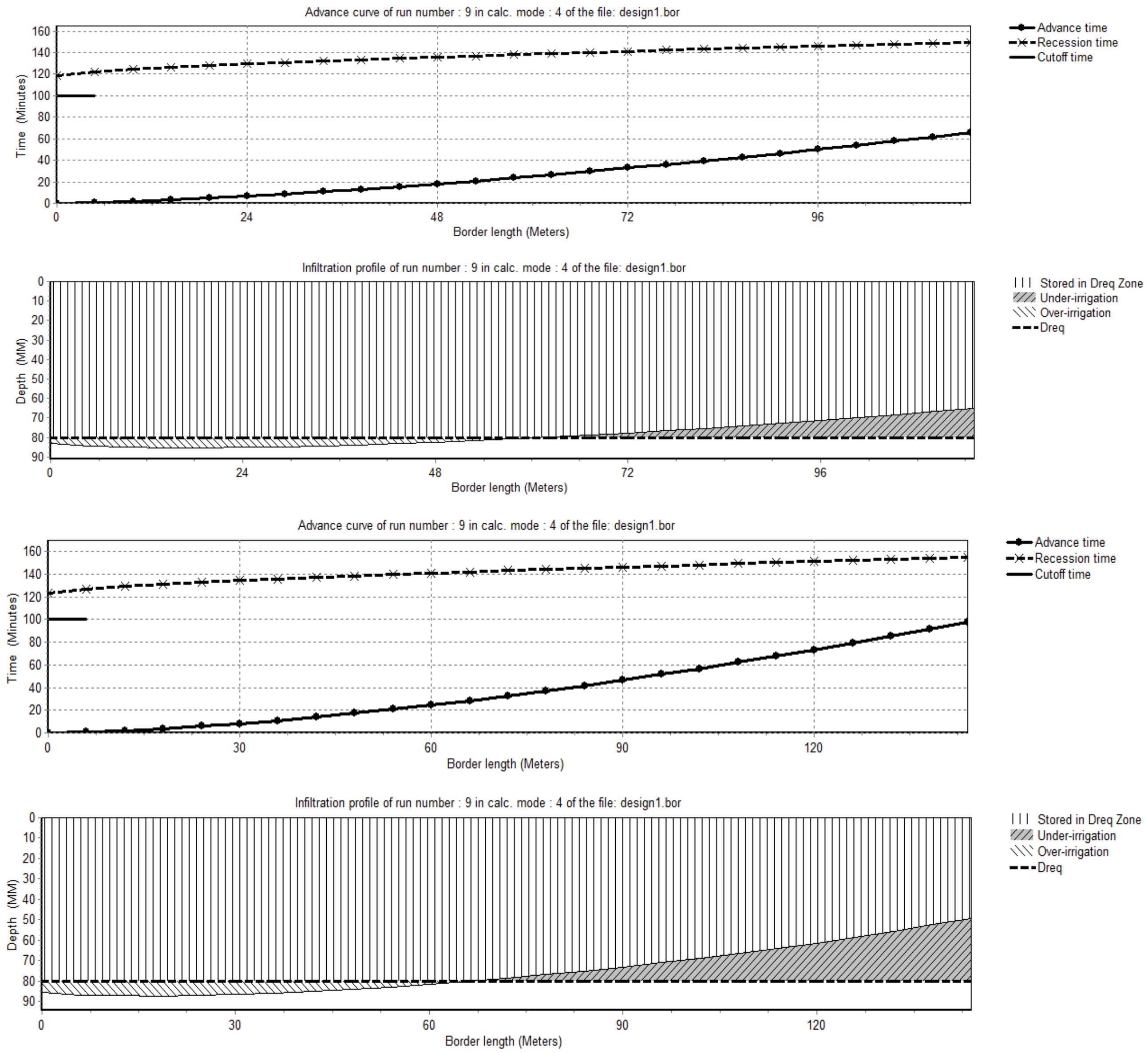

Fig. 5. Relationship between variation of time with discharge and the dimension of the field

4. Calibration

The reliability of the model is based on the calibration and verification of results as important procedures before placing the model in use [17]. Review of literature showed that the perfect determination of Irrigation efficiency and Uniformly coefficient at a field is based upon the chosen of the border irrigation formula .The values of depth requirement (10, 9.5, 7.5, 7, and 6.9) cm were used by the many researchers for the calibration process as illustrated in Table 3, Figure 6.

Table 3
Values of depth requirement with depth measurement (cm)

Item.	depth measurement (cm)	depth requirement (cm)	Chi Square
1	9	10	0.10
2	8.7	9.5	0.07
3	8.5	7.5	0.13
4	8	7	0.14
5	7.8	6.9	0.12

Chi Square computed	0.56

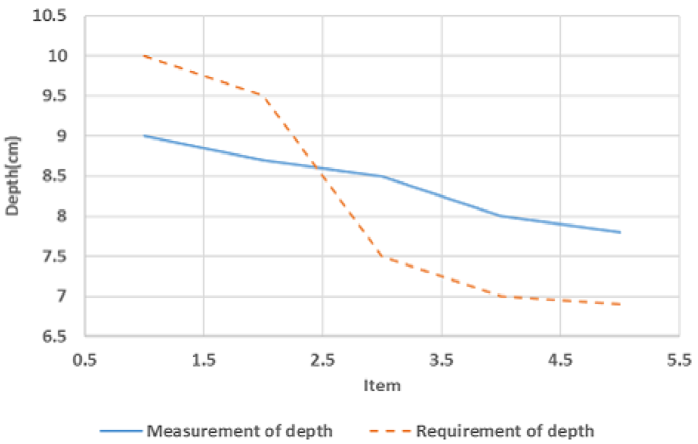

Fig. 6. Relationship between the depth requirement and depth measurement

4.1 Chi - Square Test

The Chi-Square Test was done for the values of requirement and measurement depth by using the following formula That produce the computed chi-square value:

$$\chi^2 = \sum_{i=1}^{N} \frac{(d_0 - d_c)^2}{d_c} \tag{5}$$

where d_0 : depth of measurement, d_c: depth of requirement and the table Chi Square Test χ^2 (n , λ), which equal χ^2 (4 , 0.95) where n: degree of freedom and λ: value of confidence.

It was found that computed chi-square value which calculated from Eq. (5) equals 0.56 and the table Chi-Square value equals 9.49.

5. Conclusion and Recommendation

By using surface irrigation model in two axis's, first axis, measuring the depth of irrigation with border slope and factor SCS for soil (case study), the irrigation efficiency and uniformly coefficient were estimated in different border dimensions. In the second axis, analysis was done in the relationship between the soil type with border dimension and factor SCS in which values available in stranded table with considering the infiltration time and advance time in the two axes of model and its effect on irrigation efficiency. According to results shown in Tables 1 and 2, the irrigation efficiency increases and the uniformly coefficient decreases with increasing of land area (basin dimension). The optimal dimension of the border is (120, 20) m that giving a moderate balance between the irrigation efficiency and uniformly coefficient about (77, 82) % with advance (49-66) min and appointed time (84-96) when optimal discharge ranges between (40-35) L/sec. Also, using GIS techniques is suitable for getting data about the field which contributed to reducing the cost of investigation survey work. It recommended for using irrigation of GIS and remote sensing for monitoring the soil moisture and groundwater table moreover determine the grade of agriculture soil. The improving of soil structure that contributes to reduce the time of appointing infiltration that increases the Irrigation efficiency and uniformly coefficient.

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