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Influence of cluster exposure on fruit composition and wine quality of Seyval blanc grapes

by

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Influence de l'exposition des grappes sur la composition des fruits et la qualité des vins (var. Seyval blanc)

R é s u m é : En 1981 et 1982 nous avons étudié l'influence de l'exposition des grappes sur la composition des raisins, la qualité des vins et l'incidence de la pourriture grise (*Botrytis cinerea* PERS.) sur le cépage producteur-direct Seyval blanc. Les échantillons de baies de 4 catégories d'exposition (exposition ouest, exposition est, ombrage partiel et ombrage total) avaient les valeurs les plus élevées pour les °Brix et l'acide tartrique et les plus faibles pour l'acidité totale et l'acide malique dans les raisins exposés après la véraison. L'acidité totale et l'acide malique étaient plus élevés dans les raisins exposés entre la nouaison et la véraison. Dans la saison 1981 l'exposition des grappes a également réduit l'incidence de la pourriture grise. Les différences de la qualité des vins étaient faibles et non significatives, mais les vins faits de grappes exposées étaient légèrement supérieurs. Des pratiques de formation des vignes augmentant l'exposition des fruits seraient utiles pour améliorer la qualité des raisins et du vin.

K e y w o r d s : light, berry, sugar, acidity, tartaric acid, malic acid, sensory rating, Botrytis.

Introduction

Recurring problems in the wine industry of eastern United States and Canada are low soluble solids (°Brix) and excessive titratable acidity (TA). These have been attributed to the short growing season, coupled with adverse climatic conditions. Reduction of TA has been addressed from an enological point of view (MATTICK and GOGEL 1980; MATTICK *et al.* 1980), but little attention has been paid to its viticultural abatement.

Studies in California by KLIEWER and LIDER (1968), KOBLET *et al.* (1977) in Switzerland, and GAPRINDASHVILI (1981) in Moldavian S. S. R. have demonstrated a reduction in TA and malate and an elevation of pH with increased cluster exposure, while SMART *et al.* (1985) have indicated highest pH in shaded fruit. Temperatures of berries grown in full sun were found by the former two groups to be respectively 19 °F (10 °C) and 6 °C higher than those grown in the shade. The apparent degradation of TA, especially malate, was attributed to this elevation in berry temperature. This relationship between TA and temperature is well established (AMERINE 1951; RIBÉREAU-GAYON 1959; RADLER 1965; KLIEWER 1971), and known to be due to an enhancement of malic enzyme (ME) activity (LAKSO and KLIEWER 1975, 1978) following véraison. Gluconeogenetic catabolism of malate by phosphoenolpyruvate carboxykinase (PEPCK) appears not to be temperature dependent (RUFFNER 1982 b).

Enhancement of sugar accumulation resulting from increased fruit exposure has also been documented (SHAULIS *et al.* 1966; KLIEWER and LIDER 1968; KOBLET *et al.* 1977).

This may be due to higher sink temperature, greater light intensity of the source leaves, or a combination of the two. KLENERT (1975) has suggested that following shading of berries their resultant low sugar content was due to a delay in the onset of berry maturation rather than reduced sugar accumulation. SHAULIS *et al.* (1966) recommended Geneva Double Curtain training to improve the light environment of the fruit, and to consequently increase °Brix.

Little has been published on the influence of fruit environment on the quality or the incidence of bunch rot (*Botrytis cinerea* PERS.), and results regarding the effects of temperature and light on tartrate have been very contradictory (KLIEWER 1968; KLIEWER and LIDER 1968; KOBLET *et al.* 1977). This study was initiated to investigate the influence of cluster exposure on the fruit composition and wine quality of the French-American hybrid grape cultivar Seyval blanc (Seyve-Villard 5276).

Materials and methods

1. Experimental design and plant material

Experiments were conducted during the 1981 and 1982 seasons on 10-year-old grafted Seyval blanc vines (rootstock Couderc 3309) at a 2.4 m × 2.7 vine × row spacing grown at Springledge Farms Ltd., Dundee, NY. Row orientation was north/south. Vines were trained to a midwire cordon system (REYNOLDS *et al.* 1985), pruned to a 15 + 10 pruning formula[1]), and cluster thinned to 1 cluster/shoot. All cultural practices were consistent with those recommended (JORDAN *et al.* 1981; BURR *et al.* 1982). Commencing July 8, 1981 and July 14, 1982, fruit was sampled on the basis of 4 exposure categories (treatments): W (exposed on the west side of the vine); E (exposed on the east side of the vine); P (partially shaded), and; S (fully shaded). There were 7 sampling dates at 10-d intervals from July 8 to Sept. 14, 1981 and 10 weekly from July 14 to Sept. 14, 1982. Three blocks of 48 vines each (2 short rows) were designated from a 6-row section of the vineyard, and sampling was carried out randomly across 12 vines/block (4 3-vine plots) of roughly-uniform vine size (c. 1—1.5 kg cane prunings/vine).

2. Fruit composition

Three 100-berry samples/treatment were selected on each sampling date for determination of fruit composition. Before analyzing, each sample was weighed, and a 50 g subsample was retained for analysis of TA and organic acids. The remainder of each sample was homogenized for 15 s at high speed in a Waring Blendor, and °Brix was measured on settled juice using an Abbé refractometer (Bausch and Lomb Co., Rochester, NY). Measurement of pH was performed on the homogenate using an Orion 501 digital pH meter.

Extracts were prepared from each 50 g subsample using the method of MATTICK (1983), and determination of TA was as described therein. Malate and tartrate concentrations were determined by the gas chromatographic procedure of MATTICK *et al.* (1970). The internal standard method was employed. A Beckman GC-4 gas chromatograph (GC) was used, equipped with a hydrogen flame ionization detector (FID), and a

[1]) A 15 + 10 pruning formula means that 15 nodes/vine are retained for the first lb. (0.4 kg) of cane prunings removed at pruning time and 10 nodes retained for each lb. (0.4 kg) thereafter.

180 cm × 2 mm glass column packed with 10 % SP-2100 Supelcoport 100—120 mesh. Column, detector, and injector temperatures were 190, 250, and 220 °C, respectively. Flow rates were: carrier gas (N_2): 20 ml/min; hydrogen: 20 ml/min; air: 300 ml/min. Quantitation was performed using an electrometer and a strip chart recorder (Fisher Recordall 5000), connected in parallel to a dedicated computer (Type 3353, Hewlett-Packard Corp.) suitable for the acquisition of laboratory data. The recorder was operated at a chart speed of 0.5 cm/min and 1 mV full scale.

3. Wine composition and quality

Five 15-kg samples were harvested from each exposure treatment independent of block on Sept. 14, 1981 and placed at 2 °C for 28 h. Three of the 5 samples from each treatment were chosen to generate data on incidence of bunch rot. Clusters per sample were counted and the number containing 30 % or more bunch rot by volume were noted. The 30 % figure was an arbitrary cutoff chosen due to severe bunch rot incidence in 1981. After these data were collected, all unsound fruit was removed from all samples. Vinification was carried out as described by BUTEAU *et al.* (1979), with the exception that no chaptalization, amelioration, or deacidification were possible, since

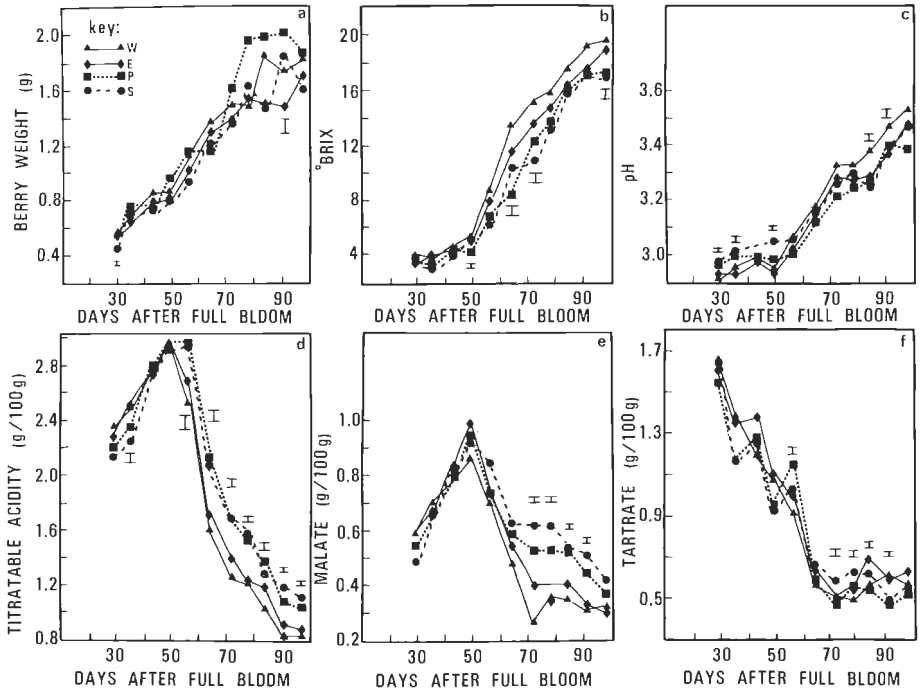

Fig. 1: Influence of cluster exposure on fruit composition of Seyval blanc, 1982. (a) berry weight, (b) °Brix, (c) pH, (d) titratable acidity, (e) malate, (f) tartrate. Vertical lines represent standard errors of the means; differences between means were significant if indicated.

Influence de l'exposition des grappes sur la composition des fruits de Seyval blanc, 1982. (a) poids moyen d'une baie, (b) °Brix, (c) pH, (d) acidité totale, (e) acide malique, (f) acide tartrique. Les lignes verticales représentent les erreurs des moyennes; les différences entre les moyennes ont été significatives si indiqués.

such procedures would have obliterated any treatment differences. The yeast used was a mixture of ST61, R92, and R107 (*Saccharomyces cerevisiae*), supplied by Dr. C. L. DUITSCHAEVER, University of Guelph. Filtration and fining were not performed. Two 20-l fermentation replicates were made per treatment. Wines were not made in 1982.

Two 250 ml wine samples were obtained from each treatment, 1 per replicate, for chemical analysis. TA and pH were determined according to AMERINE and OUGH (1974). Ethanol concentration was determined by GC using a Hewlett-Packard 5880A equipped with a hydrogen FID and a 180 cm × 2 mm glass column packed with Carbowax 600 on Chromosorb T 40—60 mesh. Column, detector, and injector temperatures were 80, 125 and 80 °C, respectively. Flow rates were: carrier gas (N_2): 20 ml/min; hydrogen: 20 ml/min, air: 250 ml/min. Sample dilution was performed with a Fisher Dilutimat to 200 : 1 with a 0.05 % butanol internal standard solution. Quantitation was as described for the Beckman GC-4, except that no strip chart recorder was necessary.

Wine quality was assessed using a 10-point line scoresheet. Three parameters were evaluated: 1. intensity of aroma; 2. perception of acidity, and; 3. overall quality. The design was a randomized complete block with 8 blocks (i. e. panelists) and 2 replicates/block. Replicate fermentations were tasted on consecutive days.

4. Meteorological effects

Fruit temperatures of the 4 exposure categories (W,E,P,S) were monitored pre-véraison (July 29 to Aug. 6, 1982) and post-véraison (Sept 17 to 23, 1982) using a Campbell CR-21 Micrologger (Campbell Scientific Inc., Logan, UT). A total of 6 thermistors were employed; 2 each for the W and S exposures, and 1 apiece for the E and P treatments. The thermistors were placed tightly against representative berries within each cluster, and secured with wire where necessary.

On Aug. 11, 1982, a typical cloudless day, 10 clusters from each exposure category were chosen for investigation of radiation levels. Measurements were begun at 09.00 h and continued every 1/2 h until 16.30 h. Photosynthetic photon flux density (PPFD) was measured by a LI-COR LI-185A integrating quantum/radiometer/photometer (LI-COR Inc., Lincoln, NB). The quantum probe (LI-190SB) was held approximately 5 cm above and in the plane of the side of each cluster.

Results

1. Fruit composition

There were few significant differences in berry weight between treatments in 1982, although P fruit tended to have the heaviest berries for the majority of the sampling dates (Fig. 1 a). Fruit composition both before and after véraison[2]) was affected by the degree of fruit exposure. Pre-véraison, °Brix was unaffected by exposure, but following véraison, the exposed treatments (W and E) displayed higher °Brix (Fig. 1 b) than shaded fruit (P and S).

In general, pH showed considerably less response to cluster exposure than did °Brix (Fig. 1 c). The S treatment had highest pH before véraison, while post-véraison, pH was generally highest for the W treatment. Total acidity tended to be highest in exposed treatments before véraison, and highest in shaded treatments after véraison. Pre-véraison, W clusters had the highest TA, while post-véraison, W had the lowest TA, followed by E, then P and/or S (Fig. 1 d).

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[2]) Actual time of véraison was approximately August 5, 1982, plus or minus a few days.

Malate response paralleled that of TA with a tendency for highest concentration in exposed fruit pre-véraison, and lowest in those same treatments post-véraison. No pre-véraison differences were apparent, but post-véraison differences between treatments were highly significant (Fig. 1 e). The W treatment tended to have the lowest malate, followed in most cases by E, then P and S. Tartrate concentration tended to decrease from a maximum shortly after bloom to a minimum at véraison, after which little change occurred. During the seasons studied, no differences between treatments were apparent pre-véraison, but following véraison, S fruit contained the highest tartrate concentration for most sampling dates. The W treatment had the lowest concentration (Fig. 1 f).

Only the 1982 fruit composition data have been presented here for the sake of conciseness and clarity. Results of 1981 displayed similar trends.

2. Must and wine composition

Bulk samples selected for winemaking showed a response to exposure in terms of a reduction in the percentage of bunch rot-infected clusters (Table 1). Effects of fruit

Table 1

Influence of cluster exposure on bunch rot infection and must and wine composition in Seyval blanc, 1981[1])

Influence de l'exposition des grappes sur la pourriture grise et la composition des moûts et des vins (var. Seyval blanc, 1981)

Exposure	Bunch rot (%)[2])	Must composition			Wine composition		
		°Brix	TA[3]	pH	ETOH[4])	TA[3]	pH
West	22.0a	17.0 a	0.82 c	3.13 b	11.2 a	0.92 b	3.27 b
East	18.2 a	16.9 ab	0.82 c	3.10 c	10.8 ab	0.94 ab	3.25 b
Partial shade	28.7 ab	16.4 b	0.86 b	3.13 b	10.4 b	0.96 ab	3.29 a
Shade	36.0 b	15.8 c	0.89 a	3.19 a	9.5 c	1.01 a	3.34 a

[1]) Means separated at P = 0.05 by Duncan's Multiple Range Test.
[2]) Percentage of total cluster number infected by *Botytis cinerea*. Clusters were considered infected if 30 % or more of their volume was occupied by bunch rot.
[3]) Titratable acidity as grams tartaric acid/ 100 ml of must or wine.
[4]) Percent ethanol.

Table 2

Influence of cluster exposure on Seyval blanc wine quality, 1981[1])

Influence de l'exposition des grappes sur la qualité des vins (var. Seyval blanc, 1981)

Exposure	Intensity of aroma[2])	Perceived acidity[2])	Quality[2])
West	5.0 a	5.1 a	4.7 a
East	5.6 a	5.1 a	5.6 a
Partial shade	4.9 a	4.6 a	4.4 a
Shade	4.9 a	5.0 a	4.7 a

[1]) Means separated at P = 0.05 by Duncan's Multiple Test.
[2]) Based on a 10-point line scoresheet.

exposure on must composition were similar to those cited previously for the berries, with TA lowest and °Brix highest for the W treatment (Table 1). In general, pH was highest for the S treatment, unlike that observed in the fruit samples.

Wine composition paralleled that of the musts, and the effects of fruit exposure were maintained through the fermentation in terms of TA and % ethanol (Table 1). Despite the compositional differences, wine scores did not differ between treatments on the basis of intensity of aroma, acidity, or quality (Table 2). A significant panelist effect was noticed for the aroma parameter.

3. Meteorological effects

Berries from W and E clusters were higher in temperature than S berries at all times of the day. The heat loads accumulated by the W and E berries during daylight hours seemed to be sufficient to counteract the expected diurnal temperature fluctuation; this might explain their higher temperatures over the P and S fruit during the early morning hours. Largest differences (4—13 °C) between exposed (W and E) and shaded (P and S) fruit occurred between 1200 and 1800 h (Table 3). Temperatures of W berries were higher than those of E berries during all times of the day, despite the fact

Table 3

Pre-véraison Seyval blanc berry temperatures, July 30, 1982

Températures des baies avant véraison, 30 juillet 1982

Time (h)	Temperature (°)			
	West	East	Partial shade	Shade
01.00	22.3	21.8	21.1	19.2
02.00	22.2	21.6	20.3	18.5
03.00	21.4	21.1	19.9	18.2
04.00	21.3	20.9	19.5	18.1
05.00	21.6	21.0	19.7	18.4
06.00	21.7	21.1	19.2	18.2
07.00	21.9	21.1	19.7	18.6
08.00	22.9	21.8	21.0	19.8
09.00	24.3	23.7	21.3	20.4
10.00	25.8	23.7	24.0	22.2
11.00	29.1	27.0	25.8	24.2
12.00	29.9	28.3	26.6	25.1
13.00	32.1	29.4	27.7	26.5
14.00	37.5	29.4	29.5	27.5
15.00	40.8	30.9	28.8	27.6
16.00	39.2	30.2	29.1	27.8
17.00	37.4	28.3	25.6	25.0
18.00	35.5	28.0	28.3	26.0
19.00	36.5	27.4	24.8	24.3
20.00	29.5	24.6	21.7	21.6
21.00	24.1	22.3	19.7	19.4
22.00	22.1	21.7	19.2	18.9
23.00	21.6	20.8	18.3	18.0
24.00	21.8	20.6	19.1	18.7

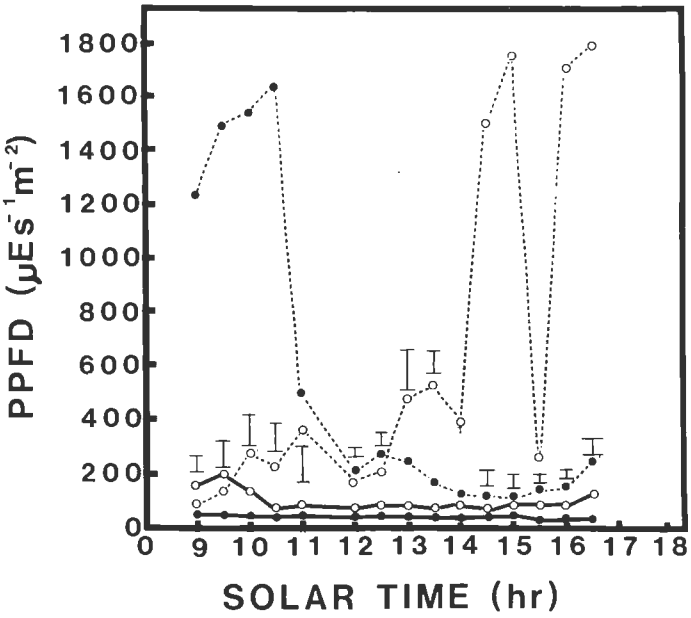

Fig. 2: Photosynthetic photon flux density for Seyval blanc clusters from 4 exposure categories, August 11, 1982. Vertical lines represent standard errors of the means. — Broken lines, solid circles — east exposure; broken lines, open circles — west exposure; solid lines, open circles — partially shaded exposure; solid lines, solid circles — fully shaded exposure.

Photon fluxe densité photosynthétique des grappes (var. Seyval blanc) de 4 catégories d'exposition, 11 août 1982. Les lignes verticales représentent les erreurs des moyennes. — Lignes discontinues, cercles blancs — esposition est; lignes discontinues, cercles noirs — exposition ouest; lignes continues, cercles blancs — exposition ombrage partiel; lignes continues, cercles noirs — exposition ombrage total.

that E fruit received more PPFD than W fruit during the morning hours (Fig. 2). Temperatures of P fruit were consistently higher than those of S fruit, and slightly lower than those of E fruit. Other sampling dates displayed similar trends (data not shown).

Large differences in PPFD were observed for clusters of the 4 exposure treatments in 1982. The S treatment varied little throughout the day as to its light environment (Fig. 2). Treatment P received consistently higher levels of radiation than the S treatment, although these were often not significantly different. The E treatment got high amounts of radiation between 09.00 and 11.00 h, after which levels diminished considerably; subsequent to this time, radiation received by E clusters still remained higher for most sampling times than that received by the P or S treatments. The W treatment tended to receive higher levels of radiation than the P or S treatments throughout the morning, but not significantly so until 11.00 h. This treatment peaked in radiation received from 14.00 h onward, except for a temporary (c. 0.5 h) drop due to overcast conditions.

Between 11.00 and 12.30 h, W and E clusters were virtually equivalent in radiation received (Fig. 2). Overall, however, for this particular day of sampling, W clusters received higher levels of PPFD during their 'peak hours' (i. e. 14.00—18.00 h) than E clusters got during theirs (09.00—11.00 h), and the period during which they received these high radiation levels was much longer than for E clusters.

Discussion

Fruit exposure had an influence on berry temperature, PPFD received, berry weight, translocation (°Brix) and acid metabolism (pH, TA, malate, and tartrate). It is generally accepted that PPFD accounts for roughly 50 % of total incoming radiation (LAKSO, personal communication), so it can be related indirectly to the heat load accumulated by the fruit. High berry weight of the P treatment for most post-véraison sampling dates is consistent with information reported by KOBAYASHI *et al.* (1965, 1967) and RADLER (1965), the former of whom indicated that the optimum day temperature for the growth of 'Delaware' berries was 22 °C. Day temperatures of P fruit ranged from 19.2 to 29.5 °C on the sampling date reported (Table 3). On the other hand, temperatures in excess of 30 °C (which were consistently attained by exposed fruit in this study) were found by KOBAYASHI *et al.* (1965, 1967) to be inhibitory to berry growth. Results obtained in this study might be attributed to lower transpiration rates in P clusters associated with the low berry temperatures, which could have led to increased cell expansion through higher turgor pressure. This evidently was sufficient to offset the apparently lower translocation rates at these temperatures, which could have contributed to a decrease in berry weight. The slight benefit of fruit exposure immediately following berry set may have been due to an increase in cell division, as was previously inferred by KOBAYASHI *et al.* (1965, 1967).

The fact that pre-véraison fruit exposure did not affect °Brix was expected, since little if any accumulation takes place during Stages I and II (WINKLER *et al.* 1974). The small amount present (about 4 %) likely was a result of translocation from the leaves, but much of this was offset by respiratory losses or used in berry growth. Temperature appeared to have no net effect on these processes.

Following véraison, the high berry temperatures associated with exposed fruit apparently increased the translocation rate sufficiently to allow the high °Brix which was characteristic of these treatments. An equally-possible explanation is that the leaves associated with the exposed clusters enjoyed high photosynthetic rates, and hence exported more photosynthate to their subtending clusters. This substantiates work by several authors (AMERINE and WINKLER 1941; RADLER 1965; KOBAYASHI *et al.* 1967; KLIEWER 1968; HOFÄCKER *et al.* 1976; KLENERT *et al.* 1978), who have associated higher °Brix with increases in fruit temperature, although WARDLAW (1974) showed virtually no response of translocation to sink temperature in wheat. Differences in °Brix were often significant between W and E fruit; the higher radiation levels striking the W fruit (if one assumes the day of sampling to be a typical one) accounted for this. It seems apparent that sink temperature in *Vitis* has a positive influence on the translocation of sugar. It is also very likely that the increase in leaf exposure on shoots bearing W and E clusters had a similar effect.

With acid metabolism, fruit exposure effects were almost exclusively on malic acid. Most studies have indicated an optimum temperature for malate synthesis (i. e. phosphoenolpyruvate carboxylase (PEPC) and phosphoenolpyruvate carboxykinase (PEPCK) activities) of 25 °C (LAKSO and KLIEWER 1975, 1978), and at least 30 °C for degradation. In 1982, TA was highest in exposed clusters pre-véraison, as shown by KLENERT (1975), presumably due to an increase in the activities of PEPC and PEPCK (RUFFNER *et al.* 1976). Although day temperatures of W and E berries were higher than optimal for the activities of these enzymes (Table 3), the temperatures of the P and S fruit were likely suboptimal, such that exposed fruit emerged with highest TA during that stage of berry development. Malate concentration for E fruit was also higher than for shaded fruit pre-véraison. Following véraison, the apparent enhanced activity of malic enzyme in W and E fruit contributed to a greater decrease in TA than that in the

shaded fruit, as a result of the associated high berry temperatures (RUFFNER 1982 b). Responses of malate were attributable to these same processes.

Tartaric acid catabolism has generally been considered to be unaffected by berry temperatures below 30 °C (GERBER 1896; KLIEWER 1964, 1971; KLIEWER and LIDER 1968; RUFFNER 1982 a). Few studies have demonstrated an influence of fruit temperature or exposure on the concentration of tartrate in the fruit (KLIEWER 1964; KLIEWER and LIDER 1968, 1970; BUTTROSE *et al.* 1971). This seemed apparent for Seyval blanc, for the data suggests that fruit (sink) temperature was of some minor consequence; during the early portions of Stage III, day temperatures of W and E clusters (Table 3) were sufficiently high to allow a greater decrease in tartrate than that in P and S fruit. Towards fruit maturity, the higher levels of radiation received by W and E fruit and their subtending leaves may have favored increased tartrate synthesis and translocation; this was evidenced by high tartrate concentration in W and E fruit. This contradicts results of KLIEWER (1968), who found higher tartrate concentration in fruit grown in phytotron rooms which were considerably cooler than the field. It is unlikely that these differences in tartrate concentration are of major consequence, since most tartrate is removed following fermentation during deacidification and/or cold stabilization.

Differences in pH were linked with those of TA and malate, but post-véraison response was likely accentuated by high K^+ (although not measured) in W and E fruit. This temperature influence on pH is substantiated by previous reports (KLIEWER 1968; KLIEWER and LIDER 1970; KOBLET *et al.* 1977).

Influence of cluster exposure on composition of the musts and wines was also comparable to previously-reported trends. The higher pH in the S musts and wines is consistent with data obtained by SMART (1982) and SMART *et al.* (1985).

Bunch rot reduction in W and E fruit was conceivably due to increased air circulation, lower relative humidity, and warmer berry temperatures. The infection and growth of *Botrytis cinerea* is favored by high relative humidity and cool (15—20 °C) fruit temperature (WINKLER *et al.* 1974).

The lack of significant wine quality differences is likely because differences in fruit composition between treatments were insufficient to evoke organoleptic differences. Also, Seyval blanc typically has a neutral wine character, and the detection of differences in such parameters as intensity of aroma and quality is extremely difficult. High TA and the apparent presence of slight amounts of H_2S in some samples may have confounded the results to some degree.

In conclusion, it appears that differences in fruit composition can be achieved through modification of the fruit microclimate. Increases in fruit exposure lead to an apparent increase in translocation (resulting in higher °Brix and/or tartrate), and a heightening of acid metabolism. Incidence of bunch rot can also be reduced. The adoption of canopy management practices which enhance fruit exposure are recommended for cool climates where high fruit quality is a major priority.

Summary

Experiments were conducted in 1981 and 1982 to investigate the influence of cluster exposure on fruit composition, wine quality, and incidence of bunch rot (*Botrytis cinerea* PERS.) of the French-American hybrid grape cultivar Seyval blanc. Berry sampling from 4 exposure categories (western exposure, eastern exposure, partial shade, and full shade) indicated highest °Brix, pH and tartrate, and lowest titratable acidity (TA) and malate in the exposed fruit post véraison. Total acidity and malate were high-

est in exposed fruit between fruit set and véraison. Exposure of the fruit also reduced the incidence of bunch rot during the 1981 season. Wine quality differences were small and not statistically significant, although wines vinted from exposed fruit tended to score higher. Canopy management practices that optimize fruit exposure would be helpful in maximization of fruit and wine quality.

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