



WATER REQUIREMENT OF CHARDONNAY VINEYARDS IN 'SERRA GAÚCHA, SOUTHERN BRAZIL'¹

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ABSTRACT: The decision to invest in irrigation systems does not have any technical subsidy on vine water relations at the edaphoclimatic conditions of Pinto Bandeira-RS that can assist the producers in defining the need of water replacement by irrigation. Based on the literature from other wine regions of the world, the poor water management in vineyards can induce vigorous and unbalanced growths and reduce the quality of the grapes. This work aims to characterize the variability of the micrometeorological conditions and their relations in the water requirement of Chardonnay vineyard destined for sparkling wines elaboration. Three sites were selected, one in Bento Gonçalves-RS and another two in Pinto Bandeira-RS, which have micrometeorological stations installed with sufficient variables to obtain the reference evapotranspiration (ET_o) estimated by Penman-Monteith method parameterized by FAO-56. The periods corresponding to the phenological stages of the Chardonnay variety were defined based on a 10-years phenology study in this region and applied FAO56 K_c values to ET estimation. It was observed that even in the same mesoregion, the vineyard water requirement of the same variety and with similar cultural management has a slight variation.

KEYWORDS: Evapotranspiration, micrometeorological stations, irrigation management

DEMANDA HÍDRICA DE VINHEDOS CHARDONNAY NA SERRA GAÚCHA, SUL DO BRASIL

RESUMO: A decisão de investir em irrigação não dispõe de nenhum subsídio técnico sobre relações hídricas da videira gerado nas condições edafoclimáticas da região de Pinto Bandeira-RS. Com base na literatura de outras regiões vitivinícolas do mundo, a má gestão da água no vinhedo pode induzir crescimentos vigorosos e desequilibrados e redução da qualidade das

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uvas. Este trabalho propõe-se a caracterizar a variabilidade das condições micrometeorológicas e suas relações na demanda hídrica de vinhedo Chardonnay destinados à elaboração de espumantes. Foram selecionados três locais, um em Bento Gonçalves-RS e outros dois em Pinto Bandeira-RS com a presença de estações micrometeorológicas com variáveis suficientes que permitissem a obtenção da ETo estimada através do método de Penman-Monteith parametrizado pela FAO-56. Foram definidos os períodos correspondentes aos estádios fenológicos da variedade Chardonnay a partir de estudo de fenologia de 10 anos na região e, com isso, aplicado valores de Kc do FAO56 para estimativa de ET. Observou-se que mesmo inseridos na mesma mesorregião, a demanda hídrica de vinhedos da mesma variedade e com manejos culturais semelhantes, tem uma ligeira variação na demanda de água.

Palavra-chave: evapotranspiração, estações micrometeorológicas, manejo da irrigação

INTRODUCTION

An accurate estimation of evapotranspiration (ET) is essential for the determination of actual plant water requirements and water resource planning. Effective water management is a main component of a successful water conservation plan (Mondéjar-Jiménez et al., 2011; Ferrari et al., 2010). Accurate determination of ET can be a viable tool in better utilization of water resources through well-designed irrigation management programs. Reliable estimates of ET are also vital to develop criteria for in-season irrigation management and changes on the water balance (Ortega-Farías, 2009).

Vine water status is dependent on soil and climate characteristics (van Leeuwen et al., 2004). Soil influences vine water status through its water-holding capacity. Climate acts on vine water status through rainfall and Reference Crop Evapotranspiration (ETo). Seasonal ET depends upon environmental conditions, characteristics of the crops (such as trellis system and row spacing in vineyards), and cultural practices (such as canopy management). Accurate estimation of vineyard ET can provide a scientific basis for developing irrigation management. Atmospheric monitoring of weather data to calculate evapotranspiration and sensors for monitoring soil water content have been used for scheduling irrigation in agriculture (Allen et al. 1998). Seasonal grape ET has been reported to range from 687 to 1,350 mm (Williams et al. 2003; Williams and Ayars 2005a; Netzer et al. 2009; Rodriguez et al. 2010). Crop evapotranspiration (ETc) is often estimated by multiplying reference crop evapotranspiration (ETo) by a crop coefficient (Kc): $ET_c = K_c \times ETo$ (Allen et al. 1998). The factors determining

the Kc are stage of crop growth, canopy height, local climate, architecture and cover, and crop management among others.

‘Serra Gaúcha’ Region is the largest and most important wine region in Brazil, accounting for about 85% of the national wine production. Vineyards encompassed about 40,000 ha of which 1,481 ha are in Pinto Bandeira-RS distributed in 478 grape farmers (De Melo, 2015). Although water is an abundant resource in this region whose rain annual depth is high, due to soil characteristics as shallow depth with waterproof horizons near the surface, the water may not be available sometimes among the year (short droughts).

Several factors that make influence on the grape evapotranspiration (ET_c) estimation in the ‘Serra Gaúcha’ region is conditioned by the topography. These topoclimatic variability generates different ET rates in the vineyards (Flores et al, 2005). The goal of this study was to assess the spatial and seasonal ET measurements in different micrometeorological conditions and their relations in the water requirement of Chardonnay vineyards.

MATERIAL AND METHODS

1. Experimental sites

The experimental sites in “Serra Gaúcha” region selected was three micrometeorological station close to *Vitis vinifera* cv. Chardonnay vineyards. Two were installed in Pinto Bandeira, RS into the commercial vineyards: 1) Geisse Winery (29°09'04”S; 51°25'38”W) about 740 m above sea level, and 2) Don Giovanni Winery (29°05'51”S; 51°26'21”W) about 690 m above sea level. The third one was installed in Bento Gonçalves at 624m above sea level (29°09'52”S; 51°32'03”W).

2. Vineyards

Similar soil texture of the three-selected-vineyards was silty clay loam with a 0.5 m maximum depth, medium water infiltration rate and water table within the reach of the roots. Grape vertical positioning system vineyards were Guyot pruned about July/August and trained with a vertical shoot positioned trellis, with two fixed and two movable wires. Vine density was about 4500 vines ha⁻¹. Usually phenological phases dates are: pruning (P) to budding (B) (between late July to late August); B to full flowering (FF) (between beginning of September to beginning to November); FF to beginning of maturation (BM) (between beginning of November to late December) and BM to harvest (H) (late December to middle of January). The study covers 2014/2015 phenological cycle.

3. ET estimation

Automatic micrometeorological stations were installed on the experimental vineyards to take half-hourly air temperature (Celsius), air relative humidity (%), wind speed (m s^{-1}), solar radiation, R_s (W m^{-2}) and rainfall (mm) and compared to 1962-2016 climatological averages. It was used FAO56 approach to net radiation (R_n) and soil heat flux (G) calculations and then reference crop evapotranspiration (ET_o) calculation by Penman-Monteith equation (Allen et al., 1998) and actual evapotranspiration (ET_c) calculated by multiplying the ET_o by a crop coefficient (K_c):

$$ET_c = ET_o K_c \quad (01)$$

where:

ET_c crop evapotranspiration [mm d^{-1}];

ET_o reference crop evapotranspiration [mm d^{-1}];

K_c crop coefficient [dimensionless].

It was used K_c values according to Conceição and Mandelli (2007) who recommend $K_{c\text{initial}}$, $K_{c\text{medium}}$ and $K_{c\text{final}}$ values, respectively, at 0.30; 0.70 and 0.45 for grape vertical positioning system which are according to reported by FAO56 (Allen et al., 1998). Based on 10 years-phenology studies of the Chardonnay variety (Mandelli et al., 2003, it was adopted K_c values mentioned above at the appropriate phenological stages (dates).

4. Vine water status

Vine water status was assessed with the pressure chamber technique (Scholander et al., 1965). Stem water potential (Choné et al., 2001) was measured with a pressure chamber in one of the water requirement critical phenological phase. The measurements were taken on exposed and shaded leaves covered with an opaque plastic bag one hour prior to measurement. Each measurement was replicated 6 times, on 6 individual vines.

5. ET Remote Sensing data

Flight campaign collecting measurements were carried out during February 10th on experimental vineyard that is relatively flat and uniform. It was used a helicopter-based unmanned aerial vehicle (UAV) equipped with multispectral camera for the generation of very high spatial resolution images that can be used as inputs in the remote sensing energy balance algorithms to estimate spatial variability of energy balance components. In this study was used METRIC algorithm and surface temperature data closed to flight time.

RESULTS AND DISCUSSION

Meteorological data mean obtained at the 2014/2015 Chardonnay phenological phases are indicated in Table 1. Wet and mild temperatures were observed at the three micrometeorological stations where mean/sum values of R_s , R_n , T_a , RH , u , VPD and $Rain$ were 362 W m^{-2} , 210 W m^{-2} , 18.1°C , 79% , 2.4 m s^{-1} , 2.95 kPa and 1051 mm during the phenological cycle. Within these atmospheric environments, values of midday stem water potential (ψ_x) ranged between -0.61 and -0.96 MPa indicating that the Chardonnay vineyard was maintained under non and moderate water stress conditions during the study period. The total rainfall was about 1000 mm . It is about 60% of the normal annual rainfall. Combined mean data from all atmospheric variables (from three station) indicated a humid subtropical climate.

Table 1. Meteorological conditions at the 2014/2015 Chardonnay phenological cycle: R_s – solar radiation; R_n – net radiation; T_a – mean air temperature; RH – mean air humidity; u – wind speed and VPD – vapor pressure deficit.

Phenological phase ¹	R_s (W m^{-2})	R_n (W m^{-2})	T_a ($^\circ\text{C}$)	RH (%)	u (m s^{-1})	VPD (kPa)	$Rain$ (mm)
Pruning (P) to budding (B) – 27 days	154	76.7	14.1	74.4	2.0	1.85	76
B to Full Flowering (FF) – 67 days	333	186	16.8	80.9	2.7	2.04	409
FF to beginning of Maturation (BM) – 51 days	523	308	19.9	77.2	2.7	2.51	340
BM- Harvest – 26 days	436	272	21.6	84.4	2.3	2.78	226
Average /Sum	362	210	18.1	79	2.4	2.95	1051

1 - Chardonnay phenological cycles: pruning (P) to budding (B) (between Aug 01 to Aug 27); B to full flowering (FF) (between Aug 28 to Nov 02); FF to beginning of maturation (BM) (between Nov 02 to Dec 23) and BM to harvest (H) (Dec 24 to Jan 18).

1. ET spatial and seasonal variability

ET measurements from all three sites indicated a slight variation on water requirement on 2014/2015 Chardonnay phenological cycle (Table 2). The Chardonnay vineyard from Geisse Winery shows accumulated $ET = 490 \text{ mm}$. It was 52 mm more than Don Giovanni Chardonnay vineyard and 44 mm difference from Embrapa vineyard. Probably this difference is results of

vineyard position. Geisse vineyard are more exposed to wind speed and it's more flat and open to incident short wave solar radiation.

Compared accumulated ET x Rainfall indicated that it's not necessary irrigation practice at 2014/2015 grape cycle. However, recent data (not showing in this paper) indicated on a specific phenological stage (between beginning of maturation and harvest – last 15 days of December to middle of January 18th) a deficit of 59 mm for Geisse vineyard in Pinto Bandeira-RS vineyards (ET > Rain). These results are similar when you compared to 1962-2016 climatological data Rainfall x Chardonnay ET (Table 3) for Bento Gonçalves, RS. Results shows that are deficit in some Chardonnay cycle (ET > Rain) from beginning of maturation to harvest phenological stage and that deficit are occurring more frequently in the last decades. Probably vineyards in Cave Geisse Winery (Pinto Bandeira-RS) were more water stressed than vineyards in Bento Gonçalves due shallow soil depth with waterproof horizons near the surface and more ET rate results of greater solar radiation and wind speed values.

Table 2. Grape evapotranspiration using ETo Penman-Monteith method parameterized by FAO-56 and Chardonnay Kc for 2014/2015 phenological cycle in Geisse (G) and Don Giovanni (DG) Wineries both at Pinto Bandeira, RS and Embrapa (E) in Bento Gonçalves, RS

Phenological phase ¹	Accumulated ETc (mm)		
	G	DG	E
Pruning (P) to budding (B) – 27 days	16	14	23
B to Full Flowering (FF) – 67 days	128	137	137
FF to beginning of Maturation (BM) – 51 days	217	210	203
BM- Harvest – 26 days	129	77	83
Sum	490	438	446

1 - Chardonnay phenological cycles: pruning (P) to budding (B) (between Aug 01 to Aug 27); B to full flowering (FF) (between Aug 28 to Nov 02); FF to beginning of maturation (BM) (between Nov 02 to Dec 23) and BM to harvest (H) (Dec 24 to Jan 18).

Table 3. Difference between Rainfall and Grape evapotranspiration (R – ET) at beginning of maturation to harvest phenological stage of Chardonnay cycle in Bento Gonçalves, Serra Gaúcha region from 1962 to 2012.

Year	R - ET	Year	R - ET	Year	R - ET	Year	R - ET	Year	R - ET	Year	R - ET
62/63	36	72/73	267	82/83	51	92/93	194	02/03	32	12/13	91
63/64	-14	73/74	64	83/84	27	93/94	-13	03/04	-42	13/14	69

64/65	94	74/75	100	84/85	-7	94/95	80	04/05	-56	14/15	152
65/66	74	75/76	53	85/86	6	95/96	151	05/06	-1	15/16	21
66/67	87	76/77	54	86/87	116	96/97	-73	06/07	2		
67/68	42	77/78	-61	87/88	-1	97/98	89	07/08	33		
68/69	93	78/79	-69	88/89	6	98/99	-62	08/09	97		
69/70	29	79/80	-1	89/90	78	99/00	84	09/10	230		
70/71	43	80/81	-17	90/91	-69	00/01	127	10/11	-35		
71/72	80	81/82	-70	91/92	96	01/02	-49	11/12	-25		

CONCLUSIONS

It was observed that even in the same mesoregion, the vineyard water requirement of the same variety and with similar cultural management has a slight variation. Results shows that are deficit in some Chardonnay cycle ($ET > Rain$) from beginning of maturation to harvest phenological stage and that deficit are occurring more frequently in the last decades. Future improvements in ET measurements using a Eddy Covariance and Surface Renewal ET flux station combined to remote sensing data and midday stem water potential will show more accurate climatological water balance for vineyards in Serra Gaúcha.

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