GPVI 1.0: SCRIPT WEB FOR HISTORICAL SERIES OF CROP WATER BALANCE

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ABSTRACT: Reference evapotranspiration and crop water balance are concepts used for different purposes in different areas of knowledge. Among them, to carry out the planning of the most suitable sowing season, with less risk of occurring periods of water deficit. The objective of this work was to present a web script to calculate hourly reference evapotranspiration and daily water balance with data from automatic meteorological stations for different soils and crops. The script was written in html and php and was connected to a mysql database. Meteorological data of automatic stations were used. Soil and crop data can be registered as needed by the user. The script allows to calculate historical series of crop water balance for different soils and crops. Selection of climatic data is facilitated skipping several steps.
KEYWORDS: Hourly evapotranspiration, water storage, web application.

GPVI 1.0: SCRIPT WEB PARA SÉRIES HISTÓRICAS DE BALANÇO HÍDRICO DE CULTIVOS

RESUMO: Evapotranspiração de referência e balanço hídrico da cultura são conceitos utilizados para diversas finalidades em diferentes áreas do conhecimento. Entre elas realizar o planejamento de época de semeadura mais adequada, com menor risco de ocorrer períodos de défice hídrico. Objetivo deste trabalho foi apresentar um script web, para calcular a evapotranspiração de referência horária e o Balanço hídrico da cultura diário, com dados de estações meteorológicas automáticas para diferentes solos e culturas. O script foi escrito em html e php e foi conectado a um banco de dados mysql. Dados meteorológicos de estações

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automáticas foram utilizados. Os dados do solo e da cultura podem ser registrados conforme a necessidade do usuário. O script permite calcular séries históricas de balanço hídrico de culturas para diferentes solos e culturas. A seleção de dados climáticos é facilitada pulando várias etapas.

PALAVRAS-CHAVE: Evapotranspiração horária, armazenamento de água, aplicativo web.

INTRODUCTION

Evapotranspiration is the sum of plant transpiration and direct evaporation of the soil water. It can be obtained through meteorological parameters. According to Allen et al. (1998), the reference evapotranpiration (ETo) is a process that occurs in a hypothetical culture, 0.12 m high, 0.23 albedo and 70 s m-1 vapor transport resistance, and can be calculated by the Penman-Monteith (PM) method. This is the standard method adopted by the Food and Agriculture Organization of the United Nations (FAO).

Because it requires a large number of variables, many researchers seek to calibrate other simpler methods. Silva et al. (2011), Lacerda & Turco (2015), Carvalho and Delgado (2016), Cunha et al. (2017) demonstrate the search for methods that use fewer variables, while pointing to the PM method as the standard, the reference for the validation of other methods. For Allen (2006) the hourily ETo is more accurate than the daily because it considers the time changes that may occur during the daily cycle.

Climatological water balance, developed by Thornthwaite and Mather (1955) is the most adopted method for monitoring the variation of soil water storage. Inputs (rain) and outputs (evapotranspiration) of water are accounted. When relating them to soil and plants characteristics to provide estimates of actual evapotranspiration, deficit, excess and soil water storage, is called crop water balance (CWB)

The first software used to automate these calculations was spreadsheets. In the last decades many computer programs have been developed for calculate ETo and CWB. Recently, the first online software appeared (Silva & Bracht, 2010; Melo et al., 2017). In practice, these software use routines, scripts, to perform the calculations. However, technical and financial obstacles make it difficult to access them. An internet-accessible script can process data for business, research, teaching and extension use.

The goal was to present a web application to calculate historical hourly ETo and daily CWB series using data from automatic weather stations for different soils and crops.

MATERIAL AND METHODS

The development of the system went through the requirements gathering, analysis, implementation and validation stages (Dias, 2003). The script was written in Personal Hypertext Preprocessor (PHP) language and generates a Hyper Text Markup Language (HTML) file (PHP, 2017; W3C, 2017).

The database was mysql (MYSQL, 2017), managed by the application in php phpmyadmin (PHPMYADMIN, 2017). The scripts and data were stored and processed in a virtual machine running Linux debian operating system, with web server, php and mysql.

The crop water balance (CWB) followed the methodology presented by Allen et al. (1998). Inputs and outputs by surface and subsurface flow were neglected. These are equivalent, canceling each other out. Capillary rise is negligible in most areas of cultivation. Percolation ceases soon after saturation and natural drainage, a condition known as field capacity. From this, only rainfall and crop evapotranspiration (ETc) were accounted for the soil water storage (Eq 1).

$$SWS = R - ETc \qquad (Eq\ 1)$$

Onde, SWS – Soil water storage [mm]; R – Rainfall [mm day^{-1}]; ETc – Crop evapotranspiration [mm day^{-1}];

The ETc was calculated by the product of a reference evapotranspiration under a standard hypothetical culture (ETo) and the culture coefficient (Kc) (Eq 2). The ETo was calculated based on the time-adjusted Penman-Monteith equation (Eq 3) as described by Allen et al. (1998), accumulating 24 hours (Eq 4).

$$ETc = ETo * Kc \qquad (Eq\ 2)$$

Onde, ETc – Crop evapotranspiration [mm day^{-1}]; ETo – Reference evapotranspiration [mm day^{-1}]; Kc – culture coefficient [dimensionless];

$$ETo_i = \frac{0{,}408\Delta(R_n - G) + \gamma \frac{37}{T_{hr} + 273} u_2(e^o(T_{hr}) - e_a)}{\Delta + \gamma(1 + 0{,}34u_2)} \qquad (Eq\ 3)$$

Onde, ETo_i – Hourly reference evapotranspiration [mm hour^{-1}]; R_n - net radiation at the crop surface [MJ m^{-2} hour^{-1}]; *G – Soil h*eat flux density [MJ m^{-2} hora^{-1}]; T_{hr} - mean daily air temperature at 2 m heigh [ºC]; Δ - saturation slope vapour pressure curve at T_{hr} [kPa ºC^{-1}]; γ - psychrometric constant [kPa ºC^{-1}]; $e^o(T_{hr})$ - saturation vapour pressure at air temperature T_{hr} [kPa]; e_a - average hourly actual vapour pressure [kPa]; u_2 - average hourly wind speed [m s^{-1}];

$$ETo = \sum_{i=1}^{24} ETo_i \qquad (Eq\ 4)$$

Onde, *ETo* - reference evapotranspiration [mm day^{-1}]; ETo_i - Hourly reference evapotranspiration [mm hour^{-1}]; *i* – hour;

For ETo*i* resolution, hourly meteorological data were obtained from the National Institute of Meteorology (INMET). In addition to solar radiation, maximum, minimum, average temperatures, relative humidity, wind speed also used latitude, longitude, altitude of each automatic station. The station can be selected on the map as shown in figure 1.

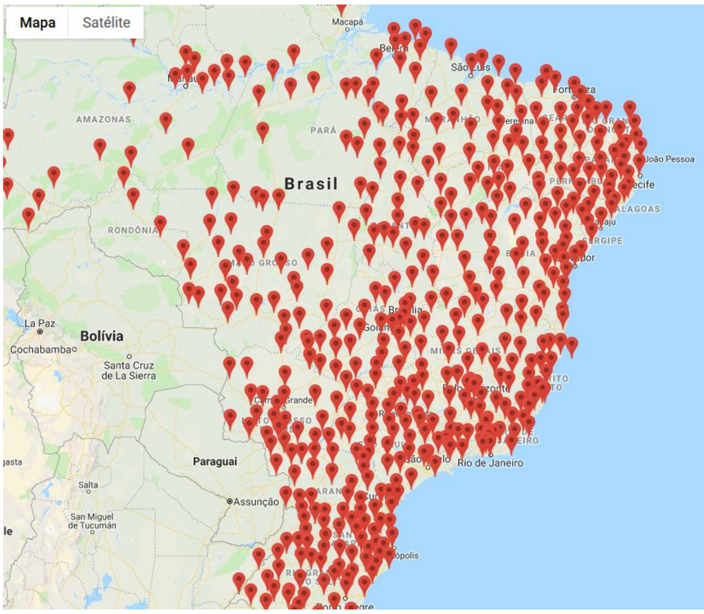

Figura 1. Map of automatic stations of INMET.

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Management areas were created for stations, crops and soils where the characteristics to be considered in the calculations are inserted or altered, as shown in figures 2 and 3 respectively. The total cycle, the number of days and the Kc of each phase of the initial, vegetative, reproductive and maturing crop development were necessary for culture. The initial, maximum effective root depth and crop factor, which refers to how much of the soil water is readily available. In this paper we used information from FAO Bulletin 56 (Allen et al, 1998), but the user can register the information they prefer, adjusting it as necessary. For soil, field capacity, permanent wilting point and density can be determined or use from the available literature as long as it approximates the characteristics of the study place.

Lista das culturas cadastradas + Nova

Mostrar 10 Pesquisar:

Ação	Identificação	Ciclo total	Período inicial	Período de crescimento	Período reprodutivo	Período de maturação	Kc nicial	Kc crescimento	Kc reprodtivo	Kc final	Z inicial	Z máximo	F cultura
	Feijão Precoce	75	15	25	22	13	0.80	1.10	1.40	0.30	10	35	0.45
	Feijão Tardio	90	15	24	36	15	0.40	0.75	1.05	0.95	10	35	0.45
	Soja Média	140	15	44	56	25	0.40	0.80	1.15	0.80	10	35	0.45
	Milho ciclo médio	140	20	44	56	20	0.52	0.87	1.22	0.98	10	50	0.50
	Cana Planta Irrigada Gotejamen	386	30	66	186	104	0.55	0.95	1.01	0.91	10	120	0.65
	Cana RB 92-579 irrigada semiar	389	30	79	238	41	0.65	0.92	1.10	0.85	10	120	0.65
	Cana FAO 56 trópicos	320	30	50	180	60	0.40	1.25	1.25	0.75	10	120	0.65
	Alface Crespa Folha	55	15	15	15	10	0.70	1.00	1.20	1.20	5	30	0.25

Figura 2. Crop management area.

Lista das solos cadastrados + Nova

Mostrar 10

Ação	Identificação	CC volume	PMP volume	CC massa	PMP massa	Densidade	classificação
	UFMS área experimental	0.4100	0.2600	0.00	0.00	1.42	argiloso
	Fundação Chapadão Projeto CAMAS / COOPER	0.1800	0.0900	0.00	0.00	1.44	arenoso
	Fundação Chapadão Costa Rica	0.4200	0.3200	0.00	0.00	1.45	argiloso leve

Pesquisar:

Primeiro Anterior 1 Próximo Ultimo

Figura 3. Soil management area.

To validate the script we used data from the Cassilândia, Mato Grosso do Sul, weather station. For soybean crop. The hypothetical date of the sowing used was october, 15th. The culture parameters were appropriate to their developmental stages by the methodology presented by Allen et al. (1998). The field capacity, permanent wilting point and density used were respectively 18%, 9% and 1.44 g cm^{-3}. Characteristic parameters of the region.

RESULTS AND DISCUSSION

The historical series of CWB are presented in Figure 1. Each row represents an annual cycle. In addition to visual output they are available to copy numeric data. The button on each line to the right of Figure 4 is a link to access the graph and numerical results of the selected years water balance, as shown in Figure 5.

For sowing on October 15, at the beginning of the annual hydrological cycle, soil water storage was above the actual soil water capacity (SWC), mainly in the vegetative and reproductive phases of the crop cycle. The historical series presented favorable climatic conditions with little possibility of water deficits that may limit the development of the crop.

Unlike the one proposed by Melo (2017) that calculates the water balance for the crop indicating the time and quantity to be irrigated, this script can be used by those producers who do not have an irrigation system, but who wish to carry out period planning. of cultivation.

With this information it is possible to plan the most appropriate sowing season, reducing the risk of positioning the crop cycle, at times with higher chances of water deficit. The application can be accessed at the Chapadão do Sul Campus Irrigation Economic Feasibility Research Group's website at the Federal University of Mato Grosso do Sul, www.gpvi.com.br. The user must register to use the application.

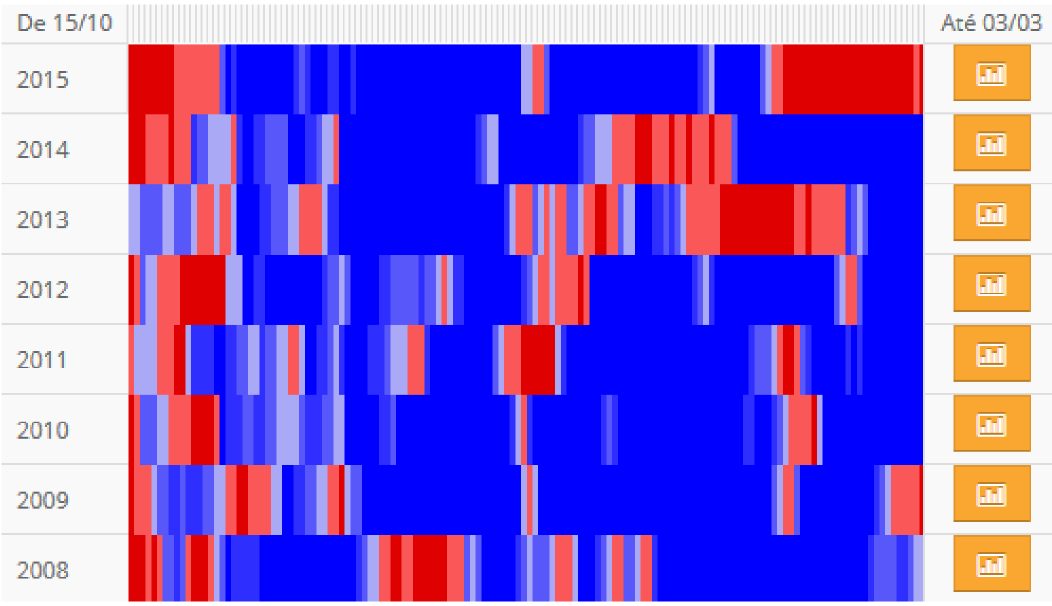

Figure 4. Series of annual water balances of soybean crop sowed on October 15th for Cassilândia – MS.

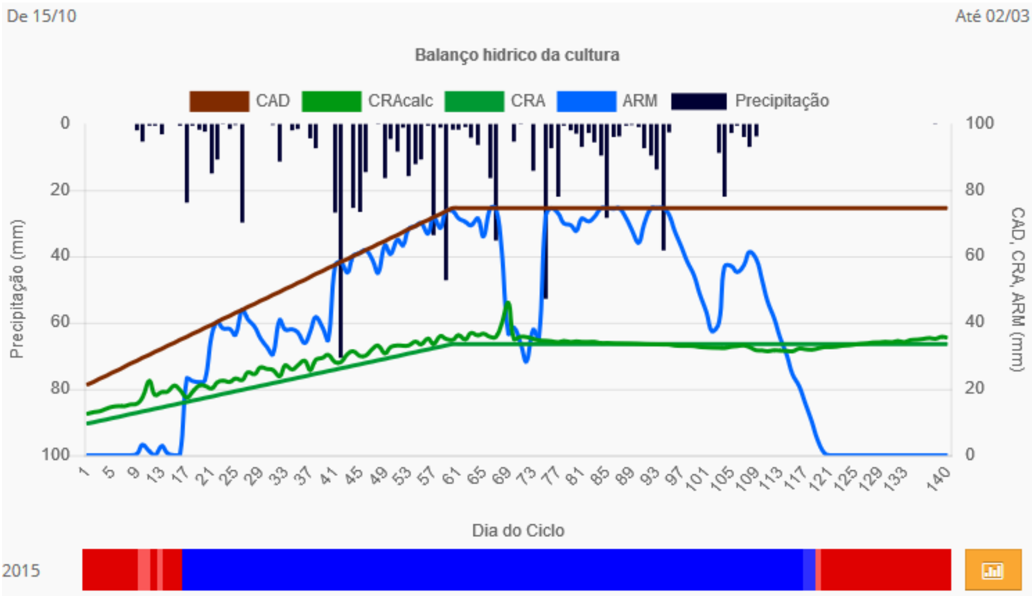

Figure 5. Water balance of soybean crop 2015 for Cassilândia-MS.
Hypothetical sowing date October 15th.

CONCLUSIONS

The script allows the calculation of historical series of hourly culture evapotranspiration and daily water balance. It is possible to select crop and soil parameters. Selecting and obtaining climate data is made easy by skipping several manual steps.

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