Viticultural climatic zoning in temperate, subtropical and tropical zones, Brazil
Bases for Estimating the Impact of Climate Change

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ABSTRACT
Fine wine production in Brazil was historically established in the extreme South of the country, in temperate climate. More recently, new producer regions appeared in South, Southeast and Northeast of the country, including subtropical and tropical type of climate in the production scenario. This work had the goal to characterize the Brazilian climate diversity related to viticulture potential, in all types of climates. The methodology used climatic database for all country - series 1961-1990. Many climatic variables and viticultural climatic indices were mapped in GIS at the whole Brazil: viticultural climatic indices of the Geoviticulture MCC System, Thermal Index of Winkler, Zuluaga Index, among others. The Frost Risk was used to separate zones of the country with viticultural potential to produce only one vegetative cycle/harvest per year, from the others, with potential to have more than one cycle and, in particular cases, more than one harvest per year. In this case, the viticultural indices were calculated for two periods: spring-summer and autumn-winter periods of the year. The results identified the climatic regions of Brazil with no potential for viticulture. Also, the results identified the regions with viticultural potential in different types of climates, with the characterization of the classes of viticultural climate for different indices. This climatic zoning will be used as a baseline for estimating, in a medium and long-term, the impact of different scenarios of Climate Change in the climatic potential of current fine wine producer regions and also to prospect potential climates for quality wine production in the future.

***Keywords: viticulture, grapevine, wine,* Vitis vinifera.**

1 INTRODUCTION
Brazil has about 100 million hectares with potential for agriculture (1), of which 80,000 hectares are used for grape production (2). Historically, the main grape producing areas for wine-making in Brazil have been located in the extreme South of the country, in temperate climate zone. However, new areas are emerging in South, Southeast and Northeast regions, including subtropical and tropical type of climate (3). Some of these areas have been developed, with specific viticulture for their local conditions (4, 5). Nevertheless, many other areas of the country could present a grape production potential for wine-making, grape juice and table grape production. Furthermore, the global climate change scenarios can modify regional climatic conditions. This work had the goal to characterize the Brazilian climate diversity related to viticulture potential, in all its types of climates.

2 MATERIAL AND METHODS

It has been employed temperature and rainfall data from 293 meteorological stations localized in all different regions of Brazil. The areas of Frost Risk (FR) were pointed as the regions with a probability higher than 20% of presenting a month per year with an absolute minimum temperature (Tmin) bellow 2°C. We considered that FR regions can produce only one harvest of grapes per year, in the spring-summer period. No-FR regions characterizes the existence of viticultural climate with intra-annual variability, making possible to have more than one vegetative cycle per year, happening particularly in subtropical and tropical type of climate. The climatic zoning for viticulture was based on the Thermal Index of Winkler (WI) (6), Heliothermal Index of Huglin (HI), Cool Night Index (CI), being HI and CI part of the MCC System (7) and Zuluaga Index (ZI) (8). For the no-FR regions, the climatic indices were calculated for two periods.

The Thermal Winkler Index was calculated using the following equation (6):

$$WI = \sum_{Mi}^{Mf}\left[(T_i - 10)d_i\right] \qquad (1)$$

where "T" is the monthly mean temperature (°C) of each month (i); "Mi" and "Mf" are the initial and the final month of the period; "d" is the number of days of each month (i). The analyses were based on two periods: 01 October – 30 April (spring-summer period) and 01 April – 31 October (autumn-winter period).

The Heliothermal Index of Huglin (HI) was calculated using the following expression (7):

$$HI = \sum_{Mi}^{Mf}\left[\frac{(T-10)+(Tmax-10)}{2}\right]d \qquad (2)$$

where "T" and "Tmax" are, respectively, the monthly mean and monthly maximum temperature (°C); "Mi" and "Mf" are the initial and the final month of the period, respectively; "d" is the length of day coefficient, with value of 1.00 for latitudes below 40°. The analyses were based on two periods: 01 October – 31 March (spring-summer period) and 01 April – 30 September (autumn-winter period). The Cool Night Index (CI) was considered as the average minimum air temperature (°C) of the last month of the grapevine cycle, considering March for the spring-summer period and September for the autumn-winter period. The Zuluaga Index (ZI) results as the sum of the product between the monthly rainfall (mm) and average mean air temperature values (°C):

$$ZI = \sum_{Mi}^{Mf}(T.P)/N \qquad (3)$$

where "T" is the average monthly mean temperature (°C); "Mi" and "Mf" are the initial and the final month of the period; "P" is the average monthly rainfall (mm); and N is the number of days in the period. The analyses were based on two periods: 01 October – 31 March (spring-summer period) and 01 April – 30 September (autumn-winter period). This index reflects the grapevine fungal diseases risk that is related to interaction "moisture excess x temperature".

3 RESULTS AND DISCUSSION

In the traditional spring-summer period (October-April for IW, October-March for IH and March for IF), there is no thermal limitation for grape production in Brazil (Figure 1). This feature remains in the climate changed scenarios and the current trend is likely to increase the temperature and thermal indices (IW, IH and IF).

In the autumn-winter period, most of the three southern states have low temperatures values (Figures 2) which prevent, currently, the production of grapes in these regions at this time of the year, which can also be seen by the Frost Risk map (Figure 3). However, trends of climate changes should increase the index values, which could enable, at least in some regions, grape production also during the autumn-winter period.

The Zuluaga Index (ZI) shows that in the spring-summer (SS) period the interaction of "high moisture x temperature conditions" may cause restrictions for grape production in the major part of the country (Figure 4). In this period, the most favorable regions are the extreme north (mainly the state of Roraima), the semiarid northeast and part of the southern states. Otherwise, in the autumn-winter (AW) period, most of the country is able for grape production, excluding the north, because of its high ZI values (Figure 4), and the southern states, because of their low temperature values (Figures 2 and 3).

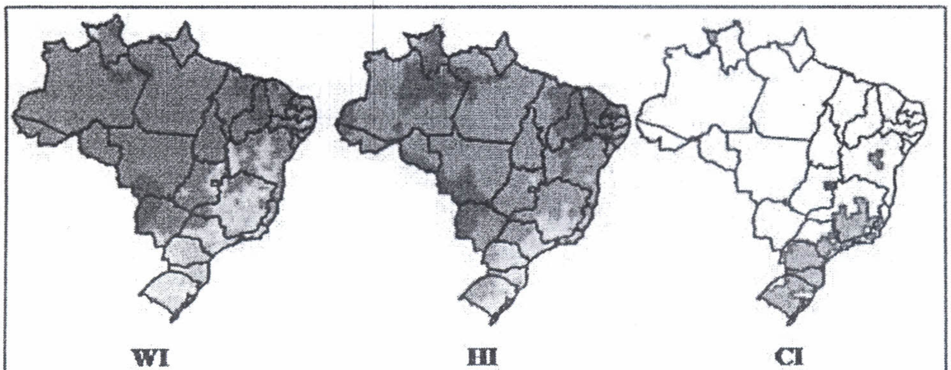

Figure 1. Thermal Winkler Index (WI), Heliothermal Index of Huglin (HI) and Cool Night Index (CI) for Brazil, in the spring-summer period. For WI and HI red/orange as the highest and yellow/green as the lowest WI values. For CI white/red/orange is the highest and red-green is the lowest temperature values.

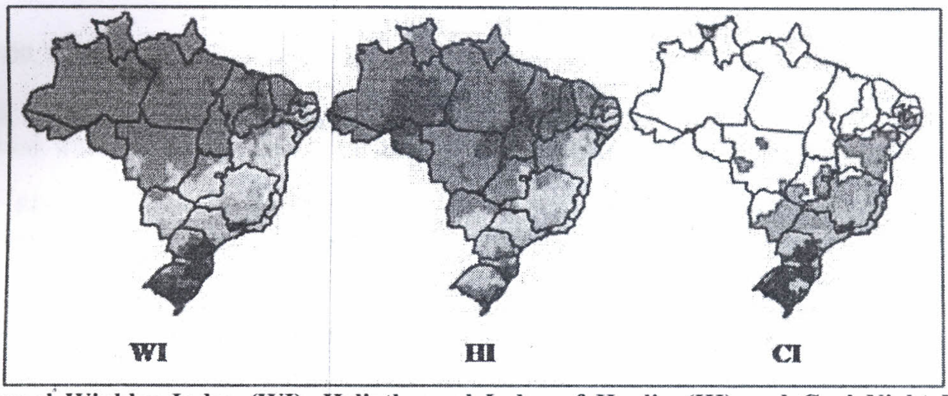

Figure 2. Thermal Winkler Index (WI), Heliothermal Index of Huglin (HI) and Cool Night Index (CI) for Brazilian regions, in the autumn-winter period. For WI and HI red is the highest and blue-green are the lowest values. For CI white/red/orange are the highest and green-blue is the lowest temperature values.

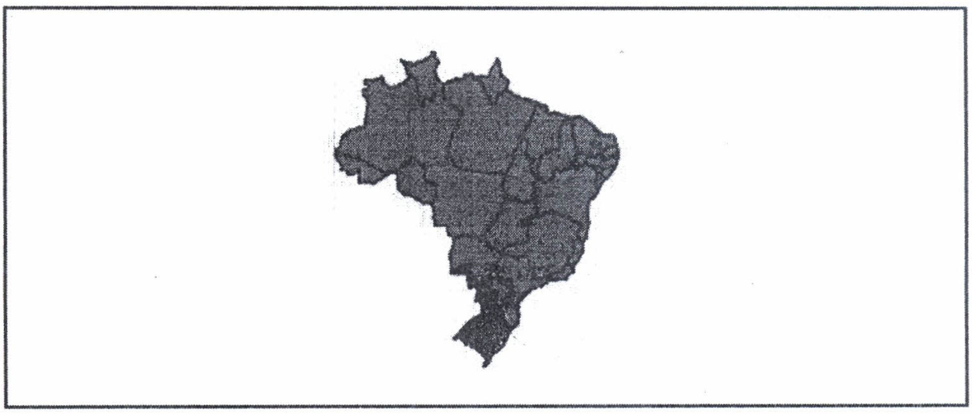

Figure 3. The Frost Risk (FR) regions in Brazil (red as the no risk and blue as risky regions).

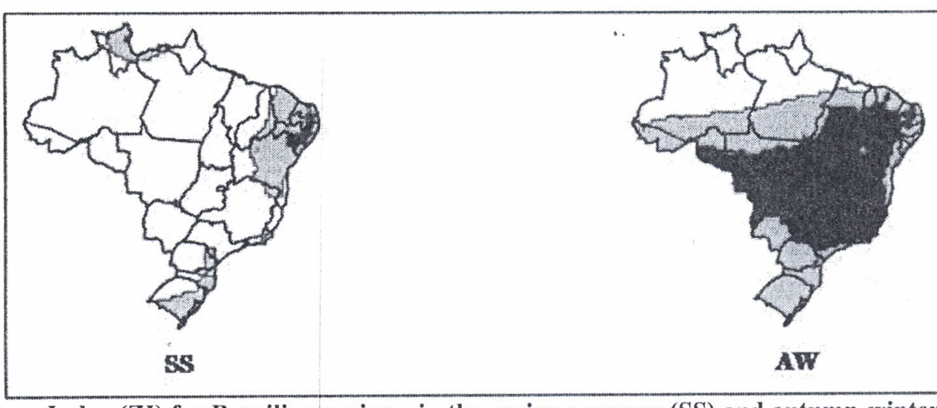

Figure 4. Zuluaga Index (ZI) for Brazilian regions, in the spring-summer (SS) and autumn-winter (AW) periods. Blue, green and red regions present low, medium and high fungal disease risk. The white regions have different levels of restrictions to grapevine production, in the respective periods, because of their high ZI values.

Special attention must be given, at the AW period, to the southeast region, that presents mild temperatures (Figure 1 and 2) with low disease risk (Figure 4). However, because of the low levels of rainfall, it is necessary the use of irrigation in this period of the year (5). The study will now focus on details of the current grape production regions of the country. Furthermore, the detailed zoning will also be used in long-term studies of climate change scenarios x grape-growing potential in Brazil.

4 CONCLUSIONS

Most of the Brazilian regions have a climatic potential for grape production. Brazilian viticulture climate types enable to produce in the spring-summer period in southern areas, while in the tropical regions of the country it is possible to have more than one cycle per year, with better climatic conditions in the autumn-winter (counter season period), the less hot and less humid period of the year. This climatic zoning will be detailed and used as basis to quantify the potential impact of climate change for grape production regions in Brazil.

REFERENCES

1. A.B DIAS, 2009. Ci. & Tróp., Recife, v.33, n.1, 1-180.
2. L.M.R. DE MELLO, 2012. Vitivinicultura brasileira: Panorama 2011, Bento Gonçalves, Brasil. 4 p.
3. J.F. DA S. PROTAS, U. CAMARGO, 2012. Vitivinicultura brasileira : panorama setorial de 2010. Bento Gonçalves, Brasil. 110 p.
4. A.H. DE C. TEIXEIRA, J. TONIETTO, G.E. PEREIRA, F. ANGELOTTI, 2012. Rev. Bras. Eng. Agríc. Amb, v.16, n.4, 399-407.
5. M.A.F CONCEIÇÃO, J. TONIETTO, 2005. Rev. Bras. Frut., v. 27, n. 3, 404-407.
6. A.J. WINKLER, 1962. General Viticulture, Berkeley, USA. 633 p.
7. J. TONIETTO, A. CARBONNEAU, 2004. Agr. For. Meteor., v. 124, 81-97.
8. P.A. ZULUAGA, E.M. ZULUAGA, J. LUMELLI, F.J. DE LA IGLESIA, 1971. Ecologia de la vid en la Republica Argentina. Mendoza: Ipsilón. 149 p.