SOFTWARE

Software for calculating irrigation management of some crops in Guyana

Software para el cálculo del manejo del riego de algunos cultivos en Guyana

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Esequiel Rolando Jiménez-Espinosa*

University of Guyana, Faculty of Agriculture & Forestry, Guyana.

ABSTRACT: The software CIRS (Crop Irrigation Requirement and Scheduling) was developed to calculate the irrigation management of some crops produced in Guyana. The programming language used was Visual Basic within the Visual Studio platform. The interface was designed so that the user interacts with the software in a simple way. The program code was based on the classic irrigation management calculation procedure, but using single crop coefficients adjusted to the agro-meteorological conditions of Guyana, and estimating the physical properties of the soil according to texture, by mean a mathematical model recommended for use in the country. As a result, irrigation management parameters are obtained with greater precision to supply the water requirements of Guyana's agricultural crops.

Keywords: CIRS, Visual Basic, Visual Studio, Physical Properties, Soil.

RESUMEN: Se elaboró el software CIRS (Crop Irrigation Requirement and Scheduling) para el cálculo del manejo de riego de algunos cultivos producidos en Guyana. El lenguaje de programación que se utilizó fue Visual Basic dentro de la plataforma Visual Studio. La interfaz fue diseñada para que el usuario interactúe con el software de manera sencilla. El código del programa se basó en el procedimiento clásico de cálculo del manejo del riego, pero utilizando coeficientes únicos de cultivo ajustados a las condiciones agro-meteorológicas de Guyana, y estimando las propiedades físicas del suelo según la textura, mediante un modelo matemático recomendado para usarlo en el país. Como resultado, se obtienen parámetros de manejo de riego con mayor precisión para satisfacer las demandas de agua de los cultivos agrícolas de Guyana.

Palabras clave: CIRS, Visual Basic, Visual Studio, propiedades físicas, suelo.

INTRODUCTION

Guyana is a country with abundant hydraulic resources. According to the Guyana National Land Use Plan (GLSC-Guyana, 2013), it was estimated by the United States Army Corps of Engineers in 1998 that there are enormous quantities of surface fresh water in much of the year (8 months) at a rate of more than 400,000 L/min. In the case of groundwater, the coastal plain also has available freshwater values greater than 400,000 L/min.

However, due to the effects of climate change, the country has suffered periods of drought that have affected agricultural activity. In the second half of 2023, the country suffered a period of drought that was predicted by the Hydrometeorological Service of the Ministry of Agriculture, when the 14th National Climate Outlook Forum was held (NCOF-Guyana, 2023).

Even so, in Guyana's agricultural practice, it is not usual to give importance to irrigation management due to the abundance of fresh water. That is why Jiménez-Espinosa *et al.* (2020), made adjustments to single crop coefficients (Kc) for the agro-meteorological conditions of Guyana, with the aim of improving irrigation management. On the other hand, the same author Jiménez-Espinosa *et al.* (2022) proposed the equations of Rawls *et al.* (1982) and Saxton *et al.* (1986), to estimate the physical properties of the soils of Guyana and determined values of bulk density, field capacity and permanent wilting point according to USDA (1987) textural class and general classification.

On the other hand, research related to irrigation activity in Guyana is scarce, so it is of crucial importance to establish tools that contribute to improving the management of this water resource.

Based on the above, this work aims to show the software CIRS (Crop Irrigation Requirement and Scheduling), for calculating irrigation management, where more precise parameters are obtained to satisfy the water requirements of agricultural crops in Guyana.

*Author for correspondence: Esequiel Rolando Jiménez-Espinosa, e-mail: esequiel.espinosa@uog.edu.gy

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SOFTWARE DEVELOPMENT

Methodology for the development of CIRS Software

The CIRS software was developed with the Visual Basic programming language of the Visual Studio platform. The language of the program is English and its interface was designed so that the user interacts in a simple way.

Main window

It has a presentation and buttons that give access to the calculation and information of the software.

Window INPUT DATA

This is the main part where the user enters all the information that is requested and all the calculations are performed. See Figure 1.

Regarding the selection of the Regions of Guyana and the type of crop, the software has data on crop coefficients adjusted to the agro-meteorological conditions of each region of Guyana. The adjustment of these coefficients was based on the previous adjustments made by Jiménez et al. (2020), using the methodology of FAO document 56 (Allen *et al.*, 1998). When selecting the textural class, the United States Department of Agriculture (USDA) classification and a general classification appear. For both cases, the CIRS software establishes values of physical properties of Guyana soils, estimated using the Saxton equations Saxton *et al.* (1986), which were recommended by Jiménez-Espinosa *et al.* (2022). In the case of saturation moisture (Θ_S), its value was multiplied by the real density of 2.65 g•cm^{-3} according to Hillel (2003) cited by González-Barrios *et al.* (2012) to obtain the bulk density (see equations 1, 2 and 3).

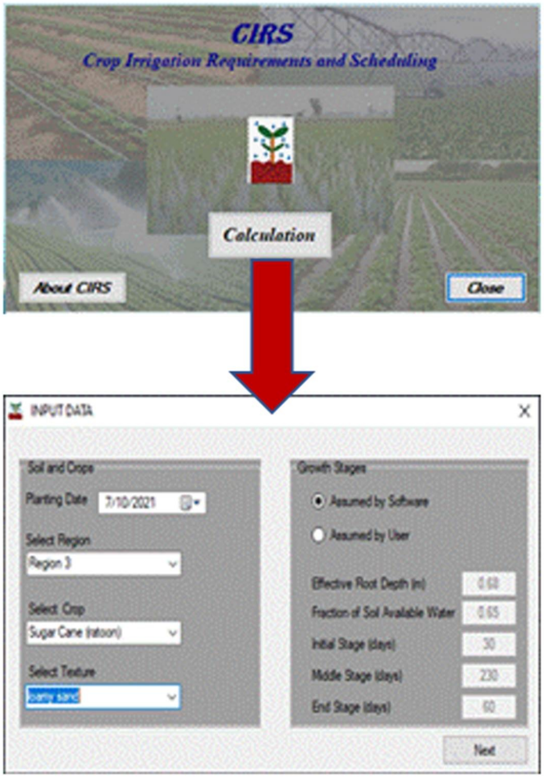

FIGURE 1. Main window and "**INPUT DATA**" window where the information for calculating irrigation parameters is selected and entered.

For the calculation process of irrigation management parameters of most crops, the irrigation requirements, Net Irrigation Depth, Irrigation Frequency and Adjusted Net Irrigation Depth were determined for each stage of crop development (Stages: initial, middle and end). For the calculation process of the irrigation parameters of the rice crop, the methodology of Camejo-Barreiro *et al.* (2017)

Field capacity:

$$\Theta_{33} = \left[\frac{\Psi_{33}/100}{exp\left[a + b(\%C) + c(\%S)^2 + d(\%S)^2(\%C)\right]}\right]^{\left[\frac{1}{e + f(\%C)^2 + g(\%S)^2(\%C)}\right]} \quad [1]$$

Permanent wilting point:

$$\Theta_{1500} = \left[\frac{\Psi_{1500}/100}{exp\left[a + b(\%C) + c(\%S)^2 + d(\%S)^2(\%C)\right]}\right]^{\left[\frac{1}{e + f(\%C)^2 + g(\%S)^2(\%C)}\right]} \quad [2]$$

Saturation moisture:

$$\Theta_s = 1 - (h + j(\%S) + k^*\log_{10}(\%C)) \quad [3]$$

Where: %S - percent sand; %C - percent clay; %Si - percent silt; OM - organic matter in %; BD - bulk density; Ψ_{33} - soil tension of 33 kPa; Ψ_{1500} - soil tension of 1500 kPa; a= -4.396, b= -0.0715; c= -4,880•10^{-4}; d= -4.285•10^{-5}; e= -3.140, f= -2.22•10^{-3}; g= -3.484•10^{-5}; h= 0.332; j= -7.251•10^{-4} and k= 0.1276.

was used with some adjustments in the duration of each irrigation stage and with the updating of the agro-meteorological and of Guyana soils. See Table 1.

Windows RESULTS

The software displays two windows. The first (Figure 2) shows the results of the irrigation parameters for each of the crops, except rice. The results of all the calculations carried out in the INPUT DATA window are shown, taking into account the selected conditions.

The other window is specific for rice crop, where each of the nine irrigation stages are shown. (see Figure 3).

Finally, Figure 4 summarizes the operation of the software through a diagram.

TABLE 1. Stages for irrigation management of Rice crop

Irrigation Stages	Duration (days)	Description
Stage 1	3	Irrigation is applied until the soil is saturated.
Stage 2	6	Irrigation is applied taking into account an infiltration coefficient.
Stage 3	10	
Stage 4	11	Irrigation is applied taking into account an infiltration coefficient, plus 5 cm flooding above the soil surface.
Stage 5	23	Irrigation is applied taking into account a Dam infiltration coefficient according to Dueñas *et al.* (1981) and Camejo-Barreiro *et al.* (2017) and an infiltration coefficient. In this way the flood of 5 cm above the soil surface is maintained.
Stage 6	6	Irrigation is applied taking into account an infiltration coefficient. The flood sheet on the soil surface is reduced to 3 cm.
Stage 7	3	Irrigation is applied taking into account an infiltration coefficient. The flood sheet on the soil surface is increased to 5 cm.
Stage 8	28	Irrigation is applied taking into account a Dam infiltration coefficient and an infiltration coefficient. In this way the flood of 5 cm above the soil surface is maintained.
Stage 9	25	

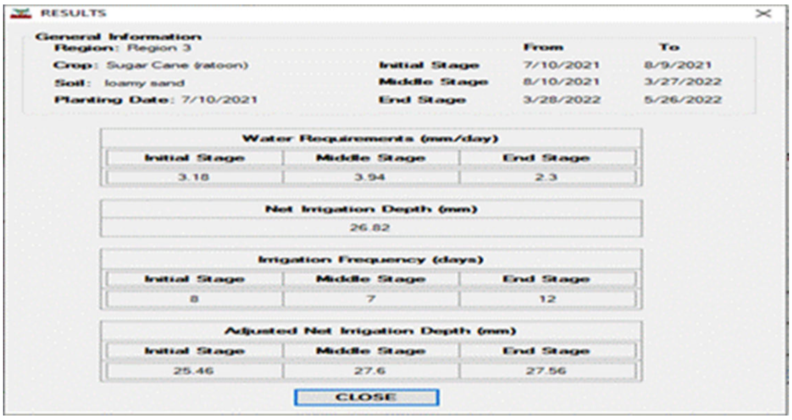

FIGURE 2. Window "**RESULTS**" with the results of the irrigation management parameters. (eg. Sugar Cane-ratton).

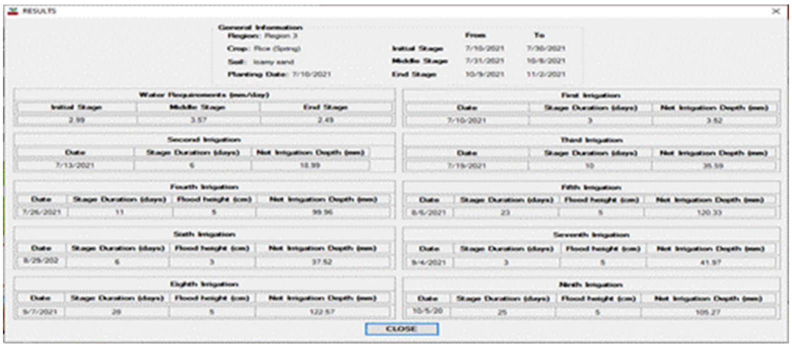

FIGURE 3. Window "**RESULTS**" with the results of the irrigation management parameters. (eg. Rice-spring).

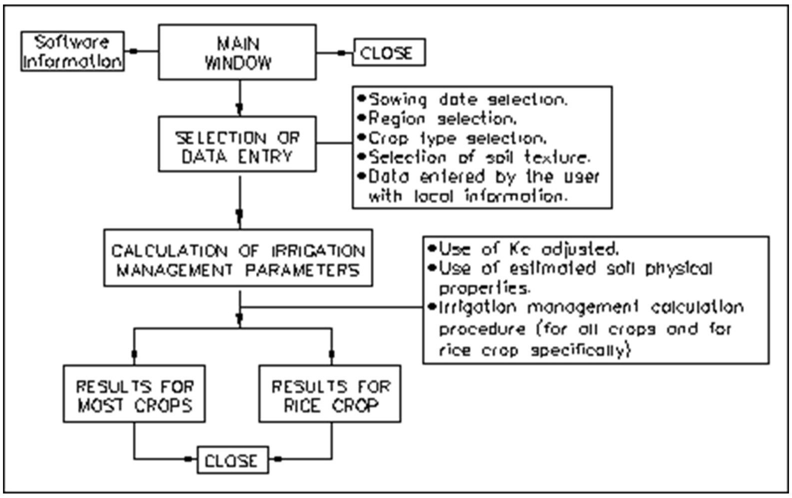

FIGURE 4. Operation diagram of software CIRS.

CONCLUSIONS

- The CIRS software allows irrigation parameters to be determined more precisely, since it takes into account adjusted crop coefficients and estimated values of soil physical properties. For both cases, recommended to use in Guyana.
- The software takes into account the agro-meteorological and soil conditions of Guyana to calculate irrigation management in rice crop.
- The CIRS software is easy to interact with, selecting an option for each requested indicator. It also allows you to enter data if there is local information.

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Esequiel Rolando Jiménez-Espinosa, Senior Lecturer, Faculty of Agriculture & Forestry, University of Guyana.