Effects of Crop Level on Fruit Composition of Pinot noir Grapes

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Introduction

A broad range of factors influences wine grape quality and its manipulation has stimulated interest among grape growers, wine makers, and research scientists alike. One such factor affecting wine grape quality is crop level, particularly for Pinot noir. Since the capacity of a vine to ripen fruit depends largely on the rate of photosynthesis and accumulation of carbohydrates, it follows that a quantitative crop level may be related qualitatively to fruit composition. Of all factors affecting fruit ripening, crop level is the most likely one which growers can manipulate (Winkler *et al.*, 1974). Many experiments have been conducted to determine the ideal crop load of several varieties grown in various climates (Winkler *et al.*, 1974; Bravdo et al, 1984, 85 & 96; Edson *et al.*, 1995; Reynolds *et al.*, 1989, 94 & 96; Koblet *et al.*, 1996; Miller *et al.*, 1996, 97 & 98). The majority of these studies however have examined the effects when clusters are thinned at fruit set. Results from these studies showed that the vines exhibited yield compensation, producing larger clusters with bigger berries. As a result, sugar concentration within the fruit is reduced due to an increased berry volume. A study conducted in Oregon during the summer of 1982 upon Pinot Noir, Chardonnay and White Riesling reported increases in soluble solids, pH and a reduction in titratable acidity for véraison thinned treatments compared to thinning treatments just after bloom (Lombard *et al.*,1983). To avoid yield compensation, clusters should be thinned at anytime after the onset of lag phase, after the final number of cells per berry has been established. At this point, further growth is by cell enlargement due to the import of sugars and water. This growth is accompanied by other changes in fruit composition such as a decrease in acid levels, an increase in anthocyanin levels, and changes in aroma and flavor compounds, each contributing to the quality of the grape. Another process occurring simultaneously with fruit ripening is the replenishment of carbohydrate reserves in the permanent structure, crucial for plant survival and yield stability (Candolfi-Vasconcelos & Koblet, 1990). Heavy or unbalanced crop loads affect the level of reserves available in the spring.

It is not uncommon for the Pinot noir of Oregon to rival those of the Burgundy region in France. It is also not uncommon for the quality of these wines to vary with each vintage, as an additional factor influential to ripening is temperature. Heat summation plays an important role in the accumulation of sugar and the rate of other metabolic processes occurring during ripening. In cooler climate regions, some cultivars are slow to ripen and cluster thinning may be employed to advance ripening (Winkler *et al.*, 1974; Reynolds *et al.*, 1989). In cooler climate regions with rainy harvest seasons, where fungus infestation threatens fruit soundness, cluster thinning is a common practice. Many Oregon wineries prefer to buy grapes from low yielding vineyards, forcing growers to thin their crop. The inherent trouble with this practice is too low of a crop level, which in some cases may equate with too little revenue for the grower. While this practice is acceptable, an optimal yield for quality has yet to be determined, and warrants further investigation in this area.

Materials and Methods

The experiment consists of two trials, each independent and at different vineyard locations. Site one (#1) was situated within the acreage of the Willakenzie Estate vineyard. The vines that were selected are double Guyot trained Pinot noir clones (Dijon 113) on 3309 rootstocks with spacing of 2.5 x 1.67 m (7.5 x 5 ft) and were planted in 1996. Willakenzie silt loam is the soil type for this site. Elevation for the Willakenzie site is approximately 152 m (500 ft). Site two (#2) was located at Hyland vineyard where selected data vines are Pinot noir clones (Coury selection) planted on own roots and are trained to a modified Lenz-Moser with two short arms supporting two canes each, similar to the standard Chablis training system. The first arises from the proximal part of the arm (closest to the trunk), and the second from the distal part of the permanent arm. In this training system, there is no overlapping of the four canes. These vines were established in 1974 and are spaced 3.33 x 3.33 m (10 x 10 ft) with Jory as their soil type. This site is also approximately 152 m (500 ft) in elevation.

Experimental Design

Data vines need to be homogeneous in their growth and fruit set to best exhibit treatment effects and to minimize confounding variables. Data vines were selected according to the average number of fruit per vine. Site #1 represents the second year in a two year study monitoring the impacts of fruit thinning and how this management practice affects vine health over successive years. Selection criteria for site #1 consisted of vines that had 25 to 35 clusters. Sixteen vine replicates per treatment level (25, 20, 15 and 10 clusters per vine) were established by cluster thinning at véraison totaling 64 vines. Thinning criteria consisted of removing green clusters first, then clusters distal to the base of the shoot. At site #2 we introduced another variable to the second year of this study: crop was thinned at two different times. New data vines were used for this revised experiment. Selection criteria for data vines at site #2 consisted of vines that had 45 to 55 clusters. Thinning criteria was that of site #1. Forty vine replicates per treatment level (25, 35 and 45 clusters per vine) were established by cluster thinning both at bloom and at véraison totaling 240 vines.

Yield and Fruit Quality

Fruit from site #1 was harvested on September 29th and from site #2 on October 6th of 2000. Mean cluster weight was determined per vine. Five clusters from each vine were randomly selected for determination of mean berry weight by randomly removing 20 berries per cluster and weighing the 100 berries. After weighing, these 100 berries were used to determine skin anthocyanin levels. The number of berries per cluster was calculated from the cluster weight to berry weight ratio. Seven clusters per vine were again randomly selected and crushed to determine °Brix, titratable acidity (TA) and pH. Analysis was performed in the viticulture laboratory of OSU using standard methods.

Carbohydrate Content

During pruning, wood samples from 2000 fruiting canes were collected and will be analyzed for carbohydrate levels using the method described by Candolfi-Vasconcelos and Koblet (1990).

Wine Quality

Fruit from both the bloom thinning and the véraison thinning treatments at the 25 and 45 clusters per vine level were separated into randomized lots and processed into wine. On October 10th, grapes were crushed, destemmed and 50mg/L SO_2 was added. Must was inoculated with 1 g/L of Lalvin RC 212 Bourgorouge yeast on October 12th and punch down was two times a day. Fermentation temperature and rates were monitored every 48 hours reaching a maximum temperature of 24^{O}C. The wine was then gently pressed from the skins using up to 4 bars of pressure on October 24. The wine then settled and racked off the gross lees and was then inoculated with .02g/gal of OSU Lalvin freeze-dried malolactic bacteria. Once cold stabilized and bottled, the wine will then be analyzed for total anthocyanin and phenolic content.

Results

Yield components at both sites that were significantly affected by crop level were those expected to be strongly correlated with cluster thinning such as yield per vine, yield per acre, clusters per shoot and the ratio of crop weight to pruning weight, or, the Ravaz Index (Tables 1, 3, 4 and 6). The regularity of shoots per vine for the differing treatment levels is an indication the overall uniformity of the data vines selected. Cluster thinning treatments linearly reduced the number of clusters per shoot from 1.5 to 0.8 at Hyland vineyard and from 1.7 to 0.7 at Willakenzie vineyard (Tables 1 and 4). Berry weights and cluster weights did not significantly increase in response to cluster thinning at site #1 but at site #2, the number of berries per cluster as well as the grape cluster weights decreased with increasing fruit levels (Tables 1 and 4). The comparison between thinning dates at site #2 showed no significant changes in yield components (Table 1). Prior research suggest that early thinning of fruit induces an increase in berry size due to accelerated cell division within the berry (Weaver *et al.*, 1974). This is a case where no yield compensation was observed. Yield component means from both the thinning date and crop level treatments were compared to determine the degree of treatment interactions and no significant changes to the means were observed (Table 1).

Juice composition for site #1 showed no response to imposed cluster thinning levels (Table 5). Data vines at site #2 with crop levels of 25 and 35 clusters per vine displayed a slight yet significant increase in juice soluble solids of the harvested fruit (Table 2). Juice pH was also negatively correlated with increasing crop levels (Table 2). Response of juice components to thinning dates showed a significant change in TA with higher acid concentrations in the fruit thinned at véraison (Table 2). Juice composition means from both the thinning date and crop level treatments were compared to determine the degree of treatment interactions and no significant changes to the means were observed (Table 2).

Pruning weights were higher at Willakenzie as compared to Hyland vineyard reflecting differences in vine maturity and spacing (Tables 3 and 6). There was no significant treatment differences in cane weights or pruning weights at both vineyard sites (Tables 3 and 6). Vines in balance should have canes in the 30 to 40 g range, 40 g being preferred in cool climates (R. E. Smart, personal communication, 1995). Cane weights from site #1 tended to be heavier than optimum where cane weights from site #2 tended to be lighter than optimum. The Ravaz index represents the ratio between reproductive and vegetative growth. Based on multi-season averages obtained at the OSU experinmental vineyard Woodhall III, balanced vines should remain between 5 and 7. When comparing vine vigor means to determine treatment interactions, the Ravax index displayed a stronger response when vines were thinned at bloom, suggesting either an accelerated increase in fruit weight or an accelerated decrease in pruning weights when clusters are thinned at bloom (Table 3 and Figure 1). Vines at Willakenzie are still in the establishment period and did not produce a full crop. Cane weights will decrease and the Ravaz index will increase as the vines mature and reach full production. Cropping vines with 45 clusters gave an optimum Ravaz index at Hyland Vineyard (Table 3). Vines thinned to 25 clusters resulted in a lower than desirable Ravaz index which may cause a progressive devigoration of the vine. Small yields and high pruning weights can give rise to a very low Ravaz index and excessively vigorous canes.

Discussion

Cluster thinning is often employed as a means of quality control as well as a method of hastening maturation. Pre-véraison removal of fruit clusters induces the cells within the berries to increase cell division activity creating larger berries and clusters, a phenomenon known as yield compensation. To avoid yield compensation, véraison cluster thinning is advisable. However, in this study no yield compensation was observed between the bloom thinned cluster weights and the véraison thinned cluster weights. In the two years of this study, removing crop at véraison did not improve fruit composition of the remaining clusters: soluble solid content, pH and titratable acidity levels did not respond to changes in crop level within the range of cropping levels we used in these experiments. When data means were tabulated as a function of crop load, ^{o}Brix (22.7 to 22.5) and pH (3.00 to 2.98) decreased marginally from with increasing crop level. The timing of crop removal had no effect on juice or yield components. However, cluster thinning changes the balance between vegetative and reproductive growth, favoring vegetative growth over fruit production. The effects of cluster thinning on vine vegetative growth and carbohydrate reserves within the perennial tissue should be followed over a period of several growing seasons to determine the long term impact of reducing crop. The evaluation of thinning effects on wine quality is in progress allowing greater elucidation of how management practices in the vineyard impact wine quality.

Further research into cluster thinning practices may allow for growers and winemakers to reevaluate the validity of the current thinning standards used to optimize juice quality.

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Table 1. Yield component means as a function of crop load and timing of crop thinning at Hyland Vineyard in 2000.

Clusters / Vine	Yield (kg / vine)		Yield (t / ac)		Berries/ cluster		Berry wt. (g)	Cluster wt. (g)		Shoots/ vine	Clusters/ shoot	
25	2.60	c [2]	1.24	c	81	ab	1.27	102	a	31	0.8	c
35	3.41	b	1.64	b	77	c	1.27	97	c	31	1.1	b
45	4.33	a	2.07	a	75	a	1.28	96	ab	31	1.5	a
Significant F	*** [1]		***		*		ns	*		ns	***	
Timing												
bloom	3.43		1.57		77		1.26	98		31	1.2	
veraison	3.46		1.63		79		1.28	100		31	1.2	
Significant F	ns		ns		ns		ns	ns		ns	ns	
Interaction												
Significant F	ns		ns		ns		ns	ns		ns	ns	

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.

Table 2. Juice composition means as a function of crop load and timing of crop thinning at Hyland Vineyard in 2000.

Clusters / Vine	Soluble solids (°Brix)		pH		Titratable acidity (g/L)	
25	22.7	a [2]	3.00	a	7.53	
35	22.7	a	3.00	a	7.43	
45	22.5	b	2.98	b	7.67	
Significant F	**		*		ns	
Timing						
bloom	22.7		3.00		7.43	b
veraison	22.7		2.99		7.62	a
Significant F	ns [1]		ns		*	
Interaction						
Significant F	ns		ns		ns	

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.

Table 3. Vine vigor means as a function of crop load and timing of crop thinning at Hyland Vineyard in 2000.

Clusters / Vine	Pruning weight (kg / vine)	Cane weight (g)	Ravaz Index	
25	0.76	25	3.7	c[2]
35	0.75	24	5.0	b
45	0.70	23	6.6	a
Significant F	ns [1]	ns	***	
Timing				
bloom	0.75	24	4.8	
veraison	0.73	24	5.0	
Significant F	ns [1]	ns	ns	
Interaction				
Significant F	ns	ns	*	

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.

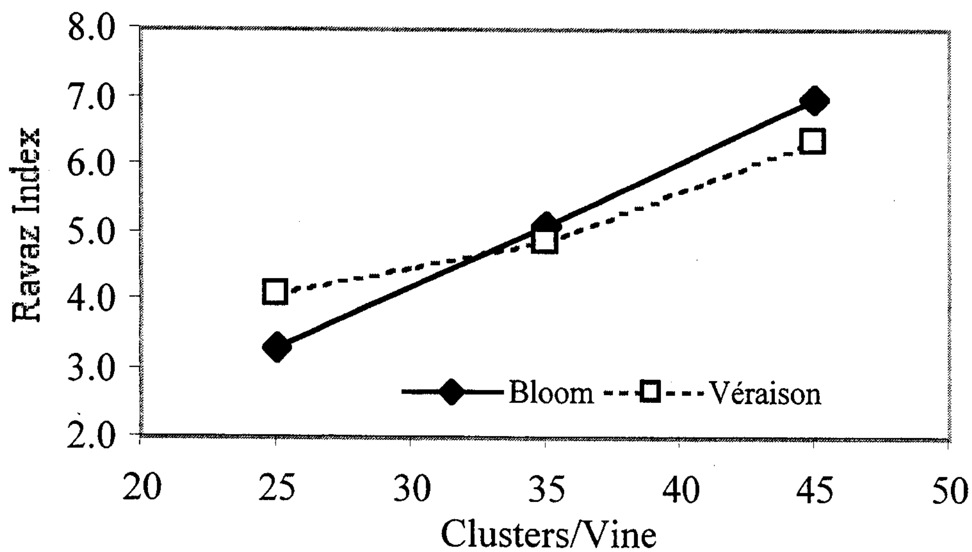

Figure 1: Interaction of crop load and timing of crop thinning on Ravaz Index at Hyland Vineyard in 2000.

Table 4. Yield components of Willakenzie Vineyard in 2000.

Clusters / Vine	Yield (kg / vine)		Yield (t / ac)		Berries/ cluster	Berry wt. (g)	Cluster wt. (g)	Shoots/ vine	Clusters/ shoot	
10	1.01	c	0.48	c	83	1.19	98.5	15	0.7	d
15	1.49	b	0.71	b	87	1.21	103.5	15	1.0	c
20	1.97	b	0.94	b	91	1.21	107.3	15	1.3	b
25	2.54	a	1.22	a	90	1.24	110.8	15	1.7	a
Significant F	***[1]		***		ns	ns	ns	ns	***	

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.

Table 5. Juice composition of Willakenzie Vineyard in 2000.

Clusters / Vine	Soluble solids (°Brix)	pH	Titratable acidity (g/L)
10	24.1	3.17	6.63
15	24.1	3.15	6.92
20	24.1	3.09	7.33
25	23.2	3.12	7.08
Significant F	ns[1]	ns	ns

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.

Table 6. Vine vigor and Ravaz Index of Willakenzie Vineyard in 2000.

Clusters / Vine	Pruning weight (kg / vine)	Cane weight (g)	Ravaz Index	
10	1.06	72	0.9	cd
15	1.14	77	1.4	bc
20	1.03	68	1.8	ab
25	1.08	74	2.5	a
Significant F	ns[1]	ns	***	

[1] ns, *, **, and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

[2] Values followed by the same letter are not significantly different.