Oregon Wine Advisory Board
Research Progress Report

1991 - 1992

The Development of Viticulture Practices to Improve Winegrape Performance and Wine Quality

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This project was initiated in 1984 and is a joint project of Department of Horticulture and the Department of Food Science and Technology. This progress report, serves as a report for Agriculture Research Foundation projects "The development of viticulture practices to improve winegrape performance" and "Evaluation of winegrapes cultural practices and processing to improve wine quality".

Objectives:

- Evaluate canopy management options available to Oregon growers for their effects on yield, grape composition, and wine quality.
- Investigate the relationships between vine growth, cluster environment, grape composition and wine quality.
- Develop techniques that improve the capabilities of Oregon winegrape growers to obtain consistent yields with maximum wine quality.
- Investigate nutritional problems in Oregon vineyards with an emphasis on nitrogen imbalances.

Progress Report:

1) Lewis-Brown Trellis Trial:

This trial was established to evaluate the effects of various trellis systems on vine growth, yield, fruit composition, and wine quality on four varieties of winegrapes. The trial consists of five trellis systems: standard upright vertical, cordon upright vertical, Scott Henry, lyre, and Geneva double curtain, and four varieties: Pinot noir, Chardonnay, Riesling, and Gewurztraminer. The standard and cordon treatments are spaced 1.5 x 2m and the double curtain systems are spaced 1.5 x 3m. AU the treatments were pruned to the same number of nodes per m^2 (5.3/rn2 or 0.5/ft2). This node density is similar to standard pruning systems used in Europe and is slightly higher than the usual node density used in Oregon vineyards. The close row spacing, however, results in a fairly low node number per meter of row (13.3 nodes/m for the single canopy systems and 10 nodes/m for the double canopy systems). These low node densities per meter of canopy have had a major impact on the results we are getting from the trial. Most trellis research has been done at higher node and shoot densities. These higher levels may tend to increase the differences between double and single canopy systems.

Vines have been in full production for three seasons. Crop loads this year were higher than previous years, ranging from 2.3 tons/acre on Gewurztraminer to 6.6 tons/acre on Riesling. There were no serious production problems this season. The trial plot had only slight injury from the December 1990 freeze and much lower levels of inflorescence necrosis than previous years. Growth, yield, and fruit composition were monitored on all four varieties and duplicate wine lots were made from all five trellis treatments in Pinot noir and Chardonnay. Morescence necrosis data from this season are discussed in the nitrogen. metabolism portion of this report.

The trial was designed to statistically compare responses to trellis within each variety and to compare the responses between the varieties. This season's full production on all four varieties allowed us to statistically compare the responses between the varieties for the first time. Much of the published information on trellises and canopy management comes from varieties not grown in Oregon. Can this information be transferred to Oregon conditions and our varieties or do different varieties respond differently?

This year's data clearly show that all four varieties have similar growth responses to trellising treatments. It also shows that production and quality responses are dependent on the variety and must be considered separately. Examples of the two types of responses are shown in Figures I and 3.

Growth Response. Pruning weight per square meter, shown in Figure 1, is typical of the growth responses observed in the trellis trial. In all four varieties, the Geneva Double Curtain (GDC) was the least vigorous trellis treatment and the upright vertical cordon pruned system (CRD) was the most vigorous. This difference is even more striking when the design of the trial is considered. All the trellis systems were pruned to the same number of nodes per square meter, so an increase in pruning weights on an area basis is synonymous with an increase in growth per node. For every node retained at pruning, the CRD had more than twice as much growth as the GDC. In addition, the GDC was the only trellis system not hedged during the summer, making the growth difference even more dramatic.

The high vigor of the CRD system is largely the result of the increased shoot numbers per node that we have seen each year with spur pruning. In addition to increasing total retained growth, the increased shoot numbers in cordon pruning also lead to denser canopies and, in some varieties, to higher acidities as well.

The growth differences between trellises are even greater when considered on the basis of pruning weight per meter of canopy (Figure 2). In this case, the design of the experiment accentuates the differences. The divided canopies were pruned to a lower number of nodes per meter of canopy [13.3 nodes/m for the upright single canopies (STD and CRD) and 10 nodes/m for the divided canopies (SH, Lyre, and GDC)I. Pruning weight per meter of canopy is often used as a benchmark. Nelson Shaulis has suggested that vines with pruning weights greater than 0.5 kg/m canopy are too dense and would respond to canopy division. In our trials this year, the cordon treatment was above that level in all four varieties and the cane pruned upright system was greater than 0.5 kg/m in Pinot noir and Gewurztraminer.

Quality Response. Quality responses were not the same with all varieties. Figure 3 is an example of a trellis response that is variety dependent (i.e. the varieties do not respond the same). Gewurztraminer and Chardonnay had very different titratable acidity responses to trellis systems. In Gewurztraminer, all the double canopy systems had higher TAs than the single canopies and in Chardonnay that response was reversed with the double canopies having lower TAs than the single upright systems.

The response difference is even more striking when TA values are correlated to pruning weights for the two varieties (Figures 4 and 5). In these figures, each data point is the mean of eight vines and represents one treatment in one block. Chardonnay showed a strong positive correlation between pruning weights per meter of canopy and TA (Figure 4). Dense canopies had higher TAs and light canopies had much lower TAs. Gewurztraminer had a very different response with a negative correlation and the least dense canopies having the highest TAs (Figure 5).

These kinds of differences are difficult to interpret without looking at many other factors. Factors that could be important include potassium and malate levels, yields, cluster weights, and the general level and time of maturity (Gewurztraminer was harvested on October 10 in hot, dry weather with light yields; Chardonnay was harvested on October 29 in cool, wet weather with high yields and high cluster weights).

Yield responses also varied by variety. Because of the design of the experiment, this trial has generally had small or insignificant differences between trellis treatments for yield on a per acre basis. All the vines are pruned to the same number of nodes per acre. This year, however, the Scott Henry trellis gave much higher yields for Chardonnay and Gewurztraminer. The increase was due both to an increase in clusters per node and cluster weight. There were no significant differences in yield per acre in Pinot noir or Riesling.

To evaluate labor requirements for pruning, man hours/acre were recorded for each variety and each trellis system for two years. Pruning time (hours/acre) was similar for Pinot noir, Chardonnay, and Riesling (STD = 51, GRD = 34, SH = 60, lyre = 60, GDC = 60). Gewurztraminer averaged about 9 hours more per acre. 'ne labor input for cordon pruning is substantially less than the other systems. This has been verified in other regions. The higher labor input for pruning the divided canopies is due to the increase in canopy length/acre (undivided = 6,642 feet of canopy/acre, divided = 8,856 feet of canopy/acre).

Yield and Quality in Pinot noir. In both 1990 and 1991, the concentration of anthocyanins and phenolics was generally higher in wine from the divided canopies (Figures 6 and 7 and Table 1). The differences were much greater in 1990. Yields and berry size were greater in 1991 than 1990 across all treatments, and the 1991 wines contained, on the average, 33% less color and total phenols.

The relationship between yield and the concentration of anthocyanins in the berry skins is shown in Figure 8. Generally, higher yields resulted in lower color. At any given yield, the anthocyanins were higher in fruit from the Scott Henry trellis. Two replications of the Scott Henry treatment had very high yields (around 10 tons/acre) while maintaining moderate color levels. Wines were made from pooled replications. The high yields in these two replications, therefore, had a disproportionate effect on maturity. That may be the cause of the low must Brix observed in the Scott Henry treatment in 1991 (Table 1). Across all treatments, the major factor affecting fruit anthocyanin concentration appeared to be berry weight (Figure 9).

In both 1990 and 1991, must pH was lower from the divided canopies. After completion of malolactic fermentation, new wines from the divided canopies had higher TAs and lower pHs than wines from the non-divided canopies (Figures 10 and 11 and Table 1).

Chardonnay Must and Wine. The 1991 must samples at harvest ranged from 19.0 to 20.1 'Brix, with the lowest Brix from the Scott Henry trellis system. The TA of the must samples was highest for the cane, cordon, and Scott Henry systems and lowest for the lyre and GDC.

The lowest pH at harvest was for the Scott Henry trellis system. Malate levels were generally greater for the single canopies than for the divided canopies. The differences in TA and pH in the new wines were similar to the must samples. The major compositional difference noted among the new wines was a greater concentration of total phenolics in the wines from the divided canopies (Table 2).

Conclusion. Growers with problems with excessive vigor may want to consider a divided canopy, particularly the GDC. The divided canopies also seem to offer a method of increasing wine color and phenolics and decreasing wine pH, provided yields are maintained at moderate levels.

2) Shoot Density Trial:

This trial was established to evaluate the effects of yield and canopy density on quality in Pinot noir. The trial was designed to separate canopy effects from yield effects. The trial includes four canopy treatments (10, 15, and 20 shoots/meter, and 20 shoots/meter on a Scott Henry trellis). Each canopy treatment is divided into two crop load treatments (full crop and 50% of the clusters removed). Cluster thinning was done just after fruit set.

Generally, the trial had higher yields in 1991 than in 1990, 2.9 and 1.7 tons/acre, respectively. These higher yields resulted in greater fruit and wine quality responses to cluster thinning and shoot densities than in 1990.

Yields and must Brix for each treatment are shown in Figure 12. The cluster thinned and unthinned treatments for each canopy are connected by a line to emphasize the thinning response. For each canopy, the thinned treatment is the point with lower yields and higher Brix. The higher yielding treatments (20 shoots/meter and 20 shoots/meter Scott Henry) had the greatest increase in Brix with thinning. It is interesting to note that the increase in Brix is proportional to the decrease in crop on all four canopy treatments (i.e. a decrease of one ton per acre resulted in an increase of about 0.6 'Brix).

Must samples at harvest had consistently higher Brix across all treatments for the thinned compared to the unthinned treatments, with 24.3 and 23.1 'Brix, respectively. Must titratable acidities of the thinned treatments were lower, averaging 6.3 and 6.9 g/l, respectively, and the pHs higher (3.22 and 3.14, respectively). The thinned and unthinned Scott Henry treatments had the lowest pH and the lowest malic acid content at harvest (Table 3).

Cluster thinning also increased the concentration of skin anthocyanins in each canopy (Figure 13). The Scott Henry canopy, however, had higher color at higher yields than the other canopy treatments. The unthinned Scott Henry trellis cropped at 5.5 tons/acre and had as much color as the 10 shoots/meter thinned treatment which cropped at 1.7 tons per acre. This response was similar but less dramatic for wine anthocyanin concentration (Table 3). In all canopy treatments, wines produced from thinned vines contained more anthocyanins. Increasing shoot density on unthinned treatments decreased wine anthocyanin content except on the Scott Henry treatment (Figure 14). The thinned Scott Henry produced new wines with greater total phenolic content as well as the highest anthocyanin content of any of the treatments.

The color response to thinning is also evident in Figure 15. This plot shows the berry weights and skin anthocyanin concentration for each replication of each treatment. Larger berry weights resulted in lower color. However, the thinned treatments generally had more color at a given berry weight than the unthinned treatments.

This trial reflected the range of cropping levels and crop adjustment decisions faced by many growers this season. Fruit composition and wine quality responses would suggest that thinning was justified in situations of high yields in 1991. However, thinning a canopy with high shoot densities was not as effective for improving fruit composition and wine quality as thinning canopies with lower shoot densities or using divided canopies. The Scott Henry trellis appeared to be able to support a higher crop level with comparable sugar and color and lower titratable acidity and pH. The Scott Henry trellis did respond to thinning, suggesting that yield is a limiting factor even in divided canopies.

3) Pinot Noir Maturity Trial:

Replicated wine lots were produced in 1991 for the Pinot noir maturity study. Previously, wines were produced and maturity monitored in 1987, 1988, and 1989. A later maturing season with higher yields than previous years suggested that data from this vintage could help profile another unique harvest season. Field samples were monitored over a 42-day period, from September 19 to October 31, for berry weight, Brix, TA, pH, malate, anthocyanin, and phenolic composition. Replicated wine lots were produced for four harvest dates: October 7, 14, 23, and 31 (Table 4). Berry weights reached a maximum by mid-October, corresponding to a maximum in anthocyanin concentration in the fruit. The phenolic content in the berry skins increased progressively up to mid-October as well. A very large increase in total phenols in the berry skins occurred between about October 10 and 14, an increase of greater than two-fold. After mid-October, the phenolic levels remained high but fluctuated up and down. Phenolic levels in the new wines showed similar fluctuations, increasing and decreasing as the concentration in the skin extracts changed (Figure 16). Anthocyanin content in the new wines reached a maximum by October 14 and did not fluctuate with the wine phenolic composition (Figure 17).

The Pinot noir maturity data from several years provides an interesting comparative profile of the differences among vintages (Table 5). In any given year, at full fruit maturity, the average berry weights may vary dramatically. The maximum concentration of anthocyanins and phenolics in the skins also varies greatly and, in general, these parameters affect the concentration of anthocyanins and phenols in the wines as well as the relative ratio of color to total phenols. 1988 and 1989 had the lowest average berry weights with the highest concentration of anthocyanins in the skins and the highest anthocyanin concentration in the new wines. The total phenolic content was greater in 1989 than 1988, however, resulting in a very different relative proportion of color to phenols (0.18 and 0.23, respectively). The 1991 average berry weights were higher than any of the other years monitored (1.26 grams). The maximum concentration of anthocyanin in the skins was lower than in 1989 and 1988 but slightly higher than in 1987. The new 1991 wines contain anthocyanin levels similar to 1987. Of the four years monitored, the ratio of anthocyanins to total phenols in new wines was lowest in 1987 and 1990.

The physiological processes of maturation in grapes are not well understood. In this trial, wines have generally increased in complexity and intensity as maturation progressed. This increase has not been predictable from changes in traditional maturity parameters. In addition, the changes in the ripening process vary with vintage to produce wines with distinct vintage characteristics. The data we have collected provide unique vintage profiles. However, at this time we have no way of measuring physiological differences affecting aroma and flavor. A primary goal for future research is to develop the capabilities to monitor specific physiological processes and to understand how they relate to the development of wine, quality.

4) Woodhall III Cane-Cordon Trial:

A trial was set up to determine if high yields observed in cordon pruned Pinot noir at the Lewis-Brown Farm trellis trial would still hold at another location. The trial compared cane vs. cordon pruning with similar nodes/vine. The area of the vineyard where the trial was located was seriously damaged by the low winter temperatures in December 1990. Many of the vines in the trial showed significant cambium damage and a delay in bud break and shoot growth. As a result, this trial became a test of pruning responses to vine winter damage.

Cordon pruned vines had more than twice the yields of the cane pruned vines. Yields on the cordon vines averaged 4.29 tons/acre compared to 1.47 tons/acre with cane pruning. This high yield in a late season resulted in a delay in maturity, with a decrease in Brix, higher TA, and lower pH with the cordon. However, the trial clearly demonstrated that cordon pruning may be an excellent tool for responding to observed winter injury. The physiological mechanism of the response in not clear but it may have to do with increased hardiness in the basal buds of canes (those kept in spur pruning). If winter injury is suspected in a portion of your vineyard, cordon pruning for that season may offset yield reductions.

5) Yield Adjustment:

One of the major problems of grape growing in Oregon is inconsistent yields. The major cause of this inconsistency is variation in fruit set. This trial was established to develop a method that would allow growers to compensate for variations potential crop after fruit set. Currently the only crop adjustment options available to growers are varying node number at pruning and cluster thinning. Three years of data from the shoot density trial (see above) has demonstrated that high node numbers followed by cluster thinning will result in some improvement in quality, but the high shoot densities may still limit quality. We are developing a new method to adjust crops based on the Scott Henry trellis and our experiences with growth diversion (see 1990-91 progress report).

An experiment was established at Woodhall III Vineyard as a preliminary test of this concept. Control vines were pruned to 28 nodes in a standard upright vertical trellis. Yield adjusted vines were trained to a Scott Henry trellis with two canopies, one upright vertical and the other growing down. A total of 42 nodes were left at pruning with 18 on the upper canopy and 24 on the lower canopy. After fruit set and a yield evaluation (based on cluster counts and cluster weights), portions of the lower canopy were removed to try to hit a target harvest yield of three tons/acre. Yield on each replication was evaluated and adjusted separately. The area of the trial had significant winter damage from the December 1990 freeze and yields were variable and generally low. Average yield for the control vines was 1.6 tons/acre. Yields on the adjusted vines averaged 2.7 tons/acre. The higher yield on the adjusted vines resulted in a slight decrease in Brix. However, the TA was lower as well, reflecting the more open canopy. We will be expanding the trial this year into commercial vineyards.

6) Phenolic Metabolism and Cluster Exposure:

Grape skins from exposed berries were compared to unexposed skins from the same clusters. Spectral evaluation of light transmission through the skins revealed that exposed skins have significantly higher light absorbance in the UV-A range. Spectral analysis of ethanol extracts of the same skins revealed that exposed skins have unique absorbance peaks at 260 and 360 nm. HPLC analysis of extracts showed a general increase in phenolic concentration and a very large increase in a specific compound that we have tentatively identified as a quercetin glycoside. This compound is responsible for the shift in light absorbance we observed in the grape skins and has been shown to be synthesized in fruit in response to UV light. In pigmented varieties (Pinot noir and Pinot gris), synthesis of this compound may compete for substrate with anthocyanins. This may explain why highly exposed grapes have delayed veraison and often a reduction in total pigment concentration (particularly Pinot gris). Quereetin has recently been identified as a potential anti-carcinogeruc compound in wine.

7) Vineyard Site Selection For Linn and Benton Counties:

The purpose of this project was to provide information to new growers to asses the appropriateness of potential and current vineyard sites in Linn and Benton Counties. Factors in site selection and criteria necessary for grape production will be described in a publication and distributed. The publication will include data from weather stations in eight different locations in the two counties. Five main geographical areas were identified and evaluated to determine their suitability. The key factors used in the assessment were: 1) topographical considerations, 2) climatic variables, 3) soil properties, and 4) other miscellaneous factors (i.e. proximity to markets). This project was made possible by a grant from the Linn-Benton Applied Research Fund under the leadership of the Regional Strategies Program to provide local economic growth.

8) Inflorescence Necrosis:

Research was continued on inflorescence necrosis in 1991 and it will be referred to as IN in the text. IN has been devastating to the Oregon winegrape industry because of cluster breakdown near bloom causing either death or partial destruction of the flower cluster, developing smaller berry clusters and, consequently, reduced yields. IN developed widely in the state during 1988 and 1990, but the incidence of IN was very low in 1991. We have found that stress such as shading, drought, and lack of nitrogen, as well as excessive shoot vigor, has been associated with IN. Our research has been directed at finding the causal agent or agents and to developing preventative methods to prevent it. Two graduate students have been working on IN research and a third will begin his research on it this year. Some of their research was reported in the 1991 Progress Report and the 1991 WAB Research Report, so I will discuss the progress since then. However, in review, we suspect that cluster ammonium may be the culprit and if so, what is the source of it and why? We believe it may be a problem in the nitrogen metabolism of the plant from either the lack of sufficient carbohydrates to make amino acids or a blockage of ammonium utilization in the plant. Or the source could be soil uptake of ammonium because of some soil condition. These are some of the questions we tried to answer in 1991.

Sanliang Gu, a Ph.D. candidate, found that he could induce IN in grape cuttings with a leaf and cluster when feeding the cutting with ammonium solutions, but not with nitrate or other ions. He also found that enzymes necessary for ammonium assimilation are either absent in the cluster stem (rachis) or they are at very low levels. He found that when 2-year-old Pinot noir vines were fed ammonium fertilizer instead of nitrate forms, there was no particular preference for ammonium uptake or build-up in e vine. We did analyze soils for various nutrients and content from two vineyards, one of which was associated with severe IN in 1990. The soil pH, potassium, calcium, magnesium boron, and nitrates were lower in the high IN vineyard. We don't suspect that the soil may be the primary factor as a source of ammonium, but it could contribute to conditioning of the vines such as excessive growth. Petiole analysis from samples in August indicated lower nitrogen, potassium, and boron but higher manganese from the same IN vineyard. Future research should follow up on soil and petiole analysis during a severe IN year.

IN severity was less in 1991 for the same vineyards as we assessed in 1990. Average severity was only about 3 to 5% as compared to 30 to 60% the previous season. This is reflected in the cluster ammonium levels of I to 4 mg/g dry weight in 1991 compared to 7 to 9 mg/g dw in 1990. Therefore, this made for difficult field research in 1991, but in summary, we did have some positive results. In evaluating the trellis trial at the Lewis-Brown Farm, we observed that the IN severity of the standard upright/cane undivided canopy was more than twice that of the others, while it was lowest for the upright/spur (cordon) undivided canopy and for the divided canopies of Scott Henry and Geneva Double Curtain (GDC). However, the cluster ammonium was highest in the standard cane and cordon spur canopies and lowest in the GDC system. Apparently, hanging shoots (in contrast to upright shoots) and spur pruning decrease IN severity. This coincided with our observations in 1990, when we found that hanging canopies with spur pruning had very little IN. The variety Riesling had the highest IN but the lowest cluster ammonium in the trellis plot. We do know that Riesling, as well as Pinot noir and Gewurztraminer, are more susceptible to IN than Chardonnay. Therefore, it appears that Riesling may be more susceptible to ammonium. Pruning and shoot weights prior to the 1991 season correlated with IN severity, also. Our results indicate that less IN occurs on less vigorous shoots, such as in the case of the spur pruned and the hanging shoots of the single wire systems found in Polk County. We found very little IN on this system in 1990 when it was serious on other canopies.

Three other field trials were conducted at Beaver Creek Vineyards in 1991 but only one treatment successfully reduced IN. Sanliang Gu tipped shoots on Pinot noir vines one month before bloom and removed all lateral shoots that developed afterward. He found that berry set was increased four-fold and IN and rachis ammonium was reduced significantly by tipping. In another trial, we trained the shoots from Pinot noir vines either upright or downward to evaluate its effect on IN, but neither IN nor ammonium were affected by either treatment. This may be due to the excessive shoot vigor on both. In the third trial, we compared the IN of vigorous shoots vs. weak shoots paired from the same vines. Clusters from week shoots had lower IN severity but the difference was not significant.

9) Mechanical/Minimum Pruning of Cabernet Sauvignon:

Cabernet Sauvignon vines were pruned to 3 systems for 2 years: 1) cane with standard upright shoots pruned in winter, 2) mechanical hedged sides and top in the winter and rehedged at a 45 degree angle to the cordon wire in August to adjust the crop load, and 3) minimum hedged at a 20 degree angle above the horizon of the cordon wire on the hanging skirt at bloom and then rehedged in August for crop adjustment as in the mechanical pruned treatment. The crop load of the hedged vines was adjusted to 11 to 13 lbs. per vine by estimating the cluster number and size. 'Me average yields were 18.0, 11.4, and 14.1 lbs. per vine for cane, mechanical, and minimum pruned vines, respectively, in 1991.

Minimum pruning at bloom had a delaying effect on the maturation even though the crop load per vine was less than the standard caned pruned system. This was due to removing considerable leaf area at bloom. Minimum pruning delayed color development and veraison about one week, but by harvest, maturity contents were equal to the other treatments. Anthocyanin and phenolic levels in the juice and wine were similar for all three treatments.

The minimum and mechanical pruned canopies were characterized by shorter shoots, smaller light green leaves, and smaller cluster and berry weights than the cane system. The cluster weight of the minimum pruned vines was 50% of the cane system, while the clusters of mechanical pruned vines were 67%. Berry sizes were reduced about 23% and 8% for minimum and mechanical pruned vines, respectively. Both hedged systems increased leaf layer numbers by a third and decreased cluster exposure about a third. The two hedged pruning systems are suitable only for mechanical harvesting. These systems on other varieties, such as Sauvignon blanc or Chardonnay, should be tried on a cooperative basis in the industry for those who are interested in mechanization.

10) Effect of Rootstock on Cluster Ammonium at Bloom for Inflorescence Necrosis (IN) Susceptibility:

Clusters and petioles of Cabernet Sauvignon, Chardonnay, Foch, Oewurztraminer, Merlot, and Riesling were sampled prior to bloom for ammonium and nitrate analysis from 11 rootstock plots in California and one rootstock trial in British Columbia to assess susceptibility to IN. Cluster ammonium ranged from 1-7 mg/g dry weight. Very little IN was found in any of the plots and the low ammonium concentrations reflected this. The ranking of rootstocks for cluster ammonium (from highest to lowest potential IN) were: 39-16 > St. George > Salt Creek = 5BB > self-rooted vines > 5C (standard rootstock in all plots) > 1202 = S04 = 3309 AXRI = 11OR > Harmony > Riparia gloire > 5A > 420A. Petiole nitrates, are being analyzed and will be used to evaluate their relationship to cluster ammonium.

11) Xylem Discontinuity in the Grape Berry:

In pre-veraison berry growth, the xylem is an important supplier of water and minerals. After veraison, when the berry is in the ripening stage, phloem takes over as the dominant supplier of materials (including, most importantly, sugar). The mechanism involved in this drastic change in imports (which occurs near veraison) to the berry remains a matter of some debate. However, xylem discontinuity is, no doubt, involved in this shift from xylem to phloem flows and has effects on the water relations between the vine and the fruit.

Our research confirmed that a disruption of xylem flow (the xylem discontinuity) exists. Dye uptake studies showed that there was a reduction in passive flow through xylem into the berry at the softening stage (about the same time the berry expands rapidly and sugars start to accumulate). Much more potassium ion (K') than calcium ion (Ca") entered the berry after veraison (CA" and K' being used commonly as indicators of xylem and phloem flow, respectively), which also suggested low xylem and high phloem inputs.

In greenhouse experiments, pre-veraison berries were very sensitive to vine water stress, shrivelling long before the vines showed any signs of wilting. Post-veraison berries did not shrivel, even when vies were severely stressed. Apparently, pre-veraison berries act as a reservoir for the vegetative parts of the vine, supplying water in times of stress. Post-veraison berries do not]have this function due to the xylem discontinuity.

When phloem flow was blocked by heat-girdling the cluster peduncle, post-veraison berries entered a state of decline, raisining relatively rapidly. Berries removed from the vine behaved similarly, suggesting that there were no phloem or xylem connections when the peduncle of a post-veraison cluster was girdled. Pre-veraison berries retained turgor (firmness) for many days after the peduncle was girdled, but berry diameter stopped increasing. Since the phloem was no longer functioning, the xylem must have supplied enough water to the berries to prevent shrivelling.

Two papers reporting the results of these studies are currently under review by the American Journal of Enology and Viticulture. The support of the Oregon Wine Advisory Board and the Weatherspoon Viticulture Fellowship made this research possible.

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Table 1. 1991 Pinot Noir Trellis Trial Lewis Brown Farm, Must and Wine Analysis

Treatment	Must						Wine				
	Brix	TA g/L	pH	MAL g/L	Anth* mg/g	Phenols* mg/g	Alc %	TA** g/L	pH**	Anth mg/L	Phenols mg/L
Cane	22.3	7.0	3.33	3.7	0.67	1.32	12.8	4.5	3.84	137	687
Cordon	21.7	7.0	3.33	3.7	0.56	1.28	12.6	4.3	3.86	125	682
Scott Henry	20.9	7.0	3.19	4.3	0.91	1.33	12.4	5.4	3.60	143	801
Lyre	22.3	7.2	3.27	4.4	0.77	1.34	13.3	4.9	3.78	149	893
GDC	21.6	6.9	3.25	4.8	0.76	1.51	12.6	5.0	3.71	149	893

* From skin extracts
** Malolactic fermentation completed

Table 2. 1991 Chardonnay Trellis Trial Lewis Brown Farm, Must and Wine Analysis

Treatment	Must				Wine			
	°Brix	TA g/L	pH	MAL g/L	Alc* %	TA g/L	pH	Phenols mg/L
Cane	19.6	8.2	3.24	5.5	12.6	8.2	3.38	231
Cordon	20.1	8.4	3.26	6.0	12.6	8.2	3.41	243
Scott Henry	19.0	8.1	3.11	4.8	12.4	8.1	3.26	292
Lyre	19.3	7.8	3.26	4.9	12.6	7.6	3.43	260
GDC	19.4	7.7	3.23	5.2	12.8	7.6	3.42	284

*Must chaptalized to 21.8 °Brix

Table 3. 1991 Pinot Noir Density Trial Woodhall Vineyards, Must and Wine Analysis

Treatment	Must					Wine				
	°Brix	TA g/L	pH	MAL g/L	Anth* mg/g	Alc %	TA**	pH**	Anth mg/L	Phenols mg/L
Cane 10 sh/M										
Unthinned	23.6	7.0	3.24	3.7	1.04	13.4	4.9	3.64	224	1,389
Thinned	24.5	6.1	3.26	3.3	1.30	14.0	4.3	3.78	246	1,425
Cane 15 sh/M										
Unthinned	23.4	6.7	3.14	3.5	1.06	13.6	4.7	3.62	202	1,419
Thinned	24.2	6.5	3.22	3.2	1.18	14.0	4.3	3.74	247	1,371
Cane 20 sh/M										
Unthinned	22.7	7.2	3.10	3.5	0.74	13.3	4.7	3.57	172	1,379
Thinned	24.3	6.2	3.24	3.5	0.99	14.0	4.1	3.78	226	1,454
SH 20 sh/M										
Unthinned	22.6	6.6	3.06	3.1	1.30	13.2	4.7	3.54	212	1,316
Thinned	24.1	6.2	3.16	3.1	1.38	14.2	4.5	3.75	259	1,679

* From skin extracts
** Malolactic fermentation completed

Table 4. 1991 Pinot Noir Maturity Trial Woodhall Vineyards, Must and Wine Analysis

	Must							Wine				
Harvest Date	Berry wt g	°Brix	TA g/L	pH	MAL g/L	Anth* mg/g	Phenols* mg/g	Alc %	TA** g/L	pH* *	Anth mg/L	Phenols mg/L
Oct. 7	1.16	22.3	7.7	3.19	4.0	0.91	2.91	12.8	5.2	3.76	186	1,048
Oct. 14	1.26	24.1	7.9	3.33	3.2	1.03	5.69	14.0	4.8	3.84	198	1,633
Oct. 23	1.23	24.4	6.1	3.40	2.9	0.90	4.50	14.7	4.9	3.94	206	1,326
Oct. 31	1.25	24.7	4.9	3.43	3.0	1.08	5.10	14.7	4.5	3.92	195	1,229

* From skin extracts
** Malolactic fermentation completed

Table 5. Pinot Noir Maturity Trial, Vintage Comparisons

	Must				Wine			
	Ave. Berry Wt g	°Brix	Anth** mg/g	Phenols** mg/g	Alc %	Anth mg/L	Phenols mg/L	A/P
1987 (9/22)*	0.92	22.8	0.91	2.39	13.0	216	1,710	.13
1988 (10/18)*	0.72	23.6	1.53	3.61	13.7	390	1,688	.23
1989 (9/29)*	0.82	24.5	1.35	...	14.2	351	1,990	.18
1991 (10/14)*	1.26	24.1	1.03	5.69	14.0	198	1,633	.12

* Harvest date
** From skin extracts

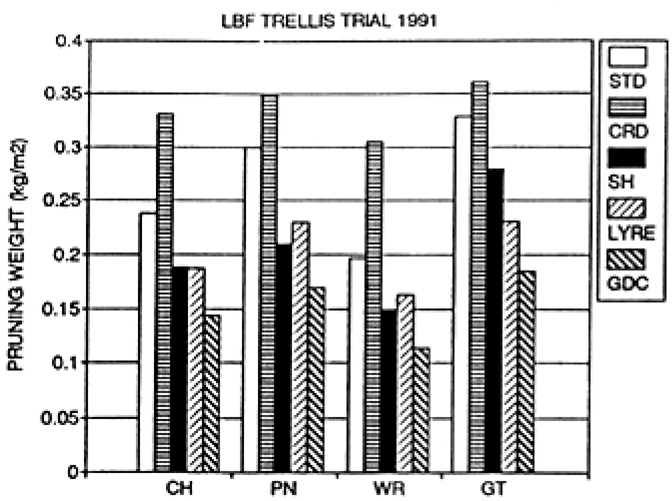

Figure 1. Pruning weights (kg/m^2) of four varieties on five trellis systems, Corvallis, Oregon, 1991. STD = upright vertical cane pruned, CRD = upright vertical cordon pruned, SH = Scott Henry training cane pruned, LYRE = lyre training cane pruned, GDC = Geneva Double Curtain cane pruned.

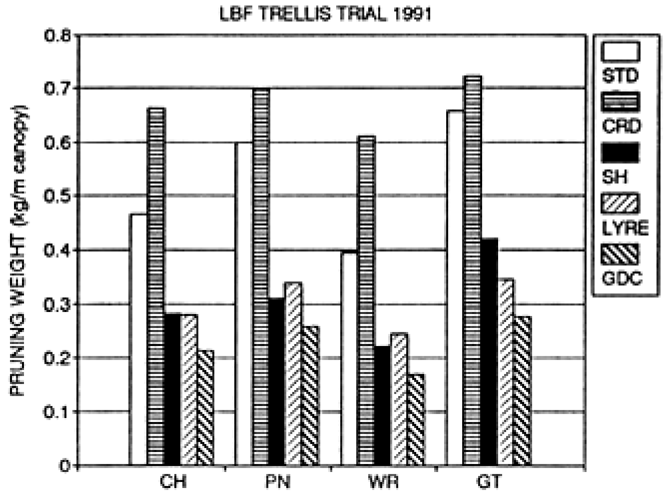

Figure 2. Pruning weights (kg/m of canopy) of four varieties on five trellis systems, Corvallis, Oregon, 1991.

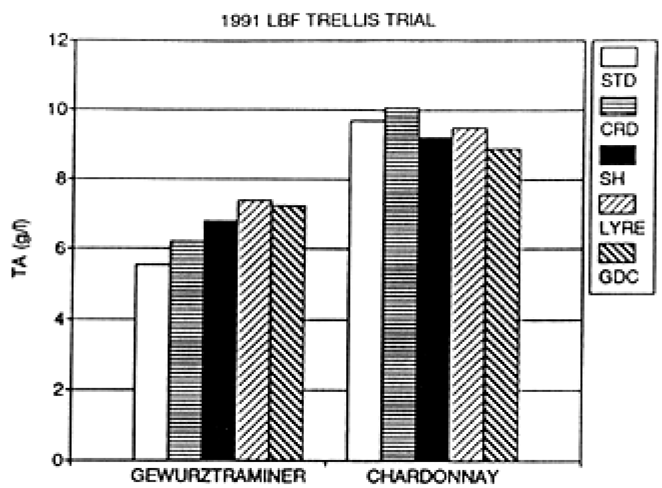

Figure 3. Harvest berry titratable acidity of two varieties on five trellis systems, Corvallis, Oregon, 1991.

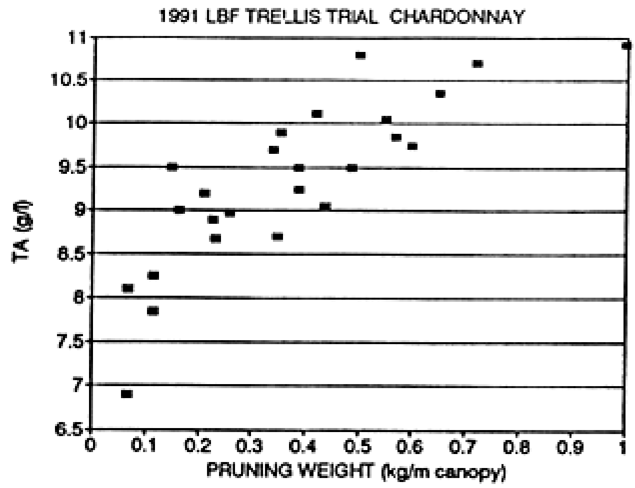

Figure 4. Effect of pruning weight on berry titratable acidity in Chardonnay, Corvallis, Oregon, 1991.

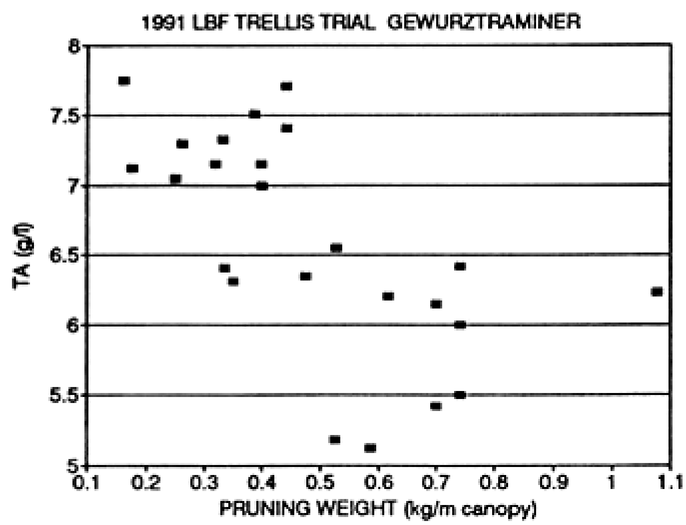

Figure 5. Effect of pruning weight on berry titratable acidity in Gewurztraminer, Corvallis, Oregon, 1991.

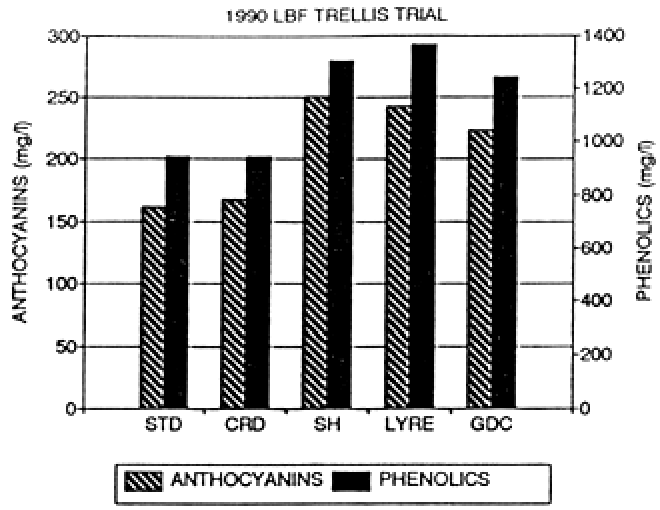

Figure 6. Wine anthocyanins and phenolics in five trellis systems, Pinot noir, Corvallis, Oregon, 1990.

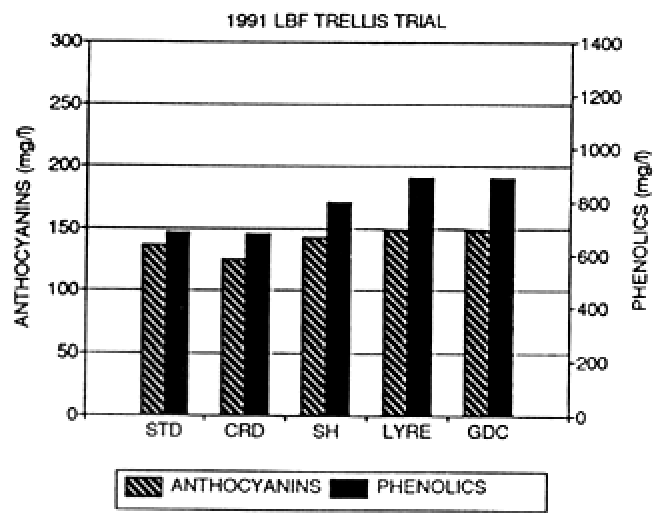

Figure 7. Wine anthocyanins and phenolics in five trellis systems, Pinot noir, Corvallis, Oregon, 1991.

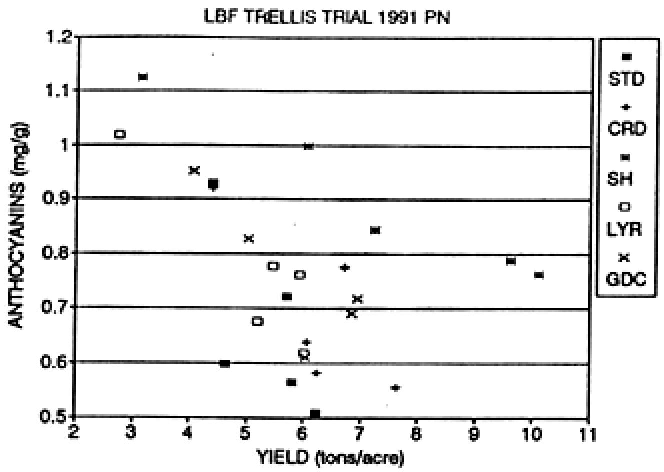

Figure 8. Effect of yield on berry skin anthocyanin concentration in five trellis systems, Pinot noir, Corvallis, Oregon, 1991.

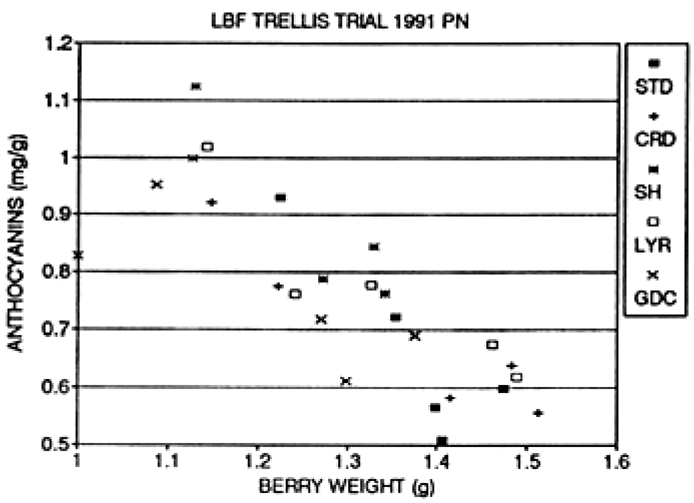

Figure 9. Effect of berry weight on berry skin anthocyanin concentration in five trellis systems, Pinot noir, Corvallis, Oregon, 1991.

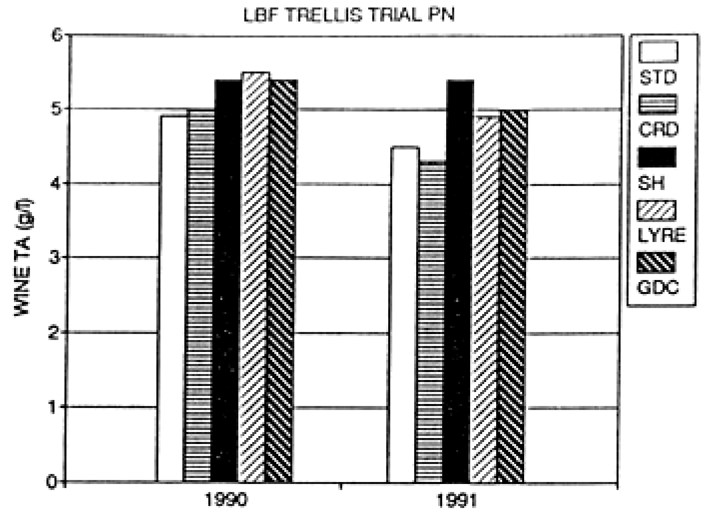

Figure 10. Wine titratable acidity in five trellis systems, Pinot noir, Corvallis, Oregon, 1990 and 1991.

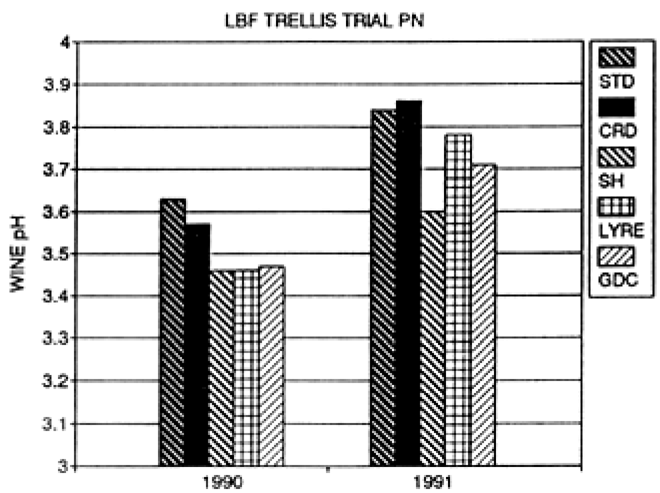

Figure 11. Wine pH in five trellis systems, Pinot noir, Corvallis, Oregon, 1990 and 1991.

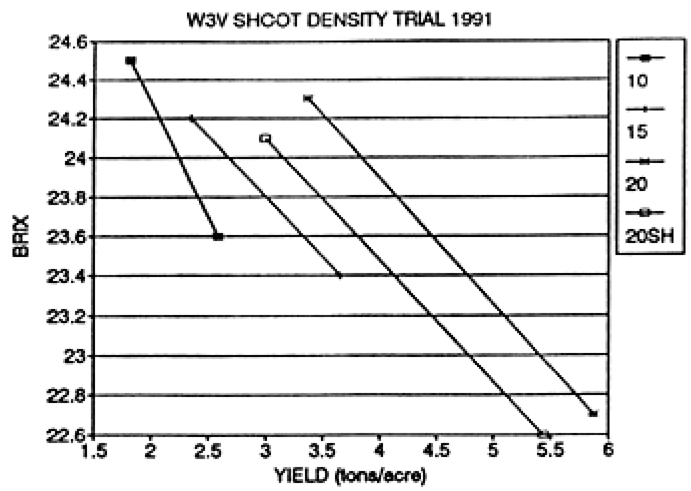

Figure 12. Effect of cluster thinning on must Brix of four canopy treatments (10 shts/m, 15 shts/m, 20 shts/m, and 20 shts/m w/Scott Henry pruning), Pinot noir, Alpine, Oregon, 1991.

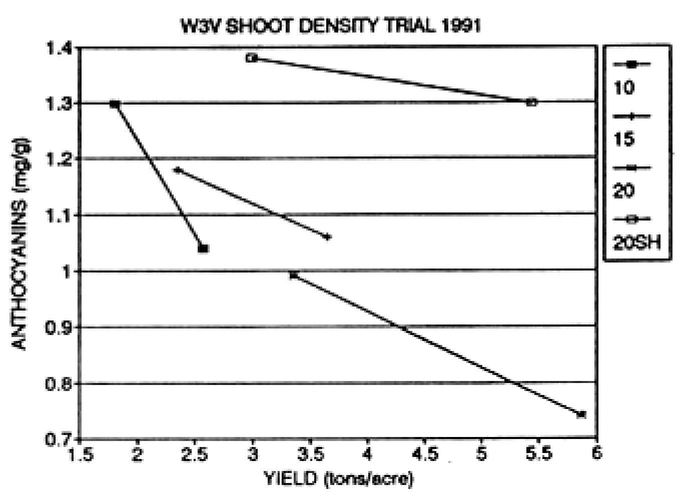

Figure 13. Effect of cluster thinning on berry skin anthocyanin concentration of four canopy treatments, Pinot noir, Alpine, Oregon, 1991.

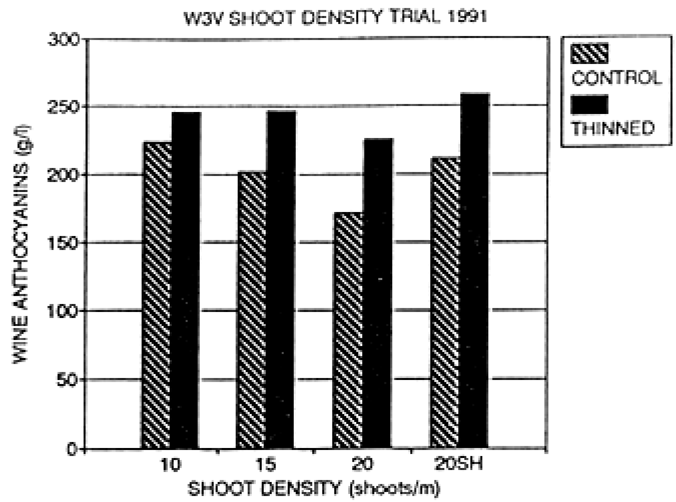

Figure 14. Effects of four shoot densities and cluster thinning on wine anthocyanins, Pinot noir, Alpine, Oregon, 1991.

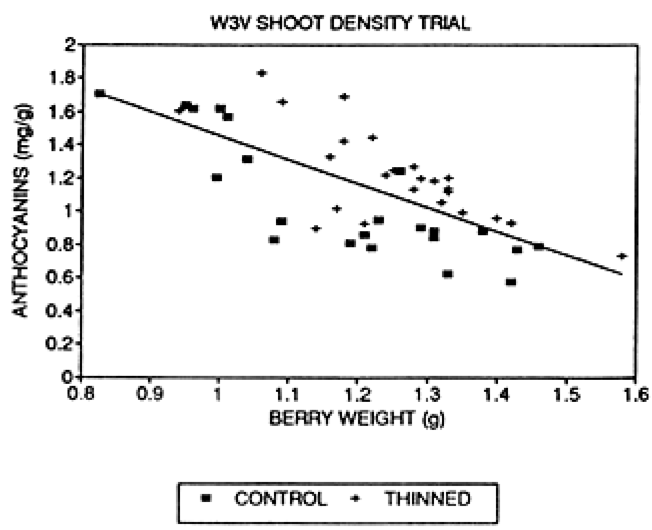

Figure 15. Effects of thinning and berry weight on berry skin anthocyanin concentration, Pinot noir, Alpine, Oregon, 1991.

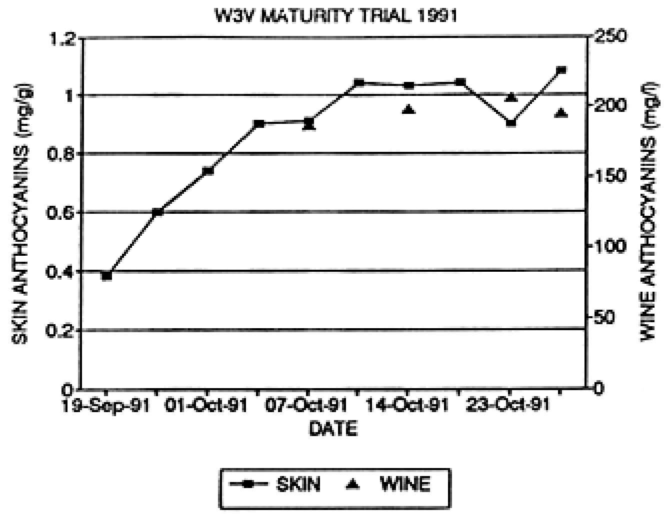

Figure 16. **Changes in wine and berry anthocyanin concentration during maturation of Pinot noir, Alpine, Oregon, 1991.**

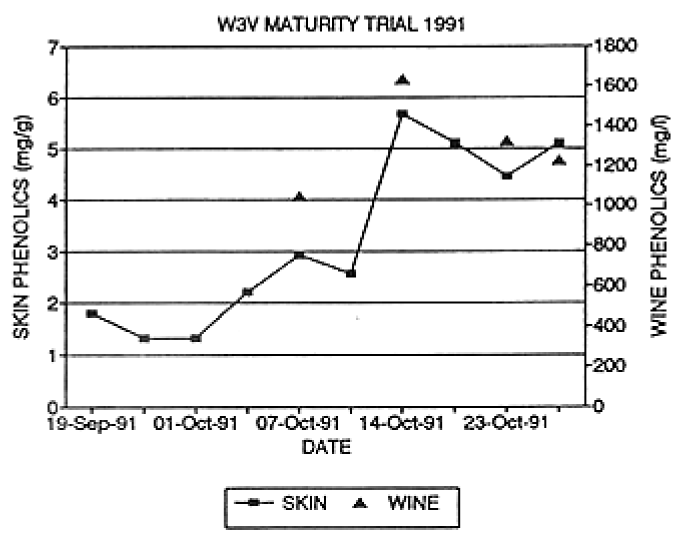

Figure 17. Changes in wine and berry phenolic concentration during maturation of Pinot noir, Alpine, Oregon, 1991.