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EFFECT OF MECHANICAL HEDGE PRUNING ON GROWTH, YIELD AND QUALITY OF CABERNET SAUVIGNON GRAPEVINES

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Abstract

The effect of mechanical hedging was studied over three growing seasons in a trial set up at a commercial vineyard, located at Cartaxo viticultural region (39° 10' N; 8° 45' W) with the variety 'Cabernet Sauvignon'. Compared with the conventional spur hand pruning (control), the hedged vines had a three times higher crop load in the first season and five fold in the following two seasons. Those high cropping levels induced a reduction in the budburst and in shoot and leaf size. However, as a consequence of a higher shoot number, the total leaf area per vine was similar to the control. During the ripening period the hedged vines showed a more negative predawn leaf water potential, but it did not affected significantly the photosynthetic rate, measured at midday on adult exposed leaves. Compared with the control shoot fruitfulness was smaller in the hedged vines but bunch number and yield per vine were significantly higher. With the exception of the total wine phenols in 1985, which was higher in the control, the must and wine quality where not significantly affected. Due to a significant reduction on shoot weight the hedged vines showed a smaller pruning weight in the first two seasons but in the third one, the values were similar to the control.

According to those three season results the mechanical hedging seems to represent a technique which can be used in this ecological situation on cordon trained vines without strong negative effects on wine quality and vine longevity. However the significant reduction recorded in the wine total phenols recommend long term trials to confirm those preliminary results.

1. Introduction

After harvesting, traditional manual winter pruning is the most expensive and labour consuming cultural operation carried out in the vineyard. Over the last two decades it was made a great research effort on winter pruning mechanisation. In Australia, where an important part of that research was made, the experimental results showed that the mechanical pruning could be done without affecting the wine quality and vine longevity (Freeman, 1983; Clingeleffer, 1988; Possingham, 1994). Actually, about 70 % of the Australian vineyards receive some form of machine pruning (Possingham, 1996).

As an easy mechanised pruning method the hedging was tried in different countries. Generally, in situations with high growth potential (hot and irrigated areas) the vine self-regulation does not affect the wine quality and plant capacity (Tassie & Freeman, 1992). However, in limiting growth situations, with natural environmental stresses, the mechanical hedging, without any hand finishing, tends to depreciate berry maturity and reduced the storage in the shoots and perennial vine structure (Carbonneau & Zhang, 1988; Eynard, 1988).

In Portugal the application of the pruning machines is restricted to the pre-pruning operation which is combined with conventional hand finishing. With the aim of studying the vine responses to the hedge pruning in our ecological conditions a trial was set up on a

commercial non irrigated vineyard, planted on a deep fertile alluvion soil. The results of three growing seasons of hedge pruning in comparison with conventionally hand spur pruned are presented.

2. Materials and methods

The research was carried out on a commercial vineyard located at Cartaxo region which have a Mediterranean climate. The thirteen-year-old 'Cabernet Sauvignon' vines, grafted on SO4, were spaced 2.8 m between and 1.3 m along rows and trained to a bilateral Royat cordon 0.6 m height on a vertical trellis.

The statistical design is a randomised complete block with three replications of three treatments: hand pruning (HP), pre-pruning with hand correction (PP) and mechanical hedge pruning (MH). As the pre-pruning treatment was utilised just for hand finishing time record only the comparison between the mechanical hedging and the control hand pruned is presented and discussed. In each plot, each treatment was applied to a row of 50 vines from which 3 groups of 5 contiguous plants were selected for data collection. On the first season the mechanical hedging was done with a Pellenc® pre-pruning machine which produced a rectangular hedge of about 35 cm large and 20 cm height. To allow the record of the pruning weight, in the following seasons the 15 selected vines per row were previously submitted to a simulated mechanical hedging.

In 1994 and 1995 seasons, leaf water potential (Ψ_l) and photosynthesis measurements were made periodically on adult well exposed leaves, with a pressure chamber and an IRGA (LCA-4, ADC) respectively.

For leaf area measurements a complete defoliation of three vines of average size per treatment was made at harvest. The leaves were separated in main and laterals, counted and measured with a leaf area meter.

For fruit composition a sample of 200 berries from each replication was collected at harvest. In the last harvest (1995) 30-40 kg of fruit per replication were used for winemaking. The must and wine analysis were made accordingly to the O.I.V. methods (O.I.V., 1990). The wines were submitted to a sensory panel.

At winter pruning the shoot number and pruning weight were recorded. During the growing season all the vines were subjected to the same standard commercial practices.

3. Results and discussion

3.1. Leaf activity

In both treatments the predawn leaf water potential (Ψ_{pd}) showed a decreasing pattern from the end of July, in 1994, and from mid June, in 1995, to the harvest date (Fig. 1). In both seasons, the mechanical hedge pruning (MH) presented a lower Ψ_{pd} around veraison but both treatments showed similar values at harvest. This more negative Ψ_{pd} indicates a higher soil water depletion on the root zone of the MH vines which can be explained by a probable higher water loss from the larger leaf canopy formed in spring as a consequence of a greater number of developed shoots per vine (Downton & Grant, 1992; Possingham, 1994).

Figure 1. Seasonal pattern of predawn leaf water potential (Ψ_{pd}) measured in 1994 and 1995. Average $\pm$ standard error of 6 adult exposed leaves. HP- hand pruning; MH - mechanical hedge pruning. 'Cabernet Sauvignon', Cartaxo, Portugal.

The seasonal pattern of the adult exposed leaves photosynthetic rates, measured at midday in 1994, showed a decrease from the beginning of July (1 month before veraison) to harvest time (Fig. 2). Both treatments showed a similar trend and no significant differences on the photosynthetic rates were detected. These data agrees with those presented by Novello & Bovio, (1988) and Ollat *et al.*, (1993). The slightly differences recorded in the Ψ_{pd} were not sufficient to significantly influence the photosynthetic rates.

Figure 2. Seasonal pattern of net assimilation rate (A) in 1994 growing season. Average $\pm$ standard error of 6 adult exposed leaves. HP- hand pruning; MH - mechanical hedge pruning. 'Cabernet Sauvignon', Cartaxo, Portugal.

3.2. Agronomic results

In 1994, as a consequence of unfavourable climate conditions at fruit set, the yield was very low. In 1995, the growing season was very hot and dry, the phenology was anticipated of about three weeks and, at harvest, the berries showed a high sugar content and a low titratable acidity (Table 1).

Compared with hand pruned (HP), the number of buds retained in the MH was three fold higher in the first season and five fold in the following two seasons. Those high cropping levels induced a significant decrease in the budburst and shoot fruitfulness and a slight, but not significant, reduction in the bunch weight. However, these reductions were not sufficient to compensate the bud number differences and, consequently, the MH presented a significantly higher bunch number and yield per vine. These results are similar to those obtained by several authors (Freeman, 1983; Carboneau & Zhang, 1988; Intrieri *et al.*, 1988; Lavee, 1988; Studer & Kliewer, 1988) and show the self-regulation mechanism of the vines when submitted to a high crop load.

Over the three seasons, at harvest both treatments presented a must with similar levels of sugar and titratable acidity. The skin anthocyanins content was also similar but the total phenols presented a significantly higher value on the control berries in 1995 (Table 1). The analysis of the 1995 wines showed that the MH did not modify the general chemical and sensorial characteristics, except the total phenols and taste intensity, which have been significantly higher on the control (Table 2). These results showed that the self-regulation mechanism had neither affected the ripening period duration nor the sugar accumulation. The small total phenols content of the MH wines could be an explanation for the significant differences detected on the wine taste intensity.

Compared to the control, the MH induced a significant reduction on leaf size, shoot weight and in the proportion of lateral leaf area. However, the great shoot number allowed the MH vines to reach a total leaf area statistically similar to the control (Table 3).

In the first two seasons the MH presented a significantly lower pruning weight but in the third one the values were similar to the control. The increasing pattern showed by the pruning weight over the 3 seasons in the MH vines pointed out a growth recovering after the decrease in the first season.

The MH vines exhibited a yield/pruning weight ratio higher than the control but the values were still lower to be considered as overcropping (Bravdo *et al.*, 1985; Smart & Robinson, 1992). When compared to the control, the lower leaf to fruit ratio presented by the MH vines, combined with the double yield with the same berry sugar content, indicates a higher fruiting efficiency.

4. Conclusions

When compared to the hand pruning, the mechanical hedging allows a higher crop load that promotes the vine self-regulating mechanism which influences the balance between shoot and fruit growth. In this ecological situation the overcharged vines reacted by decreasing the budburst, the shoot fruitfulness and the size of each individual organ. However, this self-regulating mechanism was not sufficient to compensate the differences in the bud number and, consequently, the MH presented a significantly higher bunch number and yield per vine.

According to these three season results the mechanical hedging seems to represent a technique that can be used in these ecological situation on cordon trained vines without strong negative effects on wine quality and vine longevity. However the significant reduction recorded in the wine total phenols recommend long term trials to confirm those preliminary results.

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Table 1. Influence of mechanical hedge pruning on the yield and fruit composition of 'Cabernet Sauvignon' grapes. HP- hand spur pruning; MH - mechanical hedge pruning. Cartaxo, Portugal, 1993-1995.

	1993			1994			1995			AVERAGE (1993-95)	
	HP	MH	HP	MH	HP	MH	HP	MH	MH	MH (% HP)	
<u>YIELD COMPONENTS</u>											
Crop load (nodes/vine)	16.6 b	47.3 a	18.2 b	94.8 a	14.7 b	80.1 a				450	
Budburst (%)	87.4 a	65.7 a	87.3 a	66.6 b	90.6 a	64.2 b				74	
Bunch number/shoot	1.3 a	1.3 a	1.4 a	0.8 b	2.1 a	0.9 b				67	
Bunch number/vine	31.8 b	58.3 a	21.8 b	47.6 a	33.2 b	75.1 a				209	
Bunch weight (g/bunch)	87.1 a	74.3 a	43.8 a	43.7 a	88.5 a	72.0 a				89	
Yield (kg/vine)	2.7 b	4.5 a	0.9 b	2.1 a	3.0 b	5.3 a				190	
Yield (t/ha)	7.4 b	12.4 a	2.5 b	5.8 a	8.2 b	14.6 a				190	
<u>FRUIT COMPOSITION</u>											
Sugar (g/l)	187 a	191 a	177.5 a	189.7 a	233.4 a	227.9 a				104	
Tit. acidity (g ac. tart./l)	5.4 a	4.7 a	6.0 a	5.3 a	4.8 a	4.4 a				89	
pH	3.60 a	3.60 a	3.40 b	3.57 a	3.41 a	3.47 a				102	
Total anthocyanins (mg/l)	924 a	966 a	611 a	759 a	1114 a	945 a				105	
Total phenols (IFC) ⁽¹⁾	17.7 a	17.6 a	12.9 a	14.8 a	39.0 a	31.7 b				98	

In each line and for each year means followed by the same letter do not significantly differ at 5% level. (1) Folin-Ciocalteu index.

Table 2. Influence of mechanical hedge pruning on wine quality. HP- hand spur pruning; MH - mechanical hedge pruning. Means of 3 replications. 'Cabernet Sauvignon', Cartaxo, Portugal.

	HP	MH	Significance
<u>CHEMICAL ANALYSIS</u>			
Alcohol content (%v/v)	13.2	13.6	n.s.
Titrateable acidity (g ac. tart./l)	7.7	7.8	n.s.
pH	3.41	3.41	n.s.
Colour intensity	13.8	14.3	n.s.
Total phenols (IFC) ⁽¹⁾	36.0	32.3	*
Total anthocyanins (mg/l)	624	657	n.s.
<u>SENSORY ANALYSIS</u> ⁽²⁾			
Colour: Intensity	7.0	7.2	n.s.
Nuance	2.8	3.3	n.s.
Aroma: Intensity	5.9	6.1	n.s.
Quality	5.1	5.1	n.s.
Balance	5.2	5.3	n.s.
Taste: Intensity	6.6	5.9	*
Quality	5.1	4.6	n.s.
Body	5.3	4.8	n.s.
Balance	5.4	4.8	n.s.
Finish Taste	5.6	5.0	n.s.
Global balance	5.1	5.2	n.s.

(1) Folin-Ciocalteu index. (2)- Sensory analysis made by a sensory panel of 5 tasters using an unstructured scale from 0 to 10.

* - significant at 5% level.

Table 3. Influence of mechanical hedge pruning on vegetative growth of 'Cabernet Sauvignon' grapevines. HP- hand spur pruning; MH - mechanical hedge pruning. Cartaxo, Portugal, 1993-1995.

	1993			1994			1995			AVERAGE (1993-95)	
	HP	MH		HP	MH		HP	MH		MH (% HP)	
Total leaf area (m ² /vine)				5.9 a	5.4 a		6.5 a	8.2 a		109	
Lateral leaf area (%)	-	-		46.2 a	20.1 b		44.3 a	17.4 b		41.4	
Main leaf area (cm ² /leaf)	-	-		81.8 a	54.5 b		85.1 a	66.6 b		72	
Lateral leaf area (cm ² /leaf)	-	-		34.9 a	23.0 b		34.9 a	27.0 a		72	
Shoot number/vine	28.1 a	31.3 a		24.9 b	45.7 a		26.8 b	60.2 a		173	
Shoot weight (g/ shoot)	27.8 a	15.0 b		51.5 a	18.0 b		35.1 a	14.5 b		43	
Pruning weight (kg/vine)	0.8 a	0.5 b		1.2 a	0.8 b		0.9 a	0.9 a		73	
Yield/pruning weight	3.4	9.6		0.8	2.6		3.3	6.2		265	
leaf area/yield (cm ² /g)	-	-		63.4	25.7		21.7	15.5		60	

In each line and for each year, means followed by the same letter do not significantly differ at the 5% level.