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Response of Two French Hybrid Wine-Grape Cultivars to Low Light Environments

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Abstract

The response of berry set, yield, and fruit quality characteristics to low light environments were examined for 'Seyval blanc' and 'De Chaunac' grapevines in the greenhouse. Potted vines of each cultivar with either 1 or 2 clusters were subjected to high or low light conditions, created by 80% shade cloth and supplemental lighting. 'Seyval blanc' had a higher percentage of mature berries per cluster, fewer shot berries, and a larger rachis diameter compared to 'De Chaunac'. Regardless of the cultivar or cluster number, clusters subjected to low light conditions had lower set, yields, cluster weights, berry weights, berries per clusters, and rachis diameters and had higher numbers of shot berries compared to clusters grown under high light conditions. Vines with one cluster matured a higher percentage of berries, possessed larger cluster weights and rachis diameters, and had lower yields than vines with two clusters. 'Seyval blanc' and 'De Chaunac' clusters grown under low light developed their golden and blue-red color more slowly than clusters grown under high light conditions. Overall, vines subjected to low light conditions produced clusters with lower soluble solids, pH, and potassium ion concentrations compared to vines grown under high light conditions. The soluble solids and pH of 'Seyval blanc' clusters were more sensitive to light than 'DeChaunac'. Titratable acidity levels and tartaric acid concentrations of 'Seyval blanc' were less sensitive to low light compared to 'De Chaunac' clusters.

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The soluble solids and pH of 'Seyval blanc' clusters were more sensitive to light than 'DeChaunac'.

Titratable acidity levels and tartaric acid concentrations of 'Seyval blanc' were less sensitive to low light compared to 'De Chaunac' clusters.

Introduction

Highly vigorous grapevines can contain several leaf layers within their canopies resulting in very low light levels toward the canopy interior. While the photosynthetic photon flux (PPF) levels at the canopy's exterior may be near 2000 $\mu mol\ m^{-2}s^{-1}$ on a sunny day, PPF levels at the canopies interior may fall as low as 10 $\mu mol\ m^{-2}s^{-1}$ (22,23). Low light levels within the canopy have been associated with reduced yields and lower fruit quality in many cultivars: low soluble solids (16,19,23), reduced anthocyanins and other phenolics in colored cultivars (9,16), high pH values and potassium ion concentrations (16,24), and titratable acidity levels (1,19).

'Seyval blanc' (Seyval Villard 5276) and 'De Chaunac' (Seibel 9549) are two highly productive, relatively cold hardy French-hybrid cultivars commercially produced in cool climates for white and red wine production, respectively. Because of their high fruitfulness, cluster-thinning has often been suggested in these cultivars to maintain vine size and fruit quality adequately across growing seasons (5,18,19). Reducing cluster numbers per vine has been associated with greater accumulation of soluble solids (2,12,19) and anthocyanins (9,14). The objective of this study was to compare the yield and fruit quality characteristics of 'Seyval blanc' and 'De Chaunac' vines with one or two clusters per shoot under controlled high and low light conditions in a greenhouse.

Materials and Methods

Two-year-old, own-rooted 'Seyval blanc' and 'De Chaunac' grapevine cuttings were planted in 8 L nursery pots containing a soil mixture composed of equal amounts of soil (Wooster silt loam), peat, and perlite. Vines were restricted to one shoot and a maximum of two flower clusters.

After bloom, 64 of the most advanced plants from each cultivar were divided into 4 completely randomized blocks based upon the berry size: 5 to 8 mm for 'Seyval blanc' and 2 to 6 mm for 'De Chaunac', respectively. Thirty-two vines of each cultivar were subjected to one of two light levels: 1) high light — vines receiving ambient greenhouse light supplemented with 450 watt high pressure solium HID lights (Sylvania); or 2) low light — vines receiving ambient greenhouse light and 80% shade cloth. Light fixtures were suspended 1.8 m above the surface of the bench and set with individual timers to supply light from 0700 hr to 1900 hr daily. Within each light treatment, crop levels of 1 or 2 clusters/vine were established.

Pots were completely randomized within each block on the bench and were rotated on a biweekly basis to help counteract light gradients on the bench. To manage vines, 'Seyval blanc' and 'De Chaunac' vines were restricted to 15 and 17 leaves/vine, respectively, and laterals were removed on a biweekly basis. Berry numbers of individual clusters were counted at the initiation of the study, 3 weeks later, and at harvest to assess berry set. In addition, the diameter of the rachis of each cluster was measured at week 3 and at harvest to determine if the caliper of the rachis was related to cluster size and/or berry set.

The greenhouse was maintained at day and night temperatures of 20°/17°C. From veraison to harvest, air temperatures surrounding the clusters were monitored by mounting thermocouples at cluster level within each high light and low light area on the bench. Every fifteen minutes, one minute intervals were averaged and recorded using a Micrologger by Campbell Scientific Inc. (Model 21X).

Light conditions were monitored throughout the experiment. To compare the relative PPF of each high light and low light area, one Li-Cor Integrator sensor (Model LI-510B) was mounted at cluster height within each of the light treatment areas. To compare the absolute PPF among treatments and to quantify the PPF gradation across benches, 4 sets of instantaneous readings were recorded using a Li-Cor Quantum/Radiometer/ Photometer (Model LI-185B) with a quantum sensor. Values were taken at 2 heights, 40 cm above the surface of the pot (cluster height) and 100 cm above the surface of the pot. At each height, light levels were recorded at all four corners and the center of treatment areas.

The transpiration and photosynthetic activity of 'De Chaunac' leaves were measured using an Analytical Developmental Corporation (ADC) LCA-2 portable gas analyzer with an air supply unit and Parkinson leaf chamber. Measurements were taken on leaves opposite the basal clusters at week 4 (pea size) and week 8 (veraison) and on the 14th leaf at week 10. Two data sets were taken at each of these stages: one under saturated light and one under light conditions on treatment benches. Saturated light conditions were created using a supplemental light source.

At harvest, each treatment cluster was individually removed and weighed. The final diameter of the rachis was recorded. Berries were removed, divided into mature and shot berries (no seeds), counted, and weighed. Between 40 to 50 berries were placed into centrifuged tubes, crushed by hand, and centrifuged for 10 minutes. Juice from this sample was used to analyze soluble solids, pH, and titratable acidity. Soluble solid (SS) concentration was measured using an Abbe MARK II Refractometer by AO Scientific Instruments (Model 10480 S/N) with temperature correction. Measurements of pH were taken using a calibrated Orion Research digital Ionalyzer (Model 701A). Titratable acidity (TA) was determined by diluting 5 ml of juice into 100 ml of double distilled water and titrating with a standardized NaOH solution until solution reached a pH of 8.20. After TA, pH, and SS values were recorded, samples were frozen for later analysis. To determine malate acid, tartrate acid, and potassium ion concentration of the juice, frozen samples were later thawed by placing them in a 75°C water bath for 1 hour during which time they were shaken by hand. Malate and tartrate acid concentrations were determined using reverse phase high performance liquid chromatography (HPLC) using modified methods of the Cornell University Wine Research Program in Geneva, New York (13). Potassium ion concentrations were measured using an atomic absorption spectrophotometer (Perkin-Elmer Model 2380).

Treatments were replicated four time as a split split plot, with cultivar as the whole plot, light level as the split plot and cluster number as the split split plot. Variables were averaged over both vines with the same cultivar-light level-cluster number combination within each replication prior to analysis. Analysis of variance (ANOVA) was used to compare all treatments. All statistics were analyzed using the PROC GLM on the SAS statistical software package.

Results

Growing Conditions

Light meter readings indicated that vines grown under low light conditions received approximately 12% the PPF of vines grown under high light conditions. The overall amount of PPF available to high and low light areas depended on the ambient light conditions outside the greenhouse. On sunny days, high light areas averaged 222 μmol $m^{-2}s^{-1}$PPF and low light areas averaged 27 μmol $m^{-2}s^{-1}$ PPF at cluster height (Fig. 1)., while on overcast days, high light areas averaged 82 μmol $m^{-2}s^{-1}$ PPF and low light areas averaged 12 μmol $m^{-2}s^{-1}$ PPF at cluster height. The PPF available to the vines increased toward the apical end of the vine. For example, the PPF was nearly doubled between cluster height and 60 cm above cluster height, regardless of light level or ambient conditions outside the greenhouse. Spectroradiometer and micrologger measurements showed that the R/FR ratios and air temperatures surrounding clusters exposed to both high and low light conditions averaged 1.0 and 20°C, respectively (data not shown).

Photosynthesis and Transpiration

Under saturated light conditions, 'De Chaunac' leaves opposite the cluster grown under low light had a lower net photosynthesis (Pn) and transpiration (Tr) at both the pea size and veraison stages of development (Fig. 2A and C). For instance, at veraison, the Pn rates and Tr rates of leaves grown under low light conditions were 80% and 86% the rates of leaves grown under the high light treatment. The Pn rates of leaves at the 14th node were similar under saturated conditions, while the Tr rates of leaves developed under low light conditions were slightly higher (data not presented). Measurements made under treatment conditions showed that leaves in the low light environment had much lower Pn and Tr rates regardless of developmental stage or node position (Fig. 2 B and D). At veraison, the Pn rates and Tr rates of leaves grown under low light conditions were 13% and 70% the rates of leaves

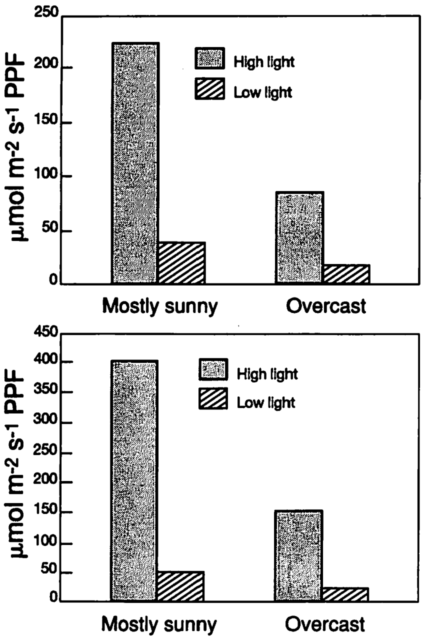

Fig. 1.Characterization of the high and low light environments surrounding 'Seyval blanc' and 'De Chaunac' vines in the greenhouse at cluster height (A) and 60 cm above the clusters (B).

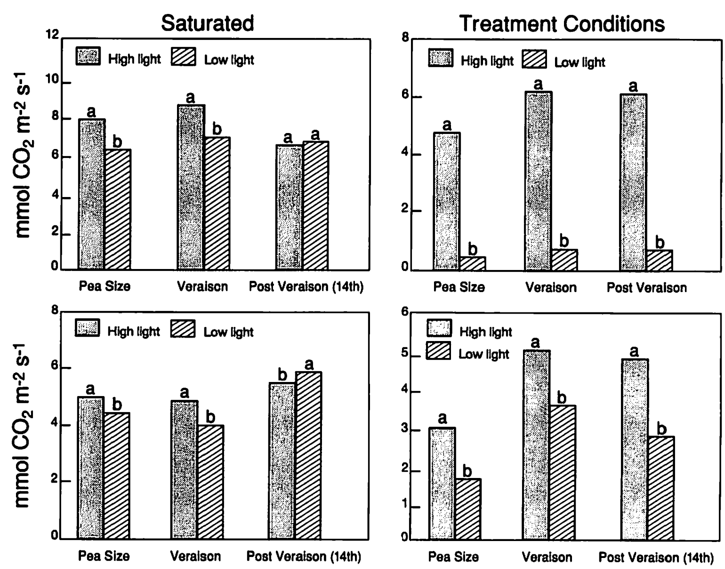

Fig. 2.Influence of high and low light environments on net photosynthesis (A and B) and transpiration (C and D) of 'De Chaunac' leaves measured under normal treatment conditions and with supplemental light to saturate photosynthesis. Different letters above bars indicate statistical difference P = .05.

Table 1. The influence of cultivar, light level, and cluster number on the cluster characteristics and yield of 'Seyval blanc' and 'De Chaunac' grapevines in the greenhouse.

Treatment	% Berries Matured	% Shot berries	Yield/vine (kg)	Cluster weight (g)	Berry weights (g)	Berries per cluster	Shot berries per cluster	Rachis diameter (mm)
Cultivar (CV)								
Seyval blanc	51a[z]	45a	55.1	35.5	0.97	36	33a	3.15a
De Chaunac	36b	59b	46.5	31.2	0.94	35	60b	2.60b
Light level (LL)								
High	61a	32a	96.5a	65.4a	1.25a	51a	30a	3.05a
Low	26b	73b	26.6b	17.1b	0.66b	20b	63b	2.70b
Cluster number (CN)								
1	47a	50	42.1a	39.6a	0.99	38	48	2.97a
2	40b	55	60.9b	28.2b	0.92	33	45	2.77b
F-significance								
CV	***	*	NS	NS	NS	NS	***	***
LL	***	***	***	***	***	***	***	***
CV X LL	NS	NS	NS	NS	**	NS	NS	NS
CN	*	NS	***	**	NS	NS	NS	**
CV X CN	NS	*	NS	NS	NS	NS	**	NS
LL X CN	NS	NS	NS	NS	NS	NS	NS	NS
CV X LL X CN	NS	NS	NS	NS	NS	NS	NS	NS

[z] Different letters within each column, cultivar, light level, and cluster number signify statistical differences at $P = 0.05$.
NS, *, **, *** Nonsignificant or significant at $P = 0.05$, 0.01, and 0.001, respectively.

grown under high light conditions, respectively.

Yield and Cluster Characteristics

Berry set was influenced by the cultivar, light level, and cluster number. 'Seyval blanc' clusters and 'De Chaunac' clusters matured 51% and 36% of the potential berries present at initiation of the experiment, respectively (Table 1). Clusters with poor set usually contained high numbers of shot berries. Clusters grown under high light levels matured more berries and possessed fewer shot berries compared to clusters grown under low light levels. For example, 'Seyval blanc' and 'De Chaunace' clusters matured 67% and 54% of their berries, respectively, under high light, but matured only 34% and 18% of their berries, respectively, under low light. In contrast, 23% and 67% of the 'Seyval blanc' berries and 40% and 79% of the 'De Chaunac' berries developed into shot berries when exposed to high light and low light levels, respectively. Moreover, 'Seyval blanc' and 'De Chaunac' clusters from vines with one cluster per vine matured more berries per cluster and contained fewer shot berries per cluster compared to vines with two clusters per vine.

Despite the differences in the per-

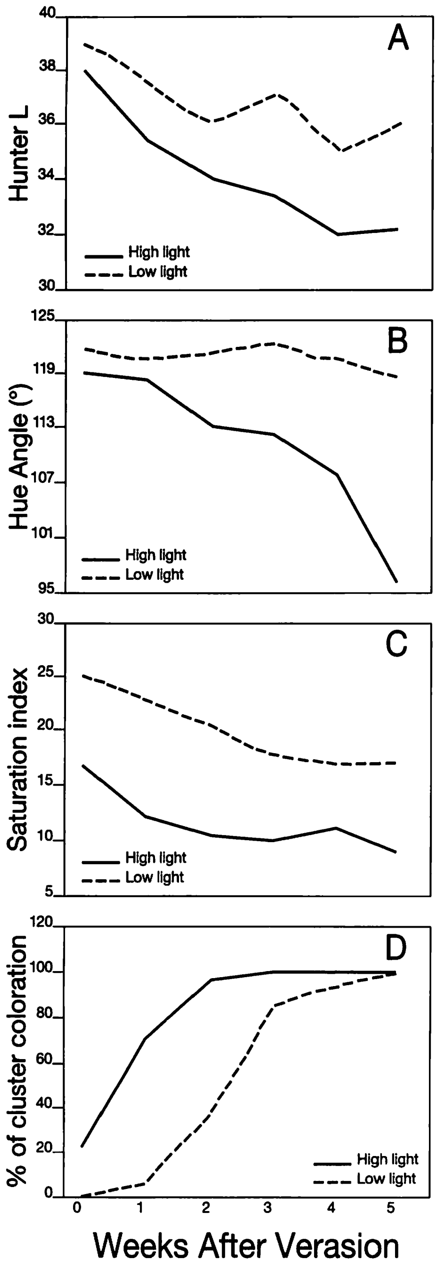

Fig. 3. Influence of high and low light on Hunter L value (A), hue angle (B), and saturation index © of 'Seyval blanc' clusters and on the % of cluster coloration (D) of 'De Chaunac' clusters between veraison and harvest.

centage of berries set, 'Seyval blanc' and 'De Chaunac' vines yielded similarly and had comparable average cluster weights, average berry weights, and berries per cluster at harvest. However, 'De Chaunac' clusters had approximately twice as many shot berries per cluster and had smaller rachis diameters compared to 'Seyval blanc' clusters. Vines grown under high light conditions exhibited higher yields, average cluster weights, average berry weights, berries per cluster, and rachis diameters and a lower number of shot berries per cluster compared to vines grown under low light conditions. Vines with one cluster had lower yields, but increased cluster weights and rachis diameters compared to vines with two clusters.

Fruit Quality

Hunter L values, hue angles, and saturation indices all declined as berries matured between veraison and harvest. 'Seyval blanc' berries exposed to high light levels exhibited decreased hue angles and saturation indexes during this entire phase of development and reduced Hunter L values in four of the six weeks measurements were made (Fig. 3). Moreover, 'Seyval blanc' vines with one cluster per vine had lower Hunter L values in two of the six weeks measurements were taken in five out of the six weeks analyzed (data not shown). Since the majority of the 'De Chaunac' berries grown under low light conditions were too small to completely cover the measuring tip of the Minolta CR-100 measuring head, the percent coloration of 'De Chaunac' clusters were recorded on a weekly basis from veraison to harvest. Visual ratings showed that 'De Chaunac' clusters grown under high light levels had a higher percentage of colored berries in the first four weeks following veraison (Fig. 3). Vines with two clusters per vine showed reduced coloration in two out of the five weeks analyzed (data not shown).

The cultivar and the light level interacted to influence the fruit quality. 'Seyval blanc' and 'De Chaunac' clusters

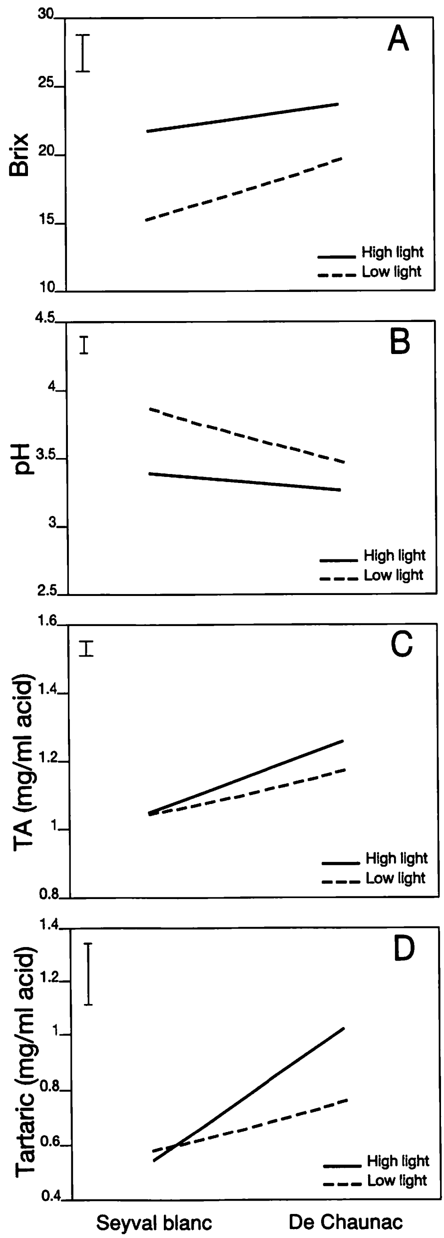

Fig. 4. Influence of cultivar and light level on soluble solids (A), pH (B), titratable acidity (C), and tartaric acid concentration (D) of 'Seyval blanc' and 'De Chaunac' grapevines. Bars represent LSD (0.05) between light levels within each cultivar.

exposed to high light conditions both accumulated soluble solids to approximately 22°Brix. The accumulation of soluble solids was depressed by low light levels in both cultivars, with 'Seyval blanc' responding the more severely with a 7°Brix reduction in soluble solids compared to a 4°Brix reduction in 'De Chaunac' (Fig. 4A). Under high light conditions, the pH of both cultivars was similar, while under low light conditions, 'Seyval blanc' had a significantly higher juice pH than to 'De Chaunac' (Fig. 4B). In both cultivars, juice from clusters grown under high light exhibited lower pH compared to their counterparts grown under low light. The titratable acidity and tartaric acid concentrations of 'Seyval blanc' were lower than 'De Chaunac' regardless of light level (Fig. 4C and D). While light level did not alter the titratable acidity or tartaric acid concentrations of 'Seyval blanc', low light levels reduced the titratable acidity and tartaric acid concentrations of 'De Chaunac'.

The cultivar and light level did not significantly interact to influence malate. Overall, the malate concentrations of 'De Chaunac' samples averaged 0.2 mg/ml acid higher than 'Seyval blanc' samples. Clusters grown under high light conditions had reduced malate concentrations compared to clusters grown under low light conditions in both cultivars (data not shown).

Cluster number did not significantly influence any of variables measured (Table 2). Vines with one cluster per vine tended to possess higher soluble solids, pH, titratable acidity, malate, tartrate, and potassium compared to vines with two clusters per vine.

Discussion

High and low light levels were successfully maintained throughout the experiment. Although there was considerable variation among sampling dates, most methods of light quantity assessment indicated low light areas received 10% to 20% of the PPF of high light treatments

Table 2. The influence of cultivar, light level and cluster number on the fruit quality of 'Seyval blanc' and 'De Chaunac' in the greenhouse.

Treatment	Soluble solids (° Brix)	pH	Titratable acid (mg/ml acid)	Malate (mg/ml acid)	Tartrate (mg/ml acid)	K+ conc. (ppm)
Cultivar (CV)						
Seyval blanc	18.5a[z]	3.56a	1.05a	0.45a	0.57a	2124
De Chaunac	20.3b	3.36b	1.23b	0.67b	0.88b	1897
Light level (LL)						
High	22.1a	3.28a	1.17a	0.48a	0.76a	1595a
Low	16.7b	3.64b	1.12b	0.64b	0.69b	2427b
Cluster number (CN)						
1	19.6	3.47	1.16	0.59	0.73	2193
2	19.2	3.45	1.13	0.54	0.71	1830
F-significance						
CV	***	***	***	***	***	NS
LL	***	***	*	***	**	*
CV X LL	**	**	**	NS	***	NS
CN	NS	NS	NS	NS	NS	NS
CV X CN	NS	NS	NS	NS	NS	NS
LL X CN	NS	NS	NS	NS	NS	NS
CV X LL X CN	NS	NS	NS	NS	NS	NS

[z] Different letters within each column, cultivar, light level, and cluster number signify statistical differences at P = 0.05.
NS, *, **, *** Nonsignificant or significant at P = 0.05, 0.01, and 0.001, respectively.

at cluster height, depending on the ambient sky conditions outside the greenhouse. For example, light quantity readings taken concurrently with photosynthesis readings under treatment conditions indicated high light and low light treatments averaged 240 μmol $m^{-2}s^{-1}$ and 21 μmol $m^{-2}s^{-1}$ PPF when taken at pea size, and 378 μmol $m^{-2}s^{-1}$ and 21 μmol $m^{-2}s^{-1}$ PPF when taken at veraison, respectively. These values correspond to light quantities observed in grapevine canopies in the field, which can fall below 10 μmol $m^{-2}s^{-1}$ PPF in extremely dense canopies (22,23). Comparisons between the photosynthetic rates of 'De Chaunac' vines taken at similar stages of development, under treatment conditions and saturated conditions, suggest that high light areas exceeded the light saturation point on some dates and fell below the light saturation point on others. In contrast, low light areas were always below the light saturation point for vines.

These light levels influenced the photosynthetic capacity of leaves. When vines were exposed to saturated light levels ≥800 μmol $m^{-2}s^{-1}$ of PPF), leaves opposite the basal clusters, normally subjected to low light levels, exhibited lower photosynthesis rates than leaves normally subjected to high light levels. In contrast, leaves at the 14th node had similar photosynthesis rates regardless of normal light level treatment, when exposed to light levels above 800 μmol $m^{-2}s^{-1}$ PPF.

Comparisons among the percentages of total treatment errors due to cultivar, light level, cluster number, and their interactions indicated that 81% of the treatment errors of the percentages of berries matured and shot berries could be attributed to light level. The percentage of berries matured, yield per vine, average cluster weight, average berry weight, and berries per cluster were severely reduced by low light treatments. In essence, low light treatments, eliminated the cropping factor under these conditions, especially in 'De Chaunac'. 'De Chaunac' clusters set approximately 21 and 14 berries per cluster, or around 21 to 28 berries per vine, under low light conditions when one and two clusters were retained, respectively, and 'De Chaunac' clusters set 54 and 51 berries per cluster, or 54 and 102 berries per vine, under high light conditions when one and two clusters were retained, respectively. In 'Seyval blanc', vines with one and two clusters per plant matured 52 and 94 berries per vine under high light, and 26 and 42 berries per vine under low light, respectively. The majority of the remaining treatment variation could be attributed to cultivar differences. For example, 14% and 10% of the remaining 19% of the treatment error for the percentages of berries matured and shot berries, respectively, was attributed to the cultivar factor.

The lower levels of photosynthesis and transpiration observed under low light conditions could help explain these large variations in development. The majority of berry abscission and cell division occurs within a three week period following anthesis (6,17). Both set and growth appear to be sensitive to environmental conditions during this time period. For example, 'Cabernet franc' vines, subjected to water-deficit conditions between anthesis and 22 days after anthesis, set only 45% as many berries and attained average berry weights at harvest only 25% as heavy as unstressed controls (11). The authors attributed these results to a combination of reduced photosynthesis, fruit turgor, and cell division brought about during the water stress. In the current study, vines grown under low light had 54% lower transpiration rates as leaves grown under high light. Considering that over 80% of the water supplied to the berries prior to veraison enters the xylem (10), this reduction in water flow could influence the water balance of the berry and subsequent berry growth early in the season. Furthermore, defoliating 'Pinot noir' grapevines at bloom and two weeks after bloom has been shown to reduce berry set by 50% and 25% the set of intact controls, respectively, whereas defoliating vines later in development has no influence on set (6). From these results, the authors concluded that the organic nutrient supply is critical to the retention of berries during this period. These findings closely correlate with results found on apple trees, where reducing the next photosynthesis of the tree either by applying a photosynthetic inhibitor or through shading was shown to promote fruit abscission (3,4). In the current study, Pn rates from low light conditions were 11% or less leaves subjected to high light levels, when berries were at pea-size. Considering that water uptake into berries post-veraison is supplied predominantly through the phloem (10), increased photosynthesis could also indirectly promote berry growth late in the season by promoting cell expansion through increased water supply entering concurrently with photosynthates.

Vines exposed to low light levels and vines with two clusters had smaller rachis diameters compared to their counterparts. Schultz and Matthews (21) reported that defruited vines grown under shaded conditions produced lower amounts of dry-matter overall and redistributed a greater percentage of their reserves away from stems and petioles toward producing larger leaves compared to vines exposed to full sun. Furthermore, they found that shaded conditions reduced the diameters of stems and petioles and decreased the number of xylem conduits in the petioles. These findings coupled with the reduced rachis diameters observed in our study suggest that clusters grown under shaded conditions could also have reduced vascular systems to support cluster growth. Vines with two clusters per shoot also possessed reduced rachis diameters compared to vines with one cluster per shoot. These results correspond with the decreased rachis size of clusters from heavily cropped 'Seyval blanc' vines in the field (13). After two years, the rachis diameters of clusters from vines supporting 80 clusters per vine were less than 70% of rachis diameters of clusters from vines with similar architects supporting 20 clusters per vine (13). In the present study, the sensitivity of the rachis size to light level and cluster number differed between the two cultivars. Light level and cluster number accounted for 88% and 5% of the treatment error for 'Seyval blanc' and accounted for 33% and 61% of the treatment error for 'De Chaunac', respectively.

In both cultivars, low light levels reduced the soluble solid concentrations and elevated the malic acid concentrations and the pH of the berries. These results correspond with previous studies examining the effect of foliage shade on berry quality (16,24). Overall, light level accounted for 84%, 70%, and 32% of the treatment error for soluble solids, pH, and malic acid concentraction, respectively. The reduced soluble solid concentrations and elevated malic acid concentration reflect the traditional delay in ripening observed under shaded conditions. In contrast, pH values were probably related to the increased potassium ion concentrations observed under low light. The cultivar x light level interactions accounted for 5%, 7%, and 6% of the treatment errors of soluble solids, pH, and titratable acidity, respectively. The soluble solids and pH of 'Seyval blanc' clusters were more sensitive and the titratable acidity levels and tartaric acid concentrations less sensitive to low light conditions compared to 'De Chaunac' clusters. The accumulation of soluble solids was depressed under low light conditions in both cultivars, with 'De Chaunac' responding the least severely with a 4° Brix reduction in soluble solids compared to a 7° Brix reduction in 'Seyval blanc'. Moreover, under low light conditions, 'De Chaunac' clusters had significantly lower pH values compared to 'Seyval blanc' clusters, even though pH values of both cultivars were similar under high light conditions. The titratable acidity and tartaric acid concentrations of 'De Chaunac' clusters were higher than 'Seyval blanc' clusters regardless of light level. Whereas low light levels reduced the titratable acidity and tartaric acid concentrations of the 'De Chaunac' clusters, light level did not alter the titratable acidity or tartaric acid concentrations of 'Seyval blanc' clusters. This increase in the tartaric acid concentration of 'De Chaunac' clusters under high light could be related to the developmental stage of berries when treatments were imposed. The accumulation of tartaric acid in grape berries occurs rapidly up until about four weeks after anthesis and then remains relatively constant on a per berry basis until harvest (16,20). Since the initiation of the experiment was begun when 'De Chaunac' vines were in this phase of rapid tartaric acid accumulation, vines exposed to high light possessed higher sugar levels available for conversion to tartaric acid during this phase of development. Overall, the influence of cluster number on fruit quality was minimal. In both cultivars, soluble solids tended to be lower and malic acid concentration tended to be higher when two clusters were retained per vine. These trends correspond with the delay in ripening traditionally observed in 'Seyval blanc' and 'De Chaunac' with increased cropping (7,8,15,19). 'De Chaunac' vines with two clusters per vine also possessed lower potassium ion concentrations and tended to have lower pH than vines with one cluster per vine.

In summary, both cultivars responded similarly to a crop load of one or two clusters per vine. The rachis diameter, average berry weight, soluble solids, and pH of 'Seyval blanc' vines responded to reduced light levels to a greater extent than 'De Chaunac'. However, low light levels had a greater influence on 'De Chaunac' for the following parameters: average cluster weight, berries per cluster, yield, tartaric acid concentration and titratable acidity. The rachis diameters of both cultivars were depressed under low light levels and when two clusters were retained per vine suggesting a reduction in vascular development under these conditions.

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Ethylene Effects on Apple Sugar Concentration

Ethylene accelerates sugar accumulation with nearly 50% of the increase in Brix of 'Delicious' apple fruit dependent on ethylene produced by the fruit during maturation. Ethylene accelerates accumulation of sucrose although sorbitol content is also significantly correlated with internal ethylene. Apples sprayed with AVG accumulated sucrose less than non-sprayed there was no effect on other sugar forms or starch. Ethylene seemed to accelerate sucrose synthesis independently of starch decomposition. From Kashimura et al. 1994. ISHS Hort Congress Abstracts O-17-2 p. 54.