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Long-term effects of zero pruning on Grenache vines under drought conditions

by

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Summary: Under drought conditions the influence of zero pruning (ZP) and hand pruning (HP) on yield, total soluble solids (°Brix), sugar production, dry matter production and total leaf area development of Grenache vines (*Vitis vinifera* L.) was assessed from 1988 to 1996. ZP was superior to HP for yield, sugar production and dry matter production. Total soluble solids were occasionally reduced by ZP. These effects of ZP can be explained by the larger total leaf area. These results are specifically important with regard to low-yield viticulture with a severely limited total leaf area.

Key words: zero pruning, soluble solids, yield, dry matter, total leaf area.

Introduction

The aims of traditional winter pruning of grapevines have been well documented and have long been regarded as necessary to maintain vine shape, productivity and fruit quality (Winkler *et al.* 1974). Traditional hand pruning with a removal of up to 85 % of the annual growth and more (Winkler *et al.* 1974) is labour intensive and has been replaced in many countries by mechanical pruning of *Vitis vinifera* L., *V. labrusca* L. and *V. rotundifolia* Michx. cultivars processed into juice or wine. In addition mechanical pruning has increased yield (Morris and Cawthon 1981; Cargnello and Lisa 1982; Reynolds 1988), but has also been associated with reduced vine vigor, cluster and berry weight (Freeman and Cullis 1981; Reynolds 1988) and total soluble solids (Freeman and Cullis 1981; Intrieri and Marangoni 1982; Intrieri and Silvestroni 1983).

Non-pruning was shown to increase growth and production of vines (Winkler 1958) but has never been considered practical because of negative effects attributed to overcropping (Winkler 1954). In some viticultural regions the adoption of an altered management has produced vigorous vines capable of sustaining increased levels of production when they are more lightly pruned (Clingeleffer 1983, 1984).

In Spain, with a low-yield model of viticulture, vineyards are mainly on dry soils, without irrigation and with a production of ca. 5 $t \cdot ha^{-1} \cdot year^{-1}$, 30 % of labor costs belonging to hand pruning. Although there are some initial experiences with mechanical pruning (Martínez de Toda 1989 a, b), little information concerning long-term effects of mechanical pruning and non-pruning under non-irrigated conditions is available (Martínez de Toda 1982, 1985).

The objective of this study was to assess the influence of zero pruning (ZP) and hand pruning (HP) on the behaviour of Grenache vines under dry conditions over 9 years.

Material and methods

Vineyard location: The unirrigated vineyard was located at Badarán, Rioja Alta (Spain). The annual rainfall is shown in Tab. 1. Mean heat summation as centigrade degree-days above 10 °C, according to Winkler *et al.* (1974) is 1380.

Plant material and treatments: Ninety mature (40-year-old) head-trained vines of Grenache grafted on Rupestris du Lot were either not pruned (ZP) or hand- pruned (HP) since 1987.

Normal cultural practices were applied and all vines survived the experimental period. In the ZP treatment the vines were trimmed 0.5 m above the ground to stop fruit and shoots contacting it. This trimming was made in 1990 and 1993 (once per year in 3-4 years) to facilitate management. In the HP treatment vines were pruned to 7 two-node spurs (similar to the traditional pruning system of Rioja with 14 nodes per vine).

Head-trained vines were spaced 2.6 x 1.6 m between and within rows. The height of the vines was 1.0 m. The vines had low vigor because of their age, the low annual rainfall and cultural practices.

Variables measured: Each year at the same time (local harvest) vines were individually harvested. Yield, cluster number, cluster and berry weight were recorded in 1988 and thereafter. From each vine 250 berries were sampled. After crushing and pressing, the juice was clarified by centrifugation. Soluble solids were quantified with a digital refractometer PR-101 (Atago Co, Ltd. Tokyo, Japan). Total sugar production per vine (g) was determined as the product of sugar concentration ($g \cdot l^{-1}$) x yield per vine (kg) x 0.72 ($l \cdot kg^{-1}$).

During winter the pruning weight per vine was recorded in the HP treatment. Total leaf area was determined according to Carbonneau (1976) at bloom (June) and harvest (October) from 1994 to 1996.

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Table 1

Annual rainfall and yield, total soluble solids (TSS) and sugar production of Grenache vines subjected to zero pruning (ZP) and hand pruning (HP) over a 9-year period (1988-96)

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	9-year mean	Signif. treat.	Signif. year	L.S.D.[z]
Annual rainfall (mm)	590	357	447	509	551	450	442	426	608	487			
Yield (kg·vine^{-1})													
HP	1.5 a	1.5 b	3.0 a	3.1 b	1.5 a	2.8 b	3.0 b	2.0 a	4.8 b	2.57 b	*	ns	2.48
ZP	2.5 a	4.4 a	4.2 a	10.5 a	3.2 a	5.1 a	6.8 a	2.9 a	14.9 a	6.05 a			
TSS (°Brix)													
HP	21.0 a	23.1 a	22.7 a	20.5 a	21.0 a	20.6 a	24.5 a	23.4 a	19.4 a	21.8 a	ns	ns	2.50
ZP	20.5 a	22.4 a	21.2 a	18.5 a	20.0 a	16.3 b	22.3 a	22.0 a	11.2 b	19.4 a			
Sugar production (g·vine^{-1})													
HP	227 a	250 b	491 a	457 b	227 a	416 a	529 b	337 a	670 b	400 b	*	ns	214
ZP	369 a	710 a	640 a	1402 a	460 a	598 a	1091 a	460 a	1201 a	770 a			

Values within columns with unequal letters differ significantly according to t-test ($p \le 0.05$).
ns,*: Not significant or significant according to F-test ($p \le 0.05$).
[z] L.S.D. values pertain to 9-year means.

Total dry matter of the vines (except roots and trunks) was estimated by adding up dry weight of clusters, pruning weight and leaves in the HP treatment and by adding up dry weight of clusters and leaves in the ZP treatment with no winter pruning. Dry weight of clusters was calculated as follows: yield x 0.23 (cluster dry weight/cluster fresh weight) (MARTÍNEZ DE TODA 1985). In the HP treatment the pruning dry weight was determined as follows: pruning weight x 0.47 (dry weight/pruning weight) (MARTÍNEZ DE TODA 1991). Leaf dry weight was calculated as total leaf area (m^2) per vine x 65 $g \cdot m^{-2}$ (specific foliar weight, MARTÍNEZ DE TODA 1985).

Statistics: Groups of 9 vines (three rows with three vines each) were randomly assigned to one of the two pruning systems in each of 5 replicates (blocks). Data were collected from the central vine within each group of 9 vines. Treatment differences were assessed each year by t-test at $p \le 0.05$. Values for all years combined were analyzed by simple factorial analysis of variance, F-test and mean separation by L.S.D. at $p \le 0.05$.

Results and Discussion

Evolution over a 9-year period: Grapevines have a considerable capacity to buffer and obscure treatment effects of only a few years duration, thus our goal was to elucidate long-term effects. Tab. 1 shows the annual and mean results of ZP and HP for yield, total soluble solids and sugar production over the period 1988-1996. Yield was greater in the latter years (1993-1996) of the study because of the greater annual rainfall in this period, the exceptional fertility and the better fruit set, especially in 1996. The year 1995 was not very representative due to spring frost that affected mainly zero-pruned vines.

On an average, there were significant effects of pruning treatments on yield and sugar production per vine but not on total soluble solids. The latter is due to the high degree of variability; the experiment probably should have included larger samples and/or more replications.

Production parameters after 7 years of ZP and HP are shown in Tab. 2. We show data from 1994 because the 1995 and 1996 data were less representative due to spring frost in 1995 and exceptional fertility in 1996. Yield was 2.2 times larger in the zero pruned vines. In these vines cluster number was 6.8 times larger but cluster and berry weight were smaller, 33 and 50 % respectively, compared to HP. Sugar production per vine was two times that of the ZP vines. There were no differences in soluble solids between both treatments.

Zero pruning over a 9-year period resulted in greater yield and sugar production compared to the HP treatment. Soluble solids were less altered suggesting that zero pruning is a viable management option to reduce

Table 2

Production of Grenache vines in 1994, after 7 years of zero pruning (ZP) and hand pruning (HP)

	HP	ZP
Yield (kg·vine^{-1})	3.0 b	6.8 a
Clusters per vine	29 b	196 a
Cluster weight (g)	111.2 a	36.7 b
Berry weight (g)	2.07 a	1.00 b
TSS (°Brix)	24.5 a	22.3 a
Sugar production (g·vine^{-1})	529 b	1.091 a

Values within rows with unequal letters differ significantly according to t-test ($p \le 0.05$).

production costs with minor effect on grape soluble solids as suggested by CLINGELEFFER (1984).

Dry matter production: Tab. 3 shows the total dry matter production and its distribution in different parts of the vine (except trunk and roots). ZP led to higher dry weights of clusters (+135 %) while total dry matter was increased by 64 % compared to HP. The dry matter accumulated in the cluster accounted for 56 and 39 % for ZP and HP, respectively, calculated on the basis of the total dry matter produced by the vines. These results indicate that ZP was more efficient than HP with regard to the dry weight accumulation in the clusters.

Table 3

Dry matter production of Grenache vines (g·vine^{-1}) subjected to zero pruning (ZP) and hand pruning (HP) over a 9-year period (1988-96)

	Cluster dry matter	Pruning dry matter	Leaf dry matter	Total dry matter
HP	591 b	492	445 b	1528 b
ZP	1392 a	0	1113 a	3505 a

Values within columns with unequal letters differ significantly according to t-test ($p \leq 0.05$).

On the other hand, the results of dry matter production and its distribution show the limiting effect of HP on crop and vine capacity, as suggested by WNKLER *et al.* (1974). ZP increased vine capacity with regard to both, growth and production.

Leaf area development: Tab. 4 shows the effects of ZP and HP on the total leaf area at bloom and harvest. At bloom, ZP was 6 times larger and at harvest ZP had a three times larger total leaf area than HP.

The bigger capacity of ZP treatment for both, growth and production is explained by the total leaf area produced. HP not only reduced the total leaf area during the growing season; it also delayed the attainment of maximal leaf area until well beyond midsummer. It thus reduced both the total leaf area and the length of time during which most of the leaves functioned. Similar results were obtained by WINKLER *et al.* (1974). These results are especially important in low-yield viticulture with a severely limited total leaf area.

Table 4

Leaf area of Grenache vines at bloom and harvest subjected to zero pruning (ZP) and hand pruning (HP), 1994-96

		Shoot leaf area (cm^2)	Shoots per vine	Total leaf area (m^2·vine^{-1})
Bloom	HP	1538 a	22 b	3.41 b
	ZP	546 b	377 a	20.58 a
Harvest	HP	2792 a	22 b	6.20 b
	ZP	550 b	366 a	20.12 a

Values within columns with unequal letters differ significantly according to t-test ($p \leq 0.05$).

Conclusions

Over 9 years ZP increased yield, sugar production per vine and dry matter production. Total soluble solids were occasionally reduced by ZP. ZP increased the capacity for both, growth and production. The higher capacity is explained by the total leaf area produced. These results are especially important in low-yield viticulture with a severely limited total leaf area.

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