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'Chambourcin' Grapevine Response to Crop Level and Canopy Shade at Bloom

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Abstract

'Chambourcin' grapevines were thinned at bloom to leave 8, 16, or 24 clusters/m of row and half were covered with 80% shade cloth for five days. All treatments were repeated on the same vines for four years. Five days of shade at bloom had no effect on any parameter measured in 1999, 2000 and 2002. In 2001, yield was reduced by shade and the interaction between shade and crop level was significant. Flower number, berries per cluster and yield were increased by shade at 8 clusters/m, but decreased at higher crop levels. As clusters per meter of row increased, clusters per vine and yield increased linearly and the following decreased linearly: number of flowers, berries per cluster, cluster weight, juice soluble solids and pH. Fruit set and juice titratable acidity were not affected by any of the treatments. Results of this study confirm that 'Chambourcin' is very sensitive to crop level and crop level may need to be reduced to 8 clusters per meter of row or 9-14 t/ha to produce high quality wine under Midwest environmental conditions.

Introduction

Work with *Vitis vinifera* L. cultivars in the field (11,12) or in controlled environments (14) showed reduced fruit set with heavy shading. Low light conditions from shortly after bloom through harvest (8) or the five weeks following bloom (4) also reduced fruit set and yield of French-American hybrid grapes under controlled greenhouse conditions. Subjecting four cultivars to five days of 80% shade at various times had little effect on 'Vidal blanc' or 'DeChaunac' (4). However, the same treatment on 'Chambourcin' reduced fruit set, cluster weight, berries per cluster and juice components. Since 'Chambourcin' is the French-American hybrid most in demand for red wine production in Ohio (3), it was important to verify if this sensitivity to a short period of shade existed under field conditions. A review of light levels during May and June over a 14 year period (1986-2000) when grapes normally bloom in Wooster, Ohio, revealed 19 instances of three or more consecutive days when irradiance was 60% to 80% below the long-term average. There were only two years when this type of shade event did not occur during the normal bloom period for grapes.

Many French-American hybrid wine grapes tend to overcrop which can decrease growth, reduce yield, increase susceptibility to winter injury and decrease wine quality (5, 7, 13). Howell (6) in a recent review emphasized that to attain the highest sustainable yields and achieve the desired fruit maturation with varietal character, many wine grapes need some crop adjustment during the season. This is particularly important in years when weather conditions are adverse and crop level must be reduced for the vine to mature the grapes. The crop level of 'Chambourcin' that can be maintained consistently under Midwest conditions has not been established. Recent sensory evaluations of 'Chambourcin' wine made from fruit of vines with different crop levels indicated that judges preferred wine made from a crop level of 8 clusters/m of row (15). Although there were differences

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between years, wine from fruit with this crop level had the highest red color intensity, total anthocyanins and total phenolics.

To the authors' knowledge, no one has looked at the potential interaction of a short period of shade at bloom and different crop levels. The goal of this study was to evaluate the influence of five days of shade at bloom on 'Chambourcin' vines with three crop levels.

Materials and Methods

Own-rooted vines of 'Chambourcin' were planted in 1996 at a spacing of 1.25 m x 3 m and trained to a single cordon at a height of 1.8 m. The vines were pruned leaving 20 buds on 5-bud canes plus several renewal spurs. Beginning in 1999 clusters were removed to leave 8, 16, or 24 clusters per meter of row just as flowers started to open. When 10-20% of the flowers were open, half the vines were covered with 80% black shade cloth so that the entire canopy was enclosed for five days. Thermocouples and quantum light sensors attached to a data logger were placed above the canopy, in the canopy, outside the shade and in the canopy inside the shade to record temperature and light levels. All treatments were repeated on the same vines for four years. Treatments were arranged as a randomized block factorial (three cluster densities x two shade levels) with six single-vine replications.

In 1999 and 2000 prior to bloom, three clusters per vine were labeled and all flower buds counted. In 2001 and 2002, five clusters per vine were labeled and flower buds counted only on the shoulders. Previous work with 'Chambourcin' showed a very high correlation of fruit set (r = 0.97) and berries (r = 0.95) on the shoulder to berries on the main cluster (4). At harvest, berries from the tagged clusters were counted and a 100-berry sample weighed, put through a food strainer and total soluble solids, titratable acidity and pH of the juice measured. The remaining clusters on the vine were counted and weighed. Cane pruning weight was recorded annually for each vine.

Table 1. Influence of three crop levels and five days of 80% shade at bloom on cluster characteristics, yield and juice components of 'Chambourcin' grapevines in 1999.

	Cluster characteristics						Juice components		
Shade	Flowers/ cluster	Fruit set (%)	Berry weight (g)	Cluster/ vine	Cluster weight (g)	Yield/ vine (kg)	Soluble solids (%)	pH	Titratable acidity gL^{-1}
Control	495	20.4	.69	23.5	199a	1.88	22.0	3.20	9.74
Shade	490	16.5	.69	25.1	158b	1.57	22.0	3.23	9.65
Clusters/m row									
8	526	16.3	.69	16.0	170	1.26	23.1	3.21	10.3
16	508	17.9	.66	25.9	170	1.71	21.7	3.24	9.4
24	444	21.7	.74	32.5	198	2.30	21.0	3.19	9.2
Linear[z]	NS	*	NS	**	*	**	**	NS	**
Quadratic	NS	NS	NS	NS	NS	NS	NS	*	NS
F Significance[z]									
Shade (S)	NS	NS	NS	NS	**	*	NS	NS	NS
Clust. (C)	NS	*	NS	**	NS	**	**	NS	**
SxC	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]NS, *, ** = nonsignificant or significant at P = 0.05 or 0.01.

Results

In 1999, five days of shade during bloom had no effect on any parameter measured except cluster weight which was reduced 21% (Table 1). As clusters per meter of row increased, the following increased linearly: fruit set, clusters per vine, cluster weight and yield. Juice soluble solids and titratable acidity decreased linearly as cluster density increased. There was no interaction between five days of shade at bloom and the three crop levels.

Five days of shade at bloom had no effect on any of the parameters measured in 2000 (Table 2). Flowers per cluster in 2000 were reduced as crop level increased, indicating a carry-over effect from the previous year. As expected, clusters per vine and yield increased as cluster density increased, while juice pH and titratable acidity declined. The interaction between shade and cluster density was significant for fruit set because fruit set was lower on shaded vines at 16 clusters per meter of row, but not at the other two cluster densities. There was no significant interaction among other measurements.

There was no effect of shade in 2001 on any of the parameters measured, except yield which was reduced (Table 3). Again, flower number declined linearly as cluster density increased, but fruit set was not affected. Consistent with past years, yield increased and berries per cluster, cluster weight, juice soluble solids, and pH decreased as cluster density increased. At a crop level of 8 clusters/m, five days of shade at bloom increased flowers on the shoulder, but at higher crop levels shade at bloom decreased flower numbers (Fig. 1A). The same pattern was evident for berries per cluster (Fig. 1B) and yield (Fig. 1D). Shot berries (small, hard, green, underdeveloped berries at harvest) per cluster at 8 clusters/m were increased by shade, decreased at 24 clusters/m and not different at 16 clusters/m (Fig. 1C).

In 2002, five days of 80% shade at bloom again did not influence any of the measurements taken (Table 4). For the third consecutive year, flowers were reduced

Table 2. Influence of three crop levels and five days of 80% shade at bloom on cluster characteristics, yield and juice components of 'Chambourcin' grapevines in 2000.

	Cluster characteristics						Juice components		
Shade	Flowers/ cluster	Fruit set (%)	Berry weight (g)	Cluster/ vine	Cluster weight (g)	Yield/ vine (kg)	Soluble solids (%)	pH	Titratable acidity gL^{-1}
Control	537	22.4	112	23.6	172	4.64	20.2	3.37	11.47
Shade	502	23.0	112	24.0	155	4.22	20.0	3.32	11.29
Clusters/m row									
8	585	22.2	121	12.5	181	3.10	20.4	3.36	11.93
16	519	23.3	117	25.0	167	4.86	19.9	3.33	11.01
24	454	22.5	98	33.8	142	5.24	20.1	3.28	11.20
Linear[z]	**	NS	*	**	*	**	NS	*	*
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS	NS
F Significance[z]									
Shade (S)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Clust. (C)	**	NS	NS	**	NS	**	NS	**	**
S x C	NS	*	NS	NS	NS	NS	NS	NS	NS

[z]NS, *, ** = nonsignificant or significant at P = 0.05 or 0.01.

linearly as crop level increased. The interaction occurred because five days of shade reduced flowers on vines cropped at 16 cluster/m, but not at the higher or lower crop levels. Fruit set and cluster weight were not affected by crop level, but berries per cluster, juice soluble solids and pH declined linearly as clusters per meter of row increased. Yield again increased linearly as more clusters were left on the vine. Cane pruning weight did not differ among crop level treatments and increased in all treatments each year of the study as the vines aged (data not shown).

Table 3. Influence of three crop levels and five days of 80% shade at bloom on cluster characteristics, yield and juice components of 'Chambourcin' grapevines in 2001.

	Cluster characteristics						Juice components		
Shade	Flowers/ shoulder	Fruit set (%)	Berries/ cluster	Cluster/ vine	Cluster weight (g)	Yield/ vine (kg)	Soluble solids (%)	pH	Titratable acidity gL^{-1}
Control	117	31.4	241.9	19	271	4.77a	21.1	3.24	11.1
Shade	105	35.5	228.6	18	265	4.17b	21.9	3.23	11.1
Clusters/m row									
8	131	34.2	252.7	9	297	3.05	22.4	3.32	11.2
16	118	32.7	255.1	19	278	4.83	21.0	3.21	10.9
24	83	33.3	197.4	27	228	5.53	21.1	3.17	11.2
Linear[z]	**	NS	**	**	**	**	**	**	NS
Quadratic	NS	NS	*	NS	*	NS	*	NS	NS
F Significance[z]									
Shade (S)	NS	NS	NS	NS	NS	**	NS	NS	NS
Clust. (C)	**	NS	**	**	**	**	**	**	NS
SxC	**	NS	**	NS	**	**	NS	NS	**

[z]NS, *, ** = nonsignificant or significant at P = 0.05 or 0.01.

Discussion

A concept that is widely used as a measure of balance between vegetative growth and cropping is crop load (yield ÷ pruning weight). A value of 10 has been suggested as appropriate for 'Seyval blanc' (13) and values below 10 were suggested as necessary to maintain the optimum balance between growth, yield and wine quality for *Vitis vinifera* cultivars (1). Ferree et al. (2) reported an average crop load of 14 with vines in balance for 'Vidal blanc', another French-American hybrid. Average crop load balances in this study in 2002 (the year with the highest yield and pruning weight) were 8 clusters/m = 7.4, 16 clusters/m = 15.0, 24 clusters/m = 25.2. It is clear that the highest crop density was well above the optimum balance and the lowest crop density was slightly below optimum.

The significant negative impact of five days of shade on yield observed in a greenhouse study (4) was not found in three of the four years of this study. Yield on these young vines increased each year of the study and, although not statistically significant, yield of vines that had the short period of shade had 5-13% lower yields each year. An examination of ambient light, temperature or humidity during the period when the shades were in place offer no explanation for the significant interactions in

2001, which had no values that were extreme for any parameter. The general lack of response to shade may have been due to the increased amount of leaf area likely present on these field-grown vines. The vines in the greenhouse were limited to a single shoot with one cluster, while in the field shoots were present without clusters and would likely contribute to the carbohydrate status of the vine. McArtney and Ferree (9) found a positive linear relationship between leaf area at bloom and number of berries per cluster. Unfortunately, leaf area was not measured in our study.

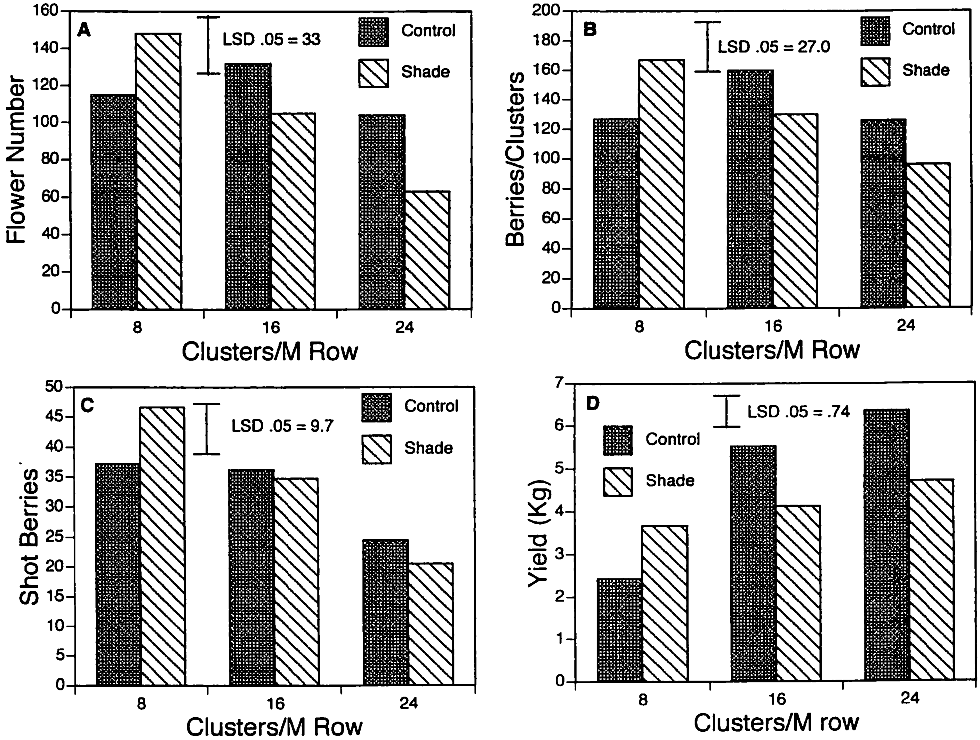

Figure 1. Interaction effects of five days of shade at bloom and three crop levels on flower number per shoulder (A), berries/clusters (B), shot berries (C) and (D) yield of 'Chambourcin' grapevines in 2001.

In a recent review (10), the authors suggest that flowering in grapevine is regulated by a gibberellin-cytokinin interaction and that "cytokinin is of central importance in the control of flowering in the grapevine". Since the treatments in this study were repeated on the same vines, it is clear that flower number per inflorescence decreased linearly as crop level increased (Tables 2-4). The increase in crop level caused a reduction or a dilution in photosynthate as evidenced by the reduction in juice soluble solids. Generally the root system is a weaker sink than fruit (10) and thus, would likely be reduced as crop level increased. This reduction could result in less cytokinin available for flower initiation, since root tips are the primary sites for cytokinin production. Removal of a portion of a 'Chambourcin' grapevine root system caused a reduction in berries per cluster, but had no effect on fruit set (9).

Fruit set was not affected by crop level in any year except 1999, but berries per cluster were reduced each subsequent year due to the decrease in flowers per cluster.

The decline in juice soluble solids and pH with increasing 'Chambourcin' crop level illustrate the sensitivity of this cultivar to crop level. In a companion study in the same vineyard with crop adjusted to the same levels, sensory judges preferred wines made from grapes at 8 clusters/m in two different years (15). Analysis showed that the preferred wines had higher red color intensity, total anthocyanins and total phenolics. In the present study production at the 8 clusters/m level tended to increase each year (1999-2002) as follows: 3.7, 9.1, 9.0, 14.3 t/ha. These are reasonable yields for vines 4-7 years old and it appears that under Midwestern conditions, yields may need to be reduced to the 9-14 t/ha range to produce 'Chambourcin' wine of the highest quality.

Table 4. Influence of three crop levels and five days of 80% shade at bloom on cluster characteristics, yield and juice components of 'Chambourcin' grapevines in 2002.

	Cluster characteristics						Juice components		
Shade	Flowers/ shoulder	Fruit set (%)	Berries/ cluster	Cluster/ vine	Cluster weight (g)	Yield/ vine (kg)	Soluble solids (%)	pH	Titratable acidity gL^{-1}
Control	131	31.6	149	20.6	253	7.25	19.7	3.30	9.60
Shade	126	30.5	141	21.0	220	6.12	19.5	3.29	9.42
Clusters/m row									
8	150	32.8	167a	11.7	257	4.84	21.2	3.36	9.68
16	123	29.2	136b	21.8	226	6.12	19.4	3.29	9.49
24	112	31.1	136b	28.9	228	7.89	18.8	3.24	9.32
Linear[z]	**	NS	**	**	NS	*	**	**	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS	NS
F Significance[z]									
Shade (S)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Clusters (C)	**	NS	**	**	NS	NS	**	**	NS
S x C	*	NS	NS	NS	NS	NS	NS	NS	NS

[z]NS, *, ** = nonsignificant or significant at P = 0.05 or 0.01.

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