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Pruning management of Chardonnay grapevines at high altitude in Brazilian southeast

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ABSTRACT: The agronomical responses of Chardonnay, a variety indicated for sparkling wine production, is influenced by the vineyard management and the edaphoclimatic conditions of the region. The objective of this study was to evaluate the effects of two pruning types (Royat and double Guyot) on vegetative and reproductive development of Chardonnay vine growing at high altitude in the Brazilian southeastern region. The experiment was carried out in a commercial vineyard located at 1,280 m of altitude in Divinolândia, São Paulo State, Brazil. The Chardonnay vines (clone 96), grafted onto 1103 Paulsen rootstock and trained in a vertical shoot positioning trellis system, were assessed. Vegetative vigor, bud fruitfulness, production and physicochemical composition of grapes were evaluated during 2014 and 2015 growing seasons. The Royat pruning induced higher vegetative vigor and increased the bud fruitfulness, the cluster number and the productivity of Chardonnay vine when compared to Guyot pruning. Even though the increase on yield was observed, there was no effect of pruning type on grape final quality. Therefore, the choice of pruning method in function of variety genetic characteristics and their interaction with environment can optimize the vineyard profitability. In the Brazilian southeast, the Royat system is the most suitable one to grow Chardonnay for sparkling wines production.

Key words: *Vitis vinifera*, Royat pruning, Double Guyot pruning, vegetative vigor, yield, grape composition.

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INTRODUCTION

The southeastern Brazil has satisfactory soil and climatic conditions for the production of high-quality fine wines. Regions around 900 m above sea level are conducive to the production of red fine wines in winter cycles (Favero et al. 2011; Dias et al. 2012; Souza et al. 2015), while areas located at higher altitudes, above 1,000 m, favor the production of sparkling wine during the summer cycle, as demonstrated by Regina et al. (2010). However, little information is available about the most appropriate management of vines for the production of sparkling wines at high altitudes in the southeastern Brazil.

The vegetative growth, productivity and quality of the berries are affected by microclimatic conditions of the vineyard, which vary according to its location (altitude, latitude and topography), the genetic characteristics of the producing varieties and rootstocks, trellis as well as pruning system adopted (Jackson and Lombard 1993; Dry 2000). Vine pruning defines the number of buds in the vineyard and aims to ensure a balance between vegetative and reproductive vigor through changes in the distribution of photoassimilates between the source (leaves) and sink (clusters) (Dry 2000; Blouin and Guimberteau 2002; Kliewer and Dokoozlian 2005). The type of pruning adopted for a given variety and region depends on the potential fertility gradient of latent buds formed along the branches in the preceding cycle (Hidalgo 2003; Vasconcelos et al. 2009). Varieties with higher fertility in buds closer to the branch base are usually subjected to spur pruning (or short pruning), while varieties with more fertile latent buds in the middle portion of the branches are subjected to cane pruning.

In the wine-growing practice, the adopted systems are Cordon Royat for short pruning, in which only two-node spurs are left on permanent cordons, and Single Guyot or Double Guyot for long pruning, where spurs and canes are left on both sides (double) or only one side of the plant (single) (Hidalgo 2003; Reynier 2005). Thus, the number of buds left on the canes or the spurs after pruning determines the size of the leaf area and the number of grape clusters. Several studies have reported differences related to the intensity and type of pruning, vegetative vigor and final composition of berries for both fresh consumption (Christensen et al. 1994; Ahmad et al. 2004) and wine production (Smithyman et al. 1997; Kurtural et al. 2006; Bindon et al. 2008; O'Daniel et al. 2012). Also, the management of the canopy according to the type and intensity of pruning has an effect on production in the next cycle, due to its impact on accumulated reserves and bud fertility (Vasconcelos et al. 2009; Pellegrino et al. 2014).

In Brazil, there are few studies on the management of Chardonnay vines, mainly in the southeastern region. In general, the traditional spur pruning in bilateral cordons has been applied for this variety, as well as for most European varieties (Regina et al. 2010). Nevertheless, it is unclear whether this is the ideal for pruning Chardonnay vine grown at high altitudes. Therefore this study aimed to compare the traditional spur pruning with Double Guyot and determine which management ensures a balance between productivity and quality of Chardonnay grape at altitudes higher than 1,000 m in southeastern Brazil.

MATERIAL AND METHODS

The experiment was conducted during the growing seasons of 2014 and 2015 in a commercial vineyard planted in 2009, in Divinolândia, São Paulo State, Brazil. The experimental area is located at 21°39'S and 46°44'W, with 1,280 m of average altitude, 1,576 mm of annual rainfall and average minimum and maximum temperatures of 15.2 and 21.3 °C, respectively.

Chardonnay vines (clone 96), grafted onto 1103 Paulsen rootstock and trained in a vertical shoot positioning trellis system, were assessed.

The vineyard was trained in a vertical shoot positioning with three wires, 2.5 × 1.0 m spaced, totaling 4,000 plants per hectare. We evaluated two pruning systems, Cordon Royat and Double Guyot, in the Chardonnay clone 96 grafted onto 1103 Paulsen rootstock. The number of buds per plant ranged from 16 to 18, for the two treatments. After pruning, the buds were brushed with hydrogen cyanamide (Dormex®) at a dose of 5% of the commercial product.

The treatments were arranged in a completely randomized design due to the homogeneity of the experimental area. Each treatment consisted of ten repetitions of eight plants per plot, with a total →

experimental area of 160 plants. Vegetative vigor was determined by dry weight of pruned branches and number of branches at the end of each production cycle. Upon pruning performed in late July, branches of each plant were collected and dried in a forced air oven at 60 °C to achieve a constant weight. The bud fruitfulness was obtained by the number of inflorescences divided by the number of branches of ten plants for each treatment, in September, during full bloom. At harvest, the number and the average weight (g) of clusters were determined for ten plants per treatment. We also estimated the number of berries per cluster and the average weight of a hundred berries per repetition. The average production per plant (kg·plant^{-1}) was estimated by multiplying the average weight of clusters by the number of bunches per plant. Productivity per hectare was estimated by the multiplication of the average production per plant by the total number of plants per hectare.

For chemical composition evaluation, we used 300 berries per repetition. Must was extracted manually, filtered through glass wool and used for quantification of soluble solids (°Brix) using a portable digital refractometer (ATAGO Pal 1) and total titratable acidity (g·L^{-1} tartaric acid) by titration with 0.1N NaOH, using phenolphthalein as an indicator. The pH was determined by a digital potentiometer (Micronal, B472), equipped with glass electrode and calibrated with pH 4.0 and 7.0 buffers.

Data were tested by analysis of variance with two factors (year and type of pruning) using the SISVAR software (analysis of variance for balanced data) given by the Department of Exact Sciences, Federal University of Lavras (Ferreira 2011). Mean values of the treatments were compared by Scott-Knott test at 5% significance level.

RESULTS AND DISCUSSION

The type of pruning had no effect on the number of clusters for both growing seasons (Table 1). The dry matter, evaluated only in 2015, was higher in vines subjected to Royat pruning. No variation was observed in the number of branches because the number of dormant buds left by two pruning systems was similar, around 16 to 18 buds per plant. However, the increase in vigor of branches provided by Royat pruning may be associated with greater accumulation of reserves in the previous year in permanent structures of vines such as cordon, trunk and root. Although roots are the major structures storing starch, the cordon, trunk and branches of vines can also accumulate this reserve carbohydrate (Bates et al. 2002; Zapata et al. 2004). Probably, carbohydrates accumulated in cordon kept in the Royat pruning may have contributed to the high vigor of the branches, while in the Guyot pruning the cordons are renewed every year, reducing the accumulation of reserves.

In addition, the type of pruning also influenced bud fertility and some of the production components (Table 2). Although bud fertility did not present significant differences in the first production cycle between the two treatments, in 2015, the bud fertility was higher in vines trained in bilateral cordons. Nevertheless, in both growing seasons, Royat pruning induced a greater number of clusters than Guyot pruning. Even though the number of branches did not vary between treatments in both years and bud fertility was the same in both treatments only in the first year, the highest variability of data sampled to determine bud fertility may have contributed to detect these differences.

The higher fertility of buds under Royat pruning management may be related to a fertility gradient along →

Table 1. Number and dry weight of pruned branches of the Chardonnay variety subjected to two pruning systems in the growing seasons of 2014 and 2015 in Divinolândia, São Paulo State.

Production cycle	Pruning system	
	Cordon Royat	Double Guyot
	Number of branches	
2014	15 ± 0,52* aB**	13 ± 0,84 aB
2015	19 ± 0,81 aA	19 ± 0,81 aA
	Dry weight of branches (g)	
2015	185,00 ± 0,01 a	147,25 ± 0,01 b

*Standard error; **means followed by different lowercase letters in the same row and different uppercase letters in the same column are significantly different by Scott-Knott test at 5% significance level.

the branches (higher at the base and lower at the ends) and/or the reduction in the accumulation of reserves, due to removal of permanent cordons of the vine by Guyot pruning, as discussed above. Several authors have demonstrated an impaired floral differentiation of latent buds caused by the reduction of reserves accumulated in the permanent structures of the vine in the preceding year (Vasconcelos et al. 2009).

The average production per plant and estimated yield per hectare were higher in vines under Royat pruning, mainly due to the larger number of clusters, since there was no effect of the type of pruning on the cluster weight and the number of berries per cluster (Table 2). An increase in the weight of berries of vines subjected to Royat pruning was verified only in 2014. The increasing number of clusters by Royat pruning promoted an increase of 30% in the vineyard yield.

There was no effect of treatments on soluble solids content and pH of berries at harvest in both growing seasons (Table 3). In 2014, there was an increase in the acidity of berries of vines subjected to Royat pruning (Table 3). However, the ranges of values registered in both treatments and in both cycles are within the range normally found for Brazilian conditions, such as the Serra Gaúcha (Rizzon et al. 2009) and the southern region of Minas Gerais State (Regina et al. 2010). The content of soluble solids observed in both production cycles, for both types of pruning, ranged between 19.5 and 21.1 °Brix and are close to the values recorded for this variety in the southern region of Minas Gerais State (19.7 °Brix) by Regina et al. (2010) and in Australia (16.2 – 21.6 °Brix) by Zoecklein (2002). Furthermore, all variables were within the ranges which determine grape quality for production of sparkling wines (Basile et al. 2012). Considering our findings, Cordon Royat pruning proved to be more advantageous than Guyot pruning for the vegetative and reproductive development of Chardonnay vine grown in southeastern Brazil for production of sparkling wine.

Table 2. Bud fruitfulness, number of clusters per plant, cluster weight, number of berries, berry weight, average production and estimated productivity of the Chardonnay variety under two pruning systems in the production cycles of 2014 and 2015 in Divinolândia, São Paulo State.

Production cycle	Pruning system	
	Cordon Royat	Double Guyot
	Bud fertility	
2014	1,40 ± 0,10* aA**	1,26 ± 0,09 aA
2015	1,52 ± 0,07 aA	1,27 ± 0,07 bA
	Number of clusters	
2014	22 ± 1,57 aA	18 ± 1,12 bA
2015	22 ± 1,37 aA	17 ± 1,47 bA
	Cluster weight (g)	
2014	100,74 ± 6,25 aA	98,20 ± 7,16 aA
2015	117,80 ± 7,47 aA	102,53 ± 4,79aA
	Number of berries·cluster^{-1}	
2014	87 ± 3,05 aA	85 ± 2,65 aA
2015	71 ± 2,44 aB	69 ± 2,74 aB
	Berry weight (g)	
2014	1,37 ± 0,03 aB	1,26 ± 0,03 bB
2015	1,56 ± 0,02 aA	1,49 ± 0,04 aA
	Average production (kg·plant^{-1})	
2014	2,19 ± 0,24 aA	1,73 ± 0,18 aA
2015	2,53 ± 0,16 aA	1,76 ± 0,14 bA
	Estimated productivity (t·ha^{-1})	
2014	8,77 ± 0,94 aA	6,93 ± 0,74 aA
2015	10,14 ± 0,64 aA	7,10 ± 0,57 bA

*Standard error; **means followed by different lowercase letters in the same row and different uppercase letters in the same column are significantly different by Scott-Knott test at 5% significance level.

Table 3. Total soluble solids, pH and titratable acidity of Chardonnay berries subjected to two pruning systems in the production cycles of 2014 and 2015 in Divinolândia, São Paulo State.

Production cycle	Pruning system	
	Cordon Royat	Double Guyot
	Total soluble solids (°Brix)	
2014	19,46 ± 0,35*aB**	20,02 ± 0,13 aB
2015	20,72 ± 0,10 aA	21,06 ± 0,13 aA
	pH	
2014	3,19 ± 0,01 aB	3,21 ± 0,01 aB
2015	3,34 ± 0,01 aA	3,33 ± 0,02 aA
	A Total titratable acidity ($g \cdot L^{-1}$)	
2014	9,40 ± 0,18 aA	8,75 ± 0,11 bA
2015	7,80 ± 0,23 aB	8,14 ± 0,16 aB

*Standard error; **means followed by different lowercase letters in the same row and different uppercase letters in the same column are significantly different by Scott-Knott test at 5% significance level.

CONCLUSION

The appropriate pruning management, combined with the genetic characteristics of the variety and its interaction with the environment, provides greater profitability to the vineyard. Cordon Royat pruning increases the vegetative vigor and productivity in the Chardonnay variety when compared to Guyot pruning, without adversely affecting the quality of grapes at high altitudes in southeastern Brazil.

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