THE EFFECTS OF THINNING AND GIRDLING ON LEAF WATER POTENTIAL, GROWTH AND FRUIT COMPOSITION OF RUBY SEEDLESS GRAPEVINES

EFFETS DE L'ECLAIRCISSAGE ET DE L'INCISION ANNULAIRE SUR LE POTENTIEL HYDRIQUE FOLIAIRE, LA CROISSANCE ET LA COMPOSITION DES RAISINS DES VIGNES RUBY SEEDLESS

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Summary: A study was conducted to determine the effects of thinning and girdling at fruitset on growth, yield and fruit composition of *Vitis vinifera* L. cv. Ruby Seedless grapevines. Leaf water potential of girdled vines was higher than that of the control vines. Thinning resulted in an increase in shoot length and pruning weight. Berry weight was increased by 7 p. cent and 14 p. cent for the girdling and thinning treatments, respectively. The greatest berry weight (28 p. cent) occurred with a combinations of both treatments. Girdling significantly decreased titratable acidity and enhanced fruit coloration. Yield per vine was significantly decreased by severe thinning treatments. This study demonstrated that moderate thinning and girdling at fruitset could improve Ruby Seedless berry weight and composition without a severe decrease in yield per vine.

Résumé : Une étude a été menée pour déterminer les effets de la charge et de l'incision annulaire sur le potentiel hydrique foliaire, la croissance et la composition des raisins des vignes *Vitis vinifera* L. (cépage Ruby Seedless). Les niveaux de charge ont été fixés par la suppression des baies ou des grappes combinée avec la pratique de l'incision annulaire au moment de la nouaison. L'éclaircissage a entraîné une augmentation de la longueur des rameaux et du poids du bois de taille. L'évolution du potentiel hydrique journalier (mesuré 14 et 30 jours après le traitement) et saisonnier (de la mi-journée) des souches incisées était moins négative que celle des souches témoins. L'éclaircissage a avancé la croissance des baies et l'accumulation des sucres, tandis que l'incision annulaire a amélioré la croissance des baies. Le poids des baies a été augmenté par 7 et 14 p. cent, respectivement par l'incision annulaire et l'éclaircissage. La croissance des baies la plus importante (de l'ordre de 28 p. cent) a résulté de la combinaison des deux traitements. La concentration en sucres des baies a été améliorée par l'éclaircissage mais diminuée par l'incision annulaire. Cette dernière opération a diminué significativement l'acidité et a amélioré la coloration des raisins. La production des vignes en raisins a diminué significativement par les traitements d'éclaircissage sévère. On n'a pas observé d'interaction significative entre les traitements pour tous les paramètres mesurés. Cette étude a montré que l'éclaircissage modéré combiné à l'incision annulaire pratiquée à la nouaison pourrait améliorer le poids et la composition des baies du cépage Ruby Seedless sans diminuer sévèrement la production des souches.

Key words: grapevine, crop load, thinning, girdling, leaf water potential

Mots clés : vigne, charge, éclaircissage, incision annulaire, potentiel hydrique foliaire

INTRODUCTION

Thinning is used as a tool for improving the quality of table grapes. It improves the nutrition of both the vine and the fruit allowing a better balance between vine capacity and crop level (WILLIAMS and MATTHEWS, 1990). Crop level can be adjusted by cluster and berry thinning. When performed before bloom, both practices were found to increase the number of berries per cluster (BRAVDO *et al.*, 1984; CHRISTODOULOU *et al.*, 1967). When performed at berry shatter, they were found to increase berry weight and soluble solids concentration (CHRISTODOULOU *et al.*, 1967). In another study, cluster thinning after berry shatter increased size, while berry thinning one month later increased color and soluble solids (WEAVER, 1952).

Girdling is also a tool to increase berry size of seedless cultivars. Girdling during the period of berry cell division has been shown to increase berry size of seedless grapes (GRIMES and WILLIAMS, 1990; SACHS

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and WEAVER,1968; WEAVER and MCCUNE, 1959). An increase in berry weight of approximately 0.8 g has been reported for both Thompson Seedless and Ruby Seedless (HARELL and WILLIAMS, 1987).

The objectives of this study were to determine the best technique to adjust crop level (cluster or berry thinning) in combination with girdling in order to improve fruit quality of Ruby Seedless grapevines grown in Morocco.

MATERALS AND METHODS

Six year-old L., cv. Ruby Seedless grapevines, grown in a commercial vineyard located near Meknes, one of the major grape production areas in Morocco, were used in this study. The vineyard soil texture was 45 p. cent silt, 38 p. cent sand, and 17 p. cent clay, with a slight slope, and was furrow irrigated at 2 to 3 weeks intervals. Vines were planted to North-South rows, on 140 Ruggeri rootstock. Vine and row spacing were 1.5 and 3.0 m, respectively. The vines were head-trained at 0.7 m and pruned to four canes of 10 to 12 buds each. The trellis system in this vineyard was a triple T. The lowest crossarm was 0.4 m wide, and located 0.8 m above the soil. The middle and the upper crossarms were 0.8 m wide, and located 0.4 and 0.8 m above the first one, respectively. Wires were placed at each end of all crossarms. The fruit-bearing canes were tied to the wires on the lowest crossarm.

Thinning treatments were applied to obtain a given crop level per vine by either berry or cluster reduction. The treatments were control vines (C), moderately thinned (M.T.) with either 25 p. cent of the berries removed per cluster or 25 p. cent of the clusters per vine removed and severely thinned (ST) by either removing 50 p. cent of the berries per cluster or 50 p. cent of the clusters per vine. These treatments were combined with girdling after the normal drop of weak flowers when berry diameter was 3-5 mm. The 10 treatments were replicated four times in a randomized complete block design. Each treatment was applied to four vines per plot. The study was conducted in 1990 and 1991.

Shoot length was measured one time per two weeks during the growing season and pruning weights were determined during vine dormancy. Berry growth and maturation were determined by collecting 100 berries per plot, chosen at random from different parts of the clusters. Berry weight and soluble solids concentration (determined by a hand refractometer, American Optical, Model 10430) were measured. Seasonal midday leaf water potential (YL) was measured for the control and girdled vines three times during the season, as described by GRIMES and WILLIAMS (1990). The diurnal pattern of YL also was measured for control and girdled vines, 14 days after the vines were girdled. The YL was measured with a pressure chamber (PMS Instrument Co., Corvallis, OR) on 8 to 12 of the youngest, fully expanded leaves on sun-exposed shoots per treatment. To avoid evaporative loss, leaves were enclosed in a plastic bag after cutting the petiole and left covered throughout pressurization.

Crop yield per vine was recorded and 100 berries per replicate were randomly collected, then analyzed for berry weight, soluble solids concentration, titratable acidity (determined by titration with 0.133N NaOH using phenolphthalein as indicator), pH with Volmatic pH-meter (model PM-14), and fruit pigmentation according to KLIEWER and WEAVER (1971) on 7 mm diameter discs of berry skin taken from the apical region of 20 berries from each sample. Least significant difference (LSD) was used to compare means.

RESULTS

The increase in shoot length, measured 15 and 30 days after treatments were applied was noticeably influenced by crop level. The average amount of shoot growth recorded 15 days after treatment, was increased by 23 p. cent and 15 p. cent for the moderate and severe thinning treatments, respectively, compared to control (data not given).

Midday YL of the control vines was less than that of the girdled vines, with a difference of - 0.08 MPa and - 0.03 MPa, measured 14 and 30 days, respectively, after treatments were applied (figure 1). Forty-

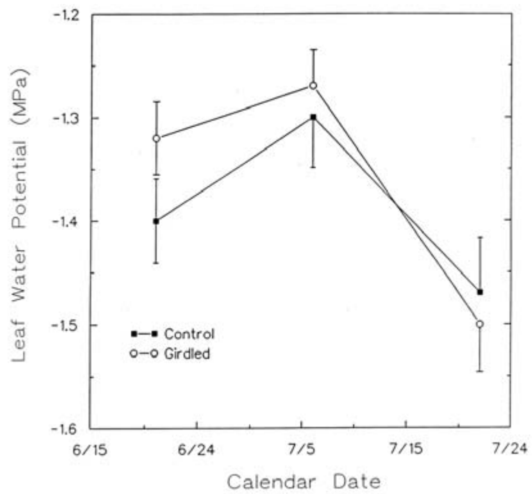

Fig. 1 - Midday leaf water potential of girdled and control Ruby Seedless grapevines measured three times during the growing season.

Bars represent + one standard error.

Potentiel hydrique foliaire des vignes du cépage Ruby Seedless incisées et témoins, mesuré trois fois pendant la période végétative.

five days after the study began YL of the girdled vines was lower than that of the control vines. The diurnal pattern of YL, measured 14 days after treatment demonstrated that YL of the control vines were always lower than that of the girdled vines throughout the day (figure 2).

Fruit growth and ripening measured over two years were consistently influenced by the thinning treatments (figures 3 A and B). Moderate and severe thinning accelerated berry growth and to a lesser degree the accumulation of soluble solids. The relative effects of these treatments on berry weight were established prior to the first sampling date (before « véraison »), and differences increased throughout the remainder of the season. The influence of thinning on the accumulation of soluble solids was evident by the third sampling date (4 weeks after « véraison »), and maintained thereafter.

Moderate and severe thinning had similar effects on soluble solids accumulation. This was not the case for berry growth as severe thinning resulted in greater berry growth between the second and the fourth sampling dates. Fruit growth of the severely thinned vines, however, increased only slightly between the fourth and fifth sampling dates.

Girdling also affected berry growth and the accumulation of soluble solids (figures 4 A and B). The influence of girdling on berry weight was established before the first sampling date (véraison). The combination of girdling and thinning resulted in the greatest berry size, although the effect on the accumulation of soluble solids was less pronounced. Berry weight was 5 p. cent and 11 p. cent greater on the first sampling date for girdled and girdled + thinned vines, respectively, compared to the controls.

All treatments resulted in an increase in berry weight relative to the control at harvest (table I). Crop weight of Ruby Seedless vines at harvest was lowest for the severely thinned cluster or berry treatments (table II). Girdling did not significantly affect crop weight per vine. There were also no significant interactions between thinning and girdling treatments. Significant

TABLE I

The average effect over two years (1990-1991) of girdling and thinning at fruitset on Ruby Seedless berry weight (g), determined on September 1 and 11 of 1990 and 1991, respectively.

Tableau I - Effet moyen pour les deux années (1990-1991) de l'incision annulaire et de l'éclaircissage appliqués à la nouaison sur le poids unitaire des baies (g) du cépage Ruby Seedless, déterminé le 1er et le 11 septembre, respectivement pour les années 1990 et 1991.

	Thinning					
		Berry		Cluster		Average effect of gird-
Girdle	None	Moderate	Severe	Moderate	Severe	
No	2.11	2.35	2.37	2.62	2.51	2.39
Yes	2.38	2.69	2.67	2.55	2.51	2.55
Average effect of thinning	2.23	2.52	2.52	2.59	2.51	
$LSD_{0.05}$	Thinning = 0.17		Girdleing = 0,11		Interaction = ns^z	

^{z}LSD was not significant at the 5 p. cent level

TABLE II

The average effect over two years (1990-1991) of girdling and thinning at fruitset on yield (kg/vine) of Ruby Seedless grapevines, determined on September 1 and 11 of 1990 and 1991, respectively.

Tableau II - Effet moyen pour les deux années (1990-1991) de l'incision annulaire et de l'éclaircissage appliqués à la nouaison sur la production (kg/souche) du cépage Ruby Seedless, déterminée le le 1er et le 11 septembre, respectivement pour les années 1990 et 1991.

	Thinning					
		Berry		Cluster		Average effect of gird-
Girdle	None	Moderate	Severe	Moderate	Severe	
No	7.91	6.70	4.93	7.17	5.47	6.43
Yes	7.16	6.80	6.18	5.85	5.28	6.25
Average effect of thinning	7.54	6.75	5.56	6.51	5.37	
$LSD_{0.05}$	Thinning = 1.24		Girdle = ns^z		Interaction = ns^z	

^{z}LSD was not significant at the 5 p. cent level

TABLE III
The average effect over two years (1990-1991) of girdling and thinning at fruitset on soluble solids concentration (°Brix) of Ruby Seedless berries, determined on September 11 and 1 of 1990 and 1991, respectively.

Tableau III - Effet moyen pour les deux années (1990-1991) de l'incision annulaire et de l'éclaircissage appliqués à la nouaison sur l'indice réfractométrique (°Brix) des raisins du cépage Ruby Seedless, déterminé le 11 et le 1er Septembre, respectivement pour les années 1990 et 1991.

	Thinning					
		Berry		Cluster		Average
Girdle	None	Moderate	Severe	Moderate	Severe	effect of gird-
No	16.2	16.4	16.5	16.7	17.1	16.6
Yes	15.8	16.2	16.0	16.7	16.0	16.1
Average effect of thinning	16.0	16.3	16.3	16.7	16.5	
$LSD_{0.05}$	Thinning = 0.39		Girdle = 0.25		Interaction = ns^{z}	

^{Z}LSD was not significant at the 5 p. cent level

TABLE IV
The average effect over two years (1990-1991) of girdling and thinning at fruitset on fruit coloration (absorbance at 520 nm) of Ruby Seedless vines, determined on September 11 and 1 of 1990 and 1991, respectively.

Tableau IV - Effet moyen pour les deux années (1990-1991) de l'incision annulaire et de l'éclaircissage appliqués à la nouaison sur la pigmentation (absorbance à 520 nm) des raisins du cépage Ruby Seedless, déterminée le 11 et le 1er Septembre, respectivement pour les années 1990 et 1991.

	Thinning					
		Berry		Cluster		Average
Girdle	None	Moderate	Severe	Moderate	Severe	effect of gird-
No	0.429	0.373	0.396	0.447	0.405	0.410
Yes	0.623	0.497	0.427	0.616	0.466	0.526
Average effect of thinning	0.526	0.435	0.411	0.532	0.436	
$LSD_{0.05}$	Thinning = ns^{z}		Girdle = 0.072		Interaction = ns^{z}	

^{Z}LSD was not significant at the 5 p. cent level

increases in berry weight as a result of thinning and girdling averaged 14 p. cent and 7 p. cent, respectively. There was no clear berry response with respect to level (moderate or severe) or type (berry or cluster) of thinning. There were also no significant interaction between girdling and the thinning treatments with regard to berry weight.

Soluble solids concentration in the fruit at harvest was significantly increased by cluster thinning, but decreased by girdling, corresponding to an average of + 0.7 and - 0.5 °Brix, respectively (table III). The highest levels of soluble solids concentration were measured for the severe cluster thinning treatment. Soluble solids concentration in fruit of berry-thinned vines were not significantly different from the controls. There was no significant interaction between girdling and thinning regarding soluble solids concentration. Girdling significantly decreased titratable acidity by an average of 0.02 g/mL, while thinning resulted in a slight, but non-significant effect (data not given). No significant response regarding fruit pH was obtained from thinning and girdling treatments (data not given). Fruit coloration was significantly enhanced by girdling with an average absorbance increase of 28 p. cent (table IV). While all girdling treatments induced better fruit coloration, the thinning treatments had no significant effect on berry color.

DISCUSSION

The increase in berry size of seedless cultivars due to girdling has been attributed to changes in carbohydrate allocation within the vine (SACHS and WEAVER, 1968; WEAVER and MCCUNE, 1959). Girdling restricts the movement of photosynthate to the roots resulting in greater amounts of carbohydrates in the vine's organs above the girdle (ROPER and WILLIAMS, 1988; SACHS and WEAVER, 1968) and therefore a more favorable carbohydrate status for berry growth. This happens despite net CO2 assimilation rate decreases in girdled vines (SACHS and WEAVER, 1968; WILLIAMS *et al.*, 1994). In this study girdled vines had higher YLs than the controls up to 30 days after the treatment was applied. This was probably due to the fact that stomatal conductance also decreased due to trunk girdling (SACHS and WEAVER, 1968; WILLIAMS *et al.*, 1994). As one would expect water uptake of grapevines also decreases during the period the girdle remains open (WILLIAMS and MATTHEWS, 1990). The YL data from this study and that of WILLIAMS *et al.* (1994) indicate that girdled vines have a more favorable vine water status than the non-girdled vines. Therefore this factor may also be responsible for the increase in berry size together with girdling.

Crop weight was significantly reduced by thinning as there was a negative relationship between thinning level and crop reduction. The average crop reduction was 12 p. cent and 28 p. cent for the moderate and severe thinning treatments, respectively. This decrease in crop weight was accompanied by better fruit nutrition, reflected by an increase in berry weight and soluble solids concentration. The improved fruit nutrition observed after thinning may be related to an increase in the leaf/fruit ratio as has been observed in other studies (JACKSON, 1986; KLIEWER and ANTCLIFF, 1970). The two levels of thinning resulted in similar decreases in yield, indicating the absence of a correlation between crop load and berry weight. A similar result was observed for Cabernet Sauvignon as cluster thinning decreased yield by 17 p. cent and 49 p. cent, but a corresponding increase in berry weight was only 17 p. cent and 20 p. cent for the moderate and severe thinning treatments, respectively (BRAVDO *et al.*, 1984). The limited effect of severe thinning on berry weight could be attributed to the limited vegetative growth observed with this treatment or to the existence of thinning level after which there is no further increase in berry weight.

Girdling significantly increased the average berry weight, (approximately 7 p. cent) but this was less than the average increase in berry weight obtained by the thinning treatment (approximately 14 p. cent). In two other studies, trunk-girdled Ruby Seedless vines at fruitset resulted in an increase in berry weight of 10 p. cent and 19 p. cent in Morocco (EZZAHOUANI *et al.*,1985), and California (HARRELL and WILLIAMS, 1987), respectively. Vines in the Californian study were girdled when berry diameter was 5.7 mm, but in this experiment berry diameter ranged from 3 mm to 5 mm. The smaller increase in berry size found in this study may be due to the fact that girdling took place prior to the berry growth stage for maximum response. It was found that berry weight of Thompson Seedless is greatest if girdling is done as early as possible after the normal drop of impotent flowers, however, girdling during the drop will increase the number of berries that

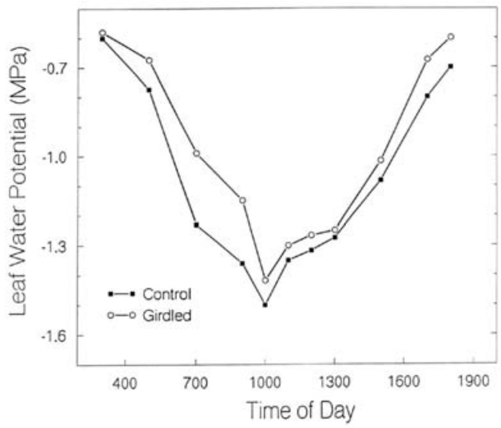

Fig. 2 - The diurnal time-course of leaf water potential of Ruby Seedless grapevines, 14 days after vines were girdled.

Potentiel hydrique foliaire journalier des vignes du cépage Ruby Seedless, mesuré 14 jours après l'application de l'incision annulaire.

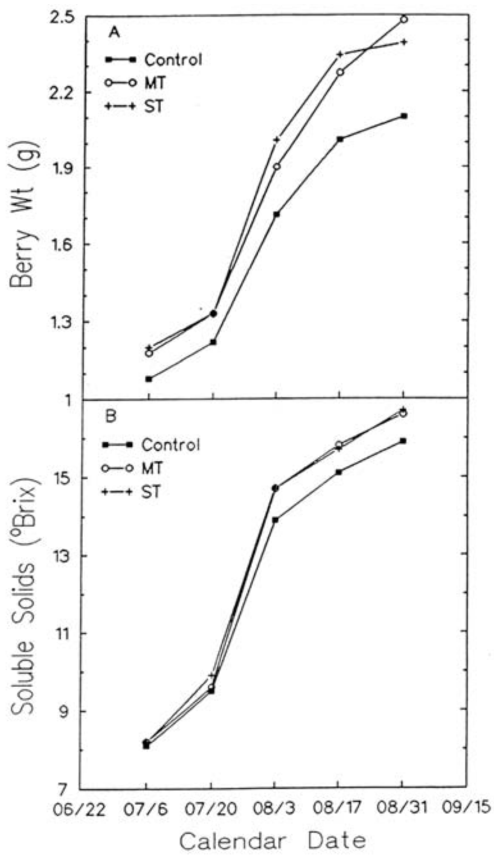

Fig. 3 - The average effect over two years (1990-1991) of thinning at fruitset on the accumulation of berry weight (A), and soluble solids (B) in Ruby Seedless grapes.

Effet moyen, pour les deux années (1990-1991), de l'éclaircissage pratiqué à la nouaison sur l'accroissement du poids (A)et des sucres (B) dans les raisins du cépage Ruby Seedless.

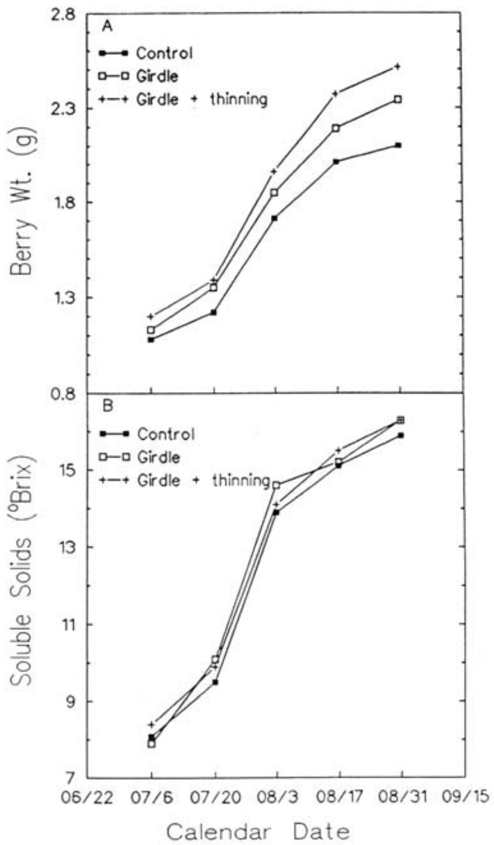

Fig. 4 - The average effect over two years (1990-1991) of girdling and thinning at fruitset on the increase in berry weight (A), and soluble solids (B) of Ruby Seedless grapes.

Effet moyen, pour les deux années (1990-1991), de l'incision annulaire et de l'éclaircissage pratiqués à la nouaison sur l'accroissement du poids (A) et des sucres (B) dans les raisins du cépage Ruby Seedless.

set (WINKLER, 1953). The greatest increase in berry weight was obtained when moderate berry thinning was done in combination with girdling thereby increasing berry weight approximately 28 p. cent compared to control fruit. In a study on Thompson Seedless grapevines girdling combined with thinning induced a further increase in berry weight (WINKLER, 1953).

Sugar accumulation rate was greater and the final soluble solids concentration was increased by all thinning treatments, but decreased with girdling. The decrease in degree Brix obtained by girdling was due to a dilution effect, which resulted from the increase in berry weight, since sugar content per berry basis were similar, 0.41 g and 0.40 g per berry for girdling and control treatments, respectively. In general, thinning can have an effect on fruit composition only when there is partial compensation in yield due to increase in berry size and number (BRAVDO *et al.*, 1984). Thus, crop reduction by cluster thinning of Cabernet Sauvignon by one third resulted in a significant increase in degree Brix (OUGH and NAGAOKA, 1984).

Berry color was significantly increased by girdling with an increase in absorbance of about 28 p. cent, compared to fruit from non-girdled vines. The effect of girdling on berry color may have been due to the increased availability of carbohydrates above the girdle (SACHS and WEAVER,1968; WEAVER and MCCUNE,1959). There was no significant effect of thinning on berry color in this study. This has been explained by a dilution resulting from larger berries. Girdling also resulted in increased berry size but without decrease in fruit color. This can be due to the fact that with girdling practice, carbohydrates flow to permanent organs (trunk and roots) was obstructed while this was not the case with thinning treatments. Therefore more carbohydrates were available in girdling treatments than thinning ones.

CONCLUSION

The results of this investigation demonstrated that moderate thinning (25 p. cent of the crop removed) and girdling at fruitset were effective in improving Ruby Seedless berry weight and maturity. Berry thinning of clusters would be preferable to that of cluster thinning as this would result in better cluster appearance. These practices, which are relatively simple and economical would have an immediate positive impact on Ruby Seedless fruit characteristics for table grape production in Moroccan vineyards.

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