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# Optimize of all Effective Infiltration Parameters in Furrow Irrigation Using Visual Basic and Genetic Algorithm Programming

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**Abstract:** In many last studies optimizing control parameters in furrow irrigation has been done. In these studies, either the goal of optimization has been only to achieve full irrigation status, or not all parameters of infiltration are optimized. In this paper, using MS Visual Basic (VB) programming the best equation of distribution curve of water in the soil were determined. Then using Genetic Algorithm (GA) coding in MATLAB software environment, all effective infiltration parameters in furrow irrigation were obtained for the best equation of distribution curve of water in the soil. The results showed that using VB and GA programming water delivery and farm size could be optimized. In addition, because reduced uncertainly amount of maximum efficiency increased.

**Key words:** Furrow irrigation, Optimization, Visual Basic, Genetic Algorithm, Infiltration parameters

## INTRODUCTION

Using a second-degree equation to approximate the relationship between available water and plants-yield, Varlev (1988) optimized the uniformity of irrigation and fertilization. Playan and mateos (2006) offered modernization and optimization of irrigation systems to increase water productivity. Lecina and *et al.* (2005) evaluated irrigation at the district irrigation situation in Spain. The simulation of surface irrigation indicated that the optimum irrigation time in the current situation is 1.7 h ha-1. The optimization of the irrigation time would lead to an average application efficiency of 76%. Their results showed that improved irrigation management could therefore result in substantial water conservation in the district. Pereira and *et al.* (2002) reviewed irrigation management under water scarcity. They identifies the need to adopt emerging technologies for water management as well as to develop appropriate methodologies for the analysis of social, economic, and environmental benefits of improved irrigation management. Wang and *et al.* (2007) presented a Visual Basic program for simulating distribution and atmospheric volatilization of soil fumigants applied through drip irrigation. They remarked that the program should be useful in helping pesticide specialists, farm managers, or policy makers to optimize the depth, rate, and duration of fumigant application to achieve the highest possible distribution uniformity and the lowest volatilization loss. Webber and *et al.* (2006) showed that alternate furrow irrigation and deficit irrigation are appropriate methods to increase water use efficiency (WUE), allowing application of less irrigation water, particularly, for green gram production. Mateos and Oyonarte (2005) assuming compliance the shape of the soil water distribution curve from normal distribution, analyzed changes in irrigation efficiencies in three periods of irrigation. Singh and Fang (1989) assuming compliance the shape of distribution curve of water in the soil from a quadratic equation simulated a full period irrigation in strips with a closed end and by a volume balance model. Ito *et al.* (2005) also obtained optimized farm dimensions for the design of irrigation furrow systems. Hume (1993) was able to determine infiltration parameters in strip irrigation system, by a field data collection and assuming compliance the amount of stored water in the soil, from a linear regression equation and using mass balance model. Montesionos *et al.* (2001) by optimizing discharge compounds, the cutoff time and irrigation duration, using genetic algorithm, were able to present seasonal furrow irrigation with vision economic. SRFR model (Strelkoff *et al.*, 1998), is a design tool for sloping, penended border strip systems BORDER (Strelkoff *et al.*, 1996), and is a design tool for level basin systems BASIN (Clemmens *et al.*, 1995). Bautista *et al.* (2009a) presented WinSRFR model for simulate surface irrigation. Bautista *et al.* (2009b) in another article showed applications of the WinSRFR. Valipour and Montazar (2012) evaluated SWDC and WinSRFR models to optimize of infiltration parameters in furrow irrigation. Using sensitive analysis increased amount of irrigation efficiencies, Valipour and Montazar (2012) in another research.

In this paper by using Visual Basic and Genetic Algorithm programming amount of input discharge, cutoff time and length and width of furrow has been optimized.

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## MATERIALS AND METHODS

According to Lewis and Milne (1938), Elliot and Walker (1982), and Valipour and Montazar (2012):

$$Z(x) = k\left(t_{final} - \left(\frac{x}{p}\right)^{\frac{1}{\gamma}}\right)^{a} + f_o\left(t_{final} - \left(\frac{x}{p}\right)^{\frac{1}{\gamma}}\right) \quad (1)$$

Where, $Z$ ($m^3/m$) as the functions from distance advance $x$ (m), $k$ ($m^3/m.s^a$), $a$, $f0$ ($m^3/m.s$), are the infiltration coefficients from the equation of modified Kostiakov-Lewis, $r$ and $p$ are the coefficients of advance equation, *tfinal* (s) is the time in which cumulative infiltration curve of water into the soil almost changes from the exponential to linear mode.

Now, by using from equation (1) for all irrigation efficiencies (Valipour and Montazar, 2012), we have:

$$\text{Goal function} = \text{Maximum}\ (\alpha DU+\beta E_a+\theta(1\text{-}DPR)+\varepsilon(1+TWR)+\mu(1\text{-}DR)) \quad (2)$$

Where, *DU* is the distribution uniformity, *Ea* is the application efficiency, *DPR* is the deep percolation ratio, *TWR* is runoff ratio, *DR* is the deficit ratio. To determine the coefficients of equation (2) we use the hierarchical analysis. All calculations related to the hierarchical analysis was conducted by the Expert Choice software and coefficients of obtained are presented in Table 1 (Valipour and Montazar, 2012).

**Table 1:** Obtained coefficients from the analysis of hierarchical by the Expert Choice software

| Coefficient | Alpha | Beta | Epsilon | Theta | Mu |
|---|---|---|---|---|---|
| Content | 0.216 | 0.426 | 0.110 | 0.056 | 0.162 |

Valipour and Montazar (2012) considered that in equation (2), shape of distribution curve of water in the soil followed from a third degree polynomial. However, it is not true in all conditions. In some cases, exponential or power functions are better selection. Therefore because of reduce uncertainly, all functions that able to achieve to needed boundary conditions for equation (1) (Valipour and Montazar, 2012), programmed in MS Visual Basic software. Using this program always the best equation for shape of distribution curve of water in the soil will be selected. Figure 1 shows the Visual Basic programmed for this research. By entry input data and click Best Model button, program start to calculate for determine one of the showed equations that have the best fitness with input data.

Because of the complexity and great size of mentioned equations, answer to equation (2) is not achievable using mathematics conventional methods. Assuming input discharge as a variable, Valipour and Montazar (2012) solved the equation (2). But, in this study assumed that input discharge, cutoff time, and length and width of furrow were changeable. For this purpose, by using programming in MATLAB software environment and in the form of genetic algorithm, the optimum input discharge, cutoff time, length and width of furrow, and thus maximum efficiency is obtained. Figure 2 shows stages of genetic algorithm programmed in MATLAB software environment. According to obtained the best model from Visual Basic program, needed code programmed to solving the equation (2). Then input and output data are defined. After determine tolerance, population size, and population type, if average change in the fitness value was less than tolerance migration information (direction, internal, and fraction) is determined. Otherwise, population size will increase. Then if average change in the fitness value was less than tolerance direction of migration will change. In next stage information of crossover and mutation are determined. If not required to change of crossover and mutation functions, output data will be obtained.

To compare results of this paper to other researches, one example presented in WinSRFR model is used. This data is actually as Benson's farm data. Table 2 show input values.

## RESULTS AND DISCUSSION

Table 3 shows the obtained results from genetic algorithm. According to the table 3 for increase of population size, amount of maximum efficiency increases and with population size equal to 10000, forward direction for migration, and select scattered and constraint dependent for crossover and mutation function, respectively, amount of maximum efficiency is 84.1%.

Table 4 compared results to other models. According to the table 4:

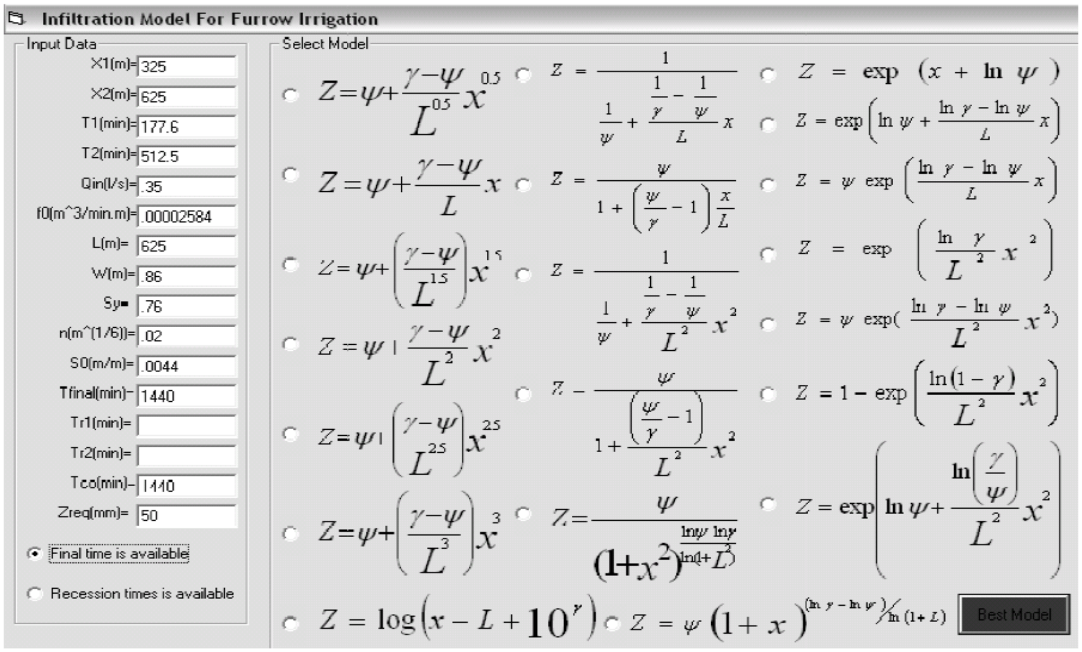


**Fig. 1:** Select the best model distribution water the for shape of curve of in soil using VB program.

**Table 2:** Input values.

| Input Data | $x_1$ (m) | $x_2$ (m) | $t_1$ (min) | $t_2$ (min) | $f_0$ ($m^3$/min.m) | L (m) | W (m) | $S_y$ | n ($m^{1/6}$) | $S_0$ (m/m) | $Z_{req}$ (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Content | 325 | 625 | 177.6 | 512.5 | 0.00002584 | 625 | 1.52 | 0.76 | 0.02 | 0.0044 | 50 |

**Table 3:** Obtained results from genetic algorithm.

| Population size | Migration direction | Crossover function | Mutation function | Qin (l/s) | L (m) | W (m) | Tc (min) | Maximum Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| 20 | Both | Single point | Gaussian | 0.47 | 557 | 0.56 | 557 | 77.0 |
| 50 | Both | Single point | Gaussian | 1.63 | 562 | 1.88 | 561 | 79.1 |
| 100 | Both | Single point | Gaussian | 0.41 | 620 | 0.61 | 794 | 79.8 |
| 1000 | Both | Single point | Gaussian | 0.35 | 625 | 0.71 | 1362 | 82.6 |
| 2000 | Both | Single point | Gaussian | 0.35 | 625 | 0.84 | 1417 | 82.7 |
| 5000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 6000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 7000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 8000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 9000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 10000 | Both | Single point | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 10000 | Forward | Single point | Gaussian | 0.35 | 625 | 0.86 | 1432 | 83.7 |
| 10000 | Forward | Two point | Gaussian | 0.35 | 625 | 0.84 | 1417 | 82.7 |
| 10000 | Forward | Intermediate | Gaussian | 0.35 | 625 | 0.84 | 1417 | 82.7 |
| 10000 | Forward | Heuristic | Gaussian | 0.35 | 625 | 0.86 | 1429 | 83.6 |
| 10000 | Forward | Arithmetic | Gaussian | 0.35 | 624 | 0.69 | 1210 | 80.6 |
| 10000 | Forward | Scattered | Gaussian | 0.35 | 625 | 0.86 | 1433 | 83.7 |
| 10000 | Forward | Scattered | Uniform | 0.35 | 625 | 0.86 | 1435 | 83.9 |
| 10000 | Forward | Scattered | Adaptive feasible | 0.35 | 625 | 0.86 | 1433 | 83.7 |
| 10000 | Forward | Scattered | Constraint dependent | 0.35 | 625 | 0.86 | 1440 | 84.1 |

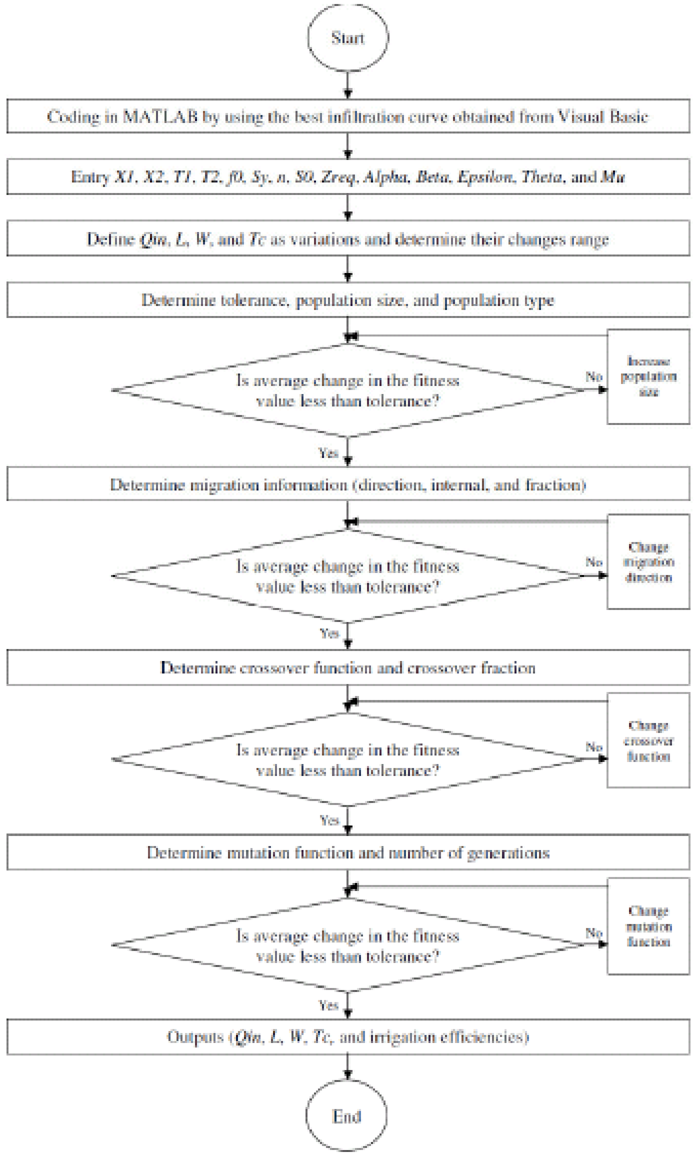


**Fig. 2:** Stages of genetic algorithm programmed in MATLAB software environment.

In WinSRFR model *Qin-tc* compounds become optimized for access to full irrigation. Therefore DR=0 but maximum efficiency is lower than other models. In this model by holding the applied discharge of farm (1.12 l/s), the amount of optimized *tc* in WinSRFR model is obtained, that this value is equal to 1138 min. In SWDC model, considered that in equation (2), shape of distribution curve of water in the soil followed from a third degree polynomial and input discharge as only variable, thus, discharge 1.27 l/s obtained as optimized discharge, without changing cutoff time compared to the actual conditions. By merge of WinSRFR and SWDC models, the amount of optimized discharge in SWDC model for tc=1138 min that was presented by WinSRFR as optimized cutoff time, is obtained (Q=0.88 l/s). Comparing this merge model with SWDC model, it is found that not only SWDC model (without an increase in *tc*), has an more total efficiency than the conditions of reduction in discharge to increase cutoff time (WinSRFR + SWDC), but also SWDC model saves the amount of 13.7 m3 in waters delivery to the furrow. Using sensitive analysis can improved the obtained result from SWDC model. In SWDC + Sensitive Analysis model, using width of furrow equal to 0.6 meter and discharge equal to 0.48 liters per second, also using cutoff time equal to 720 minutes and discharge equal to 1.16 liters per second, due to greater total efficiency (79.6% compared to 78.9%), are two better combinations than SWDC model. Finally, in Visual Basic + Genetic Algorithm model, according to the assumed that input discharge, cutoff time, and length and width of furrow were changeable and due to using programming in MS Visual Basic and MATLAB software environment, in the form of genetic algorithm, the optimum input discharge, cutoff time, length and width of furrow, and thus maximum efficiency is obtained. In addition, this model saves the amount of 46.2 m3, 16.2 m3, 29.9 m3, and 19.9 m3 in waters delivery to the furrow than WinSRFR, SWDC, WinSRFR +SWDC, and SWDC + Sensitive Analysis models, respectively.

**Table 4:** Results of all models.

| Model | Qin(l/s) | Tc(min) | L(m) | W(m) | DU(%) | Ea(%) | DPR(%) | TWR(%) | DR(%) | Maximum Efficiency(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| WinSRFR | 1.12 | 1138 | 625 | 1.52 | 83.1 | 62.3 | 12.7 | 25.0 | 0.0 | 74.4 |
| SWDC | 1.27 | 610 | 625 | 1.52 | 49.8 | 90.0 | 0.0 | 9.5 | 12.0 | 78.9 |
| WinSRFR + SWDC | 0.88 | 1138 | 625 | 1.52 | 76.4 | 74.3 | 0.0 | 25.4 | 5.9 | 77.2 |
| SWDC + Sensitive Analysis | 0.48 | 610 | 625 | 0.60 | 48.0 | 92.4 | 0.0 | 7.2 | 12.6 | 79.6 |
| | 1.16 | 720 | 625 | 1.52 | 61.3 | 85.9 | 0.0 | 13.7 | 9.3 | 79.6 |
| Visual Basic + Genetic Algorithm | 0.35 | 1440 | 625 | 0.86 | 75.4 | 83.0 | 0.0 | 15.0 | 4.6 | 84.1 |

***Conclussion:***

In this paper by using Visual Basic and Genetic Algorithm programming amount of input discharge, cutoff time and length and width of furrow has been optimized. Therefore, obtained maximum efficiency is higher than last studies.

**ABBREVIATIONS**

***Z*** = As the functions from distance advance ($m^3$/m)
***x*** = Distance (m)
$Q_{in}$ = Input discharge ($m^3$/s)
$S_y$ = Shape factor of surface flow
***k***, ***a***, $f_0$= Infiltration coefficients from the equation of modified Kostiakov-Lewis (m3/m.sa)
***W*** = Furrow width (m)
***r***, ***p*** = Coefficients of advance equation
***n*** = Manning roughness coefficient (s/$m^{1/3}$)
$S_0$ = Farm slope (m/m)
$t_{final}$ = Final infiltration time (s)
$t_c$ = Cutoff time (s)
***L*** = Length of furrow (m)
***DU*** = Distribution uniformity
$E_a$ = Application efficiency
***DPR*** = Deep percolation ratio
***TWR*** = Runoff ratio
***DR*** = Deficit ratio
$Z_{req}$ = Required depth (m)
**α,β,θ,ε,μ**: = Coefficients of goal function
**γ** = Infiltrated Water in end of furrow
**ψ** = Infiltrated Water in begining of furrow

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