Climatic potential for sugarcane in the Llanos Orientales, Colombia

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Abstract

The objective was to analyze the climatic potential for the cultivation of sugarcane in the *Llanos Orientales* region. WorldClim data were used (climate grids) with a spatial resolution of about 1 square kilometer, considering mean date of the period of 1950 to 2000. These data were compared with 2017 rainfall stations and 443 temperature stations of the IDEAM so as to validate the data Worldclim. The degree days were calculated for 1 year period (considering basal temperature of 18 °C) and the hidric deficit using the difference between precipitation and potential evapotranspiration, estimated by Thorthwaite method. Were exclude the areas of environmental reserves and rivers. The results comparing the station data with Worldclim were satisfactory with R^2 to precipitation of 0.86 and average temperature of 0.96. The total degree days, with values greater than 2500, that it is good for sugarcane. This show that the thermal energy of the region has great potential. The water deficit map shows that in every department there is no water deficit, with excess of 1500 mm in Vichada and Meta over large areas. Therefore, the region is promising for the expansion of sugarcane in Colombia.

Keywords: sugarcane, potential area, hidric deficit, precipitation.

Introduction

The Colombian sugar industry is located in the valley of the Cauca River, but there are not areas for expansion. The *Llanos Orientales*, Orinoquía region of Colombia, is characterize by being a great plain, irrigated by rivers of the basin Orinoco. It is consider as the new Colombian agricultural frontier, because of the potential and the landscape transformations [1] [2]. The region covers most of the area in departments of Meta, Arauca, Casanare and Vichada. Thus, the expansion of areas of sugarcane for this region is a possibility of growth of the sugar and ethanol industry.

The critical variables associated with agricultural production are precipitation, air temperature and solar radiation. Air temperature is the primary variable that affects the vegetative and reproductive development. The precipitation does not directly control any process in the plant, but is consider a modifier that indirectly affects many processes of growth and plant development [3]. Among the climatic elements, temperature, solar radiation and rainfall are crucial to the development of sugar cane [4].

For studies that use meteorological data, which are generally derive from conventional or automatic weather stations, may have errors or are difficult to access. Agro-meteorological data from free compilation models like the WorldClim are an alternative. Nevertheless, it is important to check the quality of this data with reliable weather stations data.

Thus, the aim of this work was to analyse the climatic potential for the cultivation of sugarcane in the *Llanos Orientales,* region of Colombia.

Experimental Apparatus

In this study was considered the total area of Colombia, where was used data of temperature (443 stations) and precipitation (2017 stations) from weather stations IDEAM (Fig. 1) which are the average monthly precipitation and average daily temperature (1981-2010) and data from the global model WorldClim (average data of 1950-2000). WorldClim is a set of global climate layers (climate grids) with a spatial resolution of about 1 square kilometer. The data can be used for mapping and spatial modeling in a GIS or with other computer programs [5]. With the aim of to validate the data of temperature and precipitation, they were compared with meteorological stations IDEAM, point to point, and obtained the R^2.

In order to exclude the restricted areas of sugarcane, were excluded areas with slopes greater than 12% (to allow mechanization), using SRTM data (Shuttle Radar Topography Mission), and national parks and reserves, as well specific areas such as rivers, other crops and urban area (Fig. 2) [6].

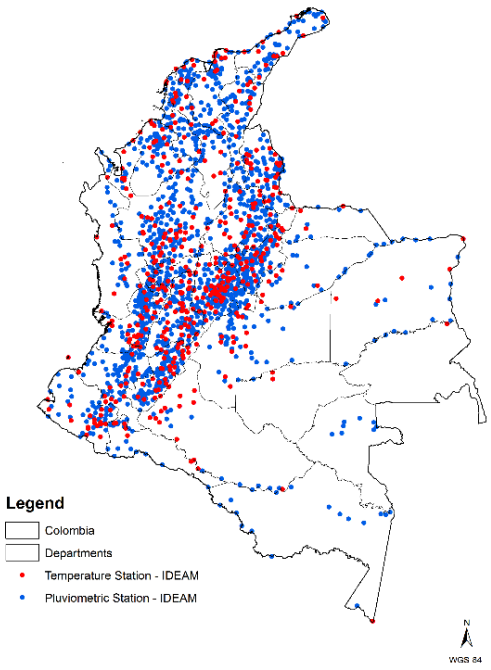

Fig. 1 Meteorological Stations from IDEAM in Colombia.

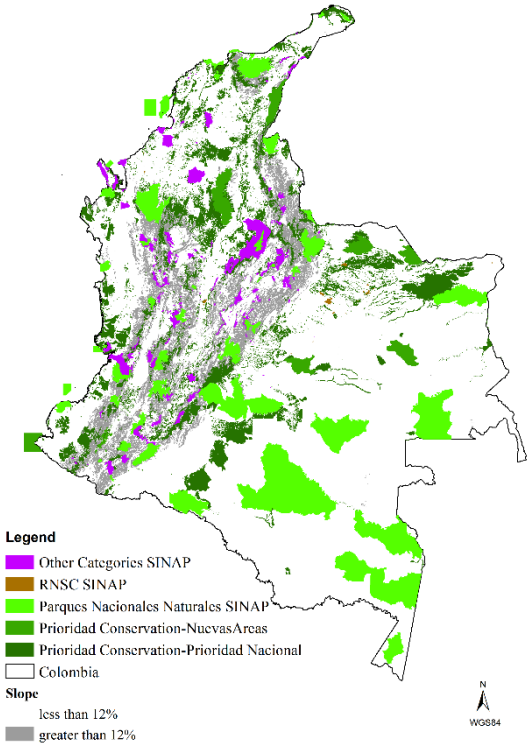

Fig. 2 Restricts areas where slope is greater than 12%, Environmental Reserve and Selected Restrictions.

For the analysis of climatic potential for sugarcane in the *Llanos Orientales*, were estimated the degree days (DD), potential evapotranspiration (ET_{pp}) and de hidric deficit (HD). The degree days were calculated according to the number of favorable temperature for growth with Basal Temperature (Tb) of 18 °C (Equation 1).

$$DD = (Tmed - Tb) * (\text{Numbers days of month}) \quad (1)$$

The Hidric Deficit was calculated as the difference between precipitation (P) provided by the WorldClim and the potential evapotranspiration estimated by the Thorthwaite method [7] using T_{med} from WorldClim (Equation 2).

$$HD = P - ET_{pp} \quad (2)$$

The potential evapotranspiration was estimate using the method of Thorthwaite (equation 3).

$$ET_{pp} = 16\left(\frac{10t_i}{I}\right)^a \quad (3)$$

Where:

ET_{pp} = monthly potential evapotranspiration (mm)

t_i = monthly mean temperature (°C)

I = a heat index which is a constant for a given location and is the sum of 12 monthly index values i, where i is a function of the monthly normal temperatures (eq. 4).

a = an empirically determined exponent which is a function of I (eq. 5)

$$I = \sum_{jan}^{dec} \left(\frac{t_i}{5}\right)^{1,514} \quad (4)$$

$$a = 0{,}49239 + (1{,}792 * 10^{-2} * I) - (7{,}71 * 10^{-5} * I^2) + (6{,}75 * 10^{-7} * I^3) \quad (5)$$

Results and discussion

Primarily is shown in figure 3 and figure 4, the results comparing the station data (precipitation and mean air temperature) with Worldclim, where were satisfactory with R^2 to precipitation of 0.86 and mean air temperature of 0.96.

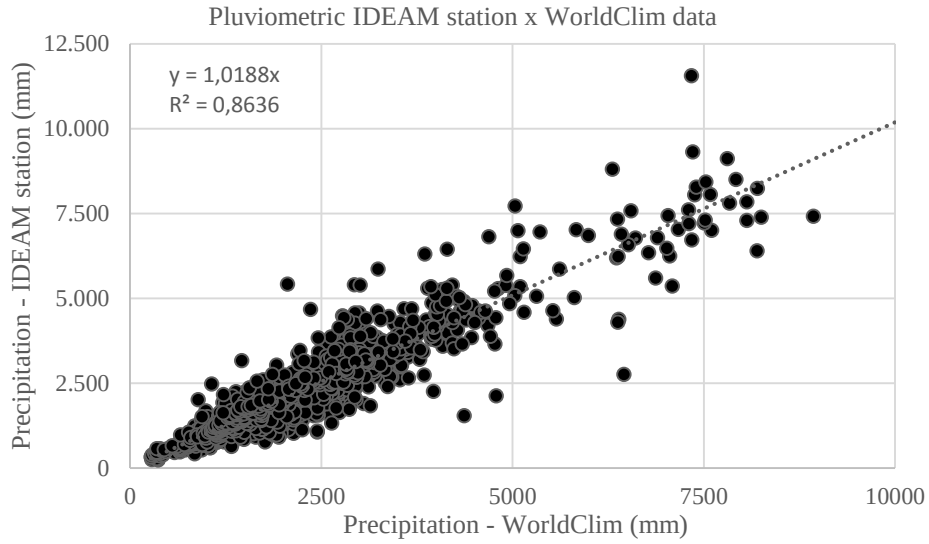

Fig. 3 Comparing the IDEAM station data of precipitation with Worldclim.

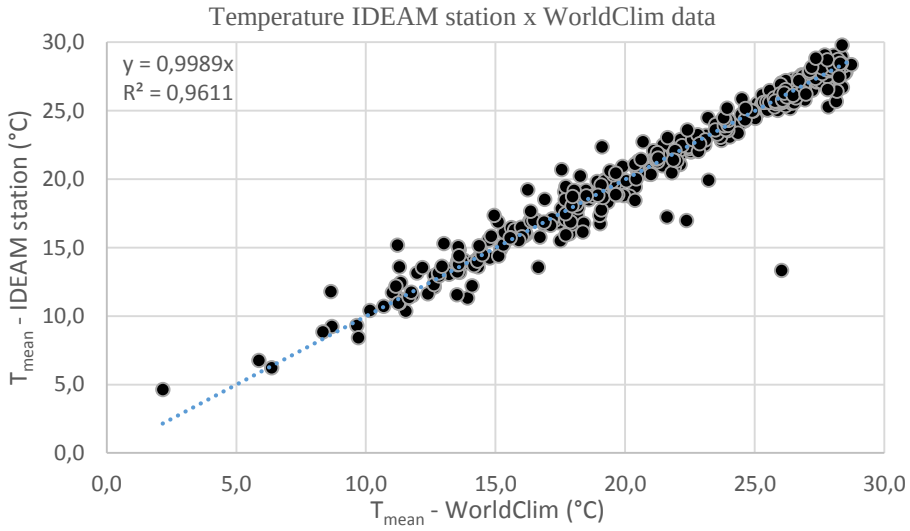

Fig. 4 Total degree-days using basal temperature of 18ºC for Llano Orientales.

In figure 5 we have the total degree days, with values greater than 2500, that it is good for sugarcane. The degree days in the cycle of sugarcane in São Paulo, Brazil, the main areas had values between 1500 and 2500 DD, with maximum of 3398 [8]. This show that the thermal energy of the region has great potential.

The water deficit map (Fig. 6) shows that in every department there is no water deficit, with excess of 1500 mm in Vichada and Meta over large areas. Therefore, the region is promising for the expansion of sugarcane in Colombia.

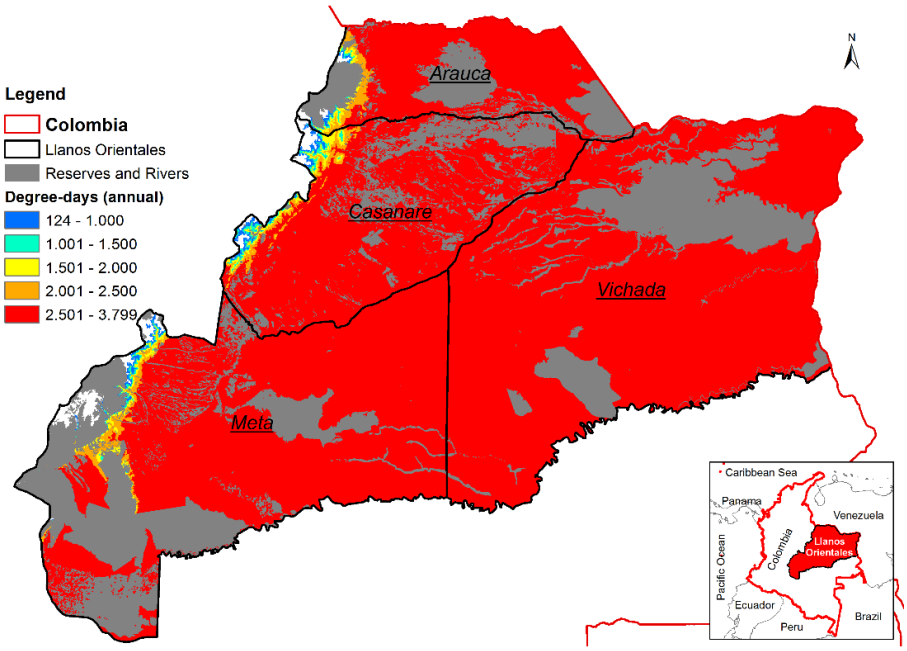

Fig. 5 Total degree-days using basal temperature of 18ºC for Llano Orientales.

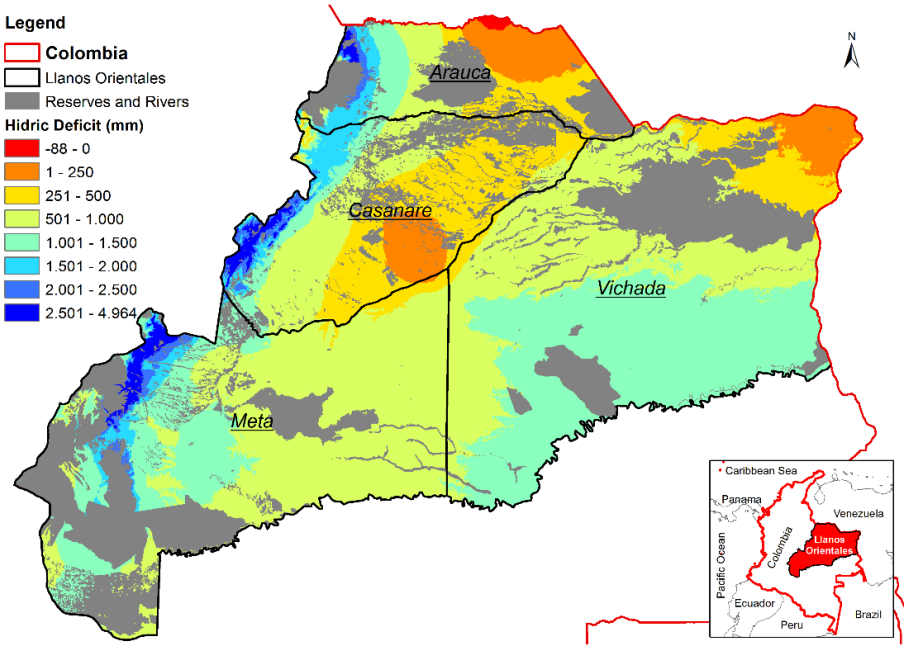

Fig. 6 Total hydric deficit for Llano Orientales.

4. Conclusions

The results of the study are summarized as follows:

(1) The average temperature, and precipitation of WorldClim can be used for analysis;
(2) The *Llanos Orientales* have thermic potential for the cultivation of sugarcane;
(3) The water deficit in the analyzed region, is virtually nonexistent (on average), allowing the cultivation of sugarcane without irrigation.

References:

[1] Romero-Ruiz MH, Flantua SGA, Tansey JC, Berrio JC. Landscape transformations in savannas of northern South America: Land use/cover changes since 1987 in the Llanos Orientales of Colombia Apllied Geography 2012 766:776-32.

[2] Goosen D. Physiography and soils of the Ilanos Orientales, Colombia 1972, 199 pp.
[3] Hoogenboom G. Contribution of agrometeorology to the simulation of crop production and its applications. Agricultural and Forest Meteorology 2000; 137-157-103.
[4] Marin FR, Lopes-Assad ML, Assad ED, Vian AE, Santos MC. Sugarcane crop efficiency in two growing seasons in São Paulo State, Brazil. Pesquisa Agropecuária Brasileira (PAB) 2008; 11-43.
[5] Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 2005; 1965:1978-25.
[6] Parques Nacionales Naturales de Colombia. Available in: http://mapas.parquesnacionales.gov.co/ Access in September 2015.
[7] Wayne CP, Vaughn Havens A. A graphical technique for determining evapotranspiration by the Thornthwaite method. Monthly Weather Review 1958 123:128-86.
[8] Moraes RA, Rocha JV, Lamparelli RAC. Determination of total accumulated rainfall, global radiation, evapotranspiration and degree-days originated from the ECMWF model to sugar cane crop. Engenharia Agrícola 2014; 322:331-34-2.