Oregon Wine Advisory Board
Research Progress Report

1998 - 1999

Development of Viticultural Practices to Improve Winegrape Performance

Experiment I: Effect of Irrigation on Ripening Dynamics, Photosynthetic Performance, and Canopy Development of Mature Pinot Noir Vines in the North Willamette Valley

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INTRODUCTION

Most quality wines are produced in areas where annual precipitation is below 700 to 800 mm (Jackson & Schuster, 1994), and evidence suggests that high rainfall or excessive irrigation lowers quality. Excessive irrigation is reported to slow ripening, increase yields partially berry enlargement, elevate juice pH and acid content, and reduce anthocyanins due to shading. In contrast, water stress enhances early ripening but reduces yield, berry weight, and malic, acid from excessive exposure (Smart & Coombe, 1983). Evidence shows that water stress also reduces overall transpiration of grapevines (Smart 1974). Timing of water stress also contributes to changes in yield and berry sugar content (Alleweldt & Ruhl, 1982, Becker & Zimmerman, 1983).

Fig. I-1 shows the annual precipitation of three locations in the Willamette Valley and at two locations in France. The total annual precipitation in the Willamette Valley is much higher than the rainfall in premium winegrape regions in France. However, as can be seen in Fig. I-1, precipitation in the Willamette Valley is concentrated in the dormant season and almost absent during the hot summer months (Fig. I-2).

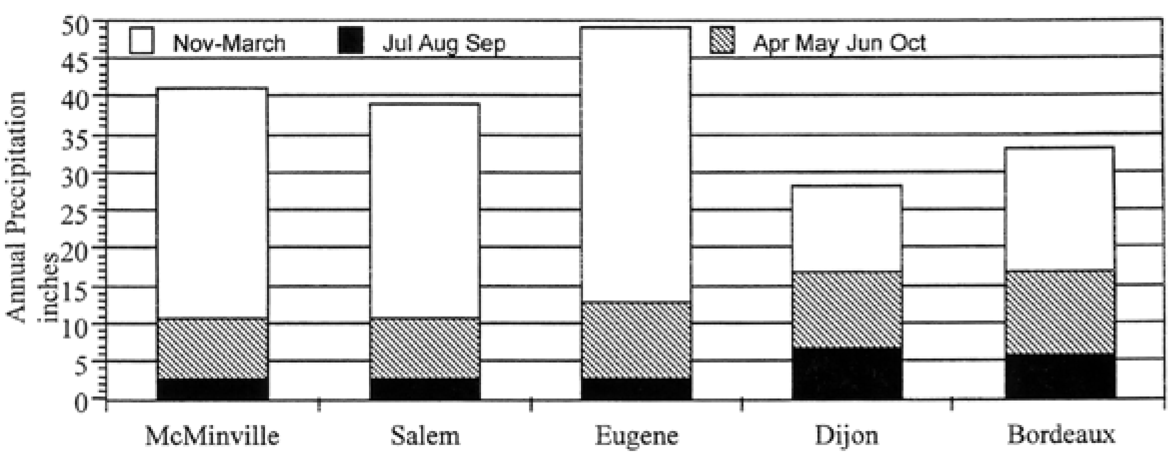

Fig. I-1: Distribution of annual precipitation in the Willamette Valley, Burgundy and Bordeaux (30 and 40 year average for Oregon and France, respectively) during the dormant (white bars) and growing season (black and gray bars)

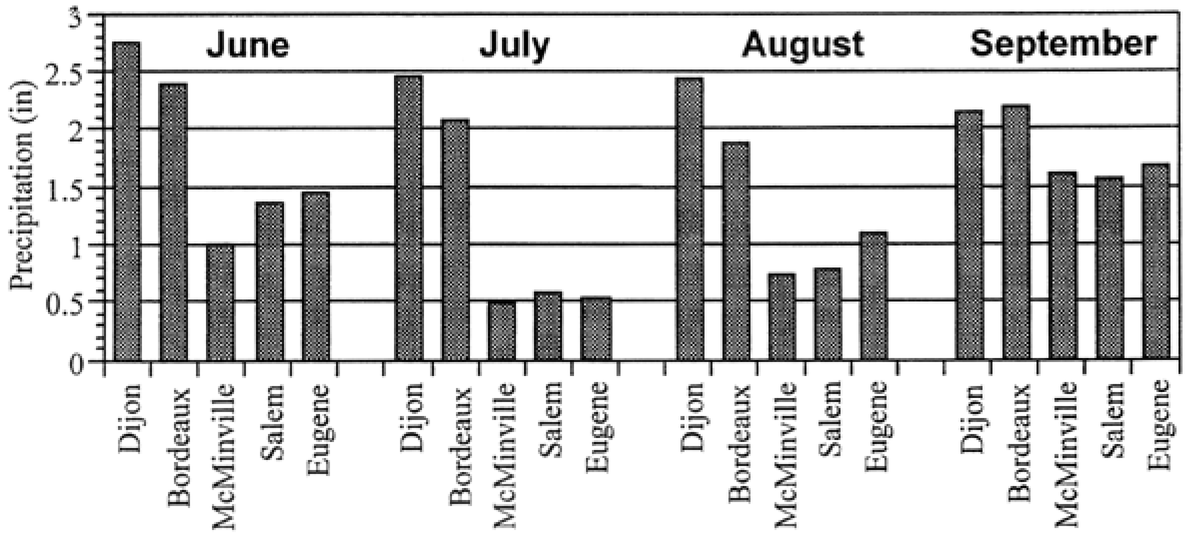

Fig. I-2: Distribution of monthly precipitation in the Willamette Valley, Burgundy and Bordeaux (30 and 40 years average for Oregon and France, respectively) during the summer.

There is presently no documentation available concerning the need to irrigate mature vines in Oregon. It is unknown if the soil water reserves accumulated during the winter will suffice throughout the season or will be reduced to suboptimal levels during the critical period of sugar accumulation in the fruit and development of aromas and flavors. If vines experience drought stress during ripening, leaf photosynthetic production will decrease since stomata are very sensitive to water deficits and close to prevent excessive loss of water through transpiration. Stomatal closure during part of the day prevents carbon dioxide from entering the leaves and inhibits photosynthesis. As a result, sugar accumulation in the fruit, and aroma and flavor development, are all hindered by lack of carbohydrate availability. Moreover, it has been shown that partitioning of biomass in water stressed plants favors the root system, a survival mechanism allowing the maximization of water extraction from deeper soil layers. By allocating more resources to the development of the root system, fruit ripening in drought stressed vines may be delayed. Phenolic composition may become unbalanced, originating off flavors such as those recently described as UTA (untypical aging).

Stuck fermentation has been a recurrent problem in Oregon. Low levels of nutrients, particularly nitrogen have been suspected of causing the problem. Nutrients are absorbed by the roots and transported in the transpiration stream to the leaves where they are redistributed within the plant via the phloem. Soil water deficit may decrease transpiration and, consequently, hinder nutrient uptake. This reduced nutrient uptake coupled with the lower rates of mineralization and lower levels of nutrient availability due to soil water deficit conditions, may aggravate the imbalance between soil nutrient availability and grapevine nutritional needs. This has been documented for nitrogen (Perret *et. al.* 1993, Fig. I-3).

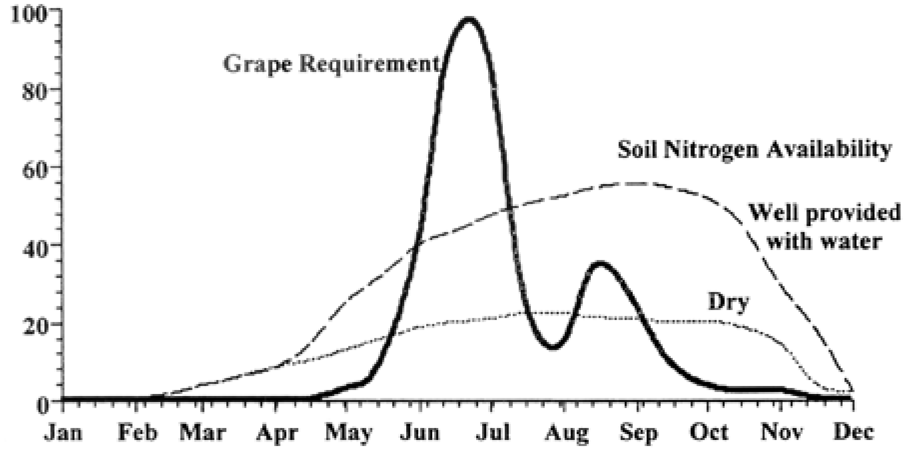

Fig. I-3: Grapevine nitrogen requirements and soil N-availability under adequate soil moisture or deficit conditions

The purpose of this experiment is to investigate the effect of supplemental irrigation on leaf photosynthetic performance, stomatal conductance, vegetative growth, fruit yield and composition, and partitioning of biomass among roots, trunk, shoots, and fruit of mature vines in a commercial vineyard in the Willamette Valley.

MATERIALS AND METHODS

This experiment is being conducted at Knudsen Vineyard, located in the north Willamette Valley. It began in May, 1998. Two treatments have been applied to 24 Pinot Noir vines on GDC (Geneva Double Curtain) with a 6-foot by 12-foot spacing. Each treatment (irrigated with approximately 2 inches of water during lag phase or non-irrigated) was repeated twice. Each replicate consists of six vines. The entire experimental plot consists of nine rows of Pinot Noir growing in Jory soil. Guard rows and Guard vines were used to adequately separate treatments. Vines were balanced pruned to 30 buds per kg of wood during February 1998.

Vines in the irrigated treatment received water at a rate of .53gal/hr/vine on seven different dates from mid August until early September. Figure M-1 illustrates supplemental irrigation in inches. The total irrigation the vines received in this window of time was approximately 2 inches. There was no measurable precipitation during August, however, in September the vines received .57 inches of precipitation. This is illustrated in figure M-2. Table 1 represents the total amount of water both treatments received.

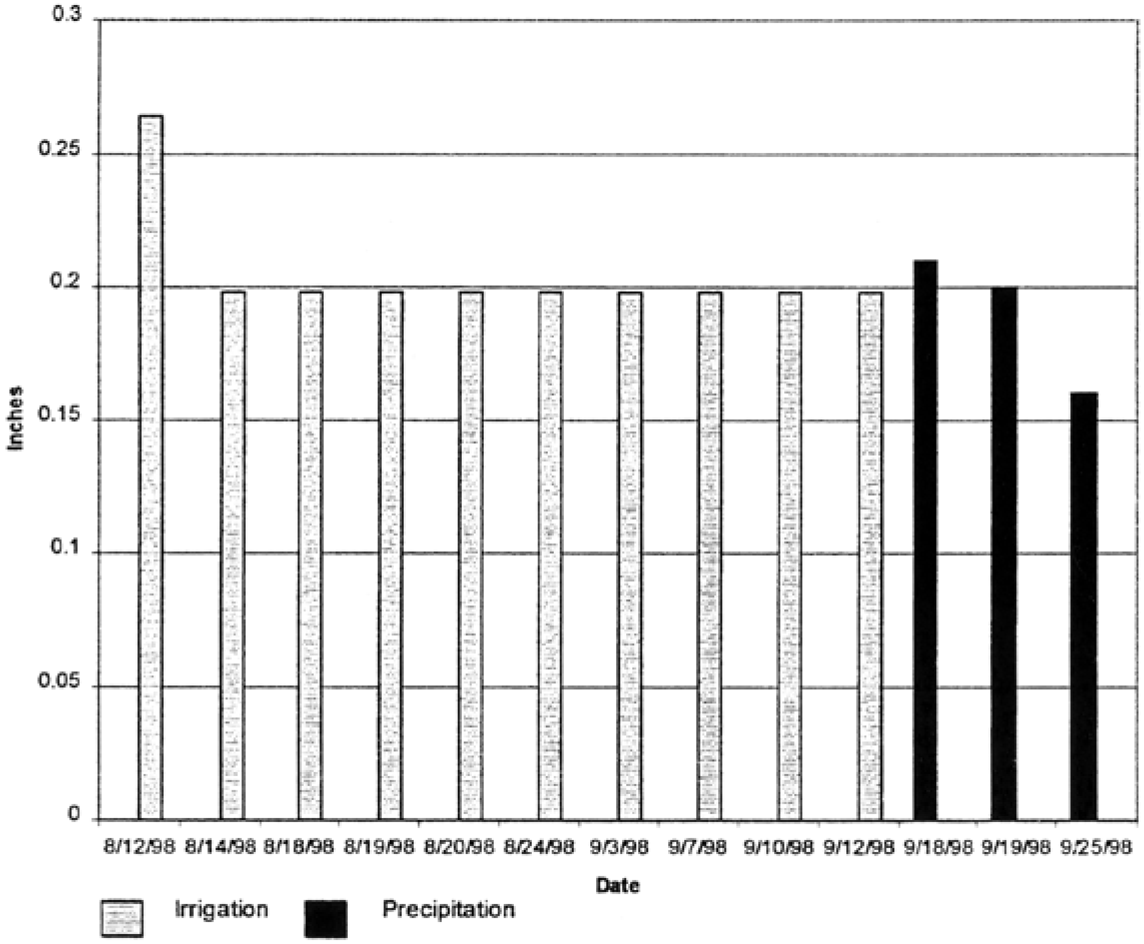

Figure M-1: Amount of water recieved by irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998

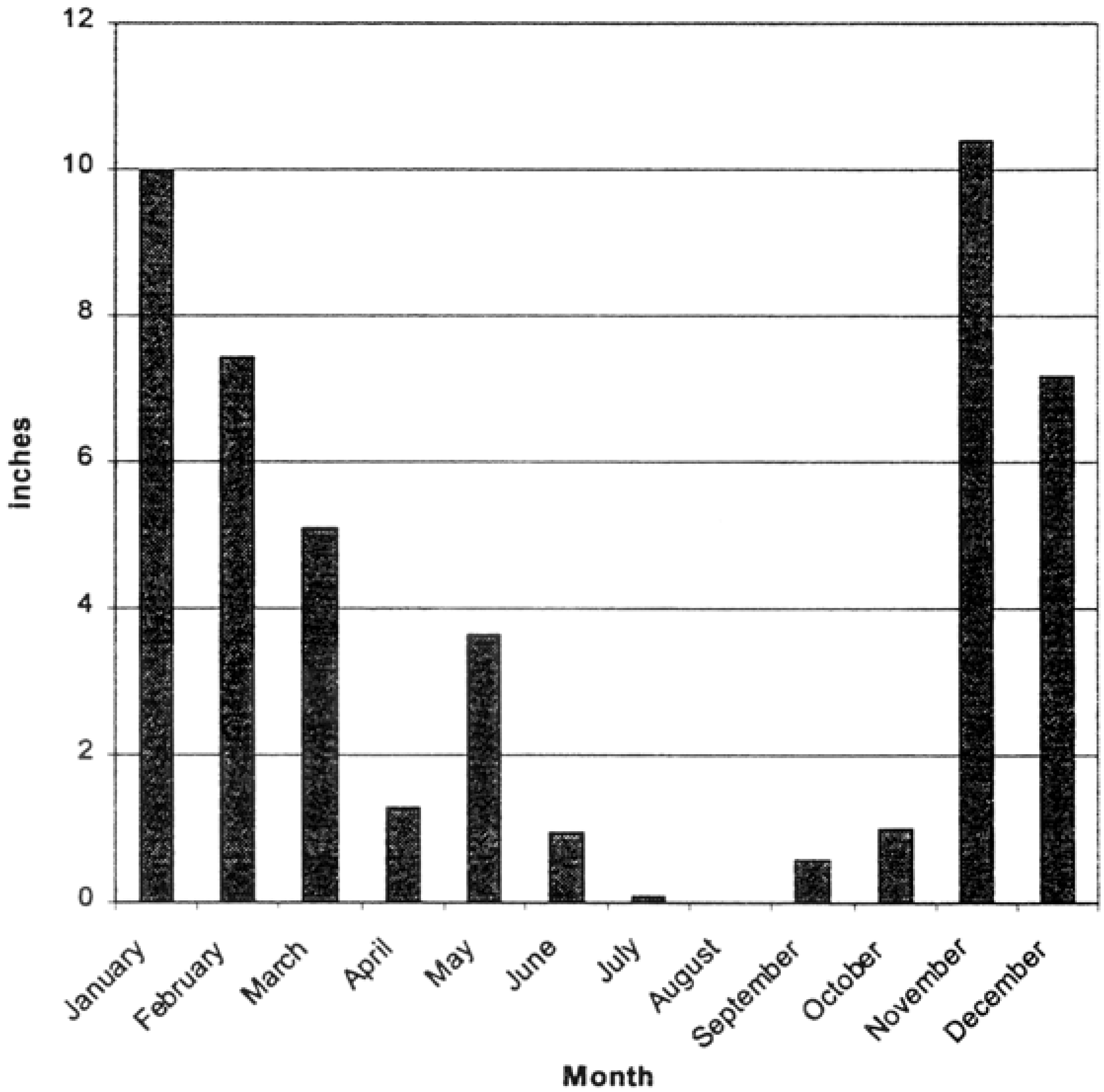

Figure M-2 Monthly Precipitation McMinnville Oregon 1998 Precipitation

One shoot on each side of the curtain (east, west) was tagged, per vine. The tenth leaf of each tagged shoot was also tagged. Only these shoots and leaves were used for the following data collection.

Leaf gas-exchange measurements

Leaf gas-exchange measurements were taken with Ciras-1 (PP SYSTEMS, Hitchin, Herts SG5 1RT UK), a portable infra-red gas analyzer. Leaves were fully exposed to sunlight and measured 6 times between July 8 and September 16 on cloudless days. Measurements were taken before 1:00 p.m and after 9:00 a.m., at photosynthetic flux densities above 1200umol PAR m -2. S -1.

Chlorophyll

Leaf greeness was measured using a SPAD-502 chlorophyll meter (Minolta). Chlorophyll content was calculated using the formula proposed by Candolfi-Vasconcelos 1994. Six readings were taken per data leaf and then averaged.

Fluorescence
Chlorophyll fluorescence emission was measured by a pulse modulated Fluorescence Monitoring System (FMS). Leaves were engaged in photosynthesis under ambient light conditions by application of a leaf clip. Leaf clips were left on for at least 15 minutes to create complete darkness. The ratio of variable to maximum fluorescence (Fv/Fm) is a measure of the light dependent reactions of photosynthesis. Chlorophyll fluorescence was measured seven times between June 30, and September 16.

Ripening Dynamics
A ripening survey was begun at the onset of veraison (veraison = 50% berries changed color). Fruit samples were taken between veraison and harvest on seven different dates. On each date, three clusters were used for juice analysis and another three clusters were frozen until further analysis. A sub-sample of 100 berries was used to calculate berry weight and skin anthocyanin content. Soluble solids of juice samples were measured using a refractometer. Titratable acidity and pH were measured by an automatic titrator (Mettler Toledo, DL21 Titrator).

Anthocyanins
Anthocyanins were measured from the skins of 100 berries. After skins were manually separated from berries, they were weighed and extracted with acidified methanol (1% Hydrochloric acid). Skins were placed in 200 ml jars with 50 ml of acidified MeOH solution. Jars were then placed on a shaker for four hours at room temperature. The extract was transferred to another jar and the skins were put through extraction two more times with 40 ml solution, for three hours, each time. The three extracts were combined and the volume was brought up to 200 ml using the same acidified MeOH solution. The extract was diluted 1:50 with the MeOH solution. Absorbency was measured at 530nm using a spectrophotometer. An extinction coefficient of 3800 was used to calculate anthocyanin content.

RESULTS AND DISCUSSION

Monthly precipitation records for 1998 from McMinnville Oregon show that there was zero precipitation at this site from mid July until mid September (figure M-2). The measurements and observations made reflect the effect of water deficit that the vines were experiencing, excluding the irrigated treatment.

Leaf Gas Exchange
Both treatments show a peak in C02 assimilation rate before veraison, as illustrated by Figure 1. After veraison, C02 assimilation rate dropped in both the irrigated and nonirrigated treatment, showing no significant difference between treatments. Figure 2 illustrates transpiration rate of both treatments. Once again, the highest rate of transpiration occurs just before veraison. Transpiration rate was reduced after veraison. A significant difference between treatments was observed after veraison. The irrigated vines continued to transpire at a significantly higher rate than the non- irrigated vines. Water use efficiency, shown in Figure 3, decreased steadily in August. Except for September 16, no treatment differences were observed in WUE.

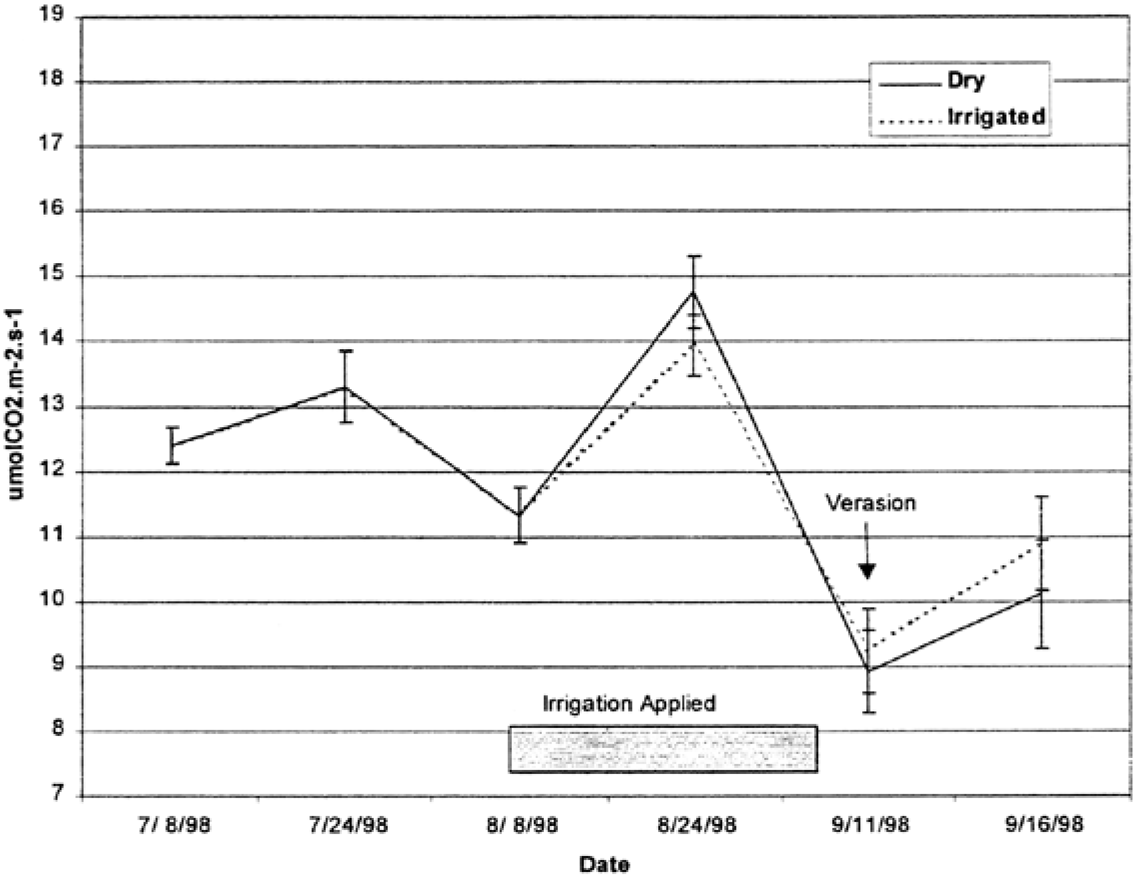

Figure 1: CO2 Assimilation Rate or irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE

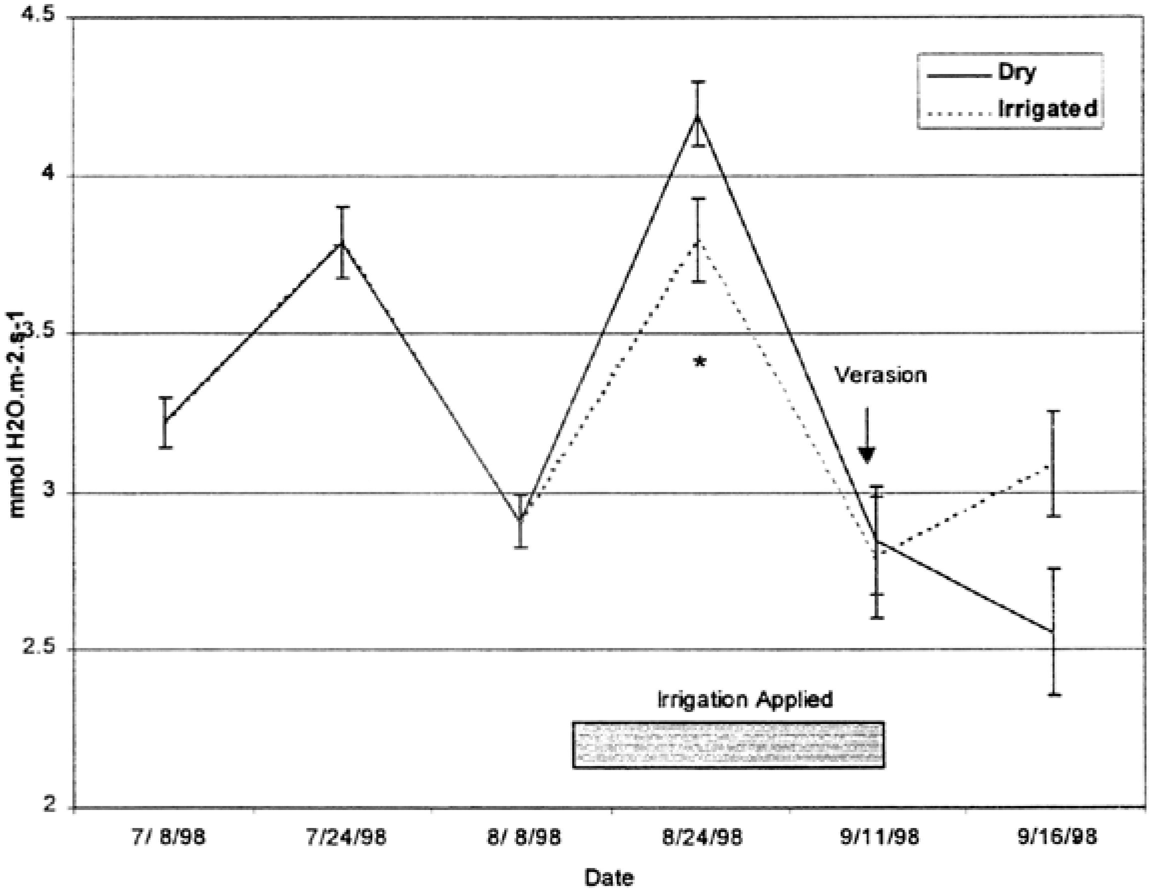

Figure 2: Transpiration Rate or irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE.

* indicates statistically significant at < 0.05 level of probability.

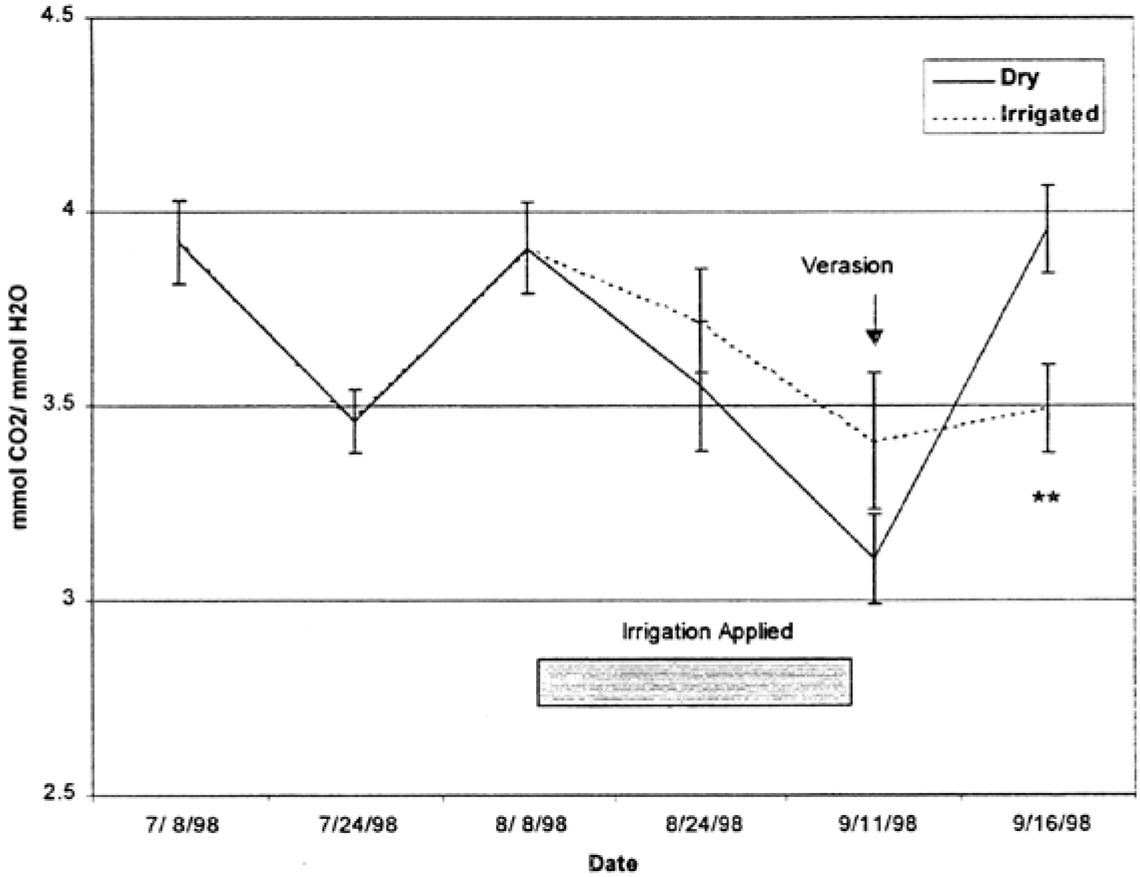

Figure 3: Water Use Efficiency of irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE.

** indicates statistically significant at < 0.01 level of probability

Chlorophyll
Chlorophyll content increased in both treatments during ripening, and began to decrease after veraison. Figure 4 illustrates that there was not a significant difference between treatments during the time of measurements. The ratio of variable to maximal fluorescence, Figure 5, was also similar between treatments and no significant difference can be noted.

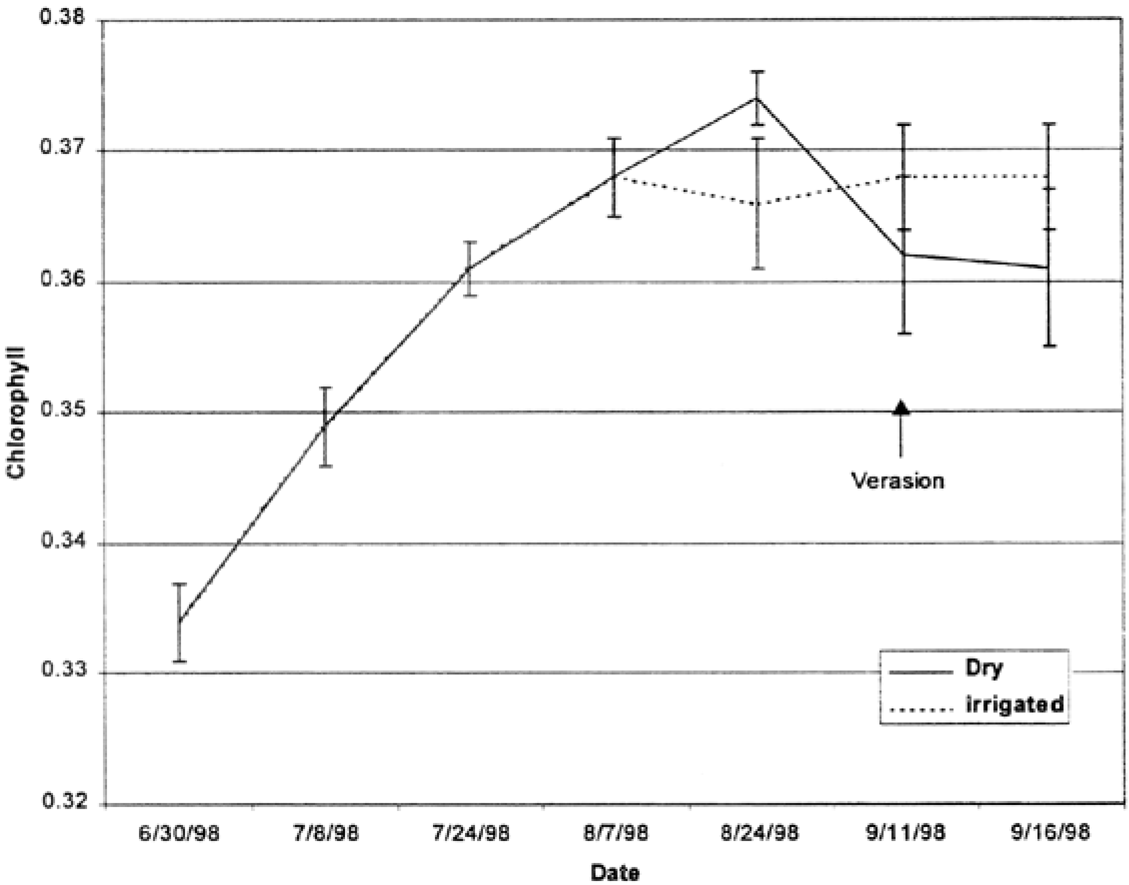

Figure 4: Chlorophyll of irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard during 1998. Vertical bars represent +-SE.

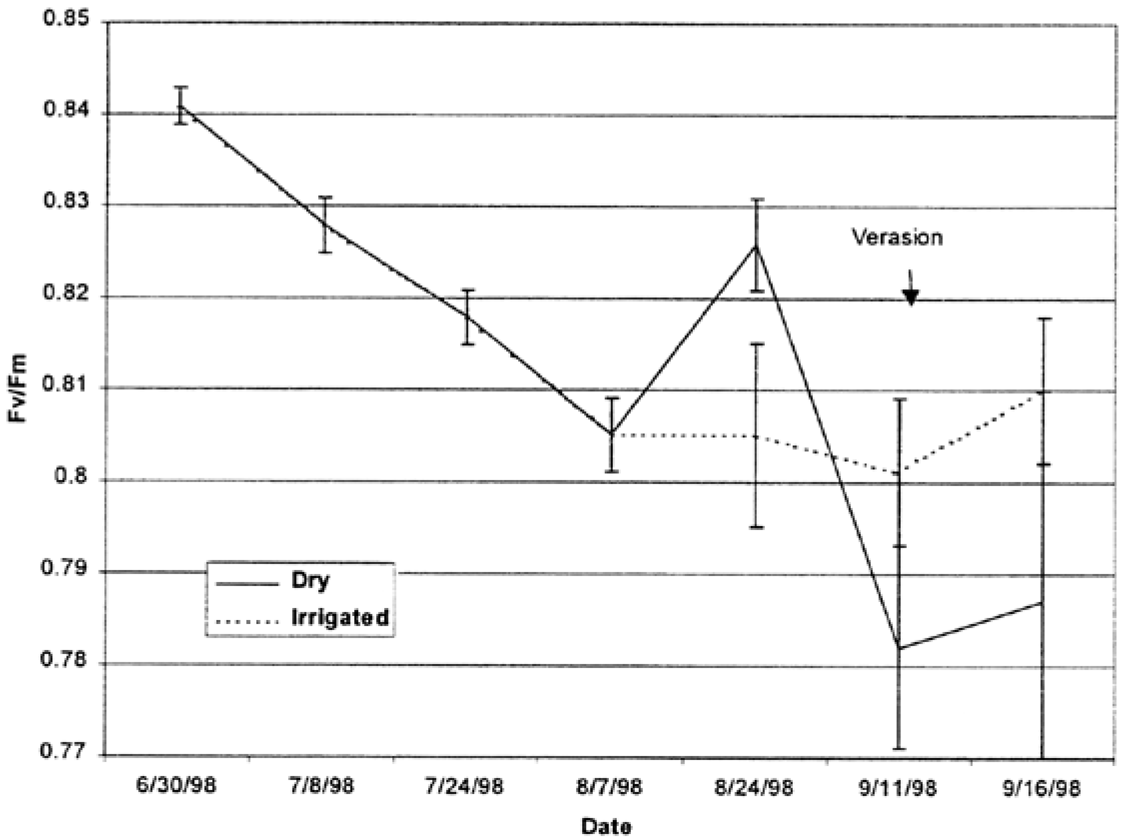

Figure 5: Trends during vegetative growth in the ratio of variable to maximal fluorescence (Fv/Fm) in irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard in 1998. Vertical bars represent +-SE.

Soluble Solids and TA

Both irrigated and non-irrigated vines show similar trends in sugar accumulation during ripening. Figure 6 illustrates a significant difference between treatments in late September where the irrigated vines slowed in soluble solid accumulation. There were no treatment differences in soluble solids at harvest. TA was higher for non-irrigated vines prior to veraison (Figure 7). After veraison both irrigated and non-irrigated vines decreased in TA similarly.

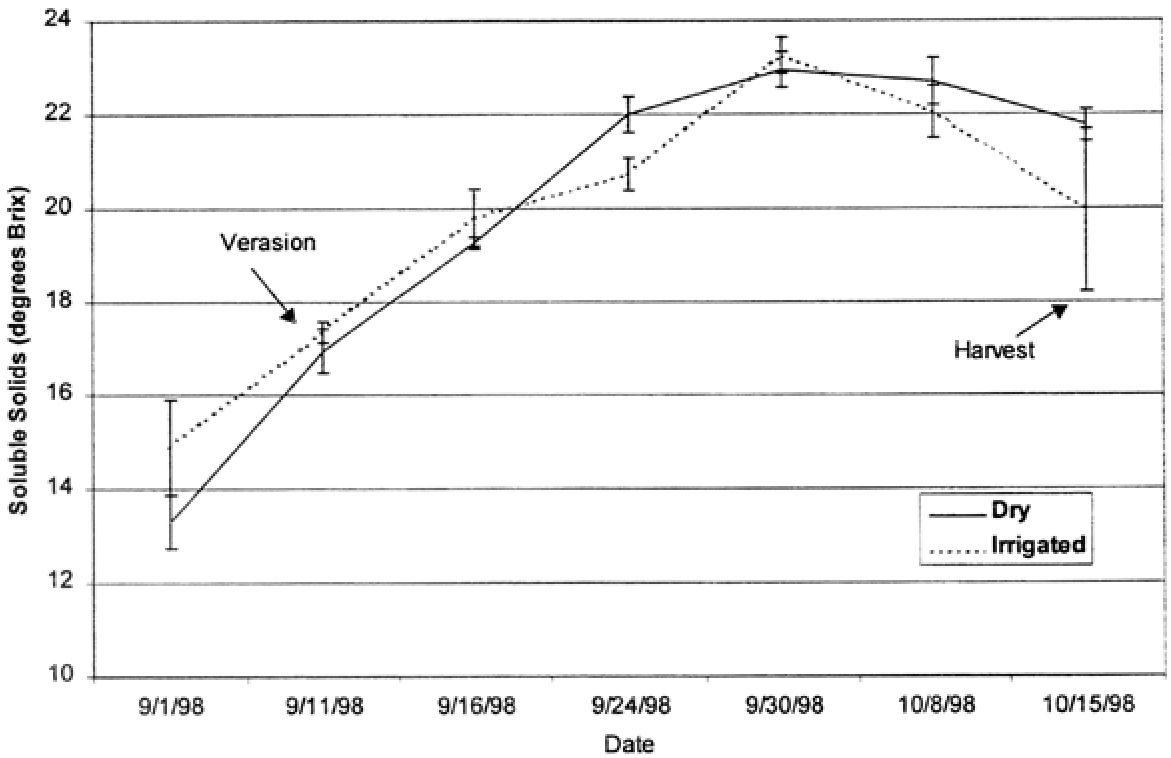

Figure 6: Trends in sugar accumulation during ripening of irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE

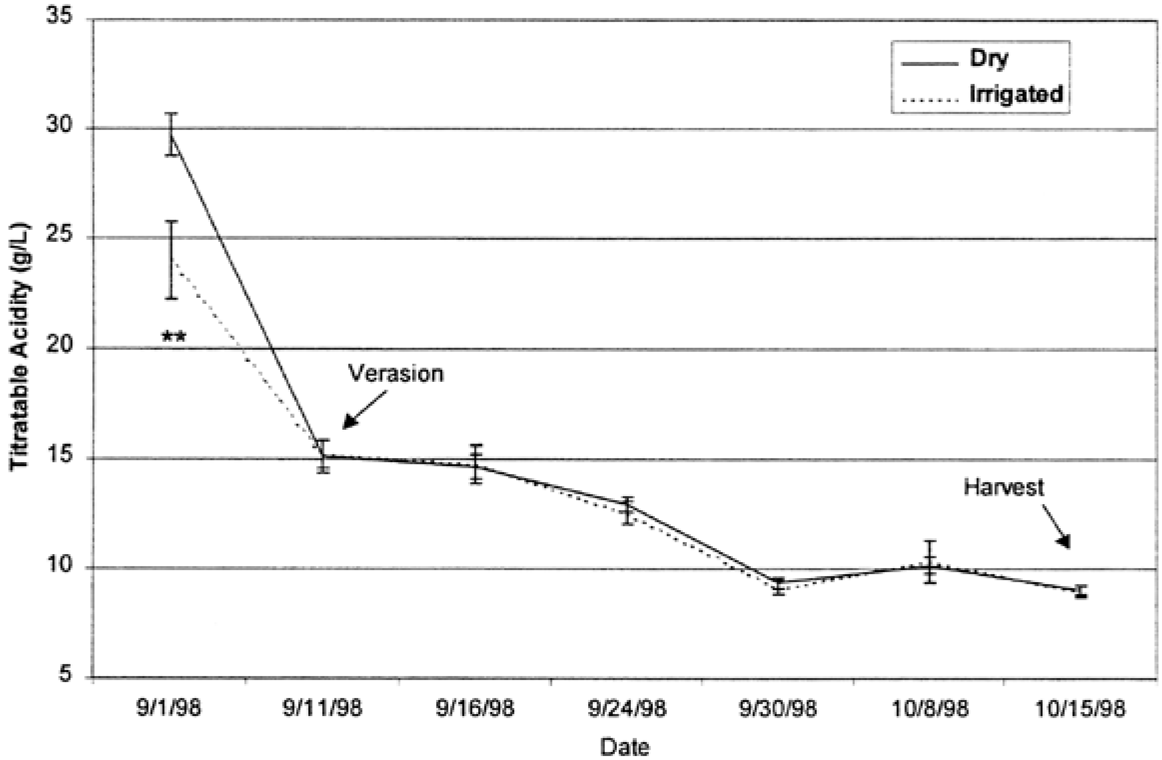

Figure 7: Changes in titratable acidity during ripening of irrigated and non-irrigated vines at Knudsen Vineyard

** indicates statistically significant at the .01 level of probability

Anthocyanins

Berry anthocyanin content increased from veraison until just before harvest in both treatments. A similar trend occurred in both treatments with respect to anthocyanin content per gram of fruit. There were no significant differences between treatments in anthocyanin concentration, expressed either in amount per berry or per gram of fruit (Figures 8 & 9).

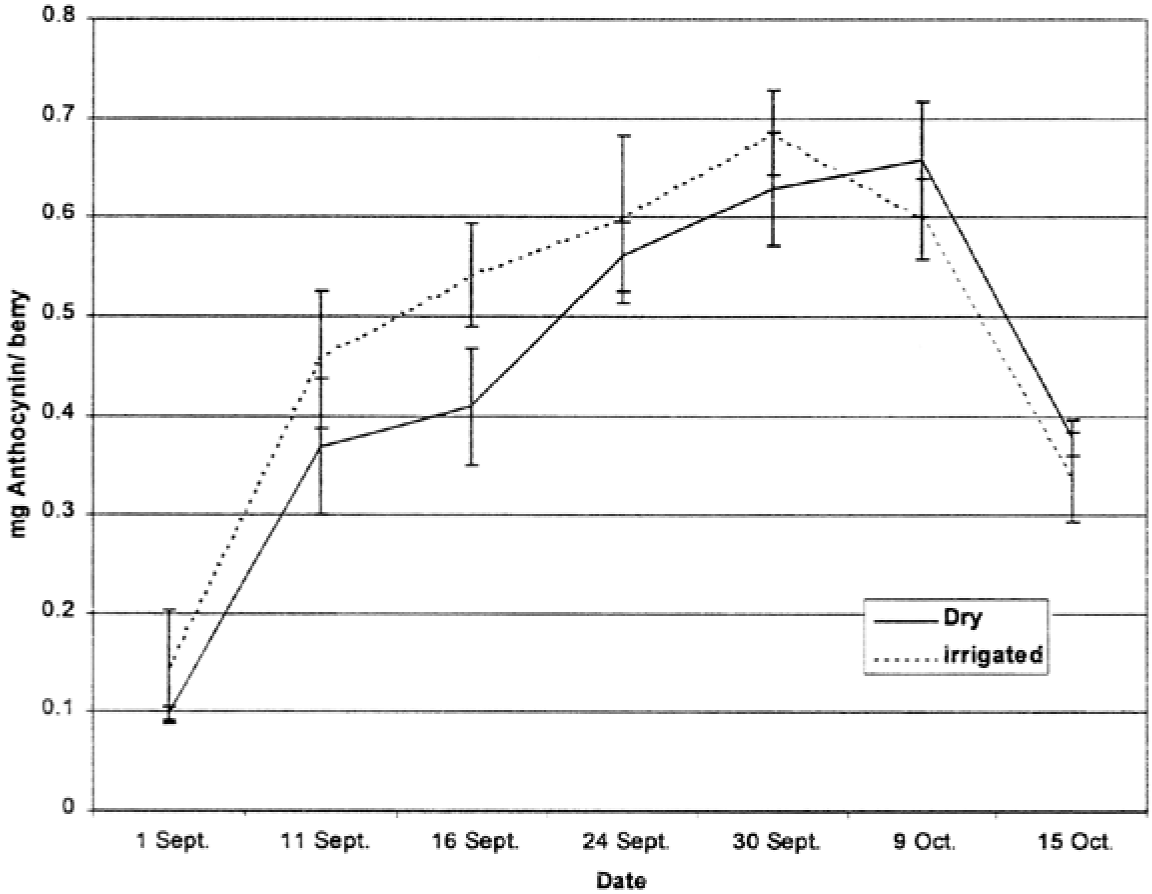

Figure 8: Berry Anthocynin Content in irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE.

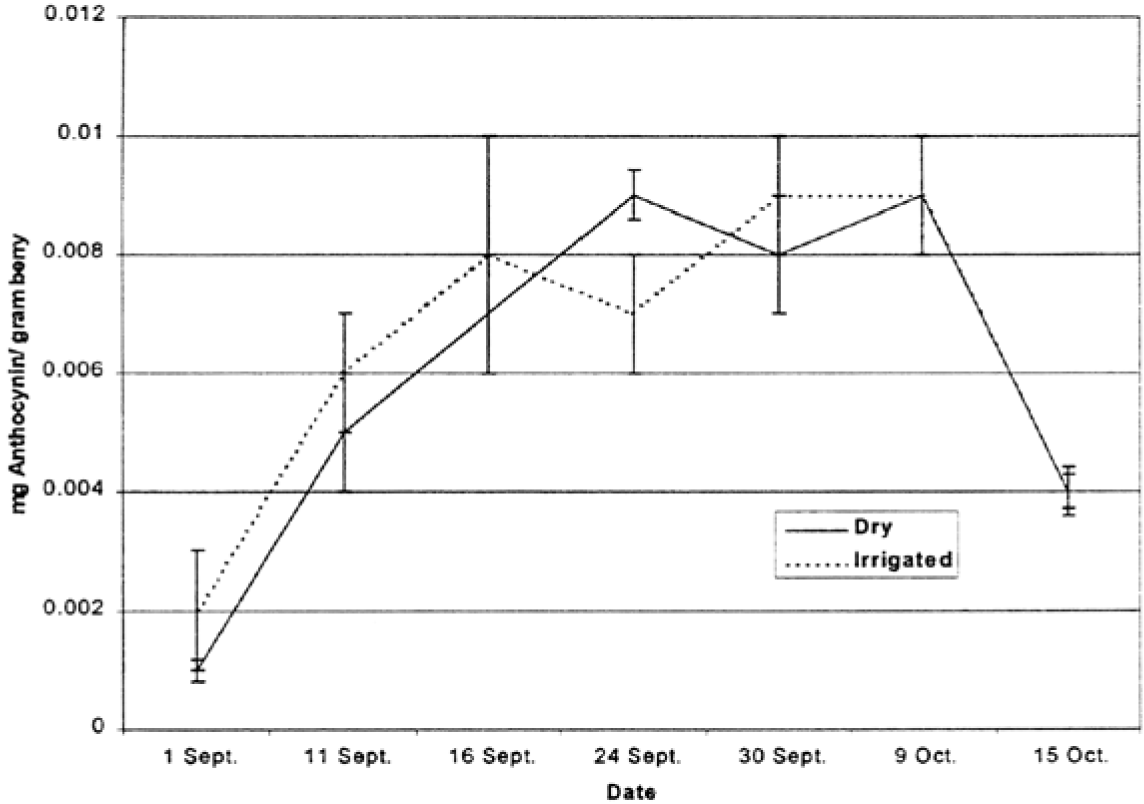

Figure 9: Anthocynin content with respect to berry weight, in irrigated and non-irrigated mature Pinot noir grapevines at Knudsen Vineyard 1998. Vertical bars represent +-SE.

Harvest
Table 2 illustrates yield components at harvest and the standard errors for both treatments. There were no significant differences in yield components between irrigated and non-irrigated vines.

Table 1: Amount of water received in inches per vine Knudsen Vineyard 1998. Data received from Oregon Climate Services Oregon State University.

		Irrigation	Precipitation	Total
Dry	August	0	0	
	September	0	0.57"	0.57"
Irrigated	August	2.05"	0	
	September	0	0.57"	2.62"

Table 2: Yield Components of the 1998 Harvest Knudsen Vineyard

	Dry	Standard Error	Irrigated	Standard Error	Significant F
Yield/vine (kg)	4.71	0.51	4.58	0.41	ns
Ton/acre	3.14	0.34	3.05	0.28	ns
Shoots/vine	41	3	41	3	ns
Clusters/shoot	1.25	0.08	1.33	0.09	ns
Cluster weight (g)	91.17	4.43	86.61	5.12	ns
Clusters/vine	52	6	54	5	ns
Berry weight (g)	1.09	0.09	1.00	0.11	ns
Berries/cluster	92	12	98	11	ns

CONCLUSIONS

It is premature to draw any conclusions from the first year of this study. Because this experiment is being carried out in a vineyard that has been irrigated for many years, we did not expect to see substantial treatment differences during this first season. In fact, ripening dynamics were not affected and only minor differences were observed in gas exchange between irrigated and non- irrigated vines. We expect to see larger differences as the effects of soil water deficit become more pronounced over the course of additional seasons. In another study, the effects of root zone competition induced by cover crops, started depressing growth and fruit quality only in the second season of treatment implementation (Candolfi-Vasconcelos *et al.* 1999). In the current study, we do not yet know what the effects of drought on the carbohydrate reserves in the permanent structure were. These analysis will be conducted during spring. Additionally, it would be interesting to know what effects irrigation has on fermentation dynamics and wine quality.

ACKNOWLEDGMENTS

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