

Topical Paper

Grapevine performance and production strategies in tropical climates

Umberto A. Camargo*, Francisco Mandelli, Marco Antonio F. Conceição and Jorge Tonietto

Embrapa/National Research Center for Grape and Wine, Bento Gonçalves, RS, Brazil.

Email: umberto.camargo@gmail.com

This paper was originally presented at the 3rd International Conference on Tropical Wine, Chiang Mai, Thailand, November 2010.

Abstract

Viticulture is a traditional activity in countries with a temperate climate which, however, has gained significance in several regions of hot climate in the world. Under tropical conditions the behaviour of the grapevine differs considerably from the one observed in temperate regions. The absence of a dormancy period and the use of an appropriate cultivation technology offer the possibility of timing the harvest for any day of the year. This feature brings about the perspective of a great expansion for the tropical viticulture, be it for the continuous market supply with table grapes, be it for the possibility to produce large volumes of wine and juice in small industrial plants. The climatic variability found in inter-tropical zones, mainly due to the altitude, has allowed for the identification of regions with great potential for the production of grapes for fine vintage wines. In this study relevant aspects of the grapevine performance in hot climates are presented and the management techniques employed in tropical viticulture in Brazil are discussed. Furthermore, aspects related to the harvest timing according to the regional and seasonal climatic variations are dealt with, as well as the kind of products (table grapes, wine, juice), the intrinsic characteristics of the cultivars used and the market opportunities for some Brazilian grape growing regions are presented as examples.

Keywords: tropical viticulture, climate, wine, juice, table grape, vineyard management, Brazil.

Introduction

Viticulture is a traditional activity in countries with a temperate climate which, however, has gained significance in several regions of hot climate in the world. Under tropical conditions the behaviour of the grapevine differs considerably from the one observed in temperate regions. The absence of a dormancy period and the use of an appropriate cultivation technology, which has been developed and improved for tropical conditions throughout the years, offer the possibility of timing the harvest for any day of the year. This feature brings about the perspective of a great expansion for the tropical viticulture be it for the continuous market supply with table grapes, be it for the possibility to produce large volumes of wine and juice in small industrial plants. On the other hand, the

climatic variability found in inter-tropical zones, due to different altitudes, distribution of rainfall and temperature variation according to the season of the year have allowed for the identification of regions with great potential for the production of grapes for fine vintage wines [1, 2, 3]. Furthermore, studies on the intra-annual climatic variability in tropical regions suggest that harvest time should be chosen in order to assign priority to wine quality [4]. In this study, relevant aspects of the grapevine performance in hot climates are presented. Management techniques are discussed as well as strategies of timing the production periods according to the regional and seasonal climatic variations, to the kind of products (table grapes, wine, juice) and to the intrinsic characteristics of the cultivars used.

Grapevines and Tropical Environment

Under tropical conditions, the grapevine does not undergo a vegetative dormancy, but grows uninterruptedly if adequate nutrition and water supply are provided. The consequences are, since they are *Vitis vinifera* varieties, excessively developed plants, with continuous growth of the apical shoots and death of the basal buds of the shoots. As a result, in order to maintain the vegetative and productive balance of the grapevine in hot climates, pruning is necessary twice a year in a cycle varying between five and seven months. Excessive vigor, especially when it is associated with the occurrence of cloudy days, may bring about negative consequences on bud fertility. This happens with most seedless grape cultivars whose economic production in tropical regions depends on an accurate management technology for control of vigor and increase of bud fertility. However, in the case of *Vitis labrusca*, a species which derives from a colder climate, some cultivars present very low vigor and difficult and irregular budburst, despite the use of the recommended techniques of irrigation, fertilizing and inducing budburst.

It seems that under tropical conditions dormancy is not induced and the apical buds burst shortly after the trimming or pruning of the shoots. The apical dominance is expressed in the rapidity of budburst, as well as in the rapidity of shoot growth. In the same way, it is observed that the buds from the latest growth burst more easily than those on the older shoots. This behaviour requires special care, not only during the formation period of the plant, but also in the canopy management of already developed plants in order to maintain an adequate canopy structure. Without artificial induction, generally, bud burst occurs only with the first and sometimes the second bud on the shoot. Through the use of inductors, uniform bud burst alongside the shoots can be achieved, however, a decreasing vigor of shoot growth is usually observed, where, beginning from the apex, the first shoot is more vigorous than the second one and so on successively. Generally, the shoots are less developed from the third apical bud on to the base of the shoot paralyzing the growth very precociously.

One of the biggest restrictions of grape growing in hot climates is the excessive humidity. Besides the direct negative effects on the product quality, rain and humidity, associated with high temperatures, favour the incidence of many diseases, especially those caused by fungi and bacteria. The most important fungal diseases are mildew (*Plasmopara viticola*), antrachnose (*Elsinoe ampelina*), leaf spot (*Isariopsis clavispora*), rust (*Phakopsora euveitis*), ripe rot (*Colletotrichum* spp.) and dieback (*Botryodiplodia theobromae*), among others. Bacterial canker (*Xanthomonas campestris p.v. viticola*) is the most important bacterial disease. Thus humid tropical regions are little propitious for growing grapes, since the permanently present conditions favour the development of these diseases implicating a high risk of loss and elevated costs. Besides, the intense use of chemical products applied for pest management are harmful to the environment as well as to human health.

The occurrence of a dry period or one with little rainfall is very important for the viticulture in tropical regions entailing, usually, the use of irrigation. Considering that, under tropical conditions, the productive cycle of the grapevine varies between 90 and 150 days, regions where the occurrence of rainfall is low throughout six or more than six months are better suited for viticulture. Another important factor is the temperature. Tropical regions of higher altitudes are preferred for grape growing as the temperatures are milder which promotes a less rapid development of vegetation and grapes. In the case of table grapes, milder temperatures and a greater alternation of day and night temperature are favourable for obtaining larger berries. With regard to grapes for wine, mild day temperatures and the occurrence of relatively cold nights favour the accumulation of quality components in red grapes, especially of anthocyanins and tannins, whereas in white grapes the aroma intensity and quality are enhanced [5, 6, 7]. Frequent practical observations of the plant behaviour over a period of time have made it possible to develop a set of techniques that have helped establish viticulture as an economic activity in the tropical regions of Brazil and other countries such as India, Thailand, Myanmar and Venezuela.

Production Strategies

The climatic variability which characterizes the Brazilian inter-tropical zone due to the variations of latitude, altitude and continentality, allows, as far as grapes for processing (wine and juice) are concerned, to select the production region according to the type of product desired. As to grapes for consumption in natura, the production region can be chosen according to the most appropriate harvest time, adopting a marketing point of view. The technology available offers the opportunity to choose between different production systems: two cycles and two harvest/year, two cycles and one harvest/year, five cycles and three harvests/two years or five cycles and two harvests/two years, depending on the production region and the precocity level of the used cultivars [8]. Regions with little rainfall throughout the year are apt for production in successive cycles because the risk of disease incidence, especially of mildew (*Plasmopara viticola*), is low. In regions where the rainy period is concentrated in up to five months it is possible to perform two harvest/year with short-cycle cultivars in the dry season in alternate years, using the system with five cycles three harvests/two years.

However, in regions where the rainy season is concentrated in six or more months, it is advisable to carry out two pruning events and one harvest per year timing the production cycle for the dry period in order to obtain a better quality and to reduce the risks. With respect to the climate, fine table grapes or grapes for wine (*Vitis vinifera*) should preferably be cultivated in regions with low rainfall and/or with a stable and prolonged dry period; in the more humid regions, where the regime of rainfall is more intense, it is preferable to plant American or hybrid cultivars, which are more resistant to diseases and present good market opportunities for consumption in natura as well as for wine and juice production in Brazil. When deciding which cultivar to use, it is important to consider, in addition to the market opportunities, the potential of the interaction genotype x environment. For table grapes and for grapes for wine and juice vigorous rootstocks, such as 'IAC 572' and 'IAC 313', have been favoured conferring to most cultivars a good vegetative development and an elevated productivity.

As for seedless grapes, which are naturally very strong, less vigorous rootstocks, such as SO4 and Harmony, have yielded better results. Also, for fine wines less vigorous rootstocks are recommended. As for the cultivars the use of precocious ones is generally interesting. In regions with a short dry season, precocious cultivars allow for performing the productive cycle off the rainy season and, in regions with a prolonged dry season it is possible to perform two harvests per year out of the rain period. However, as for fine wines, especially red wines, cultivars with a longer

cycle are more appropriate, since a more prolonged maturation period may enhance the wine quality.

Another relevant fact is that generally, under tropical conditions, the acidity of the grapes is lower and the pH higher than in temperate regions, implicating in a faster degradation of the wines. Partial research results indicate that cultivars with more acid grapes might be preferable for the hot regions [9].

In the following, some tropical grape growing regions and regions with potential for viticulture are presented as examples and possible production models are discussed according to their climatic characteristics.

Londrina (Parana)

Geographical coordinates: Latitude 23° 18'S, Longitude 51° 09'W, Altitude: 566 m

Climate: Cfa Subtropical humid.

The Londrina region is situated immediately above the Tropic of Capricorn. It is characteristic for this region that the grapevine undergoes a natural dormancy period in June and July, when there is the risk of the occurrence of frost; rainfall is spread throughout the whole year (Figure 1).

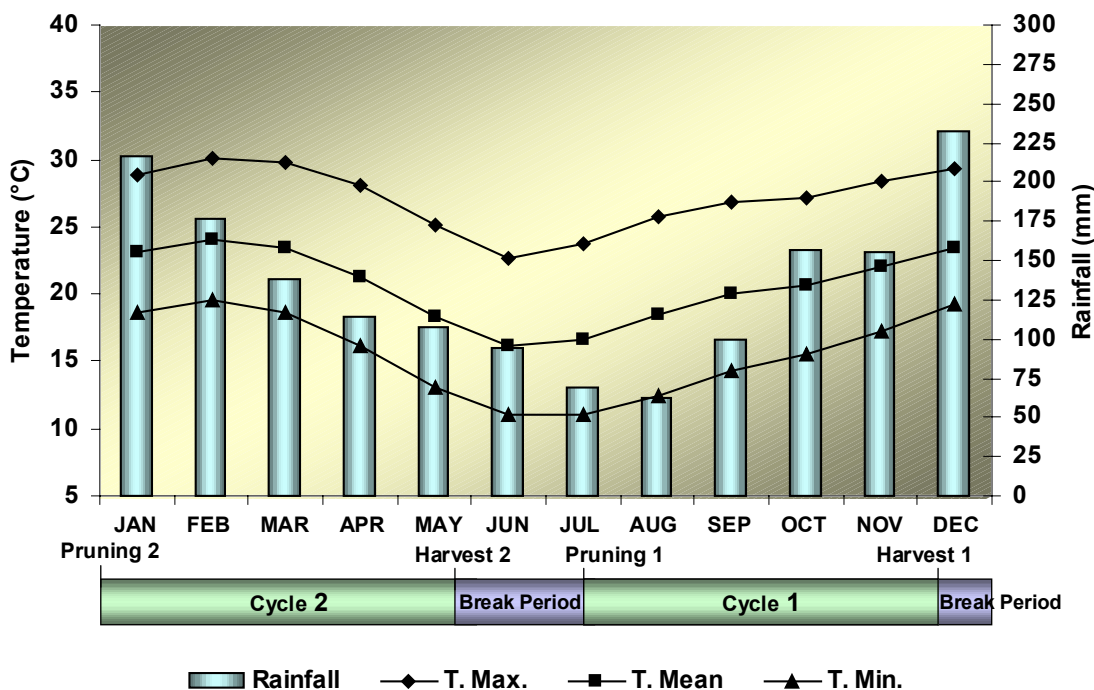


Figure 1. Monthly average temperatures (°C) and precipitation (mm) for Londrina - PR and used model for grape production.

However, the dormancy period is short, allowing for two annual cycles, especially when using short-cycle cultivars. Despite having a relatively high volume of rainfall during the vegetative period, the region possesses the advantage of being situated close to the big consumer centres and of enabling harvests in periods that are low seasons in other production regions of the country.

According to a specific management system, the same shoot is pruned twice a year. The pruning performed in July retains canes with 10-12 buds, inducing bud burst in the 4-6 apical buds. The basal buds of the cane remain dormant during the first cycle. The second pruning performed in January removes the apical part of the cane with all the shoots developed in the first cycle and,

therefore, induces the burst of the basal buds on the shoots that have remained from the first pruning. This system is used for the production of fine table grapes.

Despite the traditional production of fine table grapes, the cultivation of *labrusca* grapes, which are more resistant to disease and, consequently, better adapted to the region's rainy climate has been developed in recent years in the region. *Labrusca* cultivars are planted for both the production of table grapes and for industrial processing, especially for juice production. As to grapes for processing the carrying out of only one vegetative cycle seems to be economically more attractive since the harvest being performed between January and March the yield obtained is higher and the production costs are lower. Besides, as for concentrated juice the grape juice production is compatible with the orange juice production since the orange harvest occurs in a different period (from July to December).

Jales (Sao Paulo)

Geographical coordinates: Latitude 20° 16'S, Longitude 50° 33'W, Altitude: 483 m

Climate: Aw Tropical, rainy with dry season in winter.

In this region, generally, two annual cycles are performed: one for production during the dry season in winter and another, vegetative cycle, merely for the shoot formation during the rainy season (Figure 2). The ideal pruning period is in April, thus, according to the cultivars' cycle, the harvest occurs in August and September. Pruning can be anticipated or postponed in conformity to market opportunities. With short-cycle cultivars the model of five cycles and three harvests in two years can also be used. However, in these cases the risk, as well as the production costs relative to pest management measures, are increased due to the occurrence of rainfall at the beginning or end of the cycle.

It is recommended to carry out the pruning between September and the beginning of November so that the flower induction can still occur in a period with low precipitation and good insolation conditions. The shoot formation in the rainy period usually results in low fertility in the subsequent production cycle, especially in *Vitis vinifera* cultivars. *Vitis labrusca* cultivars and interspecific hybrids are interesting alternatives in order to extend the production period for both table grapes and grapes for industrial processing, since they present a good flower differentiation even under low insolation conditions. However, sudden temperature drops right after pruning, a phenomenon that is liable to occur especially in May and June, can cause considerable damage to the bud burst.

João Pinheiro (Minas Gerais)

Geographical coordinates: Latitude 17° 42'S, Longitude 46° 10'W, Altitude: 760 m

Climate: Aw Tropical rainy with a dry season in winter

The amount and distribution of rainfall in this region is similar to what occurs in the Jales region. João Pinheiro does not have a tradition in winegrowing, yet, its potential for the production of fine quality wines has been evaluated [3]. The harvest is timed for July and August, which is a dry period with mild temperatures (Figure 3).

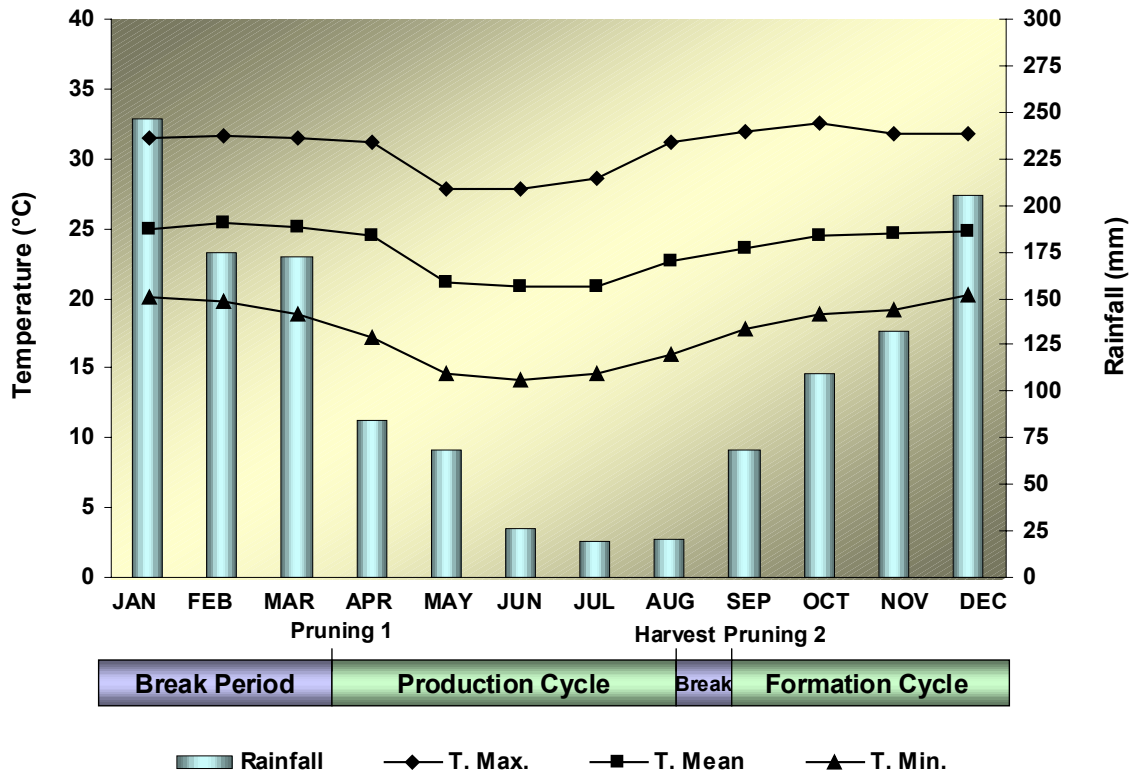


Figure 2. Monthly average temperatures (°C) and precipitation (mm) for Jales - SP and used as a model for grape production.

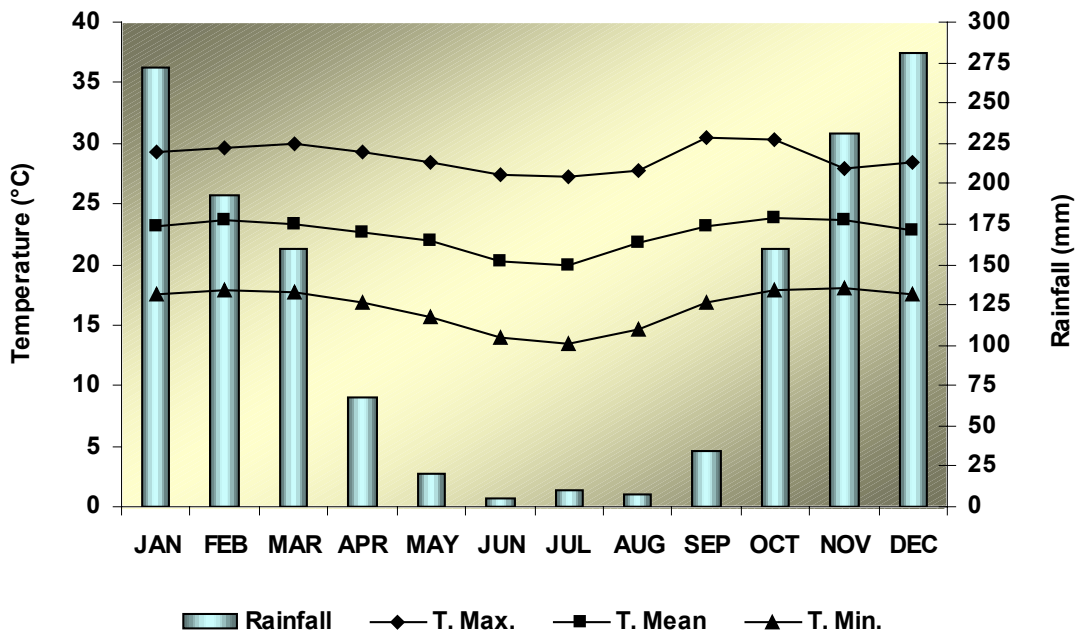


Figure 3. Monthly average temperatures (°C) and precipitation (mm) for João Pinheiro - MG.

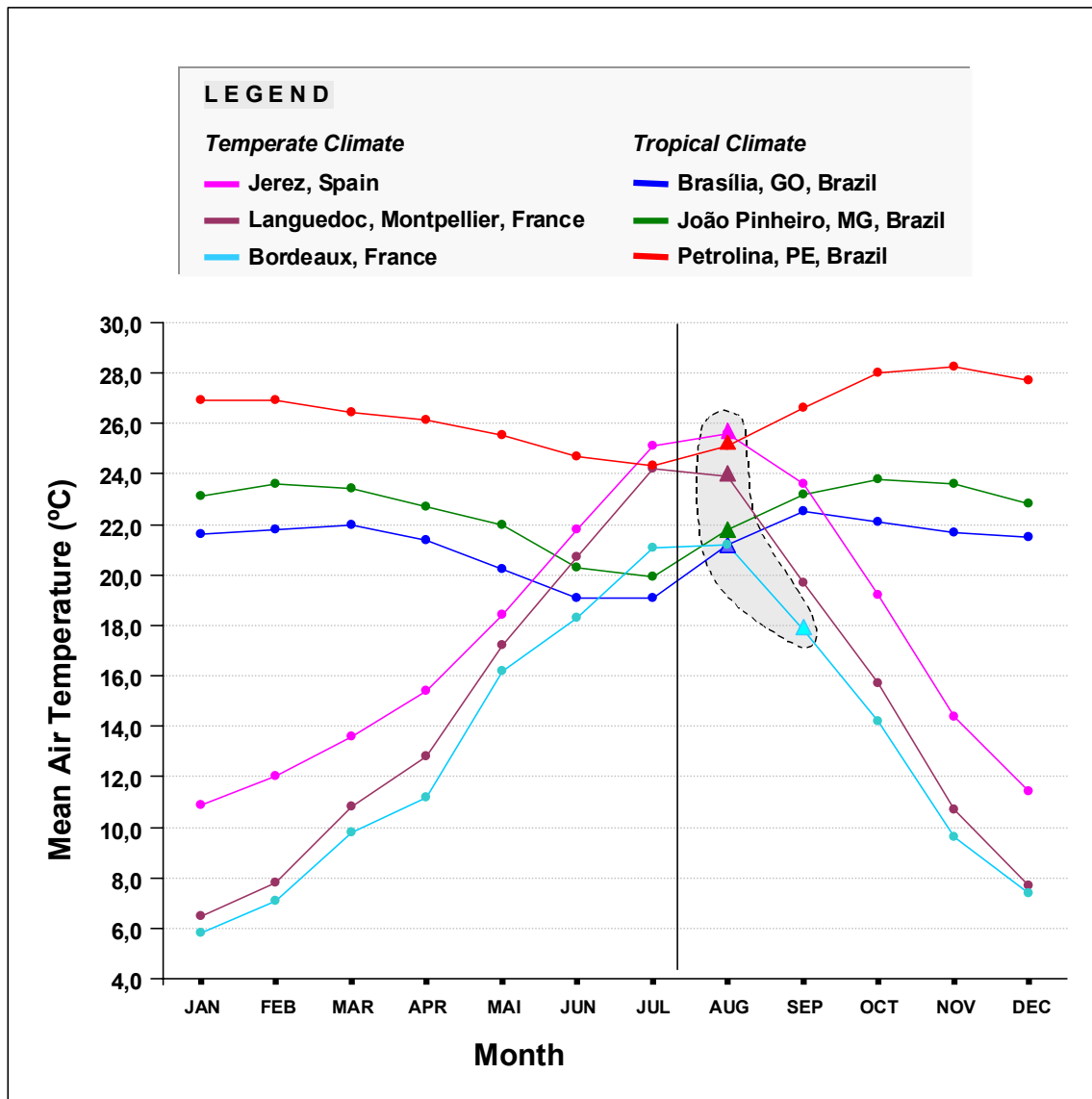


Figure 4. Annual thermal régime for different temperate and tropical wine grape regions.

Valtair, ste gráfico não consta dos que você está preparando.

Figure 4 shows the region's climatic potential for grape growing taking into consideration the thermic regime during the maturation period of the grapes in comparison to other wine producing regions of tropical and temperate climate around the world, serving as a term of reference. It was established that under the tropical conditions of João Pinheiro and Brasília the average temperatures during the maturation period of the grapes (July and August) are significantly lower than, for example, those of Petrolina and also than those found in Jerez de la Frontera – Spain, which represents an intermediate condition between the region of Langedoc, Montpellier – France, whose harvest is concentrated in August and Bordeaux – France, where the harvest is carried out in September.

It has become evident that, in contrast to what is usually assumed, the maturation of the grapes in the less hot period of the year in certain tropical regions occurs under thermic conditions which resemble those found in the traditional wine growing regions of temperate climate around the world. Based on this example and taking into account the climatic variability available, it becomes apparent that there exists a potential diversity of options for the production of fine quality wines in the tropical regions of Brazil. Conceição and Tonietto [2] discuss this potentiality by comparing

three locations in the north of Minas Gerais. Besides the potentiality for the production of grapes for fine quality wines, this region presents the aptitude for the production of table grapes, juice and table wines. Like in the region of Jales, the use of two annual cycles and only one harvest per year, timed for July and August, are recommended, due to the amount of rainfall in this region. However, with short-cycle cultivars it is possible to use the system of five cycles and three harvests every two years.

Pirapora (Minas Gerais)

Geographical coordinates: Latitude 17° 21'S, Longitude 44° 56'W, Altitude: 540 m

Climate: Aw Tropical, rainy with dry season in winter.

The climatic classification of the Pirapora region is the same as that for the regions of Jales and João Pinheiro, although the amount of rainfall is lower and the period of low rainfall is a little longer. In this region, usually, the system with two annual cycles and only one harvest is used for fine table grapes, however, the harvest period can be extended until September (Figure 5). Yet, in the case of American grapes and hybrids, which are more resistant to disease and less susceptible to damage caused by rain, an expansion of the harvest period is possible, which therefore can be performed from June to November. This condition is quite favourable for growing grapes for table wines and grape juice (cvs. *V. labrusca* and hybrid cvs.) With short-cycle cultivars it is possible to use the model of five cycles and three harvests every two years.

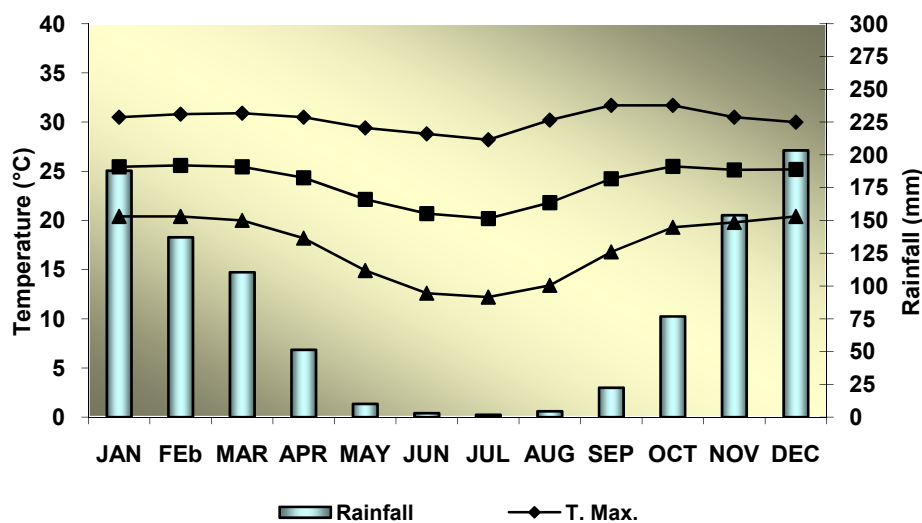


Figure 5. Monthly average temperatures (°C) and precipitation (mm) for Pirapora – MG.

Diamantino (Mato Grosso)

Geographical coordinates: Latitude 14° 24'S, Longitude 56° 27'W, Altitude: 286 m

Climate: Aw Tropical rainy with dry season in winter.

The climatic conditions in Diamantino can be used as a reference for a large area of Brazilian territory, from the midwest to the northeast, where grape growing is possible. The annual precipitation is elevated, but concentrated in six to seven months, with a dry season between five to six months (Figure 6). The best suited model of grape production under these conditions is the carrying out of two annual cycles and only one harvest, timing the production cycle for the dry season. The formation pruning is performed at the end of the dry season, right after the harvest, so that the development of the shoots and the flower differentiation can be achieved before the period of the heavier rains. The model with five cycles and three harvests in two years can be employed

provided short-cycle cultivars are used. Although it is possible to produce fine table grapes and grapes for wine, these climatic conditions favour more the cultivation of more rustic grapes, such as *Vitis labrusca* or hybrids, be it for table grapes or for table wine or juice.

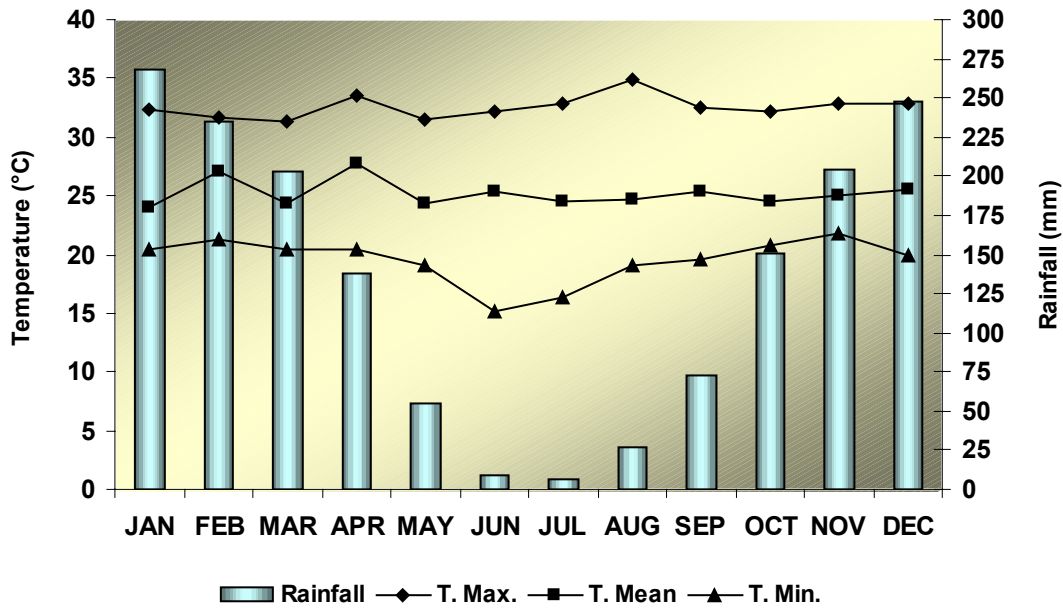


Figure 6. Monthly average temperatures (°C) and precipitation (mm) for Diamantino - MT.

Irecê (Bahia)

Geographical coordinates: Latitude 11° 18'S, Longitude 41° 52'W, Altitude: 747 m

Climate: Bsh Tropical semi-arid.

As is illustrated in Figure 7, the Irecê region offers excellent conditions for grape production having precipitation lower than 100mm during eight consecutive months. The volume of rain is low, even in the months with more elevated precipitation. Under these conditions it is possible to carry out subsequent productive cycles, the harvest being timed for any day of the year, especially when using the *Vitis labrusca* cultivar and the hybrid cultivars for table grapes, juice and table wines. When *Vitis vinifera* cultivars are used for wine or for table grapes, the ideal production period is between April and October. Thus, as for fine grapes, it is convenient not to prune between mid-November and mid-March, reducing the risks of losses due to the occurrence of disease at the beginning of the vegetative cycle when the plants are more susceptible. For fine grapes either the model with two prunings and one annual harvest can be applied, or, provided short-cycle cultivars are used, the model with five cycles and three harvests every two years (Figure 8).

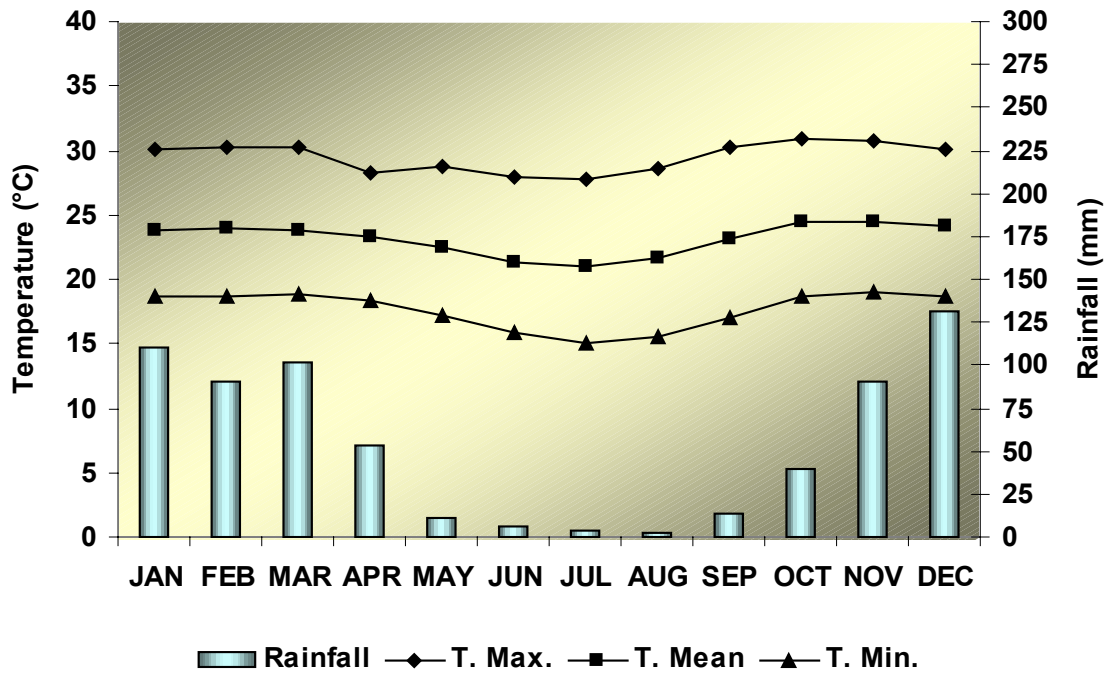


Figure 7. Monthly average temperatures (°C) and precipitation (mm) for Irecê – BA.

Petrolina (Pernambuco)

Geographical coordinates: Latitude 09° 23'S, Longitude 40° 10'W, Altitude: 370 m

Climate: Bsh Tropical semi-arid.

Petrolina is situated in the valley of Submédio São Francisco, the main production region of table grapes and tropical wines in Brazil. The climate of the region (Figure 8) is rather similar to the climate of Irecê, however, its annual precipitation is a little lower.

The climatic conditions allow for the use of successive pruning, harvest timing for any day of the year. Depending on the cycle of the cultivars it is possible to carry out five harvests every two years. However, as regards *Vitis vinifera* cultivars, the quality of table grapes as well as of grapes for wine can be seriously affected when the harvest is timed for the rainy period (December to March). In the same way, pruning in this period has higher risks of loss due to the incidence of disease in the plants, which are more susceptible in the initial phase of the vegetative cycle. In order to avoid these problems, under these conditions, the models consisting of two cycles and one harvest/year or, when using short-cycle cultivars, five cycles and three harvests every two years turn out to be good alternatives (Figure 8). The American grapes (*Vitis labrusca*) and hybrids (for table grapes, juice, and table wine), which are more resistant to problems caused by rain, are the most interesting alternative in the rainy season.

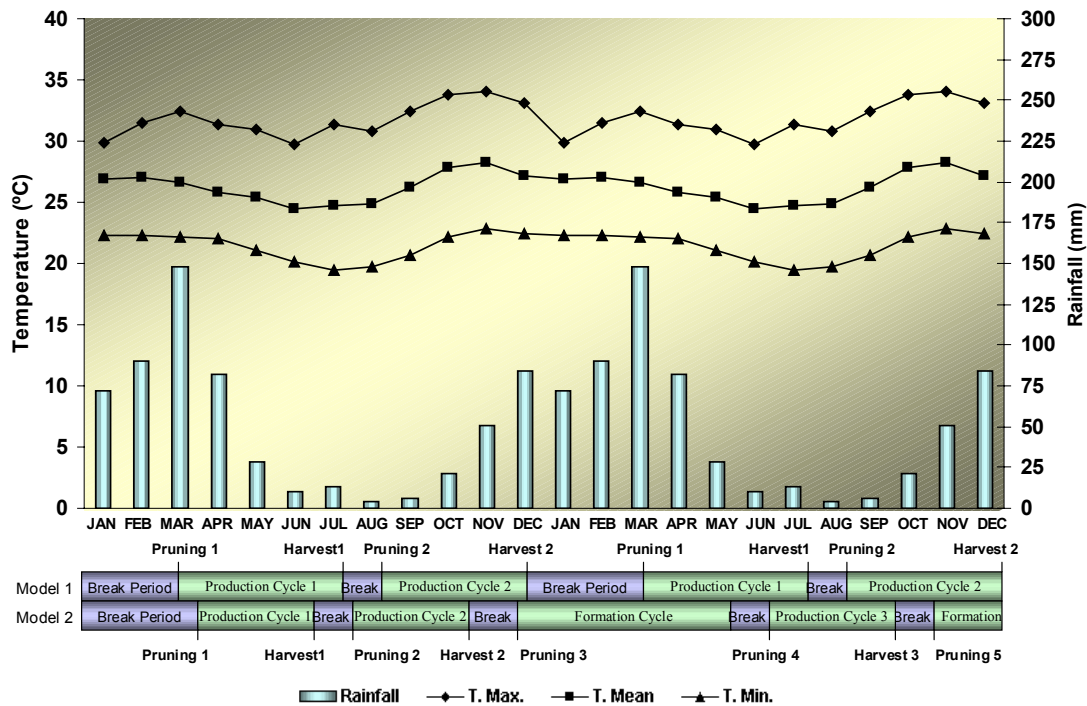


Figure 8. Monthly average temperatures (°C) and precipitation (mm) for Petrolina – PE and models for grape production.

Limoeiro do Norte (Ceara)

Geographical coordinates: Latitude 05° 08’S, Longitude 38° 05’W, Altitude: 70 m

Climate: Bsh Tropical semi-arid.

This region, located in the Jaguaribe Valley, presents a similar rainfall and a little higher temperature than the regions of Petrolina and Irecê, however, the dry season is different (Figure 9). Thus, there are the same management options with successive productive cycles, two cycles and one annual production or five cycles and three productions every two years. Equally, there are the same alternatives regarding the groups of cultivars, *Vitis vinifera* or *Vitis labrusca* and interspecific hybrids, according to the dry season and the rainy period. For fine grapes, the production pruning should ideally be carried out from May to October and the harvest should be performed from August to January. Pruning in November and January should aim at forming shoots without production. The rustic grapes, the cultivars *Vitis labrusca* and interspecific hybrids also constitute alternatives for the production throughout the year in this region.

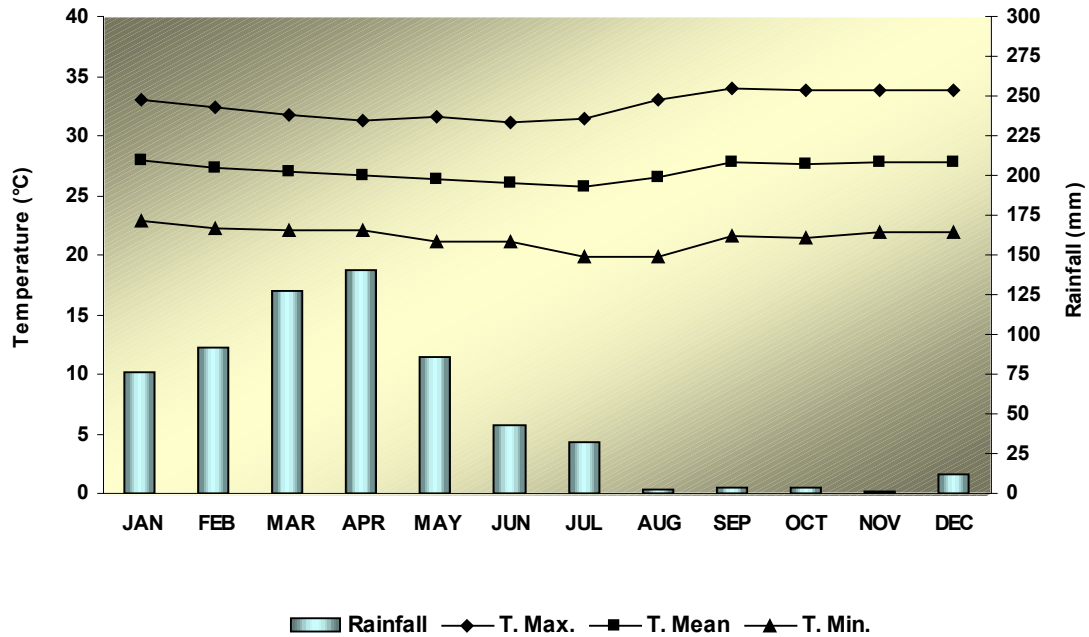


Figure 9. Monthly average temperatures (°C) and precipitation (mm) for Limoeiro do Norte – CE.

Discussion and Conclusions

The climatic diversity of the Brazilian tropical regions, if combined with appropriate production technology (cultivars and management system) offers the possibility to produce high quality grapes throughout the whole year for consumption in natura as well as for processing of grapes to table wine or juice. The production of fine high quality wines is also theoretically possible, especially in regions of high altitude and where the harvest is timed for the months with mild temperatures and low precipitation. Practical examples in commercial areas successful from a technical standpoint as well as from a commercial standpoint, are found in India (table grapes and for wine), Thailand (wine), Venezuela (table, wine) and Brazil (table grapes, wine and juice).

In the last few years, big advances have been achieved regarding production technology for grapes in tropical zones; defining the management in order to increase the fertility, traditional seedless grapes, releasing by Embrapa new cultivars for table grape, for wine and juice, adapted to the tropical climate, evaluation and selection of *Vitis vinifera* cultivars for the production of fine wines in tropical conditions. However, the physiology of the grape wine in tropical conditions is little studied; advances in this area need to be achieved as a basis for the development of more efficient techniques and management systems. Also, the development of new cultivars for different purposes (table grapes, wine, juice) which are fully adapted to the tropical climate seems to be of primary importance, as most of the cultivars currently in use are from temperate climate zones. With regard to genetic breeding, besides the intrinsic quality attributes of each product (table grapes, juice) and the adaptation to the hot climate, the issue of resistance to diseases deserves special attention in order to attain sustainability and competitiveness for tropical viticulture.

References

1. Tonietto, J. and Carbonneau, A. (2004). A multicriteria climatic classification system for grape-growing regions worldwide. *Agricultural and Forestry Meteorology*, Amsterdam, v. 124, p.81-97.
2. Conceicao, M.A.F. and Tonietto, J. (2005). Climatic potential for wine grape production in the tropical North Region of Minas Gerais State, Brazil. *Ver. Bras. Frutic., Jaboticabal, SP*, v. 27, p.404-407, 2005.
3. Tonietto, J., Vianello, R.L. and Regina, M.A. (2006). Caracterização macroclimática e potencial enológico de diferentes regiões com vocação vitícola de Minas Gerais. *Informe Agropecuário*, v.27, n. 234, p.32-55 (in Portuguese).
4. Tonietto, J. and Teixeira, A.H. de C. (2004). Climatic zoning of viticultural periods over the year in the tropical zone: application of the methodology of the Geoviticulture MCC System. In: Joint International Conference on Viticultural Zoning, 15 to 19 Nov., Cape Town: South African Society for Enology and Viticulture. P. 76-77.
5. Kliever, W.M. and Torres, R.E. (1972). Effect of controlled day and night temperatures on grape coloration. *American Journal of Enology and Viticulture*, v. 23, n.2, p. 71-77.
6. Tonietto, J. and Mandelli, F. Clima (2003). In: Uvas Viníferas para Processamento em Regiões de Clima Temperado. Bento Gonçalves: Embrapa Uva e Vinho. (Embrapa Uva e Vinho. Sistema de Produção, 4. Versão eletrônica). In Portuguese. Available from: www.cnpuv.embrapa.br/publica/sprod/UvasViniferasRegioesClimaTemperado/clima.htm
7. Mori, K., Goto-Yamamoto, N., Kitayama, M. and Hashizume, K. (2007). Loss of anthocyanins in red-wine grape under high temperature. *Journal of Experimental Botany*, p. 1-11.
8. Camargo, U.A. (2005). Grape management techniques in tropical climates. In: International Congress Viticulture GESCO, 14, 23 a 27/08/2005, Geisenheim, Anais... Geisenheim, Alemanha : Gesellschaft für Förderung der Forschungsanstalt Geisenheim, p. 251-256.
9. Camargo, U.A., Amorim, F.M. de., Guerra, C.C. and Lima, M.V.D.O. (2007). Introdução e avaliação de novas cultivares para vinho no Vale do São Francisco. In: Workshop Internacional de Pesquisa: A Produção de Vinhos em Regiões Tropicais, 1, 17 a 20/08/2004, Recife e Petrolina, PE, *Anais...* Bento Gonçalves, RS : Embrapa Uva e Vinho, p. 103-109 (in Portuguese).