INFLUENCE OF CROP LOAD ON FRUIT COMPOSITION USING PINOT NOIR GRAPES

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ABSTRACT

Influence of Crop Load on Fruit Composition Using Pinot Noir Grapes

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The two seasons for this trial were conducted in 2002 and 2003 at Bien Nacido Vineyard in Santa Maria, California. The trial consisted of pinot noir wine grapes clone 2a, grown on 101-14 rootstock. There were eight treatments with a control consisting of 25 vines per treatment, and 50 vines for the control.

The primary objective of this research experiment was to conduct different vine balance procedures and compare them to the amount of wine phenolics. The vines were altered with two procedures. First was crop yield; fruit thinning altered the treatments by providing four different crop loads and a control. The treatment levels were signified as one ton, two ton, three ton, four ton, and control. The second procedure was timing of fruit thinning. Four different crop loads were split in half giving rise to eight treatments and a control. With four of the treatments the fruit was dropped post-bloom, and the other four treatments were dropped at seventy five percent veraison. Equal amounts of early and late thinning were combined and made into wine which gave four different crop load wines and a control wine. This process was done in 2002 and repeated in 2003. Additionally, other vine growth parameters were analyzed to determine the role that crop load and timing of thinning had in their development.

Seven variables were analyzed from prunings, clusters, juice, and wine samples. They consisted of berry size, cluster weight, titratable acidity, pH, total soluble solids, phenolic profile

(consisting of eleven components), and shoot weight. The results indicated that the following were statistically significant: (1) titratable acidity was significantly different between the 2002 and 2003 growing seasons, (2) total soluble solids showed a significant difference between the early fruit thinning versus the late thinning, (3) berry size in 2002 showed a statistically significant effect of drop date on the mean caliper size, (4) in 2002 the berry size also showed a statistically significant interaction between drop level and drop date, (5) berry size in 2003 showed a statistically significant effect of drop level on the mean caliper size, (6) in 2003 there is also a statistically significant effect of drop date on the mean caliper size, (7) again in 2003 there is a statistically significant interaction between drop level and drop date, (8) cluster weights in 2002 showed a statistically significant relationship between drop level and average cluster weight, (9) in 2002 cluster weights also showed an effect of the time of fruit drop on the average cluster weight, (10) cluster weights in 2003 showed a statistically significant relationship between drop level and the average cluster weight, (11) pruning weights in 2002 showed a statistically significant relationship between drop level and average shoot weight, (12) pruning weights in 2003 showed a statistically significant relationship between drop level and average shoot weight and finally, (13) of the eleven phenolic components measured, five differed significantly by year but not across the five treatments.

Information derived from this experiment suggests that the site is a high vigour location according to Robinson and Smart's yield to pruning weight ratio. With this in mind we find that TA and pH were not a significant factor, but soluble solids (brix) ascertained a higher degree of brix with the late drop treatment. We conclude this to be an effect of both the high vigour site and more uniform fruit drop. In 2002 and 2003, we find a significant interaction between drop date and berry size with a late drop producing the smallest berries on average. Cluster weights

varied between 2002 and 2003 and the results were inconclusive. Shoot weights along with harvest totals concluded a high vigour site. The one ton level in 2002 had a significantly higher average shoot weight than the three ton level ($p<.001$), four ton level ($p=.006$), and no fruit drop control ($p<.001$). There is also a significant relationship between drop time and average shoot weight in 2002 ($p<.001$), and 2003 ($p=.049$) with the late fruit drop being followed by a lower shoot weight. This significant relationship expressed that an early drop increased the shoot weight which contributed only more vigour to an already high vigour site. The ratio of yield to pruning weight for 2002 gave us a range of .39 to 1.78, and in 2003 the range was .32 to 1.36 concluding a high vigour site. The phenolic profile expressed a statistical difference by year, but was most likely caused by a varying fermentation temperature or different climatic conditions in 2002 and 2003.

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Chapter 1

Literature Review

Pinot noir is an old red grape variety dating back to the first century AD [3]. Pinot noir belongs to the *vitis vinifera* species which accounts for ninety percent of the world's grapes [30]. Among the many different clones there are many differences in growth habit, berry size, bunch compactness and leaf shape [10]. Bunch compactness, found more prevalent in certain clones of pinot noir, gives rise to bunch rot. Bunch rot, *Botrytis cinerea*, is a fungal disease which attacks the succulent tissue, particularly the floral parts or ripening fruit [10]. Budburst in pinot noir is earlier than other varieties, which makes it susceptible to spring frost damage. Pinot noir is most prevalent in Burgundy France, which is known for fine dry wine, and in Champagne France it is known for its rose' champagnes [3]. No information has stated an exact number of pinot noir clones but some authors have claimed the existence of more than a thousand different clones [26].

Pinot Noir Clone 2A

Within a single grape variety, there is a rich variation of subtle genetic differences manifested by their growth habit and grape berry character [9]. Concerns about grapevine health, in addition to fruit quality, have led to a process called clonal selection. In viticulture, a clone is a population of vines derived by vegetative propagation from a single vine, called a mother vine. All vines grown from cuttings or buds of this vine are genetically identical. Future generations will remain identical unless a spontaneous mutation occurs, creating a bud with an altered genetic makeup [9].

In the 1940's, Professor Olmo made several trips to Europe where he collected Pinot noir cuttings from many different vineyards [9]. These vineyards were located in Germany (Geisenheim selection), France (Pommard selections), and Switzerland (Wadsenwil selection). The Pinot noir clone 2A was sourced from the mother vine in Wadsenwil, Switzerland [9]. A clonal trial was conducted in Oregon at two different vineyards located in the Willamette Valley. The trial took place in 1985 and 1986 by the viticulturists Steve Price and Barney Watson, which involved the Pinot noir clone 2A besides many others. The findings from the clone 2A demonstrated a correlation between low yield and high varietal intensity [9].

Disease Resistant Rootstock

Viticulture in the United States, as well as most wine grape growing regions, is based on varieties of the European vine, *Vitis vinifera*. This species is particularly prone to attack by two soil-borne pests, the grape phylloxera and plant parasitic nematodes [30]. It has been found that the European vine can be protected from these pests by grafting to rootstock varieties derived from other vine species and hybrids that are resistant. Many of the rootstocks used for this purpose are well adapted to particular soil types and some may also be used to overcome vineyard problems such as drought and salinity [30].

The phylloxera is native to the Mississippi Valley where resistant wild varieties were found. These American varieties were *Vitis riparia*, *Vitis rupestris*, *Vitis berlandieri*, and many more [30]. A hybrid of *riparia* and *rupestris* was obtained by Millardet in 1882 [22]. The hybrid of this is known today as 101-14 Millardet et de Grasset and is widely used throughout the industry. The 101-14 rootstock is a low to moderate vigor rootstock with much of its use in poorly drained shallow soils [22]. Its low to moderate vigor is much like 3309C which is a hybrid of *riparia* and *rupestris* as well [22]. The 101-14 rootstock does not do well in dry grape-

growing areas and has moderate resistance to nematodes. The 101-14 rootstock can only tolerate up to nine percent active lime in the soil [22].

Vine Balance

There are three major categories, developmental, cultural, and environmental, which have a direct effect on vine balance. Vine balance is the ratio between fruitfulness and vegetative growth. The amount of crop that a vineyard can produce is essentially dependent on its exposed canopy surface area. The ideal ratio of yield to canopy surface area is 0.8 kg/m² in cool climates for medium ripening varieties. Such measurements are considered essential to ensure vine balance. This is in a quantitative form, so that vineyard management practices can be monitored in relation to vine balance and ultimately wine quality [18].

The discussion of vine balance has raged for many years, and is not a new idea. Ravaz is the earliest source of relevant information, and the Ravaz Index suggests that the ratio of fruit to wood is the key to achieving both fruit quality and consistent production. He also showed a general relationship between leaf production and fruit production. As noted by Ravaz, Partridge, Shaulis, and subsequent re-searchers, balance may also be considered as the amount of leaf area required to ripen a unit of crop weight [14].

Yield at harvest, and cane weights at pruning are the most informative of all the measurements which can be made to indicate vine balance [27]. Pruning weight is proportional to leaf area carried on the shoots the previous growing season. Calculation of mean cane weight gives a useful indication of shoot vigor. Measurements of yield and cluster number allow calculation of mean cluster weight. The ratio of yield to pruning weight gives a good indication

of balance between fruit and vegetative growth. An optimal level for moderate vigor vines is a yield/pruning weight ratio of 5-10g [27].

Pruning

The cultural practice of pruning in the winter months is extremely important when trying to balance fruitfulness to vigor. Head, cane, and spur pruning styles exist and are the foundation to vine balance [27]. The more nodes/buds left behind at pruning is a direct correlation to possible fruitfulness which can be used to devigor a vigorous vine by leaving behind many buds and vice versa for a weak vine [10].

Thinning

Thinning vines increases the leaf area to fruit ratio and provides for an earlier harvest date. Thinning also appears to have a strengthening effect on the vines that is measured as greater ripe nodes of periderm and earlier leaf area development than standard vines [2].

The canopy's ability to ripen fruit, as noted by Ravaz, Partridge, Shaulis and subsequent researchers, show that balance may also be considered as the amount of leaf area required to ripen a unit of crop weight. This is commonly expressed as cm² leaf area/gm fresh weight of fruit. The literature reports a range of 7 to 14 cm²/gm to achieve ripening [14].

The amount of crop that a vineyard can produce is essentially dependent on its exposed canopy surface area. The ideal ratio of yield to canopy surface area is 0.8 kg/m² in cool climates for medium ripening varieties [18]. The vine's response to thinning is a physiological one, in which we are changing the ratio of exposed leaf area to mass of fruit. The target is to achieve fifteen cm²/g of fruit according to Melsom [18]. Other factors that can impact vine physiology

and have an impact on the response to thinning are drought stress, physical injury, damage from pests and disease [29].

Trellis

A major developmental factor is choosing the right trellis system for the variety of grape to be planted. Pinot noir has had tremendous results and is widely planted on the vertical shoot positioning trellis (V.S.P.) [27]. This trellis can be a spur or cane pruned depending on the yield desired. The vertical shoot positioning trellis is an excellent trellis for light exposure and is intended for vines with moderate growth characteristics. The V.S.P. trellis has also been adopted in places where there is a high fungal disease pressure since good air circulation exists within the canopy of V.S.P. [27].

Degree Days/Chill Hours

Degree days are the positive remainders when a plant-specific base temperature (commonly 10°C or 50°F) is subtracted from daily average temperatures. Accumulations of degree days are thought to provide a general indication of thermal conditions in a particular viticulture region [17]. The accumulation approximates the same total at specified stages of vine development. This can be a useful indicator of season length [17].

Pinot noir is a cool climate variety which grows best in region one or region two climate. Region 1 climate is 2500-degree days or less and region 2 climate is 2501-3000 degree days [30].

As grape canes mature, their buds enter a type of dormancy in which their growth is suppressed. Repeated exposure to cold temperatures sustains this form of dormancy. Once the chilling hour requirement is satisfied, it is only low temperatures which prevent bud burst. The

number of chilling hours required by grapes varies among the different varieties, but most grapes only need about 150 chilling hours [28, 1].

In California, we typically calculate chilling hours from November 1, through the end of February. Cumulative chilling hours are calculated by either summing the hours below 45 degrees or those between 32 degrees and 45 degrees. The hours can be recorded using a purchased weather station, such as an Adcon station, or by using one of several Web sites which calculate hours from weather stations nearest your vineyard [28]. A common chill accumulation model is the 450 F and Under Model, which uses “1 hour $\leq$ 450 F = 1.0 chill unit” [1].

Phenolics

Grapes and wines form a diverse class of phenolic compounds derived from a hydroxybenzene ring, a basic phenol structure [31]. Nonflavonoid phenols, flavonoid phenols, and complex phenols can summarize the phenol substances of wine. These phenolic substances are the essential components responsible for wine color (red pigments or brown-forming substrates), and mouth feel, which can be further broken down to astringency and bitterness. When these phenolics are oxidized, they can later participate in further reactions in the wine, such as the precursor to 4-ethyl-phenol, an undesirable sensory component attributed to spoilage yeast *brettanomyces* [31].

Nonflavonoid phenols, or phenolic acids, can be further subdivided into two groups, hydroxycinnamic and hydroxybenzoic acids. Hydroxycinnamates are derivatives of caffeic, p-coumaric and ferulic acids, which in grape juice are esters bonded with tartaric acid known as caftaric, coutaric, and fertaric acids [7]. The hydrolysis of non-flavonoid esters, in the presence of an esterase, occurs during alcoholic fermentation and results in ethyl phenols most importantly

4-ethyl phenol [31]. Gallic acid, being the most important of hydroxybenzoic acids, increases with pomace contact in red wines. Gallic acid has been given great attention due to its chemical structure's ability to accept, stabilize, and release the oxidation state forms of NO (nitric oxide), a molecule suspected of allowing blood vessels to relax and permit better blood flow [32]. Non-flavonoids are important in forming golden colors for white wine [6].

Flavonoid phenols that are found in skins, seeds, and pulp of the fruit contribute to the structure and color of wine. The major groups of flavonoids are flavan-3-ols, flavan-3, 4-diols, flavonols, and anthocyanins. Flavan-3-ols are primarily (+)-catechin and (-)-epicatechin. Catechins are precursors to browning in white wines and bitterness in red wines [32]. The polymeric forms of flavan-3-ols can be referred to as condensed tannins. Flavan-3, 4-diols is a group important to winemakers due to the influence it has on pinking often seen in white wines. Flavonols occur in glycosidic forms in grape skins, which can attribute to a red wine's bitterness [32]. Plant pigments possess a large group known as anthocyanins, which give red grapes its color.

Complex tannins, or complex phenols, are polymers of both flavonoid and non-flavonoid phenols. These polymers have been given the generic term, "tannins". Hydrolyzed flavonoid phenols exist as esters and can be classified as hydrolysable tannins. Condensed tannins cannot be easily decomposed by hydrolysis. The astringent tannins are the result of the formation of blue-color complexes reacting with Fe^{3+} , which reacts with protein [32]. The phenolic compounds encouraging these reactions typically have a molecular weight from 500 to 5,000, however, as the wine ages and further polymerization occurs molecular weights range from 2,000 to 5,000 [32].

Acids

Acidity plays a vital part in determining wine quality. Lack of acid will produce poor fermentation, medicinal taste and a flabby, not vibrant feeling on the palate. In any wine it is essential that acidity, tannin content and sweetness be in balance with the type of wine you are making [21]. Ninety percent of acids in wine are malic and tartaric acids [15, 20, 24]. The remaining ten percent are found in small quantities. They are: galacturonic, glucuronic, gluconic, oxalic, mucic, citramilic, dimethyglyceric, pyruvic, ketoglutaric succinic, lactic, acetic, and citric, which is the primary acid in most fruits other than grapes [21]. The favorable, soft tasting, tartaric acids are rarely found in any other fruit except grapes and pineapples. It is considered the strongest acid and the amount present in the grape has the greatest effect on pH [21]. Tartaric acid respire slowly, if at all, and concentrations are reduced during ripening by dilution with water due to berry growth [10, 20]. The other dominate acid found in wine, malic acid, is fragile and is easily metabolized. Decreased total acidity in the grape is attributed to decreased malic acid content. Malic acid levels also metabolize faster in warmer climates compard to cooler climates because of increased respiration [10,20,21,24]. Malic acid can be reduced or eliminated by inoculating into the wine selected lactic acid bacteria strains such as *Pediococcus*, *Lactobacillus*, and *Leuconostoc* [13,16,24]. This process is known as malo-lactic fermentation, and is a bioconversion of malic acid to lactic acid and carbon dioxide. Not only will malo-lactic fermentation de-acidify the wine, but has also proven to improve the biological stability of wine [4]. Malo-lactic fermentation can also occur spontaneously after alcoholic (yeast) fermentation due to the existence of micro-organisms found in the cellar of fermentation vats [13, 24].

pH

The pH (true acidity) of wine is an important chemical parameter in premium wine production. High pH can have a negative effect on: microbiological stability, potassium bitartrate stability (cold stability), calcium stability, protein stability, color, oxidation rate, and tannin solubility [25, 31]. Similar to titratable acidity, pH also measures free hydrogen ions, but does not include un-dissociated forms of organic acids. This is why pH only measures values that can be tasted [19, 24]. The pH measurement is based on a logarithmic scale. An example, pH of 2.0 is ten times more acidic than a pH of 3.0 [31]. Therefore, small numerical differences in pH correlate with large reactivity and flavor differences [6]. Mathematically, pH is defined as subscript ten of the concentration of hydroxonium ions in an electrically conductive solution: $\text{pH} = -\log_{10}[\text{H}_3\text{O}^+]$ [23]. The pH is measured with a pH meter that has two glass electrodes, generally calibrated at pH 4 and pH 7 known as a two-point calibration [19, 24, 25]. At pH 7.0 the juice and wine solution is neutral, below it is increasingly acidic and tart to a minimum of zero, and above increasingly alkaline to a maximum of fourteen [6].

Titratable Acidity

The titratable acidity (TA), also known as total acidity, present in wine and juices is a measure of the concentration of free hydrogen ions plus any un-dissociated forms of acids, which include volatile acids, inorganic acids such as phosphoric acid, organic acids, and amino acids. It is difficult to predict TA of a wine based on the acidity of the juice because yeasts and bacteria consume acids. However, yeast and bacteria also produce acids, for instance, succinic and lactic acids [25]. Titration analysis uses standardized sodium hydroxide to the pink endpoint of pH 8.2. Furthermore, TA is expressed on the basis of grams tartaric acid per liter [6, 10, 19, 24, 25, 31].

Total Soluble Solids (Brix)

Total soluble solids (sugar) are often measured, among other methods, with a refractometer or a hydrometer. The refractometer is an instrument that measures juice weight by utilizing a calibrated prism. When held against the light, a drop of juice on the prism causes light to be refracted in proportion to the concentration of sugar in the juice. Similarly, the hydrometer also measures juice weight, but the juice is put into a graduated cylinder and the lines on the floating hydrometer correspond to the density of the juice. Both methods measure Brix or Balling, based on the fact that grape juice is heavier than water. One milliliter of water weighs one gram, thus the excess weight of one milliliter of juice is the weight of the substances dissolved in it. Fortunately, ninety percent of the solutes in grape juice are sugars, making these type of measuring methods a fairly accurate way of determining sugar levels of juice and calculating alcohol content of the wine. As the concentration of sugar in the grapes increases, the fermentation process produces higher levels of alcohols, which range from eight to as high as eighteen percent. Alcohol affects both the sensory attributes and stability of the wine [24, 25]. Therefore, sugar content of grapes is important in ascertaining harvest date and ultimately the quality of the finished product [19, 25].

Winemaking

Though the art of making wine has remained the same for centuries the differences put into style are what keeps all wines a little unique. The condition of the grapes at the time they are picked is absolutely crucial to wine quality. The potential of a crop of grapes for making the best possible wine can be compromised by picking at the wrong time [5]. The decision to harvest grapes is dictated by maturity parameters that are guided by many factors. These include wine style, variety, and maturity criteria. Typically, these criteria include the course of when

sugars accumulate, titratable acidity declines, pH rises, color, and phenolic compounds increase. It would be highly desirable to have all these parameters in ideal balance, but this is difficult to achieve since these parameters are influenced by many different factors [11].

Once grape maturity has arrived the harvest begins. It is imperative that crushing and de-stemming be done immediately in order to advert spoilage. This is done by machine and the object of de-stemming and crushing is to remove the stem and gently break the berry skin. The crushed fruit consisting of the pulp, skin, and seed is called must. It is transferred to a container and about 30-50 ppm of SO₂ is added. The purpose of the SO₂ addition is to prevent development of unwanted microbes such as indigenous yeast and harmful bacteria [11]. Standard information suggests these steps be done in the following order: crush, add SO₂, wait 12 hours, add yeast, ferment to 0 brix and press [12]. This order is a standard practice and many manipulations to this order can be done, which can result in more interesting wines which define the winemaker style.

Chapter 2

Materials and Methods

Variable Yield Trial Site Description

The variable yield trial site was conducted at Bien Nacido Vineyards, Santa Maria, California. The vineyard is located on Santa Maria Mesa road, approximately 10 miles east of Highway 101. The soil type at the trial site is a gravely/sandy loam. Grapevines were first planted in this block in 1973, and then tore out in 1992. The Pinot Noir clone 2A on 101-14 rootstock was then planted in 1994.

Rows are planted in a north-south direction. The vines are spaced 4 feet by 8 feet (vine x row spacing), drip irrigated, and cane pruned. The canes are tied onto a vsp (vertical shoot positioning) trellis system. The training wire is 34 inches from the ground with four moveable catch wires above it.

Experimental Design

The trial consisted of 8 treatments and a control. The treatments and control totaled 258 vines. The 8 treatments encompassed 25 vines each and the control had 50 vines. A buffer vine separated the eight treatments and the control. The test plot consisted of 9 rows with the first containing 18 vines, second 21 vines, third 24 vines, fourth 27 vines, fifth 29 vines, sixth 31 vines, seventh 32 vines, eighth 37 vines, and the ninth had 38 vines. The irrigation and fertilizer program was kept consistent throughout the block with no variation. Removal of leaves was standardized across all 8 treatments and the control. The east side was striped of most leaves around the fruiting zone for sunlight exposure and the west side was moderately removed to encourage air flow. The leaf removal was performed on 6-13-02 and 6-16-03. Suckering

(removal of non-fruitful shoots) was performed on 6-14-02 and 6-17-03, on the entire block. Mechanical hedging of the canopy throughout the block was performed once on 8-14-02 and 7-16-03.

Crop Load Adjustments

The historical data taken from Bien Nacido Vineyards on cluster weights showed an average of .25 pounds per cluster in pinot noir. In order to forecast the possible cropping levels this data was used in collaboration of cluster counts. The first 4 treatments were early fruit drops at post-bloom on 6-23-02 and 6-23-03. The first treatment was stripped of excess clusters, leaving seven for a possible crop load of 1 ton per acre. The second treatment left 14 for a possible 2 tons/acre, the third 21 clusters for a possible 3 tons/acre, and the fourth 28 clusters for a possible 4 tons/acre. The second 4 treatments were fruit drops on 8-30-02 and 8-17-03, at 75% veraison (fruit becomes soft with the red varieties changing color) with the greenest of the fruit being discarded first. Again the first treatment left 7 clusters behind, second 14 clusters, third 21 clusters, and the fourth 28 clusters. The control was left alone, with no fruit removed.

Caliper Readings

A caliper is a tool used to measure small objects in either millimeters or inches. Caliper readings began on 7-9-02 and 7-18-03, with only the post-bloom treatments and control recorded. The readings were performed once a week with a random sampling method for choosing the clusters. Each cluster had 3 berries measured, one berry from the top, middle, and bottom of cluster. A total of 17 clusters were measured from each treatment. The 17 clusters yielded 51 berry readings.

Fruit was dropped on 8-30-02 and 8-17-03, from the remaining 4 treatments at 75% veraison. Caliper readings began on 9-6-02 and 8-22-03, for the 4 treatments of 75% veraison. The eight treatments and the control were now being recorded weekly with 51 berry samples taken from each. Digital pictures were also taken in conjunction with the caliper readings on a weekly basis (Olympus, Camedia model #D-360L). The caliper readings continued until harvest on 10-12-02 and 9-29-03.

Harvest

Harvest commenced on 10-12-02 and 9-29-03, with all eight treatments and the control being harvested. Each vine was harvested separately, with the clusters being counted and weighed. This made it possible to figure out the average cluster weight for each vine within the eight treatments and the control. Each treatment and the control was crushed and destemmed separately so that an accurate measurement of sugar and acid content could be recorded. The sugar content was recorded in degree brix using a handheld temperature compensating refractometer (Atago, model ATC-1E). An Orion analog pH meter, model 301, was used in conjunction with 0.10N sodium hydroxide to measure the total acidity of each treatment.

Wine Process

The eight treatments were combined into four. The post-bloom fruit drop was combined with the 75% veraison fruit drop, keeping the 7 cluster, 14 cluster, 21 cluster, and the 28 cluster samples separate. This yielded four cropping level treatments and also the control. The sugar content and total titratable acidity was again recorded in the same manner. The treatments along with the control were acidulated to a total titratable acidity of 7.5 grams per liter, or .75 %, with tartaric acid. The acidity needed to be consistent for all the treatments since extractable phenols

are very dependant upon the acid content (ETS Laboratories). Potassium meta-bi-sulfate (sulfur) was added at a rate of 30 parts per million, .23g/gallon, to kill off the wild strains of yeast that may be present in the must. Enoferm RA17 Burgundy isolate yeast was added at a rate of 2 grams per liter of must. Fermentation was performed in 115 liter Sterilite plastic storage totes with the cap being punched down twice a day. The must was measured for sugar content using a hydrometer until 0% sugar remained (dry). The must was then pressed using a 15-gallon basket press. The wine then was placed in 5-gallon glass carboys. Wine samples from the 4 treatments and the control were taken out of the glass carboys on 2-5-03 and 2-10-04, then sent to ETS Laboratories in Saint Helena to perform a red wine phenolic report. Lino Bozzano of Tantara Winery was used as a consultant throughout the wine process.

Pruning

Pruning first took place on 1-15-02, 1-24-03, and 2-3-04. The first pruning job was a double cane per vine with no renewal spurs left. The canes were each left approximately 4 feet long causing them to overlap the vine next to it. This brought the total fruiting length of each vine to approximately 8 feet long. The second and third pruning job on 1-24-03 and 2-3-04, was done exactly in the same manner as the first with the two 4 feet long canes left per vine. The shoots from each vine were counted and then weighed on a temperature compensated field scale (CCI Scale Company) with the data recorded.

Statistical Analysis

All data were analyzed using Minitab version 15. Results were determined using an appropriate General Linear Model. All analyses were performed at the 0.05 level.

Chapter 3

Results and Discussion

Titrateable Acidity (TA) was significantly different between the 2002 and 2003 growing seasons ($p=0.017$) with TA lower in 2003 than 2002. As mentioned in Chapter 1, titrateable acidity measures the undissociated forms of acids, besides the concentration of free hydrogen ions. The undissociated forms of acids include organic acids, volatile acids, amino acids, and inorganic acids such as phosphoric acids [25]. This result is most likely due to the growing conditions of the two separate years. Year 2003 contained less chill hours, rain fall, and was harvested two weeks earlier than 2002 [Figure 3, Table 1]. There was no significant difference in titrateable acidity between the early and late fruit thinning ($p=0.694$). These results indicate that the post bloom drop compared to seventy five percent veraison drop only slightly affected TA. There was also no significant difference between the tonnage treatments ($p=0.157$). The one ton, two ton, three ton, and four ton cropping levels also had minimal effect on TA. To summarize TA for both 2002 and 2003, we find the significant difference was by year and most likely caused by climatic conditions not treatments.

There was no significant difference with regards to pH between the 2002 and 2003 growing seasons ($p=0.888$). The early versus late fruit thinning resulted in no significant difference ($p=0.576$) with regards to pH. The tonnage treatments also resulted in no significant difference ($p=0.316$) with regards to pH. No statistically significant change in pH was discovered in either year, timing of thinning, or cropping level. This was not the result found by Price et al., where reduced crop levels increased pH [23]. We would suspect the pH to have been significantly higher in reduced cropping levels. Table 1 exhibits that in 2002 the two ton early

level was highest and in 2003 the four ton late was highest. We must conclude that pH was not a significant factor in this study.

Total Soluble Solids (Brix) analysis showed a significant difference between the early versus late fruit thinning ($p=0.033$) with the late fruit thinning resulting in a higher brix. Seventy five percent veraison thinning (late drop) as opposed to post set thinning (early drop) shows that there is an advanced amount of maturation that occurs, with concern to sugar content. This is most likely due to the added stress placed on the vine to ripen the added crop load (29). Another factor that must be taken into account is that the greener/less ripe fruit was noticeable at the time of the late drop due to the change in color. Less advanced fruit was dropped first in order to create a more uniform harvest. This selective fruit drop most likely caused the higher brix as opposed to the lower brix found in the early fruit drop. There was no significant difference between the tonnage treatments ($p=0.064$) with regards to brix. According to Bravado et al., high crop loads delayed the date of harvest throughout their five year trial [7]. Although not statistically significant according to appendix O, we find a trend that exhibits a delay in ripening for lower tonnage levels [table 1]. There was no significant difference between the 2002 and 2003 growing seasons ($p=0.934$) with regards to brix. We can conclude that late fruit thinning ascertained a higher degree of brix most likely caused by two factors. First, the trial was conducted in a high vigour location which caused the vine to naturally be vegetative in growth, by leaving the fruit on the vine and dropping later caused a certain amount of added stress producing a more balanced vine causing the vine to ripen earlier. Second, the late fruit drop gave us the advantage of selecting (visually) more uniform clusters to drop, due to the change in color known as veraison [30].

There was not a statistically significant effect of drop level on the mean caliper size in 2002 ($p=0.338$). There is a statistically significant effect of drop date (early vs. late) on the mean caliper size in 2002 ($p=0.22$). When the drop is early, we estimate the mean caliper size to be 0.0114 larger than when the drop is later. This result is the mean caliper size across all eight treatments, which suggests that in general dropping early will usually leave larger berries. Larger berries can have a negative impact on phenolics, which can produce a less attractive wine do to less skin contact during the fermentation process [21]. According to Bravdo et al., increased berry weight/size did not improve wine quality, therefore an early fruit drop would not be advantageous to wine quality [7]. There is a statistically significant interaction between drop level and drop date in 2002 ($p=0.000$). In particular, with a 3-ton drop level, an early drop produces grapes that are 0.0250 smaller than we would expect in the additive model and a late drop produces grapes that are 0.0250 larger than we would expect with the additive model. Compared to the no drop as a control group. This would suggest that the early three ton drop level would have a positive impact on phenolic extraction with smaller berries contributing more skin contact during fermentation when compared to the late three ton drop level [21]. There is not a statistically significant difference with the location of the berries within the cluster, top/middle/bottom in 2002 ($p=0.207$). To summarize the caliper measurements in 2002, when we compare drop date to the mean caliper size (berry size) we find that a late drop produces the smallest berries, on average, in a vigorous site. When we compare drop level to drop date, we find that at the three ton level, an early drop would be more advantageous to wine phenolics as opposed to a three ton late drop.

There is a statistically significant effect of drop level on the mean caliper size in 2003 ($p=0.000$). As opposed to 2002, this suggests that tonnage levels do impact the size of the

berries. There is not a noticeable difference between a four ton drop and no drop at all, but three, two, and one ton drop levels produce larger grapes than no drop. This suggests that dropping time/date set aside, lower cropping levels produce larger grapes. According to Price et al., reducing crop levels led to a higher berry weight/size [23]. There is a statistically significant effect of drop date on the mean caliper size in 2003 ($p=0.000$). When the drop is early, we estimate the mean caliper size to be 0.0327 larger than when the drop is later. Therefore, 2003 suggests, as does 2002, that dropping early and lower tonnage levels will produce larger grapes. There is a statistically significant interaction between drop level and drop date in 2003 ($p=0.000$). In particular, with a three ton drop level, an early drop produces grapes that are 0.0440 larger than we would expect in the additive model and a late drop produces grapes that are 0.0440 smaller than we would expect with the additive model. This result contradicts what we find in the 2002 growing season. 2002 produced smaller berries with the three ton early drop as opposed to the late drop. With a four ton drop level, an early drop produces grapes that are 0.0445 smaller than we would expect with the additive model and a late drop produces grapes that are 0.0445 larger than we would expect with the additive model. Compared to no drop as a control group. There is not a statistically significant difference with the location of the berries within the cluster, top/middle/bottom in 2003 ($p=0.315$). To summarize the caliper measurements in 2003, when we compare drop date to the mean caliper size (berry size) we find that a late drop produces the smallest berries, on average, in a vigorous site. This is also the conclusion in 2002 which strengthens the argument that a late fruit drop is most advantageous to wine quality in a vigorous site. We can also conclude that the interaction in 2003 between drop level and drop date at the three ton level suggests that an early drop would produce larger grapes, contradicting the findings of 2002.

There is a statistically significant relationship between drop level and average cluster weight in 2002 ($p < .001$). A post-hoc comparison of treatment group means was performed via the Tukey-Kramer procedure and those results indicate that on average, a one ton level has significantly higher oz/cluster/vine than the 2 ton level ($p < .001$), three ton level ($p < .001$), four ton level ($p < .001$) levels. No other differences were observed. There is also a statistically significant effect of the time of fruit drop on the average cluster weight in 2002 ($p = .001$). Early has higher weights than late, on average. There is a statistically significant interaction between drop time and drop level ($p < .001$). At the 1, 2, and 3 ton levels there is not a significant difference between the mean cluster weights. At the four ton level, early fruit drop has a significantly higher cluster weight. To summarize the cluster weights in 2002, with small clusters producing the best possible wine quality, then we must ascertain that the one ton level produces the heaviest clusters thus the least attractive. According to Price et al., reducing crop level led to slightly less yield per vine, but higher cluster weights, berries per cluster, and berry weights [23]. The one ton level produced an actual .96 tons/acre on the early drop and 1.01 tons/acre on the late drop [table 1]. We can also conclude that on average, the early fruit drop had heavier clusters. If we wanted to produce more tons to the acre and still have smaller clusters, then we find that at the four ton level with a late drop had the greatest impact producing small clusters. The early four ton level produced an actual 3.39 tons to the acre and late four ton level produced 2.53 tons to the acre [table 1]. In conclusion, the 2002 growing season produced the best quality (smallest) clusters on average with the late fruit drop.

There is a statistically significant relationship between drop level and the average cluster weight in 2003 ($p < .001$). A post-hoc comparison of treatment group means was performed via the Tukey-Kramer procedure and those results indicate that on average, a two ton level has

higher mean cluster weights than the control ($p < .014$). The three ton level has higher mean cluster weights than the four ton level ($p = .019$), and the control ($p = .001$). No other statistically significant differences were observed. There is not a statistically significant relationship between drop time and average cluster weight in 2003 ($p = .121$). There is a statistically significant interaction between drop time and drop level. At the one ton level, the early drop has a lower mean weight than we would have expected from an additive model ($p = .005$). No other statistically significant interactions were observed. To summarize the cluster weights in 2003, we find that the three ton level produced higher mean cluster weights on average than the four ton level ($p = .019$), and the control ($p = .001$). The three ton level produced an actual 2.57 tons to the acre on the early drop and 2.1 tons to the acre on the late drop [table 1]. The one ton level with early drop had a lower mean weight than we would have expected from an additive model, which opposes our findings in 2002. In conclusion the 2003 growing season opposed the results found from the 2002 growing season.

We are using the square root of the 2002 pruning weight (in ounces) as the response variable for our analyses. This is because if we had used the actual pruning weights we would have reason to believe the ANOVA assumption of normality to be invalid. With this change in the response variable, there is a statistically significant relationship between drop level and average shoot weight in 2002 ($p < .001$). The average shoot weight is significantly higher at the one ton level than it is at the three ton level ($p < .001$), four ton level ($p = .006$), and no fruit drop ($p < .001$) levels. No other significant effects were found. There is also a significant relationship between drop time and average shoot weight in 2002 ($p < .001$) with the late fruit drop being followed by a lower shoot weight. There is not a significant interaction between drop level and drop time in 2002 ($p = .053$). This means that there effect of drop level on the shoot weights does

not significantly differ by drop time. To summarize the shoot weights in 2002, we find that all treatments would be classified as high vigour according to Robinson and Smart [27]. The yield to pruning weight ratio model used by Robinson and Smart states that the yield to pruning weight ratio is considered high vigour at <3 [27]. The ratio of yield to pruning weight for 2002 gives us a range of .39 to 1.78, concluding a high vigour site [table 3].

We are using the square root of the 2003 pruning weight (in ounces) as the response variable for our analyses. This is because if we had used the actual pruning weights we would have reason to believe the ANOVA assumption of normality to be invalid. With this change in the response variable, there is a statistically significant relationship between drop level and average shoot weight in 2003 ($p=.004$). The average shoot weight is significantly lower at the three ton level than it is at the one ton level ($p=.041$) and at the four ton level ($p=.029$). No other significant effects were found. There is a significant relationship between drop time and average shoot weight in 2003 ($p=.049$) with the late drop resulting in lower pruning weights. There is not a significant interaction between drop level and drop time in 2003 ($p=.344$). This means that there effect of drop level on the shoot weights does not significantly differ by drop time. To summarize the shoot weights for 2003, we find that all treatments would be classified as high vigour according to Robinson and Smart [27]. The yield to pruning weight ratio model used by Robinson and Smart states that the yield to pruning weight ratio is considered high vigour at <3 [27]. The ratio of yield to pruning weight for 2003 gives us a range of .32 to 1.36, concluding a high vigour site [table 4]. 2003 expressed a significantly lower shoot weight at the three ton level than at the one ton level ($p=0.41$), and at the four ton level ($p=.029$), which strengthens the findings in 2002 that a lower tonnage level increased growth vigour. Both 2002 and 2003 found a significant relationship between drop time and average shoot weight, 2002 ($p<.001$), and 2003

($p=0.049$). This significant relationship expressed that an early drop increased the shoot weight which contributed only more vigour to an already high vigour site.

The mean level of gallic acid differs significantly by year ($F=28.63$, $p=0.006$), but not across our five treatments ($F=1.48$, $p=0.357$). The main sources of gallic acid in wine are grape seeds and oak cooperage. Since no oak was used on the wine, prior to laboratory analysis, we can assume the gallic acid content is derived from the seeds. Sourcing that seeds are the contributing factor here to a significant difference between years with concern to gallic acid, one must assume the earlier harvest in 2003 as a possible explanation.

The mean level of catechin differs significantly by year ($F=53.45$, $p=0.002$), but not across our five treatments ($F=1.45$, $p=0.363$). Catechin is known as a flavonol, flavon-3-ols, or procyanidins. Catechin compounds are found in high concentrations in seeds, stems, and may be found in the skins of immature grapes [8]. As grapes mature the seed coat is formed making seed phenolics increasingly difficult to extract. This leads to the assumption that the difference in maturity varied significantly by year leaving a higher content of the catechin flavonol in 2003.

The mean level of epicatechin differs significantly by year ($F=30.91$, $p=0.005$), but not across our five treatments ($F=2.16$, $p=0.237$). Epicatechin is known also as a flavonol, flavon-3-ols, or procyanidins. Epicatechin compounds are found in high concentrations in seeds, stems, and may be found in the skins of immature grapes [8]. Once again, as grapes mature the seed coat is formed making seed phenolics increasingly difficult to extract. This leads to the assumption again that the difference in maturity varied significantly by year leaving a higher content of the epicatechin flavonol in 2003.

The mean level of polymeric phenols differs significantly by year ($F=14.9672$, $p=0.01801$), but not across our five treatments ($F=0.2352$, $p=0.90506$). Wine tannins are

complex polymers that strongly affect wine flavor and color. Tannin includes phenolic polymers from grape seeds, skins, and stems as well as compounds formed or modified in wine.

Extraction of polymeric phenols (tannins) is driven by temperature, time, alcohol content and physical manipulations such as pumpovers [8]. The significant difference between years leads us to believe that the extraction process during the fermentation process could have been skewed since no temperature readings were reported for either year.

The mean level of caftaric acid does not differ significantly by year ($F=3.4177$, $p=0.1382$), and not across our five treatments ($F=2.96$, $p=0.161$).

The mean level of quercetin glycosides differs significantly by year ($F=11.59$, $p=0.027$), but not differ across our five treatments ($F=0.40$, $p=0.802$). Quercetin is a flavonol present in grape skins and stems as several different glycosides (compounds with attached sugars).

Quercetin accumulates in grape skins to protect against damage from ultra violet light. There are high concentrations of quercetin in sun exposed grape skins and in wine made from sun exposed grapes. Quercetin is readily extracted from grape skins during fermentation [8]. Quercetin glycosides are significantly different with a higher content found in the 2002 growing season. The practice of leafing was performed in the same manner both years, but was not measured. We must assume that more ultra violet light was exposed to the fruit in 2002 than in 2003, thus giving us a higher content of quercetin glycosides in 2002.

The mean level of quercetin aglycone does not differ significantly by year ($F=2.67$, $p=0.178$), and does not differ across our five treatments ($F=4.00$, $p=0.104$).

The mean level of malvidin glucoside does not differ significantly by year ($F=0.0176$, $p=0.9008$), and does not differ across our five treatments ($F=1.8992$, $p=0.2748$).

The mean level of polymeric anthocyanins does not differ significantly by year ($F=0.1546$, $p=0.7142$), and does not differ across our five treatments ($F=0.1787$, $p=0.9380$).

The mean level of total anthocyanins does not differ significantly by year ($F=0.1803$, $p=0.6930$), and does not differ across our five treatments ($F=2.5213$, $p=0.1961$).

The mean level of monomeric anthocyanins does not differ significantly by year ($F=0.1801$, $p=0.6931$), and does not differ across our five treatments ($F=2.1831$, $p=0.2341$).

To summarize the phenolic analysis of 2002 and 2003, we find the only significant difference was found in five of the eleven phenolic compounds. The five significant differences differed only by year, and not across the five treatments. We must conclude that the differences found between 2002 and 2003 were most likely caused by two factors. First, the climatic conditions varied widely for both 2002 and 2003 [figure 3]. Secondly, we did not record or control the temperature of the fermentations in either year. Temperatures during fermentation can play an important role on the amount of phenolic extraction, with higher temperatures enhancing the extraction of phenols and color [21,31,32].

In conclusion, for pinot noir wine grapes, with high vine vigour, under similar trial conditions, it probably is unnecessary to perform cultural practices that decrease the tonnage level below the four ton treatment. Furthermore, early (post-bloom) thinning is not recommended, as berry size increased, sugars decreased and shoot weights increased, creating a detrimental vine balance.

Chapter 4

Recommendations for Further Study

Recommendations for further study would narrow the experiment down to a reasonable amount of variables. I believe we took on too much for this study and some analyses may have suffered. As a vineyard manager, I believe we should have kept the vineyard practices separate from the wine making procedures. We should have used juice samples, sending the juice samples to ETS laboratories for analysis which would have minimized the problems incurred by producing the wine. The problems during the wine making process varied, but most stemmed from too small amount of juice which led to a multitude of problems, including stuck fermentations. My recommendation would be to send ETS laboratories a juice, berry, or cluster sample for a rapid phenolic panel which measures four components, catechin, polymeric anthocyanins, tannins, and total anthocyanins.

If we were to continue with the wine producing segment of this experiment then we should quadruple the treatment size at a minimum, so that we have a large enough sample base for the wine production, keeping the early and late drops separate along with the tonnage levels. A professional wine maker should oversee the production of winemaking with accurate notes taken on fermentation temperatures to ensure an even extraction of phenols and color from all treatments.

Caliper readings should also be in concert with berry counts at time of harvest. Berry counts per cluster would have given us a better estimate of berry weight. Shoot weights should also be measured along with diameter of shoots and number of nodes per shoot to give a more accurate account of vigour across our eight treatments.

Finally, we should perform a statistical combined analysis of both years, 2002 and 2003. Our conclusions had conflicting results when comparing the 2002 and 2003 growing seasons in regards to berry size (caliper readings), cluster weights, and shoot weights. A combined analysis may offer some more refined conclusions.

Figure 1. Degree hours accumulated from Adcon weather station for both 2002 and 2003 growing years.

Figure 2. Chill hours accumulated from Adcon weather station for both 2002 and 2003 growing years.

Figure 3. Weather data from Adcon weather station, 2002 & 2003 side by side.

Figure 4. Photograph of Trial Site.

Photograph of two ton early drop treatment.

Figure 5. Photograph of one ton early drop treatment pre-veraison.

Photograph of five ton control treatment pre-veraison.

Figure 6. Photograph of pruned three ton treatment.

Photograph of pruned trial site.

Figure 7. Map layout of trial site.

Vines	Rows								
	1	2	3	4	5	6	7	8	9
1								r	r
2	y	yy	yy	ww	ww	pp	pp	r	r
3	y	yy	yy	ww	ww	pp	pp	r	r
4	y	yy	yy	ww	ww	pp	pp	r	r
5	y	yy	yy	ww	ww	pp	pp	r	r
6	y	yy	yy	ww	ww	pp	pp	r	r
7	missing	missing	yy	ww	ww	pp	control	r	r
8	y	yy	yy	ww	ww	pp	b	r	r
9	y	yy	yy	ww	ww	pp	b	r	r
10	y	yy	yy	ww	ww	pp	b	r	r
11	y	yy	yy	ww	ww	pp	b	r	r
12	y	yy	y	ww	ww	pp	b	r	r
13	y	yy	yy	ww	ww	pp	b	control	r
14	y	yy	control	control	ww	pp	b	bb	r
15	y	yy	w	w	control	pp	b	bb	r
16	y	control	w	w	p	pp	b	bb	r
17	y	y	w	w	p	pp	b	bb	r
18	y	y	w	w	p	pp	b	bb	r
19	y	y	w	w	p	pp	b	bb	missing
20	y	y	w	w	p	pp	b	bb	r
21		y	w	w	p	pp	b	bb	r
22		y	w	w	p	control	b	bb	r
23		y	w	w	p	p	b	bb	r
24			w	w	p	p	b	bb	r
25			w	w	p	p	b	bb	r
26				w	p	p	b	bb	r
27				w	p	p	b	bb	r
28		NORTH		w	p	p	b	bb	r
29	WEST	+	EAST		p	p	b	bb	r
30		SOUTH			p	p	b	bb	r
31						p	b	bb	r
32		Y = Post-Bloom drop/1 ton				p	b	bb	r
33		YY = 75% veraison drop/1 ton					control	bb	r
34		W = Post-Bloom drop/2 ton					missing	bb	r
35		WW = 75% veraison drop/2 ton					bb	bb	r
36		P = Post-Bloom drop/3 ton					stunted	bb	r
37		PP = 75% veraison drop/3 ton						bb	r
38		B = Post-Bloom drop/4 ton							r
39		BB = 75% veraison drop/4 ton							r
40		R = Control							

Figure 8. 2002 growing season.

1-13-03 Trial site map containing number of canes pruned/vine.

	1	2	3	4	5	6	7	8	9
1								r15	r20
2	y11	yy19	yy24	ww20	ww17	pp22	pp20	r11	r18
3	y17	yy22	yy19	ww23	ww25	pp23	pp19	r21	r17
4	y15	yy21	yy20	ww17	ww21	pp14	pp19	r22	r22
5	y24	yy25	yy30	ww19	ww18	pp26	pp19	r23	r22
6	y21	yy23	yy15	ww22	ww20	pp20	pp26	r17	r22
7	missing	missing	yy20	ww24	ww13	pp27	control	r18	r19
8	y24	yy17	yy22	ww19	ww18	pp25	b19	r23	r23
9	y20	yy15	yy22	ww23	ww20	pp22	b20	r16	r22
10	y22	yy19	yy22	ww24	ww23	pp31	b25	r18	r16
11	y25	yy15	yy22	ww17	ww16	pp20	b21	r20	r20
12	y20	yy25	yy20	ww20	ww27	pp24	b17	r25	r13
13	y20	yy19	yy22	ww19	ww21	pp21	b21	control	r27
14	y21	yy21	control	control	ww20	pp16	b13	bb18	r24
15	y18	yy15	w21	w17	control	pp22	b18	bb15	r17
16	y19	control	w18	w20	p21	pp19	b21	bb31	r28
17	y25	y18	w23	w22	p21	pp24	b26	bb26	r22
18	y17	y22	w19	w24	p20	pp26	b18	bb18	r28
19	y19	y17	w24	w24	p19	pp20	b26	bb26	missing
20	y27	y29	w21	w24	p22	pp20	b16	bb28	r27
21		y19	w20	w21	p21	pp27	b17	bb22	r21
22		y18	w23	w27	p22	control	b23	bb20	r22
23		y22	w20	w20	p23	p24	b26	bb21	r18
24			w19	w19	p23	p25	b24	bb24	r22
25			w23	w21	p22	p27	b20	bb25	r22
26				w20	p17	p25	b20	bb23	r19
27				w19	p23	p23	b21	bb25	r22
28				w21	p22	p24	b21	bb25	r20
29					p15	p22	b21	bb20	r24
30					p21	p18	b20	bb26	r25
31						p18	b19	bb23	r25
32			NORTH			p26	b31	bb22	r23
33		WEST	+	EAST			control	bb24	r24
34			SOUTH				missing	bb28	r29
35							bb28	bb23	r26
36							stunted	bb26	r21
37								bb27	r19
38									r24
39									r22

Figure 9. 2002 growing season.

1-13-03 Trial site map containing ounces of prunings/vine.

	1	2	3	4	5	6	7	8	9
1								r36	r36
2	y39	yy45	yy51	ww60	ww52	pp56	pp46	r14	r26
3	y36	yy46	yy54	ww64	ww64	pp43	pp44	r57	r26
4	y75	yy36	yy57	ww25	ww45	pp15	pp41	r58	r54
5	y63	yy62	yy58	ww44	ww22	pp36	pp25	r41	r33
6	y91	yy43	yy36	ww43	ww34	pp48	pp69	r30	r39
7	missing	missing	yy43	ww65	ww46	pp34	control	r56	r32
8	y66	yy44	yy42	ww41	ww20	pp28	b43	r49	r32
9	y44	yy38	yy43	ww41	ww32	pp34	b46	r48	r48
10	y100	yy42	yy45	ww72	ww53	pp52	b53	r38	r52
11	y54	yy28	yy53	ww46	ww37	pp41	b34	r51	r29
12	y58	yy50	yy45	ww42	ww50	pp36	b38	r25	r20
13	y53	yy42	yy28	ww34	ww26	pp28	b50	control	r71
14	y55	yy46	control	control	ww36	pp29	b28	bb24	r37
15	y55	yy24	w54	w32	control	pp47	b36	bb20	r34
16	y63	control	w38	w49	p60	pp25	b57	bb39	r52
17	y77	y52	w46	w55	p42	pp48	b42	bb56	r38
18	y34	y50	w40	w56	p43	pp80	b39	bb33	r83
19	y51	y36	w60	w40	p38	pp62	b47	bb34	missing
20	y93	y63	w51	w57	p32	pp40	b35	bb64	r34
21		y49	w51	w49	p52	pp60	b45	bb40	r40
22		y48	w41	w54	p30	control	b56	bb38	r31
23		y48	w58	w49	p40	p42	b52	bb62	r48
24			w25	w37	p40	p45	b46	bb62	r36
25			w69	w57	p28	p50	b40	bb34	r55
26				w45	p45	p50	b51	bb45	r40
27				w37	p30	p48	b47	bb38	r54
28				w46	p57	p54	b80	bb42	r41
29					p38	p53	b52	bb47	r50
30					p73	p44	b37	bb63	r37
31						p51	b28	bb34	r66
32			NORTH			p75	b80	bb53	r38
33		WEST	+	EAST			control	bb63	r34
34			SOUTH				missing	bb53	r83
35							bb10	bb62	r57
36							stunted	bb54	r33
37								bb88	r56
38									r39
39									r38

Figure 10. 2002 growing season.

10-12-02 Number of clusters harvested/vine.

	1	2	3	4	5	6	7	8	9
1								r30	r22
2	y4	yy7	yy7	ww15	ww12	pp22	pp24	r18	r23
3	y7	yy7	yy7	ww9	ww17	pp25	pp19	r31	r30
4	y8	yy9	yy6	ww15	ww16	pp11	pp24	r33	r31
5	y8	yy5	yy8	ww15	ww14	pp22	pp23	r37	r27
6	y3	yy8	yy7	ww15	ww14	pp26	pp25	r34	r32
7	missing	missing	yy7	ww15	ww10	pp25	control	r30	r31
8	y6	yy8	yy7	ww14	ww12	pp23	b29	r36	r37
9	y11	yy4	yy6	ww13	ww15	pp23	b30	r23	r23
10	y6	yy9	yy9	ww15	ww14	pp30	b27	r32	r32
11	y8	yy7	yy9	ww14	ww18	pp20	b30	r37	r37
12	y8	yy7	yy10	ww13	ww25	pp28	b31	r34	r20
13	y7	yy8	yy20	ww11	ww13	pp23	b29	control	r26
14	y6	yy7	control	control	ww14	pp16	b19	bb26	r38
15	y8	yy6	w14	w14	control	pp16	b29	bb22	r15
16	y7	control	w13	w13	p17	pp17	b27	bb30	r38
17	y6	y6	w14	w16	p24	pp19	b24	bb35	r29
18	y9	y10	w16	w13	p17	pp18	b26	bb21	r35
19	y8	y8	w16	w11	p24	pp18	b29	bb29	missing
20	y9	y9	w11	w19	p18	pp18	b27	bb28	r35
21		y8	w15	w16	p21	pp22	b21	bb26	r21
22		y6	w13	w15	p21	control	b28	bb33	r34
23		y7	w14	w14	p23	p16	b26	bb27	r24
24			w12	w14	p21	p23	b25	bb20	r25
25			w9	w14	p21	p20	b28	bb18	r36
26				w15	p17	p11	b26	bb29	r22
27				w13	p24	p16	b29	bb28	r35
28				w14	p22	p15	b24	bb20	r28
29					p16	p19	b25	bb25	r42
30					p20	p20	b36	bb32	r32
31						p11	b22	bb22	r32
32			NORTH			p22	b26	bb20	r24
33		WEST	+	EAST			control	bb26	r20
34			SOUTH				missing	bb27	r40
35							bb28	bb25	r38
36							stunted	bb26	r21
37								bb29	r29
38									r17
39									r37

Figure 11. 2002 growing season.

10-12-02 Ounces of harvested fruit/vine.

	1	2	3	4	5	6	7	8	9
1								r83	r60
2	y14	yy19	yy17	ww41	ww29	pp56	pp82	r27	r56
3	y20	yy23	yy25	ww17	ww41	pp66	pp52	r103	r75
4	y30	yy28	yy20	ww36	ww48	pp19	pp76	r76	r70
5	y16	yy11	yy24	ww30	ww32	p58	pp68	r125	r66
6	y5	yy27	yy17	ww39	ww38	pp86	pp57	r92	r99
7	missing	missing	yy26	ww33	ww28	pp77	control	r70	r84
8	y12	yy24	yy21	ww32	ww32	pp62	b103	r88	r120
9	y32	yy14	yy15	ww34	ww40	pp70	b87	r69	r72
10	y12	yy28	yy25	ww42	ww36	pp89	b86	r78	r106
11	y27	yy16	yy26	ww32	ww55	pp45	b104	r129	r120
12	y33	yy22	yy32	ww31	ww44	pp64	b100	r89	r44
13	y19	yy29	yy60	ww16	ww35	pp61	b88	control	r53
14	y20	yy26	control	control	ww41	pp41	b73	bb52	r96
15	y27	yy17	w23	w28	control	pp46	b93	bb56	r38
16	y18	control	w34	w36	p52	pp43	b89	bb80	r113
17	y17	y31	w36	w43	p66	pp47	b82	bb82	r87
18	y20	y27	w35	w34	p44	pp39	b69	bb54	r96
19	y22	y25	w47	w22	p68	pp35	b100	bb61	missing
20	y33	y34	w28	w47	p56	pp51	b96	bb69	r84
21		y28	w37	w37	p47	pp51	b54	bb59	r56
22		y19	w32	w34	p52	control	b67	bb75	r77
23		y22	w36	w29	p64	p43	b72	bb59	r64
24			w25	w35	p40	p48	b74	bb45	r40
25			w31	w42	p40	p49	b62	bb36	r81
26				w45	p45	p29	b88	bb77	r55
27				w41	p47	p42	b66	bb60	r69
28				w34	p53	p43	b52	bb43	r66
29					p46	p49	b63	bb65	r93
30					p64	p36	b92	bb82	r66
31						p24	b40	bb37	r50
32			NORTH			p76	b90	bb37	r41
33		WEST	+	EAST			control	bb64	r51
34			SOUTH				missing	bb56	r110
35							bb49	bb70	r91
36							stunted	bb58	r41
37								bb63	r74
38									r27
39									r112

Figure 12. 2003 growing season.

2-5-04 Trial site map containing number of canes pruned/vine.

	1	2	3	4	5	6	7	8	9
1								r18	r21
2	y13	yy20	yy26	ww18	ww20	pp24	pp23	r9	r19
3	y14	yy23	yy17	ww19	ww30	pp20	pp9	r21	r19
4	y19	yy17	yy19	ww19	ww19	pp14	pp19	r17	r18
5	y20	yy17	yy30	ww19	ww15	pp18	pp22	r20	r20
6	y19	yy23	yy18	ww19	ww22	pp14	pp20	r19	r21
7	missing	missing	yy17	ww20	ww26	pp18	control	r19	r22
8	y21	yy25	yy19	ww14	ww17	pp17	b21	r18	r17
9	y23	yy20	yy19	ww18	ww14	pp15	b21	r20	r20
10	y22	yy27	yy17	ww20	ww19	pp29	b28	r25	r19
11	y24	yy17	yy17	ww15	ww16	pp15	b13	r15	r21
12	y16	yy26	yy20	ww13	ww22	pp19	b18	r24	r16
13	y16	yy15	yy16	ww17	ww15	pp23	b18	control	r22
14	y13	yy21	control	control	ww14	pp16	b8	bb18	r24
15	y17	yy19	w19	w22	control	pp16	b17	bb18	r19
16	y21	control	w21	w19	p26	pp20	b23	bb20	r24
17	y22	y13	w30	w21	p21	pp20	b22	bb20	r20
18	y15	y20	w17	w20	p19	pp25	b20	bb18	r26
19	y18	y14	w31	w20	p20	pp18	b15	bb23	missing
20	y22	y24	w15	w24	p25	pp17	b21	bb19	r20
21		y18	w23	w20	p28	pp20	b20	bb23	r21
22		y23	w24	w21	p18	control	b20	bb18	r21
23		y19	w19	w23	p24	p17	b21	bb26	r19
24			w17	w16	p27	p19	b22	bb14	r19
25			w30	w20	p15	p30	b17	bb18	r21
26				w20	p19	p21	b20	bb24	r28
27				w17	p21	p19	b17	bb27	r20
28				w16	p23	p19	b27	bb17	r19
29					p28	p22	b15	bb25	r16
30					p31	p21	b16	bb20	r26
31						p12	b13	bb25	r29
32			NORTH			p21	b25	bb26	r20
33		WEST	+	EAST			control	bb21	r15
34			SOUTH				missing	bb19	r29
35							bb21	bb19	r24
36							stunted	bb21	r25
37								bb28	r21
38									r23
39									r15

Figure 13. 2003 growing season.

2-5-04 Trial site map containing ounces of prunings/vine.

	1	2	3	4	5	6	7	8	9
1								r37	r52
2	y49	yy56	yy40	ww50	ww45	pp50	pp54	r12	r48
3	y22	yy40	yy46	ww52	ww52	pp34	pp28	r65	r42
4	y65	yy34	yy42	ww26	ww40	pp16	pp46	r49	r38
5	y60	yy61	yy55	ww44	ww26	pp36	pp29	r46	r46
6	y66	yy47	yy32	ww42	ww54	pp46	pp82	r33	r52
7	missing	missing	yy52	ww27	ww52	pp31	control	r57	r48
8	y49	yy58	yy55	ww38	ww36	pp23	b46	r50	r49
9	y42	yy44	yy33	ww36	ww38	pp25	b54	r45	r47
10	y92	yy60	yy46	ww66	ww56	pp60	b69	r42	r43
11	y65	yy42	yy62	ww26	ww38	pp42	b26	r45	r52
12	y45	yy52	yy47	ww30	ww58	pp36	b39	r28	r45
13	y44	yy43	yy31	ww43	ww20	pp33	b56	control	r44
14	y42	yy46	control	control	ww34	pp28	b22	bb27	r58
15	y58	yy33	w54	w26	control	pp43	b49	bb29	r54
16	y66	control	w53	w47	p63	pp29	b58	bb42	r45
17	y76	y52	w50	w43	p50	pp42	b52	bb46	r46
18	y20	y40	w46	w54	p45	pp61	b44	bb33	r48
19	y40	y30	w57	w42	p51	pp44	b52	bb39	missing
20	y76	y54	w46	w54	p39	pp24	b39	bb77	r47
21		y46	w56	w43	p69	pp36	b54	bb48	r50
22		y34	w45	w50	p38	control	b60	bb28	r39
23		y40	w54	w42	p55	p36	b59	bb82	r45
24			w24	w33	p47	p33	b50	bb53	r39
25			w74	w47	p31	p38	b40	bb36	r54
26				w46	p49	p43	b56	bb54	r39
27				w33	p22	p40	b34	bb39	r56
28				w38	p59	p45	b86	bb40	r54
29					p55	p34	b54	bb50	r50
30					p65	p37	b36	bb59	r46
31						p49	b30	bb40	r66
32			NORTH			p58	b77	bb66	r55
33		WEST	+	EAST			control	bb52	r48
34			SOUTH				missing	bb52	r70
35							bb49	bb60	r53
36							stunted	bb40	r48
37								bb70	r42
38									r56
39									r34

Figure 14. 2003 growing season.

9-29-03 Number of clusters harvested/vine.

	1	2	3	4	5	6	7	8	9
1								r34	r30
2	y7	YY9	yy9	ww15	ww18	pp22	pp25	r16	r31
3	Y6	YY10	yy11	ww13	ww18	pp24	pp14	r36	r42
4	Y8	yy9	yy11	ww14	ww17	pp22	pp24	r28	r27
5	Y8	YY8	yy15	ww18	ww16	pp24	pp22	r32	r34
6	Y8	yy8	yy8	ww22	ww15	pp23	pp25	r29	r26
7	missing	missing	yy8	ww17	ww18	pp22	control	r34	r41
8	Y8	yy8	yy11	ww20	ww18	pp30	b30	r34	r23
9	Y9	yy7	yy7	ww15	ww20	pp16	b27	r36	r32
10	Y8	yy9	yy9	ww18	ww19	pp31	b32	r36	r35
11	Y8	yy10	yy9	ww20	ww15	pp28	b22	r27	r43
12	Y8	yy8	yy12	ww15	ww19	pp18	b26	r44	r38
13	Y8	yy11	yy7	ww19	ww18	pp24	b29	control	r28
14	Y5	yy6	control	control	ww20	pp20	b13	bb30	r37
15	Y10	yy10	w8	w17	control	pp18	b18	bb24	r28
16	Y9	control	w16	w16	p32	pp20	b30	bb38	r37
17	Y8	y11	w16	w14	p23	pp23	b25	bb28	r24
18	Y11	y12	w12	w15	p18	pp27	b25	bb41	r37
19	Y6	y5	w22	w9	p22	pp23	b33	bb35	missing
20	Y7	y8	w13	w16	p21	pp20	b26	bb26	r43
21		y10	w16	w12	p22	pp27	b26	bb34	r30
22		y9	w18	w16	p22	control	b27	bb22	r36
23		y5	w18	w16	p21	p36	b32	bb34	r32
24			w11	w13	p29	p33	b30	bb36	r32
25			w14	w16	p16	p40	b24	bb24	r28
26				w14	p20	p22	b37	bb25	r36
27				w12	p28	p24	b31	bb40	r45
28				w15	p23	p32	b34	bb24	r28
29					p18	p28	b21	bb32	r28
30					p22	p28	b34	bb32	r26
31						p15	b19	bb40	r42
32			NORTH			p20	b35	bb31	r26
33		WEST	+	EAST			control	bb28	r25
34			SOUTH				missing	bb23	r22
35							bb34	bb22	r37
36							stunted	bb26	r34
37								bb34	r27
38									r27
39									r30

Figure 15. 2003 growing season.

9-29-03 Ounces of fruit harvested/vine.

	1	2	3	4	5	6	7	8	9
1								r51	r49
2	y11	yy16	yy24	ww44	ww39	pp46	pp49	r25	r60
3	y14	yy24	yy24	ww18	ww54	pp43	pp24	r72	r76
4	y20	yy20	yy28	ww29	ww42	pp52	pp50	r41	r46
5	y21	yy16	yy25	ww35	ww26	pp66	pp46	r76	r65
6	y10	yy19	yy20	ww44	ww31	pp51	pp46	r60	r56
7	missing	missing	yy20	ww37	ww50	pp52	control	r86	r97
8	y14	yy17	yy22	ww41	ww35	pp73	b50	r62	r66
9	y20	yy28	yy13	ww31	ww51	pp30	b51	r79	r74
10	y13	yy24	yy25	ww49	ww39	pp73	b46	r86	r64
11	y17	yy16	yy23	ww50	ww24	pp65	b36	r75	r103
12	y19	yy26	yy33	ww35	ww46	pp38	b66	r118	r108
13	y18	yy15	yy18	ww30	ww35	pp54	b60	control	r53
14	y14	yy18	control	control	ww57	pp38	b38	bb70	r55
15	y12	yy13	w13	w53	control	pp34	b42	bb53	r41
16	y13	control	w30	w41	p88	pp45	b85	bb94	r84
17	y13	y24	w52	w40	p60	pp50	b59	bb63	r28
18	y19	y23	w26	w34	p36	pp56	b70	bb77	r56
19	y11	y11	w64	w11	p56	pp46	b83	bb76	missing
20	y16	y22	w23	w36	p68	pp49	b71	bb49	r94
21		y22	w33	w33	p61	pp56	b42	bb66	r70
22		y18	w39	w35	p50	control	b58	bb40	r56
23		y10	w36	w34	p45	p73	b54	bb57	r73
24			w16	w34	p64	p68	b69	bb55	r68
25			w52	w38	p28	p92	b27	bb46	r56
26				w30	p63	p60	b73	bb80	r100
27				w23	p65	p54	b63	bb99	r104
28				w29	p76	p72	b64	bb43	r51
29					p58	p66	b30	bb60	r44
30					p65	p46	b42	bb81	r34
31						p33	b24	bb79	r75
32			NORTH			p64	b84	bb57	r45
33		WEST	+	EAST			control	bb55	r40
34			SOUTH				missing	bb37	r30
35							bb62	bb44	r57
36							stunted	bb44	r65
37								bb62	r40
38									r46
39									r48

Figure 16, Interaction Plot for TA from 2002 and 2003 growing seasons based on early and late fruit drop.

Figure 17, Interaction Plot for pH from 2002 and 2003 growing season based on early and late fruit drop.

Figure 18, Interaction Plot for Brix (Total Soluble Solids) from 2002 and 2003 growing seasons based on early and late fruit drop.

Figure 19, Interaction Plot for Berry Size from the 2002 growing season.

Figure 20, Interaction Plot for Berry Size from the 2003 growing season.

Figure 21, Interaction Plot for Average ounces/cluster/vine for the 2002 growing season based on early and late fruit drop.

Figure 22, Interaction Plot for Average ounces/cluster/vine for the 2003 growing season based on early and late fruit drop.

Figure 23, Interaction Plot for the Average ounces/shoot/vine for 2002 growing season based on early and late fruit drop.

Figure 24, Interaction Plot for Average ounces/shoot/vine for 2003 growing season based on early and late fruit drop.

Figure 25, Scatterplot of gallic acid versus ttt based on 2002 and 2003 growing seasons

Figure 26, Scatterplot of catechin versus ttt based on 2002 and 2003 growing seasons.

Figure 27, Scatterplot of epicatechin versus ttt based on 2002 and 2003 growing seasons.

Figure 28, Interaction Plot for polymeric phenols based on 2002 and 2003 growing seasons.

Figure 29, Interaction Plot for caftaric acid based on 2002 and 2003 growing seasons.

Figure 30, Interaction Plot for Caffeic Acid based on 2002 and 2003 growing seasons.

Figure 31, Interaction Plot for quercetin glycosides based on 2002 and 2003 growing seasons.

Figure 32, Interaction Plot for quercetin aglycone based on 2002 and 2003 growing seasons.

Figure 33, Interaction Plot for malvidin glucoside based on 2002 and 2003 growing season.

Figure 34, Interaction Plot for polymeric anthocyanins based on 2002 and 2003 growing seasons.

Figure 35, Interaction Plot for total anthocyanins based on 2002 and 2003 growing seasons.

Figure 36, Interaction Plot for monomeric anthocyanins based on 2002 and 2003 growing seasons.

Table 1. Harvest Results.

2002 Growing Season

Harvested 10-12-02

<u>Treatments</u>		<u>Brix</u>		<u>pH</u>		<u>TA</u>		<u>Actual Tons/Acre</u>
Y 1 ton early		23.8		3.2		0.78		0.96
YY 1 ton late		23.8		3.2		0.85		1.01
W 2 ton early		22.8		3.5		0.73		1.48
WW 2 ton late		24.5		3.3		0.64		1.5
P 3 ton early		24.2		3.4		0.58		2.08
PP 3 ton late		25.6		3.2		0.75		2.45
B 4 ton early		25.2		3.2		0.73		3.39
BB 4 ton late		24.4		3.3		0.72		2.53
R 5 ton control		24.8		3.3		0.66		3.26

2003 Growing Season

Harvested 9-29-03

<u>Treatments</u>		<u>Brix</u>		<u>pH</u>		<u>TA</u>		<u>Actual Tons/Acre</u>
Y 1 ton early		23.4		3.21		0.855		0.69
YY 1 ton late		24.2		3.17		0.95		0.9
W 2 ton early		23.5		3.19		0.65		1.45
WW 2 ton late		24.8		3.21		0.795		1.65
P 3 ton early		23.6		3.3		0.99		2.57
PP 3 ton late		25		3.36		0.84		2.1
B 4 ton early		25		3.39		0.89		2.36
BB 4 ton late		25		3.41		0.8		2.64
R 5 ton control		26.2		3.37		0.82		2.73

Table 2. Pruning Results.

2002 Growing Season

Pruned 1-13-03

		<u>AVG.</u> <u>Pounds/Shoot</u>			<u>AVG.</u> <u>Pounds/Vine</u>		<u>Pounds/Acre</u>		<u>Tons/Acre</u>
Y 1 ton early		0.178			3.633		4944.741		2.472
YY 1 ton late		0.134			2.753		3746.841		1.873
W 2 ton early		0.141			2.990		4070.138		2.035
WW 2 ton late		0.135			2.735		3723.019		1.862
P 3 ton early		0.133			2.900		3947.625		1.974
PP 3 ton late		0.121			2.668		3631.134		1.816
B 4 ton early		0.139			2.905		3954.431		1.977
BB 4 ton late		0.122			2.895		3940.819		1.970
R 5 ton control		0.127			2.694		3666.867		1.833

2003 Growing Season

Pruned 2-5-04

		<u>AVG.</u> <u>Pounds/Shoot</u>			<u>AVG.</u> <u>Pounds/Vine</u>		<u>Pounds/Acre</u>		<u>Tons/Acre</u>
Y 1 ton early		0.171			3.183		4332.178		2.166
YY 1 ton late		0.143			2.893		3937.416		1.969
W 2 ton early		0.138			2.893		3937.416		1.969
WW 2 ton late		0.140			2.573		3501.816		1.751
P 3 ton early		0.132			2.878		3916.997		1.958
PP 3 ton late		0.130			2.445		3328.256		1.664
B 4 ton early		0.162			3.105		4226.681		2.113
BB 4 ton late		0.143			3.028		4121.184		2.061
R 5 ton control		0.144			2.946		4010.583		2.005

Table 3, Pruning to Fruit ratios 2002

2002 Growing Season

~Measured in
Pounds

		<u>shoot:cluster</u>	<u>prunings/vine:fruit/vine</u>	<u>prunings/acre:fruit/acre</u>
<u>Y</u>	one ton early	.178 : .192	3.63 : 1.41	4945 : 1916
<u>YY</u>	one ton late	.134 : .190	2.75 : 1.48	3747 : 2015
<u>W</u>	two ton early	.141 : .156	2.99 : 2.18	4070 : 2964
<u>WW</u>	two ton late	.135 : .154	2.74 : 2.21	3723 : 3002
<u>P</u>	three ton early	.133 : .160	2.90 : 3.06	3948 : 4162
<u>PP</u>	three ton late	.121 : .168	2.67 : 3.60	3631 : 4904
<u>B</u>	four ton early	.139 : .185	2.91 : 4.98	3954 : 6772
<u>BB</u>	four ton late	.122 : .143	2.90 : 3.72	3941 : 5067
<u>R</u>	five ton control	.127 : .160	2.69 : 4.79	3667 : 6520

		<u>shoot:cluster</u>	<u>prunings/vine:fruit/vine</u>	<u>prunings/acre:fruit/acre</u>
<u>Y</u>	one ton early	1 to 1.07	1 to .39	1 to .39
<u>YY</u>	one ton late	1 to 1.42	1 to .54	1 to .54
<u>W</u>	two ton early	1 to 1.11	1 to .73	1 to .73
<u>WW</u>	two ton late	1 to 1.14	1 to .81	1 to .81
<u>P</u>	three ton early	1 to 1.20	1 to 1.01	1 to 1.05
<u>PP</u>	three ton late	1 to 1.39	1 to 1.35	1 to 1.35
<u>B</u>	four ton early	1 to 1.33	1 to 1.71	1 to 1.71
<u>BB</u>	four ton late	1 to 1.17	1 to 1.28	1 to 1.29
<u>R</u>	five ton control	1 to 1.26	1 to 1.78	1 to 1.78

Table 4, Pruning to Fruit ratios 2003

2003 Growing Season

~Measured in
Pounds

		<u>shoot:cluster</u>	<u>prunings/vine:fruit/vine</u>	<u>prunings/acre:fruit/acre</u>
<u>Y</u>	one ton early	0.171:0.125	3.18:1.01	4328:1375
<u>YY</u>	one ton late	0.143:0.143	2.89:1.32	3933:1797
<u>W</u>	two ton early	0.138:0.146	2.89:2.14	3933:2913
<u>WW</u>	two ton late	0.140:0.139	2.57:2.43	3498:3307
<u>P</u>	three ton early	0.132:0.154	2.88:3.78	3920:5145
<u>PP</u>	three ton late	0.130:0.135	2.45:3.08	3334:4192
<u>B</u>	four ton early	0.162:0.126	3.11:3.47	4233:4723
<u>BB</u>	four ton late	0.143:0.127	3.03:3.87	4124:5267
<u>R</u>	five ton control	0.144:0.124	2.95:4.01	4015:5458

		<u>shoot:cluster</u>	<u>prunings/vine:fruit/vine</u>	<u>prunings/acre:fruit/acre</u>
<u>Y</u>	one ton early	1 to .73	1 to .32	1 to .32
<u>YY</u>	one ton late	1 to 1	1 to .46	1 to .46
<u>W</u>	two ton early	1 to 1.06	1 to .74	1 to .74
<u>WW</u>	two ton late	1 to .99	1 to .95	1 to .95
<u>P</u>	three ton early	1 to 1.17	1 to 1.31	1 to 1.31
<u>PP</u>	three ton late	1 to 1.04	1 to 1.26	1 to 1.26
<u>B</u>	four ton early	1 to .78	1 to 1.12	1 to 1.12
<u>BB</u>	four ton late	1 to .89	1 to 1.28	1 to 1.28
<u>R</u>	five ton control	1 to .86	1 to 1.36	1 to 1.36

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APPENDICES

Appendix A

Wine Phenolic Analysis for 2002 growing season

LABORATORIES

**LABORATORY
REPORT**
133188

Greg Phelan
809 East Cook Street
Santa Maria, CA 93454

Samples Received
12 February 2003 4:52PM

Analyses Reported
20 February 2003 2:32PM

302120303	1 Ton Pinot Noir phenolic profile (HPLC)		
	gallic acid	18	mg/L
	catechin	120	mg/L
	epicatechin	55	mg/L
	polymeric phenols	243	mg/L
	caffeic acid	< 1	mg/L
	quercetin glycosides	10	mg/L
	quercetin aglycone	37	mg/L
	malvidin glucoside	4	mg/L
	polymeric anthocyanins	168	mg/L
	total anthocyanins	12	mg/L
	monomeric anthocyanins	214	mg/L
		202	mg/L
302120304	2 Ton Pinot Noir phenolic profile (HPLC)		
	gallic acid	21	mg/L
	catechin	158	mg/L
	epicatechin	75	mg/L
	polymeric phenols	269	mg/L
	caffeic acid	< 1	mg/L
	quercetin glycosides	14	mg/L
	quercetin aglycone	34	mg/L
	malvidin glucoside	4	mg/L
	polymeric anthocyanins	125	mg/L
	total anthocyanins	14	mg/L
	monomeric anthocyanins	165	mg/L
		151	mg/L
302120305	3 Ton Pinot Noir phenolic profile (HPLC)		
	gallic acid	22	mg/L
	catechin	130	mg/L

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Appendix A cont.

Wine Phenolic Analysis for 2002 growing season

**LABORATORY
REPORT
#133188**

Greg Phelan

302120305	3 Ton Pinot Noir		
	phenolic profile (HPLC)		
	epicatechin	69	mg/L
	polymeric phenols	348	mg/L
	caftaric acid	8	mg/L
	caffeic acid	6	mg/L
	quercetin glycosides	37	mg/L
	quercetin aglycone	3	mg/L
	malvidin glucoside	35	mg/L
	polymeric anthocyanins	20	mg/L
302120306	4 Ton Pinot Noir		
	phenolic profile (HPLC)		
	gallic acid	20	mg/L
	catechin	138	mg/L
	epicatechin	67	mg/L
	polymeric phenols	321	mg/L
	caftaric acid	1	mg/L
	caffeic acid	11	mg/L
	quercetin glycosides	45	mg/L
	quercetin aglycone	3	mg/L
302120307	5 Ton Control Pinot Noir		
	phenolic profile (HPLC)		
	gallic acid	18	mg/L
	catechin	137	mg/L
	epicatechin	63	mg/L
	polymeric phenols	321	mg/L
	caftaric acid	11	mg/L
	caffeic acid	3	mg/L
	quercetin glycosides	35	mg/L

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Appendix A cont.

Wine Phenolic Analysis 2002 growing season

LABORATORY
REPORT
#133188

Greg Phelan

302120307

5 Ton Control Pinot Noir
phenolic profile (HPLC)

quercetin aglycone	3	mg/L
malvidin glucoside	80	mg/L
polymeric anthocyanins	17	mg/L
total anthocyanins	121	mg/L
monomeric anthocyanins	104	mg/L

Gordon Burns
Technical Director

A handwritten signature in black ink, appearing to read "Gordon Burns".

Page 3 of 3

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Appendix B

Wine Analysis 2002 growing season 1 ton treatment compared to 5 ton control

Appendix C

Wine Analysis 2002 growing season 2 ton treatment compared to 5 ton control

Appendix D

Wine Analysis 2002 growing season 3 ton treatment compared to 5 ton control

Appendix E

Wine Analysis 2002 growing season 4 ton treatment compared to 5 ton control

Appendix F

Wine Analysis 2002 growing season 5 ton control

**REPORT
133188
SUPPLEMENT**

Greg Phelan
Cal Poly SLO
809 East Cook Street
Santa Maria, CA 93454

Samples Received
12 February 2003

Analyses Reported
17 February 2003

302120307

PN 5 ton

gallic acid (mg/l)	18	total anthocyanins (mg/l)	121
catechin (mg/l)	137	malvidin glucoside (mg/l)	80
epicatechin (mg/l)	63	monomeric anthocyanins (mg/l)	104
polymeric phenols (mg/l)	321	polymeric anthocyanins (mg/l)	17
caffeic acid (mg/l)	11	quercetin glycosides (mg/l)	35
quercetin aglycone (mg/l)	3	quercetin aglycone (mg/l)	3

catechin:epicatechin ratio 2.1746 catechin:polymeric phenols ratio 0.43

Comments: The reference for the radar plot is sample 302120307.

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Appendix G

Wine Phenolic Analysis 2003 growing season

LABORATORY REPORT # 164036

Greg Phelan
Attn:
809 East Cook Street
Santa Maria, CA 93454

Samples Received
26 February 2004 1:00 pm

Analysis Reported
10 March 2004 12:39 pm

402260296 1 Ton

phenolic profile (HPLC)

gallic acid	38	mg/L
catechin	366	mg/L
epicatechin	111	mg/L
polymeric phenols	451	mg/L
caftaric acid	< 1	mg/L
caffeic acid	10	mg/L
quercetin glycosides	31	mg/L
quercetin aglycone	6	mg/L
malvidin glucoside	111	mg/L
polymeric anthocyanins	19	mg/L
total anthocyanins	153	mg/L
monomeric anthocyanins	134	mg/L

402260297 2 Ton

phenolic profile (HPLC)

gallic acid	40	mg/L
catechin	463	mg/L
epicatechin	147	mg/L
polymeric phenols	453	mg/L
caftaric acid	< 1	mg/L
caffeic acid	13	mg/L
quercetin glycosides	30	mg/L
quercetin aglycone	6	mg/L
malvidin glucoside	92	mg/L
polymeric anthocyanins	18	mg/L
total anthocyanins	131	mg/L
monomeric anthocyanins	113	mg/L

402260298 3 Ton

phenolic profile (HPLC)

gallic acid	34	mg/L
catechin	359	mg/L
epicatechin	119	mg/L
polymeric phenols	428	mg/L
caftaric acid	< 1	mg/L
caffeic acid	12	mg/L
quercetin glycosides	24	mg/L

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Appendix G cont.

Wine Phenolic Analysis 2003 growing season

ETS
LABORATORIES

**LABORATORY
REPORT
164036**

402260298 3 Ton	quercetin aglycone malvidin glucoside polymeric anthocyanins total anthocyanins monomeric anthocyanins	3 90 16 124 108	mg/L mg/L mg/L mg/L mg/L
402260299 4 Ton	phenolic profile (HPLC) gallic acid catechin epicatechin polymeric phenols caffeic acid quercetin glycosides quercetin aglycone malvidin glucoside polymeric anthocyanins total anthocyanins monomeric anthocyanins	30 330 115 405 < 1 10 20 3 88 16 119 103	mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L
402260300 5 Ton Control	phenolic profile (HPLC) gallic acid catechin epicatechin polymeric phenols caffeic acid quercetin glycosides quercetin aglycone malvidin glucoside polymeric anthocyanins total anthocyanins monomeric anthocyanins	25 261 81 371 3 8 19 3 84 15 110 95	mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L

Gordon Burns
Technical Director

Page 2 of 3

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Appendix H

Wine Analysis 2003 growing season 1 ton treatment compared to 5 ton control

Appendix I

Wine Analysis 2003 growing season 2 ton treatment compared to 5 ton control

Appendix J

Wine Analysis 2003 growing season 3 ton treatment compared to 5 ton control

Appendix K

Wine Analysis 2003 growing season 4 ton treatment compared to 5 ton control

Appendix L

Wine Analysis 2003 growing season 5 ton control

**REPORT
164036
SUPPLEMENT**

Greg Phelan
Greg Phelan
809 East Cook Street
Santa Maria, CA 93454

Samples Received
12 February 2004

Analyses Reported
10 March 2004

402260300

5 ton

gallic acid (mg/l)	25	total anthocyanins (mg/l)	110
catechin (mg/l)	261	malvidin glucoside (mg/l)	84
epicatechin (mg/l)	81	monomeric anthocyanins (mg/l)	95
polymeric phenols (mg/l)	371	polymeric anthocyanins (mg/l)	15
caffeic acid (mg/l)	3	quercetin glycosides (mg/l)	19
quercetin aglycone (mg/l)	8	quercetin aglycone (mg/l)	3
catechin:epicatechin ratio	3.2222	catechin:polymeric phenols ratio	0.70

Comments: The reference for the radar plot is sample 402260300 (5 ton).

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Appendix M

ANOVA Tables

General Linear Model: TA versus E/L, tons, season

Analysis of Variance for TA, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
E/L	1	0.001225	0.001225	0.001225	0.16	0.694
tons	3	0.048256	0.048256	0.016085	2.15	0.157
season	1	0.061256	0.061256	0.061256	8.19	0.017
Error	10	0.074806	0.074806	0.007481		
Total	15	0.185544				

S = 0.0864906 R-Sq = 59.68% R-Sq(adj) = 39.52%

Term	Coef	SE Coef	T	P
Constant	0.78438	0.02162	36.28	0.000
E/L				
e	-0.00875	0.02162	-0.40	0.694
tons				
1	0.07437	0.03745	1.99	0.075
2	-0.08062	0.03745	-2.15	0.057
3	0.00562	0.03745	0.15	0.884
season				
2002	0.06188	0.02162	2.86	0.017

Appendix N

ANOVA Tables

General Linear Model: pH versus E/L, tons, season

Analysis of Variance for pH, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
E/L	1	0.00360	0.00360	0.00360	0.33	0.576
tons	3	0.04328	0.04328	0.01443	1.34	0.316
season	1	0.00023	0.00023	0.00023	0.02	0.888
Error	10	0.10767	0.10767	0.01077		
Total	15	0.15477				

S = 0.103767 R-Sq = 30.43% R-Sq(adj) = 0.00%

Term	Coef	SE Coef	T	P
Constant	3.28375	0.02594	126.58	0.000
E/L				
e	0.01500	0.02594	0.58	0.576
tons				
1	-0.08875	0.04493	-1.98	0.076
2	0.01625	0.04493	0.36	0.725
3	0.03125	0.04493	0.70	0.503
season				
2002	-0.00375	0.02594	-0.14	0.888

Appendix O

ANOVA Tables

General Linear Model: Brix versus E/L, tons, season

Analysis of Variance for Brix, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
E/L	1	2.1025	2.1025	2.1025	6.12	0.033
tons	3	3.4400	3.4400	1.1467	3.34	0.064
season	1	0.0025	0.0025	0.0025	0.01	0.934
Error	10	3.4350	3.4350	0.3435		
Total	15	8.9800				

S = 0.586089 R-Sq = 61.75% R-Sq(adj) = 42.62%

Term	Coef	SE Coef	T	P
Constant	24.3000	0.1465	165.85	0.000
E/L				
e	-0.3625	0.1465	-2.47	0.033
tons				
1	-0.5000	0.2538	-1.97	0.077
2	-0.4000	0.2538	-1.58	0.146
3	0.3000	0.2538	1.18	0.265
season				
2002	0.0125	0.1465	0.09	0.934

Appendix P

ANOVA Tables

2002 growing season

General Linear Model: Caliper versus Drop Level, DD, Week, TMB

Factor	Type	Levels	Values
Drop Level	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, control
DD	fixed	2	E, L
Week	fixed	3	1, 2, 3
TMB	fixed	3	B, M, T

Analysis of Variance for Caliper, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	0.037974	0.037974	0.009494	1.14	0.338
DD	1	0.043919	0.043919	0.043919	5.26	0.022
Drop Level*DD	4	0.215915	0.215915	0.053979	6.46	0.000
Week	2	0.111144	0.111144	0.055572	6.65	0.001
TMB	2	0.026344	0.026344	0.013172	1.58	0.207
Error	1336	11.165437	11.165437	0.008357		
Total	1349	11.600733				

S = 0.0914186 R-Sq = 3.75% R-Sq(adj) = 2.82%

Appendix Q

ANOVA Tables

2003 growing season

General Linear Model: Caliper versus Drop Level, DD, Week, TMB

Factor	Type	Levels	Values
Drop Level	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, control
DD	fixed	2	E, L
Week	fixed	3	1, 2, 3
TMB	fixed	3	B, M, T

Analysis of Variance for Caliper, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	1.70855	1.70829	0.42707	15.71	0.000
DD	1	0.36179	0.36142	0.36142	13.30	0.000
Drop Level*DD	4	1.06010	1.05911	0.26478	9.74	0.000
Week	2	0.19384	0.19416	0.09708	3.57	0.028
TMB	2	0.06294	0.06294	0.03147	1.16	0.315
Error	1336	36.31256	36.31256	0.02718		
Total	1349	39.69977				

Appendix R

ANOVA Tables

General Linear Model: 2002 growing season Avg.oz/cluster/vine versus Drop Level, Drop Time

Analysis of Variance for oz/cluster/vine, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	9.7853	9.7853	2.4463	10.80	0.000
Drop Time	1	2.6171	2.6171	2.6171	11.56	0.001
Drop Level*Drop Time	4	4.8782	4.8782	1.2195	5.39	0.000
Error	240	54.3498	54.3498	0.2265		
Total	249	71.6305				

S = 0.475876 R-Sq = 24.12% R-Sq(adj) = 21.28%

Term	Coef	SE Coef	T	P
Constant	2.65485	0.03010	88.21	0.000
Drop Level				
1 ton	0.38454	0.06019	6.39	0.000
2 ton	-0.16636	0.06019	-2.76	0.006
3 ton	-0.05093	0.06019	-0.85	0.398
4 ton	-0.04132	0.06019	-0.69	0.493
Drop Time				
E	0.10232	0.03010	3.40	0.001
Drop Level*Drop Time				
1 ton E	-0.09258	0.06019	-1.54	0.125
2 ton E	-0.07854	0.06019	-1.30	0.193
3 ton E	-0.14202	0.06019	-2.36	0.019
4 ton E	0.23911	0.06019	3.97	0.000

Appendix S

ANOVA Tables

General Linear Model: 2003 growing season **Avg.oz/cluster/vine versus Drop Level, Drop Time**

Analysis of Variance for oz/cluster/vine, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	4.4804	4.4804	1.1201	5.29	0.000
Drop Time	1	0.5136	0.5136	0.5136	2.42	0.121
Drop Level*Drop Time	4	3.6927	3.6927	0.9232	4.36	0.002
Error	240	50.8523	50.8523	0.2119		
Total	249	59.5390				

S = 0.460309 R-Sq = 14.59% R-Sq(adj) = 11.39%

Term	Coef	SE Coef	T	P
Constant	2.14832	0.02911	73.79	0.000
Drop Level				
1 ton	0.04056	0.05823	0.70	0.487
2 ton	0.10259	0.05823	1.76	0.079
3 ton	0.16524	0.05823	2.84	0.005
4 ton	-0.11828	0.05823	-2.03	0.043
Drop Time				
E	0.04533	0.02911	1.56	0.121
Drop Level*Drop Time				
1 ton E	-0.20256	0.05823	-3.48	0.001
2 ton E	-0.00364	0.05823	-0.06	0.950
3 ton E	0.13134	0.05823	2.26	0.025
4 ton E	-0.04244	0.05823	-0.73	0.467

Appendix T

ANOVA Tables

2002 growing season

General Linear Model: sqrt(oz/shoot/vine) versus Drop Level, Drop Time

Factor	Type	Levels	Values
Drop Level	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, control
Drop Time	fixed	2	E, L

Analysis of Variance for sqrt(oz/shoot/vine), using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	0.87783	0.87783	0.21946	6.30	0.000
Drop Time	1	0.45359	0.45359	0.45359	13.02	0.000
Drop Level*Drop Time	4	0.33119	0.33119	0.08280	2.38	0.053
Error	240	8.36339	8.36339	0.03485		
Total	249	10.02599				

S = 0.186675 R-Sq = 16.58% R-Sq(adj) = 13.45%

Term	Coef	SE Coef	T	P
Constant	1.46359	0.01181	123.97	0.000
Drop Level				
1 ton	0.10876	0.02361	4.61	0.000
2 ton	0.01244	0.02361	0.53	0.599
3 ton	-0.04878	0.02361	-2.07	0.040
4 ton	-0.01929	0.02361	-0.82	0.415
Drop Time				
E	0.04260	0.01181	3.61	0.000
Drop Level*Drop Time				
1 ton E	0.06720	0.02361	2.85	0.005
2 ton E	-0.02347	0.02361	-0.99	0.321
3 ton E	-0.00083	0.02361	-0.04	0.972
4 ton E	-0.00360	0.02361	-0.15	0.879

Appendix U

ANOVA Tables

2003 growing season

General Linear Model: sqrt(oz/shoot/vine) versus Drop Level, Drop Time

Factor	Type	Levels	Values
Drop Level	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, control
Drop Time	fixed	2	E, L

Analysis of Variance for sqrt(oz/shoot/vine), using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drop Level	4	0.57876	0.57876	0.14469	4.01	0.004
Drop Time	1	0.14101	0.14101	0.14101	3.91	0.049
Drop Level*Drop Time	4	0.16259	0.16259	0.04065	1.13	0.344
Error	240	8.65633	8.65633	0.03607		
Total	249	9.53869				

S = 0.189916 R-Sq = 9.25% R-Sq(adj) = 5.85%

Term	Coef	SE Coef	T	P
Constant	1.51739	0.01201	126.33	0.000
Drop Level				
1 ton	0.06222	0.02402	2.59	0.010
2 ton	-0.02971	0.02402	-1.24	0.217
3 ton	-0.07293	0.02402	-3.04	0.003
4 ton	0.03872	0.02402	1.61	0.108
Drop Time				
E	0.02375	0.01201	1.98	0.049
Drop Level*Drop Time				
1 ton E	0.03540	0.02402	1.47	0.142
2 ton E	-0.02519	0.02402	-1.05	0.295
3 ton E	-0.01096	0.02402	-0.46	0.649
4 ton E	0.02531	0.02402	1.05	0.293

Appendix V

ANOVA Tables

General Linear Model: gallic acid versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	95.40	95.40	23.85	1.48	0.357
Year	1	462.40	462.40	462.40	28.63	0.006
Error	4	64.60	64.60	16.15		
Total	9	622.40				

S = 4.01871 R-Sq = 89.62% R-Sq(adj) = 76.65%

Term	Coef	SE Coef	T	P
Constant	26.600	1.271	20.93	0.000
Treatment				
1 ton	1.400	2.542	0.55	0.611
2 ton	3.900	2.542	1.53	0.200
3 ton	1.400	2.542	0.55	0.611
4 ton	-1.600	2.542	-0.63	0.563
Year				
2002	-6.800	1.271	-5.35	0.006

Appendix W

ANOVA Tables

General Linear Model: catechin versus Treatment, Year

Analysis of Variance for catechin, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	13049	13049	3262	1.45	0.363
Year	1	120122	120122	120122	53.45	0.002
Error	4	8989	8989	2247		
Total	9	142160				

S = 47.4062 R-Sq = 93.68% R-Sq(adj) = 85.77%

Term	Coef	SE Coef	T	P
Constant	246.20	14.99	16.42	0.000
Treatment				
1 ton	-3.20	29.98	-0.11	0.920
2 ton	64.30	29.98	2.14	0.099
3 ton	-1.70	29.98	-0.06	0.958
4 ton	-12.20	29.98	-0.41	0.705
Year				
2002	-109.60	14.99	-7.31	0.002

Appendix X

ANOVA Tables

General Linear Model: epicatechin versus Treatment, Year

Analysis of Variance for epicatechin, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	1661.6	1661.6	415.4	2.16	0.237
Year	1	5953.6	5953.6	5953.6	30.91	0.005
Error	4	770.4	770.4	192.6		
Total	9	8385.6				

S = 13.8780 R-Sq = 90.81% R-Sq(adj) = 79.33%

Term	Coef	SE Coef	T	P
Constant	90.200	4.389	20.55	0.000
Treatment				
1 ton	-7.200	8.777	-0.82	0.458
2 ton	20.800	8.777	2.37	0.077
3 ton	3.800	8.777	0.43	0.687
4 ton	0.800	8.777	0.09	0.932
Year				
2002	-24.400	4.389	-5.56	0.005

Appendix Y

ANOVA Tables

General Linear Model: polymeric phenols versus Treatment, Year

Analysis of Variance for polymeric phenols, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	2308	2308	577	0.24	0.905
Year	1	36724	36724	36724	14.97	0.018
Error	4	9814	9814	2454		
Total	9	48846				

S = 49.5338 R-Sq = 79.91% R-Sq(adj) = 54.79%

Term	Coef	SE Coef	T	P
Constant	361.00	15.66	23.05	0.000
Treatment				
1 ton	-14.00	31.33	-0.45	0.678
2 ton	-0.00	31.33	-0.00	1.000
3 ton	27.00	31.33	0.86	0.437
4 ton	2.00	31.33	0.06	0.952
Year				
2002	-60.60	15.66	-3.87	0.018

Appendix Z

ANOVA Tables

General Linear Model: caftaric acid versus Treatment, Year

Analysis of Variance for caftaric acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	68.650	68.650	17.163	1.98	0.262
Year	1	25.600	25.600	25.600	2.96	0.161
Error	4	34.650	34.650	8.663		
Total	9	128.900				

S = 2.94321 R-Sq = 73.12% R-Sq(adj) = 39.52%

Term	Coef	SE Coef	T	P
Constant	2.6000	0.9307	2.79	0.049
Treatment				
1 ton	-2.100	1.861	-1.13	0.322
2 ton	-2.100	1.861	-1.13	0.322
3 ton	1.650	1.861	0.89	0.425
4 ton	-1.850	1.861	-0.99	0.377
Year				
2002	1.6000	0.9307	1.72	0.161

Appendix AA

ANOVA Tables

General Linear Model: caffeic acid versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Analysis of Variance for caffeic acid, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	66.600	66.600	16.650	2.85	0.168
Year	1	8.100	8.100	8.100	1.38	0.305
Error	4	23.400	23.400	5.850		
Total	9	98.100				

S = 2.41868 R-Sq = 76.15% R-Sq(adj) = 46.33%

Appendix BB

ANOVA Tables

General Linear Model: quercetin glycosides versus Treatment, Year

Analysis of Variance for quercetin glycosides, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	56.60	56.60	14.15	0.40	0.802
Year	1	409.60	409.60	409.60	11.59	0.027
Error	4	141.40	141.40	35.35		
Total	9	607.60				

S = 5.94559 R-Sq = 76.73% R-Sq(adj) = 47.64%

Term	Coef	SE Coef	T	P
Constant	31.200	1.880	16.59	0.000
Treatment				
1 ton	2.800	3.760	0.74	0.498
2 ton	0.800	3.760	0.21	0.842
3 ton	-0.700	3.760	-0.19	0.861
4 ton	1.300	3.760	0.35	0.747
Year				
2002	6.400	1.880	3.40	0.027

Appendix CC

ANOVA Tables

General Linear Model: quercetin aglycone versus Treatment, Year

Analysis of Variance for quercetin aglycone, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	9.6000	9.6000	2.4000	4.00	0.104
Year	1	1.6000	1.6000	1.6000	2.67	0.178
Error	4	2.4000	2.4000	0.6000		
Total	9	13.6000				

S = 0.774597 R-Sq = 82.35% R-Sq(adj) = 60.29%

Term	Coef	SE Coef	T	P
Constant	3.8000	0.2449	15.51	0.000
Treatment				
1 ton	1.2000	0.4899	2.45	0.070
2 ton	1.2000	0.4899	2.45	0.070
3 ton	-0.8000	0.4899	-1.63	0.178
4 ton	-0.8000	0.4899	-1.63	0.178
Year				
2002	-0.4000	0.2449	-1.63	0.178

Appendix DD

ANOVA Tables

General Linear Model: malvidin glucoside versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Analysis of Variance for malvidin glucoside, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	7282.6	7282.6	1820.7	1.90	0.275
Year	1	16.9	16.9	16.9	0.02	0.901
Error	4	3834.6	3834.6	958.7		
Total	9	11134.1				

S = 30.9621 R-Sq = 65.56% R-Sq(adj) = 22.51%

Term	Coef	SE Coef	T	P
Constant	94.300	9.791	9.63	0.001
Treatment				
1 ton	45.20	19.58	2.31	0.082
2 ton	14.20	19.58	0.73	0.509
3 ton	-31.80	19.58	-1.62	0.180
4 ton	-15.30	19.58	-0.78	0.478
Year				
2002	1.300	9.791	0.13	0.901

Appendix EE

ANOVA Tables

General Linear Model: polymeric anthocyanins versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Analysis of Variance for polymeric anthocyanins, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	7.40	7.40	1.85	0.18	0.938
Year	1	1.60	1.60	1.60	0.15	0.714
Error	4	41.40	41.40	10.35		
Total	9	50.40				

S = 3.21714 R-Sq = 17.86% R-Sq(adj) = 0.00%

Term	Coef	SE Coef	T	P
Constant	16.400	1.017	16.12	0.000
Treatment				
1 ton	-0.900	2.035	-0.44	0.681
2 ton	-0.400	2.035	-0.20	0.854
3 ton	1.600	2.035	0.79	0.476
4 ton	0.100	2.035	0.05	0.963
Year				
2002	-0.400	1.017	-0.39	0.714

Appendix FF

ANOVA Tables

General Linear Model: total anthocyanins versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Analysis of Variance for total anthocyanins, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	9403.0	9403.0	2350.8	2.52	0.196
Year	1	168.1	168.1	168.1	0.18	0.693
Error	4	3729.4	3729.4	932.4		
Total	9	13300.5				

S = 30.5344 R-Sq = 71.96% R-Sq(adj) = 36.91%

Term	Coef	SE Coef	T	P
Constant	131.500	9.656	13.62	0.000
Treatment				
1 ton	52.00	19.31	2.69	0.055
2 ton	16.50	19.31	0.85	0.441
3 ton	-33.00	19.31	-1.71	0.163
4 ton	-19.50	19.31	-1.01	0.370
Year				
2002	4.100	9.656	0.42	0.693

Appendix GG

ANOVA Tables

General Linear Model: monomeric anthocyanins versus Treatment, Year

Factor	Type	Levels	Values
Treatment	fixed	5	1 ton, 2 ton, 3 ton, 4 ton, 5 ton
Year	fixed	2	2002, 2003

Analysis of Variance for monomeric anthocyanins, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	9817	9817	2454	2.18	0.234
Year	1	202	202	202	0.18	0.693
Error	4	4497	4497	1124		
Total	9	14517				

S = 33.5298 R-Sq = 69.02% R-Sq(adj) = 30.30%

Term	Coef	SE Coef	T	P
Constant	115.10	10.60	10.86	0.000
Treatment				
1 ton	52.90	21.21	2.49	0.067
2 ton	16.90	21.21	0.80	0.470
3 ton	-34.60	21.21	-1.63	0.178
4 ton	-19.60	21.21	-0.92	0.408
Year				
2002	4.50	10.60	0.42	0.693