INFLUENCE OF CROP LEVEL ON 'CHAMBOURCIN' YIELD, FRUIT QUALITY, AND WINTER HARDINESS

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INTRODUCTION

Crop load, the ratio of crop weight and pruning weight, is a practical and reliable indicator of vine balance status between shoot and fruit production (Bravdo et al., 1985; Howell, 2001; Naor et al., 2002). Crop load is determined primarily by cluster number per vine and vegetative growth determined by node number per vine retained after pruning. Kliewer and Dokoozlian (2000) defined well-balanced grapevines as those that do not overcrop and ripen their fruit to desired soluble solids with a given accumulation of degree-days. They found that optimum crop loads fall within a specific range of 4 to 10 in several *Vitis vinifera* cultivars. Reynolds et al. (1994; 1995) reported that crop load ratios were higher for the hybrid cultivars, 'Seyval' and 'Chancellor', than for *V. vinifera*. This is primarily due to the bud fruitfulness and larger clusters in most hybrids than in *V. vinifera* cultivars. 'Chambourcin' is a French hybrid cultivar with fruitful buds and thus it tends to overcrop (Ferree et al., 2003). It has a higher disease and winter resistance than *V. vinifera* cultivars, thus it is well adapted to Midwestern and Eastern US environmental conditions. Therefore, 'Chambourcin' is desired by grape producers and has emerged as one of the most promising red hybrid cultivar producing quality wine. However, there are no documented reports on the best methods of cropping this cultivar to achieve the highest sustainable yields and desired fruit quality without sacrificing winter survival. The goal of this study was to identify the optimum crop loads of 'Chambourcin' that can be recommended to grape producers in the Midwestern US. The specific objectives were to determine the effects of different cropping levels on yield, fruit composition and winter hardiness of Chambourcin grapevines grown in a cool, short growing season in Ohio and a warm, long growing season in southern Illinois.

RESULTS AND DISCUSSION

'Chambourcin' did not respond to different levels of balance pruning (data not shown). Therefore, only the effects of cluster thinning (crop levels) are discussed. The response of 'Chambourcin' grapevines to cluster thinning was similar at both locations. Crop weight per vine decreased linearly as cluster thinning increased (Table 2). As a result, yield also decreased and ranged from 11.1 t ha^{-1} to 17.3 t ha^{-1}. These results corroborate previous findings on other grape cultivars (Howell, 2001; Kliewer and Dokoozlian, 2000; Naor et al., 2002). Furthermore, it is noted that even though vine density in Ohio was twice as high as that in Illinois, the yield per hectare was similar. Pruning weights per vine also followed a linear trend and increased as clusters per vine were reduced (Table 2). Reports on the response of pruning weight to crop levels has varied; some authors have reported an increase in pruning weight as crop levels were reduced (Bravdo et al., 1985) while others reported no effect (Naor et al., 2002). Crop load decreased linearly as clusters per vine increased (Table 2). At both locations and throughout the duration of the experiments, crop load ratios varied from 4 to over 30, which would indicate an over-cropping situation (not all data shown). Crop loads between 4 and 10 were considered ideal to produce optimum wine quality in *V. vinifera* cultivars (Kliewer and Dokoozlian, 2000). Grapevines with crop loads greater than 10 were considered over-cropped with the exception of some hybrid cultivars. Reynolds et al. (1994; 1995) reported crop loads of 10 to 17 in 'Chancellor' and 18 to 28 in 'Seyval'. In our study, grapevines were considered over-cropped with a crop load greater than 8 and 14 in Ohio and Illinois, respectively. We suggest that the variation in crop load between the two regions is due to vine spacing as reported by Reynolds et al. (1994; 1995) and length of growing season and heat unit accumulation as indicated by Howell (2001).

Cluster thinning did not affect PN at the four phenological stages of development it was measured (Table 3). This agrees with similar findings on 'Seyval' grapevines (Edson et al., 1993). However, PN varied from berry touch to one week post-harvest in a similar fashion at two vineyards in southern Illinois. PN increased as vines approached fruit ripening at which time PN was at its maximum in both vineyards (Table 3). However, PN decreased drastically one week post-harvest.

Soluble solids increased linearly as crop levels were reduced (Table 4). Similar findings have been reported in other cultivars (Naor et al. 2002; Kliewer and Dokoozlian, 2000). In general, total titratable acidity did not respond to different crop levels over the years at either location. Whereas pH was inconsistent but tended to increase with a lower crop level. These responses have been previously reported and are typical of increasing crop levels, which generally result in delayed fruit ripening. Furthermore, it is noted that soluble solids and pH in 'Chambourcin' grown in Illinois were always higher and TA lower than those in Ohio. This is another typical response of fruit composition under a longer growing season with more growing degree-days. Therefore, fruit maturity of 'Chambourcin' is better suited in a longer season with more heat degree-days.

Ripened (lignified) nodes per vine increased linearly as crop levels decreased at both locations (Table 5). Ripe nodes in Ohio were much lower than those in Illinois. This may be explained by the longer growing season in Illinois as compared to Ohio. Furthermore, the Ohio vineyard experienced an earlier than normal killing frost which may have stopped further node lignification. Crop levels affected bud cold hardiness measured as LT50 in both vineyards. Grapevines with the highest crop levels had the highest LT50, or were the least cold hardy (Table 5). In Illinois, there was a linear trend between clusters per vine and LT50 (Table 5). Furthermore, cold hardiness seemed to increase as more nodes are lignified in both vineyards. The findings are somewhat different than those by Wample and Wolf (1996) who reported no effect of crop levels on ripe nodes and cold hardiness was only affected early in the fall.

CONCLUSIONS

'Chambourcin' grapevines require cluster thinning in addition to pruning in order to optimize yield, fruit quality and winter hardiness. Optimum crop loads developed for Midwestern US conditions should take into account not only fruit quality but also bud cold hardiness. Crop loads varied with vineyard geographical location and optimum levels range between 4 and 8 in Ohio and 10 and 14 in Illinois. It is concluded that 'Chambourcin' grapevines grown at a wider spacing with a longer growing season (southern Illinois) were able to sustain a higher crop load than those grown in a narrower spacing and shorter season (Ohio).

Literature Cited

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Tables

Table 1. Description of vineyard sites at the two experimental locations.

	Southern Illinois	Northeast Ohio
Climate Description		
Macroclimate	Continental	Continental
Growing season length (0 C basis)	195 (Long)	160 (Short)
Growing degree days (10 C basis)	2180	1590
Climatic growing region class	Region IV (Hot)	Region II (Cool)
Vineyard Description		
Spacing (vine x row) (m)	2.4 x 3.0	1.2 x 3.0
Vine density (per hectare)	1362	2722
Training system	High bi-lateral cordon	High simple cordon
Duration of study	2 years	4 years

Table 2. Effects of clusters per vine on yield, pruning weight and crop load measured on 'Chambourcin' grapevines at two locations. Crop load is cluster weight divided by pruning weight.

	Clusters/vine[1]	Cluster wt. (kg vine^{-1})	Yield (t ha^{-1})	Pruning wt. (kg vine^{-1})	Crop load
Ohio 2002	12 c	4.14	11.1	0.32	14
	23 b	5.82	15.9	0.19	31
	31 a	6.32	17.3	0.20	34
Linear Regression[2]		***	***	**	**
Illinois 2003	45 c	8.73	11.8	0.87	10
	54 b	10.5	14.3	0.84	13
	61 a	12.27	16.6	0.72	17
Linear Regression		***	***	*	**

[1]Means separation within columns at $P \leq 0.05$ by Duncan's multiple range test.
[2]*, **, ***, and ns indicate statistical significance at $P \leq 0.05$, 0.01, 0.001 and not significant, respectively.

Table 3. Effect of crop level on whole vine photosynthesis (PN) 'Chambourcin' grapevines at different phenological stages of in Illinois 2003.

Phenology	PN (µmoles CO_2 vine^{-1} s^{-1})[1]	
	Vineyard 1	Vineyard 2
Berry touch	4.4 b	3.1 bc
Veraison	5.8 b	4.1 b
Harvest	8.9 a	7.1 a
One week post harvest	4.8 b	2.8 c

[1]Means separation within columns at $P \leq 0.05$ by Duncan's multiple range test.

Table 4. Effect of crop levels on fruit composition of'Chambourcin' grapes at two locations.

	Clusters vine^{-1}	°Brix	pH	TA (g/L)
Ohio 2002	12	21.3	3.22	10.0
	23	19.7	3.14	8.8
	31	19.8	3.13	8.6
Linear Regression[2]		**	**	ns
Illinois 2003	45	23.4	3.43	6.3
	54	23.0	3.42	6.4
	61	22.9	3.42	6.4
Linear Regression		*	ns	ns

[1]Means separation within columns at $P \leq 0.05$ by Duncan's multiple range test.
[2]*, **, ***, and ns indicate statistical significance at $P \leq 0.05$, 0.01, 0.001 and not significant, respectively.

Table 5. Effects of crop levels on node lignification and bud cold hardiness (LT50) of

‘Chambourcin’ in two locations. Note that data from Ohio is from 2003 and not 2002 as found in previous tables.

	Clusters vine^{-1}	Shoots Vine^{-1}	Lignified nodes vine^{-1}	LT50 (C)	% Bud injury @ -17.5C
Ohio 2003	14 c	22	59	-18.3 b	22 b
	23 b	22	41	-17.5 a	60 a
	32 a	21	35	-17.7 ab	44 ab
Linear Regression[2]		ns	**	ns	ns
Illinois 2003	46 b	37	577	-25.1 b	
	49 ab	38	452	-25.1 b	
	56 a	37	203	-21.9 a	
Linear Regression		ns	***	**	

[1]Means separation within columns at $P \leq 0.05$ by Duncan’s multiple range test.
[2]*, **, ***, and ns indicate statistical significance at $P \leq 0.05$, 0.01, 0.001 and not significant, respectively.
Buds collected on 23 Dec 2003 in OH and on 14 Jan 2004 in IL.