Fertility of buds and pruning recommendation of different grapevine varieties grown in altitude regions of Santa Catarina State, Brazil

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ABSTRACT

Low bud fertility index is frequently observed in different grapevine varieties grown in high altitude of Santa Catarina Sate; in many cases less than one cluster per bud is observed. The objective of this study was to assess bud fertility of twenty six *Vitis vinifera* L. varieties and from this information, to recommend the method of pruning more suitable for these varieties in high altitude conditions. The grapevine canes and buds were collected from production vineyards located in São Joaquim, Santa Catarina State, in two consecutive vintages. Fifteen cane cuttings containing 10 nodes per variety were collected to determine bud fertility and placed in a growth chamber with controlled relative humidity, light, temperature. After budbreak, buds were classified as fertile or non-fertile according to the presence or absence of the inflorescence. The bud fertility varies according to the variety and its position in the cane. Merlot, Cabernet Franc, Cabernet Sauvignon, Tinta Roriz and Tinta Caiada, which present higher fertility in basal buds, are recommended for short or long pruning. The varieties Chardonnay, Manzoni Bianco, Sauvignon Blanc, Sangiovese, Pinot Gris, Tempranillo, Pinot Noir, Syrah, Montepulciano, and Touriga Nacional should be pruned preferentially in long pruning. While the varieties Viognier, Glera (Prosecco), Fiano, Garganega, Vermentino, Nebbiolo, Teroldego, Rebo, Canaiolo Nero and Touriga Francesa must be pruned exclusively with long pruning in order to ensure adequate cluster production.

Keywords: *Vitis vinifera* L. productivity; bud position; floral primordia.

INTRODUCTION

The vineyards of Santa Catarina State high altitude regions are located between 900 and 1400 meters above sea level, this zone is characterized by longer phenological cycles, higher solar radiation availability and greater thermal amplitude compared to other Brazilian wine producing regions. These characteristics favor the cultivation of *Vitis vinifera* L. varieties, which reach maturation indices suitable for elaboration of quality wines, differentiated by their intense color, aroma and acidity (Brighenti *et al*. 2015; Malinovski *et al*. 2016).

However, low bud fertility index is frequently observed in this region. In many cases less than one cluster per bud is observed, resulting, in most grapevine varieties, annual variations in productivity (Rosa *et al*. 2014; Würz *et al*. 2019). Several causes may be related to low bud fertility, for example, genetic diversity, pruning method, temperature, light intensity, mineral nutrition and hormone concentrations (Srinivasan & Mullins, 1981; Dokoozlian, 2000; Botelho *et al*. 2009; Andreini *et al*. 2009; Taiz & Zeiger, 2009; Brighenti *et al*. 2017).

The fertile bud formation is consequence of bud apex differentiation in undifferentiated reproductive primordium, then in inflorescence primordium, and later will develop in inflorescence and in cluster (Botelho *et al*. 2009; Srinivasan & Mullins, 1981). Fertility is a genetic characteristic of vine

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varieties, and it means the ability to differentiate vegetative buds into fruit buds, which will determine their productivity. Each variety has a typical pattern of bud fertility along the cane and the knowledge of fertile bud position is fundamental in defining the method of pruning to be used in the vineyard (Leão & Silva, 2003).

The objective of this work was to assess the bud fertility of twenty six grapevine varieties (*Vitis vinifera* L.), determine the position of their fertile buds along the cane and from this information indicate the type of pruning more suitable for these varieties in the conditions of Santa Catarina high altitude regions.

MATERIALS AND METHODS

Twenty-six *Vitis vinifera* varieties were evaluated, divided into three groups: *Italian origin* - Glera (Prosecco), Fiano, Garganega, Manzoni Bianco, Vermentino (white grapes), Montepulciano, Nebbiolo, Rebo, Sagrantino, Canaiolo Nero, Sangiovese and Teroldego (red grapes). *French origin* - Sauvignon Blanc, Viognier, Chardonnay, Pinot Gris (white grapes), Cabernet Sauvignon, Pinot Noir, Merlot, Pinot Noir, Cabernet Franc and Syrah (red). *Iberian origin* - Tempranillo, Tinta Caiada, Tinta Roriz, Touriga Francesa and Touriga Nacional (red grapes).

To perform this experiment, grapevine buds were collected in vineyards located in the city of São Joaquim, in Santa Catarina State, Brazil (28º17’38"S, 49º55’1"W, at an average altitude of 1,300 m a.s.l.), in the growing seasons of 2011/2012 and 2012/2013. The climate of the region is a mesothermal humid (Cfb) according to Köppen-Geiger classification, i.e, humid subtropical, oceanic climate, without dry season, with temperate summer (Alvares *et al*. 2014). The soil of the experimental orchard is a “Cambissolo Húmico” (Inceptisol) (Pasa *et al*., 2017; Pasa *et al*. 2018).

As a mean to determine bud fertility, in August 2011 and August 2012, after the winter pruning, 15 cane cuttings of each variety containing 10 buds were sampled and placed in a growth chamber with controlled relative humidity, light and temperature. The evaluations were performed at the Fruit Production Laboratory of Santa Catarina State University (CAV/UDESC). The cane cuttings were cut on one-node segments and their buds separated in positions 1 to 10. Each cane segment was placed in hydrated phenolic foam, and arranged in ascending order of 1 to 10 according to the bud position in the cane. The buds were placed in a growth chamber in such conditions that ensure the best development to study bud fertility. Conditions have been adjusted to: temperature of 25 °C (± 1), photoperiod 12 h of light at 300-400 $\mu E \cdot m^{2} \cdot s^{-1}$ and 60% relative humidity (Andreini *et al*. 2009).

After budbreak, the buds were evaluated until visible inflorescence phenological stage (Baillod & Baggiolini 1993). Then, buds were classified as fertile or non-fertile according to the presence or absence of the inflorescence. Buds in positions 1 to 3 were classified as basal, buds in positions 4 to 6 were considered medium and buds in positions 7 to 10 were classified as apical. At the end of the evaluation, the fertility percentage of basal, median and apical buds and the total per variety were calculated.

The experiment was arranged in a completely randomized design, in a 26x3 factorial scheme, 26 of which were vine varieties and 3 were cane segments, with 3 replicates of 5 canes with 10 buds each. Data expressed as percentage was transformed by arcsin [square root (n + 1)]. Data were submitted to analysis of variance (ANOVA) and Tukey’s test was performed to compare varieties and bud position.

RESULTS AND DISCUSSION

When evaluating fertility of first ten buds of the cane, great influence of the variety is observed. Higher values of bud fertility were observed for the Merlot and Cabernet Franc varieties, presenting 90% and 94%, while Glera (Prosecco), Touriga Francesa, Fiano, Sagrantino and Tinta Roriz varieties showed the lowest bud fertility percentage, with 27, 31, 35, 40, 40 and 41%, respectively (Table 1). *Vitis vinifera* germplasm is characterized by high diversity, such diversity is result of centuries of human and natural selection. Tha selection established a close relationship between the variety and the environment where it was grown. As consequence, it is possible to find remarkable differences in morphological and physiological behavior between varieties (Andreini *et al*. 2009).

Fertility also varied according to vintage and bud position along the cane. Total fertility may provide an important information about the variety adaptation to a particular environment; the results express the evident differences between varieties and vintages. Merlot, Cabernet Franc and Cabernet Sauvignon presented the highest average fertility, which may indicate better adaptation to high altitude regions of Santa Catarina.

In an earlier work, Würz *et al*. (2019) observed a higher percentage of bud fertility in Merlot, Sauvignon Blanc and Chardonnay, presenting respectively 99%, 93% and 93%, while the lowest bud fertility was observed in Cabernet Franc and Cabernet Sauvignon, which showed 86% and 89%. This fact confirms the potential of so-called “international” varieties, such as Cabernet Sauvignon, Merlot and Chardonnay, which have in common the fact that they are adapted to different climates and soils, show high plasticity, good fertility and have the ability to be managed in different ways (Mannini, 2004).

The highest percentage of fertile buds was concentrated in the medium and apical buds for almost all evaluated vine varieties (Table 2). For the French varieties, higher fertility of apical buds was observed in Pinot Gris, while Cabernet Sauvignon presented the highest fertility in medium buds; the other French varieties showed the highest fertility in medium and apical buds. For the Italian varieties, higher fertility of apical buds was observed in Canaiolo Nero, whereas Glera, Vermentino and Nebbiolo had the highest fertility in medium buds; the other Italian varieties showed the highest fertility in the medium and apical buds. For the Iberian varieties, higher fertility of apical buds was observed in Touriga Nacional, while Tinta Roriz presented the high fertility in basal buds; Tempranillo and Touriga Francesa presented high fertility in medium and apical buds; Tinta Caiada did not present a significant statistical difference in fertility of buds according to position in the cane.

Studies with the French varieties Cabernet Sauvignon, Chardonnay, Merlot, Sauvignon Blanc, Cabernet Franc, and the Italian genotypes Nebbiolo, Greco di Tufo and Coda di Volpe grown in Santa Catarina State also observed low fertility of basal buds of the studied varieties (Rosa *et al*. 2014, Munhoz *et al*. 2016, Würz *et al*. 2019). Cultivar has a major effect on dormant bud fruitfulness with genotypes differences observed for the number fertilre shoots, number of clusters per shoot, and bud position of the cluster on the shoot. For example, the differences between Thompson Seedless and Riesling cultivated under the same conditions with Thompson Seedless having only 1 cluster at bud 6 and Riesling having 3 clusters at buds 3, 4, and 6. Thompson Seedless also has low fertility at basal buds and this variety difference influences the type of pruning performed in winter. Riesling can be pruned in spur cordon to leave two or three basal buds to provide the crop for the following season as the dormant buds at these positions are fertile and contain immature inflorescences (Carmona *et al*. 2008).

Table 1: Total fertility (%) of the first 10 buds of different grapevine (*Vitis vinifera* L.) varieties during 2011/2012 and 2012/2013 vintages in high altitude regions of Santa Catarina State – Brazil

Variety	Bud Fertility (%)		
	2011/2012	2012/2013	Average
		French Varieties	
Chardonnay	77 b	42 d	59 c
Sauvignon Blanc	77 b	53 c	65 c
Viognier	43 c	50 c	47 d
Pinot Gris	66 b	58 c	62 c
Pinot Noir	63 b	66 c	64 c
Syrah	57 b	65 c	67 c
Merlot	98 a	90 a	94 a
Cabernet Franc	88 a	92 a	90 a
Cabernet Sauvignon	80 a	74 b	77 b
		Italian Varieties	
Glera (Prosecco)	31 c	31 d	31 e
Fiano	23 c	57 c	40 e
Manzoni Bianco	58 b	72 b	65 c
Garganega	72 b	59 c	66 c
Vermentino	68 b	58 c	63 c
Sangiovese	60 b	42 d	51 d
Nebbiolo	62 b	31 d	51 d
Teroldego	51 c	56 c	54 d
Rebo	33 c	75 b	54 d
Sagrantino	44 c	35 d	40 e
Montepulciano	69 b	51 c	60 c
Canaiolo Nero	41 c	51 c	46 d
		Iberian Varieties	
Tempranillo	62 b	30 d	46 d
Touriga Francesa	49 c	21 e	35 e
Tinta Roriz	62 b	19 e	41 e
Touriga Nacional	67 b	68 c	69 c
Tinta Caiada	72 b	67 c	70 c
CV (%)		20.7	

*Different letters within columns indicate significant differences according to Tukey's test ($p < 0.05$).

As buds are formed in the year prior to production of flowers and clusters, winter pruning is closely related to fertility and defined according to the position of the fertile buds in the canes. The position of the fertile bud influences the pruning system to be adopted, for varieties that have low fertility of basal buds, it is necessary to adopt a long or mixed pruning system. By adapting the type of pruning to the position of the most fertile buds it is possible to increase productivity, as there will be an increase in the number of inflorescences and consequently an increase clusters produced per vine (Srinivasan & Mullins, 1981; Brighenti *et al*. 2017; Würz *et al*. 2019).

In previous evaluations in Santa Catarina State, the spur pruning method (short pruning) for some Italian varieities, like Rebo, Verdicchio and Nebbiolo was not efficient, especially in relation to yield, plant balance and grape quality. In Italy other authors suggest that short pruning would be more appropriate for Canaiolo Nero and Manzoni Bianco; while the mixed pruning for Sagrantino, Sangiovese and Vermentino. And long pruning would be more appropriate for Fiano, Garganega, Rebo and Teroldego (Calò *et al*. 2006). While in altitude conditions of Santa Catarina State it was observed that long pruning would be more suitable for Rebo and Nebbiolo, due to the low bud fertility in the basal position of the cane (Brighenti, *et al*. 2017; Würz *et al*. 2018).

In both vintages evaluated, it was observed that the grape varieties grown in altitude region of Santa Catarina had low bud fertility, in many cases, this value was less than 50%. The low fertility indexes observed in this experiment may be a consequence of low temperatures recorded during the months between August and November, when occurs the vegetative development and bud induction and differentiation for the next vintage (Srinivasan & Mullins, 1981; Botelho *et al*. 2009). Temperature is a determining factor that influences grapevine fertility. Normally, varieties of American grape species produce inflorescences at

Table 2: Fertility of basal, medium and apical buds (%) of different grapevine (*Vitis vinifera* L.) varieties during 2011/2012 and 2012/2013 vintages in high altitude regions of Santa Catarina State – Brazil

Variety	Bud Fertility (%)		
	Basal Buds (1st to 3rd)	**Median Buds (4th to 6th)**	**Apical Buds (7th to 10th)**
		French Varieties	
Chardonnay	49 b	54 ab	65 a
Sauvignon Blanc	58 b	72 a	70 ab
Viognier	24 b	46 a	58 a
Pinot Gris	35 c	57 b	69 a
Pinot Noir	47 b	75 a	75 a
Syrah	45 b	70 a	70 a
Merlot	84 b	99 a	97 a
Cabernet Franc	78 b	94 a	94 a
Cabernet Sauvignon	71 b	86 a	50 b
		Italian Varieties	
Glera (Prosecco)	27 b	40 a	26 b
Fiano	26 b	47 a	56 a
Manzoni Bianco	44 b	78 a	83 a
Garganega	32 b	63 a	80 a
Vermentino	27 c	76 a	67 b
Sangiovese	32 b	62 a	73 a
Nebbiolo	29 b	53 a	37 b
Teroldego	14 b	69 a	73 a
Rebo	25 b	53 a	59 a
Sagrantino	27 b	42 ab	60 a
Montepulciano	39 b	66 a	68 a
Canaiolo Nero	16 c	36 b	52 a
		Iberian Varieties	
Tempranillo	34 b	43 ab	49 a
Touriga Francesa	13 b	29 a	37 a
Tinta Roriz	50 a	36 c	44 b
Touriga Nacional	55 b	68 b	87 a
Tinta Caiada	77 a	77 a	71 a

*Different letters within rows indicate significant differences according to Tukey's test ($p < 0.05$).

lower temperatures (21 to 22 °C) than varieties of *Vitis vinifera* (27 to 28 °C) (Mullins *et al*. 2007). Other authors previously reported that in the high altitude regions of Santa Catarina State, mean temperatures below 20 °C are frequently recorded during the period of grapevine floral differentiation (Brighenti *et al*. 2015; Munhoz *et al*. 2016; Würz *et al*. 2019).

CONCLUSIONS

Based on the data referring to bud fertility, it is concluded that Merlot, Cabernet Franc, Cabernet Sauvignon, Tinta Roriz and Tinta Caiada, which present higher fertility in basal buds, are recommended for short or long pruning. The varieties Chardonnay, Manzoni Bianco, Sauvignon Blanc, Sangiovese, Pinot Gris, Tempranillo, Pinot Noir, Syrah, Manzoni Bianco, Sangiovese, Montepulciano, Tempranillo and Touriga Nacional should be pruned preferentially in long pruning. While the varieties Viognier, Glera (Prosecco), Fiano, Garganega, Vermentino, Nebbiolo, Teroldego, Rebo, Canaiolo Nero and Touriga Francesa must be pruned exclusively with long pruning in order to ensure adequate cluster production.

REFERENCES

Alvares CA, Stape JL, Sentelhas PC, Golçalves JLM & Sparovek G (2014) Köppen's climate classification map for Brazil. Meteorologische Zeitschrif, 22:711-728.

Andreini L, Viti R & Scalabrelli G (2009) Study on the morphological evolution of bud break in Vitis vinifera L. Vitis, 48:153-158.

Baillod M & Baggiolini M (1993) Les stades répères de la vigne. Revue Suisse de Viticulture Arboriculture Horticulture, 28:07-09.

Botelho RV, Pires EJP & Terra MM (2009) Fertilidade de gemas em videiras: fisiologia e fatores envolvidos. Ambiência, 2:129-144.

Brighenti AF, Malinovski LI, Stefanini M, Vieira HJ & Silva AL (2015) Comparação entre as regiões vitícolas de São Joaquim - SC, Brasil e San Michele All'Adige - TN, Itália. Revista Brasileira de Fruticultura, 37:281-288.

Brighenti AF, Cipriani R, Malinovski LI, Vanderlinde G, Allebrandt R, Feldberg NP & Silva AL (2017) Ecophysiology of three Italian cultivars subjected to two pruning methods in Santa Catarina, Brazil. Acta Horticulturae, 1157:381-388.

Calò A, Scienza A & Costacurta A (2006) Vitigni d'Italia - Le varietà tradizionali per la produzione dei vini moderni. Bologna, Edagricole. 919p.

Carmona MJ, Chaib J, Martinez-Zapater JM & Thomas MR (2008) A molecular genetic perspective of reproductive development in grapevine. Journal of Experimental Botany, 59:2579-2596.

Dokoozlian NK (2000) Grape Berry Growth and Development. In: Christensen LP (Ed.) Raisin Production Manual. Oakland, University of California. p.30-37.

Leão PCS & Silva EEG (2003) Brotação e fertilidade de gemas em uvas sem sementes no Vale do São Francisco. Revista Brasileira de Fruticultura, 25:375-378.

Malinovski LI, Brighent AF, Borghezan M, Guerra MP, Silva AL, Porro D, Stefanini M & Vieira HJ (2016) Viticultural performance of Italian grapevines in high altitude regions of Santa Catarina State, Brazil. Acta Horticulturae, 1115:203-210.

Mannini F (2004) Italian Indigenous Grapevine Cultivars: Guarantee of Genetic Biodiversity and Economic Resource. Acta Horticulturae, 652:87-95.

Mullins MG, Bouquet A & Williams LE (2007) Biology of the grapevine. Cambridge, University Press. 239p.

Munhoz B, Welter JF, Pescador R, Brighenti AF & Silva AL (2016) Fertilidade e Análise de gemas das videiras Greco di Tufo, Coda di Volpe e Viognier cultivadas em São Joaquim – Santa Catarina. Revista Agropecuária Catarinense, 29:68-72.

Pasa MS, Carra B, Silva CP, Ciotta MN, Brighenti AF, & Pereira AJ (2017) Early spring application of aminoethoxyvinilglycine (AVG) increases fruit set and yield of 'Rocha' pears. Revista Brasileira de Fruticultura, 39:e-982.

Pasa MS, Felippeto J, Nava G, Silva CP, Brighenti AF & Ciotta M (2018) Performance of 'Fuji Suprema' apple trees treated with budbreak promoters, in São Joaquim-SC. Revista Brasileira de Fruticultura, 40:e-325.

Rosa AM, Pescador R, Silva AL, Brighenti AF & Bruneto G (2014) Fertilidade e reserva de carbono e nitrogêncio em gemas de ramos das viníferas 'Cabernet Sauvignon' e 'Nebbiolo'. Revista Brasileira de Fruticultura, 36:576-585.

Srinivasan C & Mullins MG (1981) Physiology of flowering in the grapevine – A review. American Journal of Enology and Viticulture, 32:47-63.

Taiz L & Zeiger E (2009) Fisiologia Vegetal. 4ª ed. Porto Alegre, Artmed. 848p.

Würz DA, Marcon Filho JL, Allebrandt R, De Bem BP, Rufato L & Kretzschmar AA (2018) Reguladores de crescimento na fertilidade de gemas e maturação da cultivar 'Nebbiolo' em região de elevada altitude de Santa Catarina. Scientia Agrarian Paranaensis, 17:90-95.

Würz DA, Canossa AT, Reineher J, Allebrandt R, Bem BP, Outemane M, Rufato L & Krezschmar AA (2019) Avaliação da fertilidade de gemas de variedades de uvas viníferas cultivadas em região de elevada altitude de Santa Catarina. Revista de Ciências Agroveterinárias, 18:81-86.