

PHENOLOGY AND BIOCLIMATE OF GRAPEVINE VARIETIES IN THE TROPICAL REGION OF THE SÃO FRANCISCO VALLEY, BRAZIL

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Summary

The region of the São Francisco Valley, located at 9° S, has been increasing the production of fine wines during the last years. The region has a tropical semi-arid climate (viticultural climate with intra-annual variability according to the Geoviticultural CCM System : "very warm, with warm nights, very dry to sub-humid" depending on the period of the year in which the grapes are produced). The research aims at characterizing the phenology and bioclimatology of the region's wine grapes. Four cultivars with different levels of precocity were evaluated – Syrah, Cabernet Sauvignon, Muscat Canelli and Schönburger, grafted on IAC 572, a vineyard in its first productive cycle, using the pergola as training system. The phenological stages bud burst (B) – stage 05, flowering (F) – stage 23 and veraison (V) – stage 35 were evaluated according to the system of Eichhorn & Lorenz. The date of the harvest (H) corresponds to the commercial grape harvest. The duration of the phenological subperiods B-F, F-V V-H and B-H has been calculated. For each subperiod 16 thermal and hydric climatic indices have been calculated. The results of the São Francisco Valley have been compared with the same cultivars from a temperate climate region – the Serra Gaúcha ("temperate warm, with temperate nights, humid viticulture climate" according to the Geoviticultural CCM System), located 29°S. The results have shown that the duration of the period B-H has been 124, 123, 116 and 104 days for Syrah, Cabernet Sauvignon, Muscat Canelli and Schönburger, while in the Serra Gaúcha the duration has been 158, 160, 160 and 138 days, respectively. As for the bioclimatic characteristics, the mean air temperature in the São Francisco Valley in the period B-H have varied from 25,4 to 28,1°C, whereas in the Serra Gaúcha the temperatures have oscillated between 15,8 and 21,8°C. The potential evapotranspiration, even when showing higher mean day values in the Valley, was similar in both regions during the whole period B-H. The global solar radiation for the period B-H in the São Francisco Valley was lower when compared with the Serra Gaúcha. This result is related especially to the latitude (photoperiod) and the shorter duration of the B-H period under tropical conditions. The study presents the bioclimatic indices by cultivar and subperiod, comparing the region of low with that one of mean latitude. It has been concluded that the vegetative cycle of the grapevine (B-H) is significantly shorter in the the São Francisco Valley (mean duration, for the 4 evaluated cultivars, 37 days less than in the Serra Gaúcha). Such behavior is a consequence, essentially, of a shortening of the period B-F (29 days shorter in the average). It can be stated that the phenological behavior of the grapevine in the São Francisco Valley, although distinct from a temperate climate region, can be understood above all by the particular bioclimate found in the tropical zone.

Résumé

La région de la Vallée du São Francisco, située à 9° S, est en train d'augmenter la production des vins fins les dernières années. La région présente un climat de type tropical semi-aride (climat viticole à variabilité intra-annuelle selon le Système CCM Géoviticole : "très chaud, à nuits chaudes et à sécheresse forte à sub-humide" en fonction de la période de l'année dans laquelle le raisin est produit). La recherche objective la caractérisation de la phénologie et de la bioclimatologie des raisins de cuve dans la région. Ont été évaluées 4 cépages avec différents niveaux de précocité - Syrah, Cabernet Sauvignon, Muscat Canelli et Schönburger, greffés sur IAC 572, vigne en premier cycle productif conduite en système pergola. Ont été évalués les stades phénologiques suivants selon le système

d'Eichhorn & Lorenz : débourrement (B) - stade 05, floraison (F) - stade 23 et véraison (V) - stade 35. La date de récolte (H) correspond à la récolte commerciale des raisins. La durée des sous-périodes phénologiques B-F, F-V, V-H et B-H a été calculée. Sur chacun des sous-périodes, ont été calculés 16 indices climatiques thermiques et hydriques. Les résultats de la Vallée du São Francisco ont été comparés avec les mêmes cépages d'une région de climat tempérée - la Serra Gaúcha (climat "tempéré chaud, à nuits tempérées, humide" selon le Système CCM Géoviticole), située à 29° S. Les résultats ont montré que la durée de la période B-H a été de 124, 123, 116 et 104 jours pour la Syrah, Cabernet Sauvignon, Muscat Canelli et Schönburger, tandis que dans la Serra Gaúcha, la durée a été de 158, 160, 160 et 138 jours, respectivement. Pour les caractéristiques bioclimatiques, dans la Vallée du São Francisco les températures moyennes de l'air de la période B-H ont varié entre 25,4 à 28,1 °C, tandis que dans la Serra Gaúcha les températures ont varié entre 15,8 et 21,8 °C. L'évapotranspiration potentielle, même si elle a présenté des moyennes journalières plus élevées dans la Vallée, ont été similaires pour le total dans la période B-H entre les 2 régions. Le rayonnement solaire global de la période B-H dans la Vallée du São Francisco a été inférieur si comparé avec la Serra Gaúcha. Ce résultat est lié surtout à la latitude (photopériode) et à la durée plus courte de la période B-H en condition tropicale. Le travail présente les indices bioclimatiques par cépage et sous-période, en comparant la région de basse avec la région de moyenne latitude. On a conclu que le cycle végétatif de la vigne (B-H) est significativement plus court dans la Vallée du São Francisco (durée moyenne, pour les 4 cépages évalués, 37 jours inférieure que dans la Serra Gaúcha). Tel comportement est dû essentiellement à un raccourcissement de la période B-F (29 jours plus court en moyenne). On observe que le comportement phénologique de la vigne dans la Vallée du São Francisco, distinct par rapport à une région de climat tempérée, peut être expliqué surtout par le bioclimat particulier trouvé en zone tropicale.

1. Introduction

In Brazil, wine is traditionally produced in the southern states which have temperate climate and where the vegetative period goes from September (bud burst) to February (harvest). In the 1980s, a new viticulture belt emerged, under tropical conditions, in the São Francisco Valley, located at 9° S. The region has a tropical semi-arid climate (vicultural climate with intra-annual variability according to the Geoviticultural CCM System: "very warm, with warm nights and very dry to sub-humid" depending on the period of the year in which the grapes are produced) (Tonietto & Carbonneau, 2004). In the last years, the wine production has increased in this region, consolidating this belt as producer of fine wines.

Although there exist phenological studies of the grapevine in different winegrowing regions of Brazil, such as the ones on table grapes for the São Francisco Valley by Leão & Silva (2003) and those for the Serra Gaúcha by Mandelli (2002), information on this topic is scarce, and the bioclimatology of the grapevine for wine in the São Francisco Valley has not been studied so far.

This research aimed at characterizing the phenology and bioclimatology of cultivars of winegrapes in the tropical region of the São Francisco Valley. A temperate climate region from Southern Brazil was taken as term of comparison.

2. Materials and Methods

The research was carried out in the São Francisco Valley (9° S) at an experimental vineyard, in its first productive cycle, which had been installed on the Milano Farm, in the municipality of Santa Maria da Boa Vista, State of Pernambuco. The cultivars were grafted on IAC 572, and the pergola as training system; the vineyard was held under irrigation.

Immediately after pruning, carried out on August 28, 2003, hydrogenated cyanamide in the concentration of 2,5% was applied in order to induce and uniform bud burst. The data were sampled in the vegetative cycle which had started in September 2003. Four cultivars with different levels of precocity were evaluated: Schönburger, Muscat Canelli, Cabernet Sauvignon and Syrah. The reading of the phenological data was made every other day, and the following phenological stages were recorded according to the system of Eichhorn & Lorenz (1977): bud burst: B (stage 05); flowering: F (stage 23); veraison: V (stage 35). The harvest date (H) corresponds to the commercial grape harvest. The duration of the phenological subperiods B-F, F-V, V-H and B-H was calculated. For each subperiod 16 thermal and hydric climatic indices were calculated. T: mean air temperature (°C); Tx: maximum air temperature (°C); Tn: minimum air temperature (°C); ST: sum of the medium air

temperatures ($^{\circ}\text{C}$); ST10: sum of the medium air temperatures over 10°C ; EqHI: sum of the equivalent to Huglin's heliothermic index; SS: sum of the sunshine (hs); DS: daily mean sunshine (hs); SP: sum of the photoperiod (hs); DP: daily mean photoperiod (hs); SRg: sum of the global solar radiation (J/cm^2); DRg: daily mean global solar radiation (J/cm^2); SR: Sum of rainfall (mm); SETP: sum of the Penman's ETP (mm); DETP: daily mean EPT (mm); RH: mean air relative humidity (%).

Results obtained in the São Francisco Valley were compared with mean values of a ten years evaluation (1984/1985 through 1993/1994) of the same cultivars, recorded in a temperate climate region, the Serra Gaúcha (viticultural climate "temperate warm, with temperate nights, humid" according to the Geoviticultural CCM System), situated at 29°S (Tonietto & Carbonneau, 2004). In this region data were collected in a vineyard grafted on the rootstock 101-14, conducted as trellis, without using hydrogenated cyanamide or irrigation.

3. Results and Discussion

3.1. Phenology

Tables 1 to 4 contain data on the phenology of each one of the cultivars of the São Francisco Valley and of the Serra Gaúcha. Analyzing the average values on the phenology of the four cultivars, it was observed that the average number of days of the subperiod B-F was 21 days, varying between a minimum of 20 days for the cv. Cabernet Sauvignon and a maximum of 22 days for the cv. Syrah. For reaching the subperiod F-V an average of 52 days were required, varying between 43 days for the cv. Schönburger to 58 days for the cv. Cabernet Sauvignon. The subperiod V-H showed a mean value of 44 days, 40 days relating to cv. Schönburger and 49 days for the cv. Syrah. The average duration of the subperiod B-H was 117 days, 104 days for the cv. Schönburger, 116 days for the cv. Muscat Canelli, 123 days for the cv. Cabernet Sauvignon and 124 days for the cv. Syrah.

In the Serra Gaúcha, respectively 50, 66, 38 and 154 days were necessary for subperiods B-F, F-V, V-H and B-H (mean values for the four studied cultivars).

It was observed that the subperiods B-F and F-V presented the higher mean differences between both climatic regions. The subperiods were shorter 29 (B-F) and 15 days (F-V) in the São Francisco Valley when compared with data from the Serra Gaúcha, while the subperiod V-H displayed only a short difference, being slightly longer in the São Francisco Valley.

The subperiod B-H in the São Francisco Valley was 37 days shorter than in the Serra Gaúcha (mean values of the four cultivars), due mainly to the shortening of the subperiod B-F. Evaluating table grape cultivars in the same region, Leão & Silva (2003) obtained similar results.

Additionally, it is to be stressed that in the São Francisco Valley the time of the grapevine bud burst occurred (B), respectively, only 7, 9, 9 and 11 days after pruning which had been carried out on August 28, 2003 in the cultivars Schönburger, Muscat Canelli, Syrah and Cabernet Sauvignon, showing a behavior distinct from temperate climate regions.

3.2. Bioclimate

The Tables 1 to 4 display the bioclimatic indices for each of the four cultivars studied in the São Francisco Valley and in the Serra Gaúcha.

Analyzing the average bioclimatic values for the four cultivars, it was observed that, in the São Francisco Valley, the mean air temperature in the subperiod B-C was $27,1^{\circ}\text{C}$. On account of the different subperiods the mean temperatures varied between $25,4$ to $28,1^{\circ}\text{C}$. The ST10 was, on average, 329, 870, 813 and 2012 degrees-day, respectively, for the subperiods B-F, F-V, V-H and B-H. The average EqHI for the subperiod B-H was 2.447°C . The SS for the subperiod B-H varied from 951 (cv. Schönburger) to 1.117 hs (cv. Cabernet Sauvignon), while the DS was found to be between 9,0 and 9,1 hs, varying between 8,4 and 9,9 hs on account of the subperiods. The mean SRg of subperiod B-H was $211.171 \text{ J}/\text{cm}^2$. On average, the SR for subperiod B-H was 44 mm, while a SETP was 577 mm. The average DETP of subperiod B-H was 4,9 mm, with a variation between 4,4 and 5,3 mm on account of the subperiods.

As for the conditions of the Serra Gaúcha, a mean air temperature of 19,2°C was observed for subperiod B-H, having varied, on account of the different subperiods, from 15,8 to 21,8°C. The ST10 were, on average, 306, 664, 454 and 1.425 degrees-day, respectively for the subperiods B-F, F-V, V-H and B-H. The EqHI for subperiod B-H was, on average, 1.856°C. The SS for subperiod B-H varied from 925 hs (cv.Schönburger) to 1.151 hs (cv. Cabernet Sauvignon), while the DS varied from 5,2 to 7,9 hs on account of the different subperiods. The mean SRg of subperiod B-H was 308.243 J/cm². The SR for subperiod B-H was, on average, 786 mm, while the SETP was 618 mm. The DETP of subperiod B-H was 4,0 mm, having varied, on account of the different subperiods, between 2,7 and 4,7 mm.

It was observed that, during the subperiod B-H, the temperatures T, Tx and Tn were higher in the Francisco Valley than they were in the Serra Gaúcha, their mean values being 7,9, 9,8 and 5,0, respectively. The thermal necessities of subperiod B-H, estimated on the basis of ST10 and EqHI were higher in the São Francisco Valley, while the values for the ST were less discrepant. The potential evapotranspiration, while having a higher daily average in the Valley, showed a similar total in the period B-H between both climatic regions. The total of sunshine (SS) in the period B-H in the São Francisco Valley was smaller than in the Serra Gaúcha. Such phenomenon is due essentially to the latitude (photoperiod) and to the shorter duration of the period B-H under tropical conditions.

The evaluation of a longer period for the different cultivars in the São Francisco Valley should improve the phenologic characterization of the grapevine and its bioclimate in the region.

4. Conclusions

It is concluded that the vegetative cycle of the grapevine (B-H) is significantly shorter in the São Francisco Valley (average duration for the four evaluated cultivars, 37 days less than in the Serra Gaúcha). Such behavior is mainly a result of the shortening of the period B-F (in the average 29 days shorter).

The phenologic behavior of the grapevine in the São Francisco Valley, which distinguishes it from that of a temperate region, can be explained by the particular bioclimate occurring in a tropical zone.

5. Literature Cited

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Table 1. Phenology and bioclimate of the cultivar Syrah in São Francisco Valley and the Serra Gaúcha.

Climatic indices	Phenological subperiods							
	São Francisco Valley				Serra Gaúcha			
	B-F	F-V	V-H	B-H	B-F	F-V	V-H	B-H
Duration of the subperiod (days)	22	53	49	124	54	62	42	158
T	25,7	26,8	28,1	27,1	16,2	20,0	21,8	19,2
Tx	33,3	34,2	35,3	34,5	21,7	25,0	27,4	24,8
Tn	18,4	19,9	20,9	20,0	11,9	14,8	17,6	14,9
ST	566	1422	1403	3391	876	1240	936	3052
ST10	346	892	903	2141	336	620	506	1462
EqHI	429	1089	1085	2602	483	795	627	1905
SS	197	458	461	1116	316	476	328	1120
DS	9,0	8,6	9,4	9,0	5,9	7,6	7,9	7,1
SP	263	645	615	1523	668	847	581	2096
DP	12,0	12,2	12,6	12,3	12,5	13,6	13,9	13,3
SRg	38908	91871	94637	225417	89735	135365	92812	317912
DRg	1769	1733	1931	1818	1674	2169	2226	2016
SR	0	10	46	56	321	282	215	818
SETP	100	258	256	614	166	277	195	638
DETP	4,6	4,9	5,2	5,0	3,1	4,4	4,7	4,0
RH	67	65	65	66	75	72	75	74

Table 2. Phenology and bioclimate of the cultivar Cabernet Sauvignon in São Francisco Valley and the Serra Gaúcha.

Climatic indices	Phenological subperiods							
	São Francisco Valley				Serra Gaúcha			
	B-F	F-V	V-H	B-H	B-F	F-V	V-H	B-H
Duration of the subperiod (days)	20	58	45	123	46	68	47	160
T	26,0	26,9	28,1	27,2	16,6	20,2	21,7	19,6
Tx	33,6	34,3	35,4	34,6	22,1	25,9	27,1	25,2
Tn	18,4	19,9	21,0	20,0	12,2	15,7	17,7	15,3
ST	519	1558	1295	3372	745	1374	1040	3158
ST10	319	978	835	2132	295	694	560	1548
EqHI	396	1193	1002	2591	420	887	691	1998
SS	190	504	424	1117	274	533	344	1151
DS	9,5	8,7	9,4	9,1	6,0	7,9	7,3	7,2
SP	239	706	566	1511	564	930	640	2134
DP	12,0	12,2	12,6	12,3	12,4	13,8	13,6	13,3
SRg	36876	100683	88001	225560	78054	150577	98370	327001
DRg	1844	1736	1956	1834	1715	2231	2093	2044
SR	0	10	46	56	256	297	256	808
SETP	95	284	235	614	145	309	205	659
DETP	4,8	4,9	5,2	5,0	3,2	4,6	4,4	4,1
RH	66	65	66	65	74	72	76	74

Table 3. Phenology and bioclimate of the cultivar Muscat Canelli in São Francisco Valley and the Serra Gaúcha.

Climatic indices	Phenological subperiods							
	São Francisco Valley				Serra Gaúcha			
	B-F	F-V	V-H	B-H	B-F	F-V	V-H	B-H
Duration of the subperiod (days)	21	53	42	116	53	71	37	160
T	25,6	26,8	28,1	27,1	16,0	20,1	21,8	19,2
Tx	33,2	34,2	35,3	34,4	21,4	25,8	27,3	24,7
Tn	18,3	19,9	20,8	19,9	11,7	15,6	17,7	14,8
ST	538	1422	1208	3168	846	1429	828	3103
ST10	328	892	778	1998	316	719	448	1483
EqHI	407	1088	934	2429	459	922	554	1935
SS	187	458	403	1047	307	551	282	1141
DS	8,9	8,6	9,6	9,0	5,8	7,8	7,7	7,1
SP	251	644	529	1425	652	969	512	2133
DP	12,0	12,2	12,6	12,3	12,3	13,7	14,0	13,3
SRg	36856	91631	79973	208460	86682	156089	80324	323096
DRg	1755	1729	1904	1797	1636	2205	2201	2016
SR	0	10	42	52	308	319	196	823
SETP	95	256	221	573	159	320	169	648
DETP	4,5	4,8	5,3	4,9	3,0	4,5	4,6	4,0
RH	67	66	64	65	75	72	75	74

Table 4. Phenology and bioclimate of the cultivar Schönburger in São Francisco Valley and the Serra Gaúcha.

Climatic indices	Phenological subperiods							
	São Francisco Valley				Serra Gaúcha			
	B-F	F-V	V-H	B-H	B-F	F-V	V-H	B-H
Duration of the subperiod (days)	21	43	40	104	49	64	25	138
T	25,4	26,6	28,0	26,9	15,8	19,6	21,7	18,7
Tx	32,8	34,1	35,3	34,3	21,0	25,2	27,2	24,1
Tn	18,3	19,6	20,7	19,8	11,9	15,3	17,8	14,6
ST	534	1146	1147	2826	759	1274	565	2597
ST10	324	716	737	1776	279	624	305	1207
EqHI	402	877	887	2165	403	806	375	1585
SS	176	378	397	951	251	479	194	925
DS	8,4	8,8	9,9	9,1	5,2	7,5	7,8	6,7
SP	251	521	504	1276	582	878	358	1818
DP	12,0	12,1	12,6	12,3	12,0	13,6	14,4	13,2
SRg	35049	74629	75568	185247	71745	137179	56037	264962
DRg	1669	1736	1889	1781	1474	2132	2251	1922
SR	0	10	0	10	287	280	129	697
SETP	92	207	208	507	132	276	118	525
DETP	4,4	4,8	5,2	4,9	2,7	4,3	4,7	3,8
RH	69	65	65	66	75	72	76	74