Oregon Wine Research Institute

Improving Wine Grape Quality through Water Use Optimization in Southern Oregon Vineyards: Impact of Time and Irrigation Strategy on Vine Performance of Tempranillo and Syrah Cultivars (physiology, growth and berry composition)

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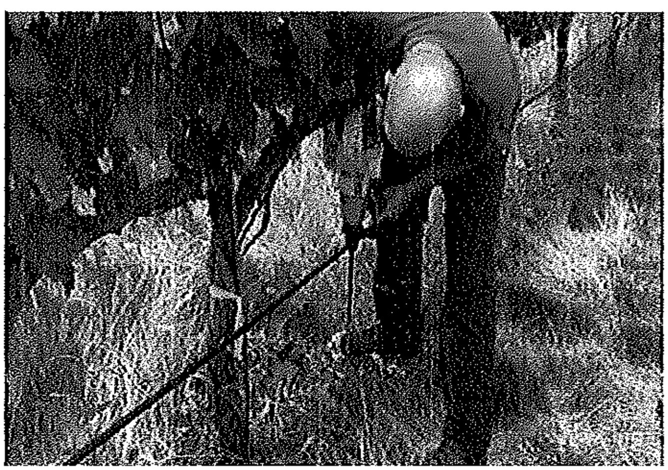

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- **Earl Jones/ Jason Coates**
  Abacela Winery
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- **Chris Martin/Brian Gruber**
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- **Richard Ellis**
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Abstract

Irrigation is a complex aspect of grape growing in Southern Oregon. The grape industry in this region, as in other arid and semi-arid areas of the world is seeking more sustainable practices to deal with water stress during the growing season. Grape growers and wineries in Southern Oregon strive for consistent production of high quality fruit and wine. Therefore, the overall purpose of this multiannual study is to find the best irrigation strategies for various cultivars, in order to save water and improve grape quality, and indirectly increase farm revenue. Research conducted on the interaction of soil-climate-cultivar water needs and fruit quality can provide a broader understanding of issues that govern the optimization of a limited supply of water.

There is a consensus that controlled deficit irrigation management is a key cultural practice that can influence fruit and wine quality, but the diversity of mesoclimate, topography and grape varieties found in Southern Oregon require specific guidelines for irrigation practices.

Background

Previous irrigation research conducted in Southern Oregon stressed the importance of this research topic for the grape growers from Southern Oregon. The Research and Technical Committee of Rogue Valley indicated that irrigation is and will remain the top priority research project for Southern Oregon.

Southern Oregon has more than 110 different kinds of soil and a large diversity of mesoclimatic zones that differ dramatically in their irrigation needs; moreover, the entire area is characterized by high evapotranspiration and little precipitation during the growing season. Different irrigation regimes can bring about substantial alterations in grapevine physiology, affecting yield and grape composition. All these changes must be very accurate assessed since they could have a great impact on fruit and wine quality. The response of grapevines to irrigation is affected also by other factors such as harvest time, yield and stress levels. Vineyard location and site is of utmost importance. Irrigation regimes exert a major impact on grape juice composition because of the higher water content of the berries, which results in dilution of some important components, such as color pigments and aroma compounds.

Little research relative to irrigation has been published on the Tempranillo cultivar, even though it is one of the most important wine grape cultivars in Spain. However, there are much more studies conducted on Syrah, but not under similar conditions of Southern Oregon.

Due to the importance of regional and site influences on grape culture, these strategies have been and should be investigated in most, if not all, of the major semi-arid growing regions in the U.S. and the world.

This is an industry conceived and supported project and it will be the first comprehensive research and demonstration project in the region that examines the interaction of different deficit irrigation strategies, soil types, cultivars and mesoclimate. The effect on growth, berry development and composition of two important red wine grape varieties grown in Southern Oregon will be assessed. This study was developed based on a current demonstration and training project funded by the Oregon Wine Board to broaden the implementation of ET-based irrigation management for wine grape vineyards.

Executive Summary

The irrigation field experiments implemented at three sites on Tempranillo and Cabernet Sauvignon cultivars in 2010 were redesigned in 2012. Since Cabernet Sauvignon ripens the last in Southern Oregon year by year, and no variation among different variables measured was observed in two years of the experiment, the current PI along with all cooperators decided to replace this variety with Syrah. In spring of 2012, we set up the same irrigation experiment in two blocks of Syrah located in two different areas: Applegate and Rogue Valley respectively. Each cooperator of the project initiated their irrigation trials when leaf water potential reached – 1.2 MPa. The water need for each application was calculated based on weekly ETo data and canopy size, and they maintained the following irrigation treatments until one –two weeks before harvesting: (SD-1) initiate irrigation at 70 percent of ETc until harvest; and (RDI-1) initiate irrigation at 70 percent ETc until veraison, then 35 percent of ETc to harvest; (SD-2) initiate irrigation at 35 percent of ETc for the entire season; (RDI-2) initiate irrigation at 35 percent of ETc until veraison, then 70 percent of ETc until harvest.

Due to a late access to funds in 2012, the profile probe was bought late in the season. Since the Teflon tubes were installed into the ground in late May beginning of June, we found some errors in soil moisture readings which might be explained by the presence of some air gaps due to late installation and lack of proper contact between tubes and soil. By the time we installed the tubes, the soil had already dried in the first two feet of the soil profile. However, due to the amount of precipitation received in fall of 2012 and winter 2013 we expect better readings of soil moisture in 2013. This data will allow tracking soil moisture at six depths, giving a better understanding of the soil drying pattern according with the root system depth and irrigation strategy used. At beginning of the season, one water flow meter was installed in each treatment from one replicate at all three experimental sites. This allowed both PI and each cooperator to increase the accuracy in water applied in each irrigated treatment.

In 2012, an ACCUPAR LP-80 ceptometer was purchased to collect leaf area index data. This index provides important information on the canopy size which helps us to assess the effect of degree of water stress on vine vegetative system. The preliminary data collected is not shown in this report. We were able to collect data only half of the season, because the instrument was ordered in late June of 2012. However, the data helped us to optimize the protocol for data collection.

The plant water stress was evaluated in 2012 using four parameters that might be easy and more accurate to interpret by the growers. Relationship among predawn water potential, midday stem water potential, midday leaf water potential and early morning water potential were assessed as well.

The nutrient status was assessed at bloom (petioles) and veraison (leaf blade) at all sites and for both varieties. All tissue samples were analyzed by A & L Western Laboratories (OR, Portland). Even some variation was found for various macro- and micro-elements at bloom among the irrigation treatments, this was significant just for few minerals. The irrigated treatments had a higher effect on plant nutrient status at veraison.

Yield data for vintage of 2012 was collected from all three experimental sites by Dr. Gabriel Balint and his crew as follow: Tempranillo - Abacela Vineyards (Umpqua Valley; October 9th 2012, two weeks earlier than previous season), Tempranillo - Ellis Vineyards (Rogue Valley, October 4th, 2012 three weeks earlier than 2011), Syrah – Ellis Vineyards (Rogue Valley, October 17, 2012), Syrah – Troon Vineyards (Applegate Valley, October, 5th 2012)

All chemical analyses were performed at Viticulture Lab, SOREC. Anthocyanins, total phenols, D glucose/Dfructose, primary Amino nitrogen and Amonia were determined by colorimetric methods using kits from Unitech Scientific.

Weather

After two cooler than average vintages in 2010 and 2011, the 2012 vintage was closer to normal conditions. The 2012 vintage was characterized by prolonged dry and warm period from July through mid-October that provided near ideal ripening conditions and a relatively easy harvest rush. The 3383 GDD as measured at the Medford airport station is most comparable to 2003 and 2006 vintage (data not shown). The higher GGD in the 2012 vintage largely came from higher maximum temperatures (up to 4.0°F above normal) over the season. However, data from Agrimet Weather station (SOREC) indicated only 2734 GDD (Table 1). This difference between these weather stations located at 2 miles apart, emphasis the diversity of Southern Oregon mesoclimates. One of the big differences between the 2012 vintage and the prior two was the spring conditions was that in 2012 the spring was much warmer and allowed earlier growth.

Table 1. Reference evapotranspiration, precipitation and growing degree days from the AgriMet weather station at SOREC for the 1981-2010 climate normal, 2011, and 2012. Note ET is not calculated for the climate normal.

Period	ET_0 (inches)			Precipitation (inches)			Growing Degree-Days		
	1981-2010	2011	2012	1981-2010	2011	2012	1981-2010	2011	2012
April		3.3	3.5	1.91	2.17	1.67	36	14	120
May		5.0	5.7	1.70	2.69	0.92	228	103	259
June		7.2	6.9	0.85	1.00	2.03	409	367	353
July		6.3	7.0	0.55	0.38	0.07	630	580	644
August		6.0	6.3	0.41	0.00	0.00	602	659	698
Sept		4.2	4.7	0.78	0.00	0.00	354	536	501
October		1.9	2.1	1.45	0.66	2.02	80	141	160
Season		33.9	36.2	7.65	6.90	6.71	2339	2398	2734

The reference evapotranspiration data from 2012 showed a similar pattern with that from 2011. However, the monthly values were higher than in 2011, except June. Precipitation amount was lower in 2012, the water deficit started to build up in April and May. Even if in June of 2012 the precipitation amount was double comparing with the similar period from previous year, this was not enough to refill the soil profile at field water capacity.

Phenology:
Summarizing the phenological observations for two distinct regions of Southern Oregon shows an average of 7 to 9 days difference between various vegetation stages (Table 2). The least difference between sites was observed at bloom, which was only 4 days.

Table 2 Phenological events for experimental Tempranillo vineyards of two sites representing two sub-regions of Southern Oregon American Viticulture Area (Site 1 – Ellis Vineyards, Site 2 – Abacela Vineyards).

	Site 1 (Bear Creek Valley)	Site 2 (S. Umpqua Valley)
Bud Break	May 2	April 23
Bloom	June 23	June 19
Verasion	Aug. 20	Aug. 28
Harvest	Oct. 18	Oct. 9

Vine Nutrients Status.

In 2012, nutrient status of vines from the experimental trials was assesses at both vegetative stages bloom and veraison respectively. Even if irrigation was not initiated until mid-July, we expected to find variation in the nutrient status as a carryover effect from the previous year irrigation treatments.

At veraison, Tempranillo vines from SD2 had more N and S, while RDI2 had more K. compared to other irrigation treatments. The variation across treatments at veraison increased considerably across treatments which suggest that in irrigated vineyards samples collected at veraison are more relevant to the nutrient status of vines. In deep soils, Tempranillo vines were affected by irrigation treatments for most of the nutrients except P, Mg, B and Cu which were stable across the treatments. In deep soil, N and Al were the only minerals which increased in 2012 compared to 2011 vintage (table 3).

In shallow soils, N increased overall in all irrigation treatments compared to 2011 vintage (tables 3 and 4). The nutrients in Tempranillo vines were much less in shallow soils compared to deep sols, except Mg and Mn which were three times higher in shallow soils. Tempranillo vines from RDI 2 treatment in shallow soils had overall the highest content of micro-elements compared to other irrigation treatments.

The irrigation treatments had a significant impact on potassium content only on deep soil but not on shallow soils (table 3). However, a surprising observation was that the amount of potassium in leaves was two to three times higher in 2012 compare to the similar treatments from 2010, but less than 2011. IF B and Zn were highly affected by irrigation treatments in 2011, this was not the case in 2012. This suggests that season has a great impact on nutritional status. Three way ANOVA analyses will be conducted in order to find the interactive effect of various factors on nutritional status.

In Syrah, the irrigation treatments did not show a consistent trend in the first year of experiment at any site analyzed, possible because they were under consistent irrigation strategy for the last couple of years (table 7).

Table 3. Impact of irrigation strategy on nutrients status (primary and secondary minerals) in grapevine leaves of Tempranillo, at veraison, grown on two types of soils (2010-2012)

Treatment	N(%)	S(%)	P(%)	K(%)	Mg(%)	Ca(%)	Na(%)
			Deep soils (Ellis)				
2010							
SD-1	2.26 b	0.24	0.13 b	0.44 b	0.14 b	1.00 b	31.5 a
SD-2	2.38 a	0.23	0.16a	0.78 a	0.28 a	2.11 a	41.7 b
2011							
SD-1	2.48a	0.18a	0.21a	1.49b	0.23	2.11b	0.01
SD-2	2.22b	0.17ab	0.18b	1.52b	0.25	2.21ab	0.01
RDI1	2.09c	0.14b	0.19ab	1.84a	0.24	2.20ab	0.01
RDI2	2.34ab	0.15b	0.19ab	1.81ab	0.25	2.29a	0.01
2012							
SD-1	2.92a	0.22a	0.18	1.31c	0.25	2.21ab	0.01
SD-2	2.81b	0.21ab	0.20	1.28c	0.24	2.26a	0.01
RDI1	2.60d	0.17b	0.17	1.48b	0.23	2.01c	0.01
RDI2	2.72c	0.18b	0.18	1.52a	0.25	2.09c	0.01
			Shallow Soils (Abacela)				
2010							
SD-1	1.60 b	0.13	0.12	0.21 b	0.39 a	0.83 a	116.4 a
SD-2	1.87 a	0.14	0.12	0.27 a	0.33 b	0.75 b	101.8 b
2011							
SD1	1.83ab	0.14	0.12	0.84a	0.62b	1.81a	0.01
SD2	1.70b	0.14	0.13	0.73b	0.72a	1.81a	0.01
RDI1	1.85a	0.13	0.12	0.68b	0.64b	1.76b	0.01
RDI2	1.70b	0.15	0.12	0.74b	0.64b	1.77b	0.01
2012							
SD1	1.97a	0.13	0.13	0.68b	0.57b	1.57b	0.01
SD2	1.92ab	0.14	0.14	0.66b	0.64a	1.70a	0.01
RDI1	1.94ab	0.13	0.13	0.66b	0.60ab	1.66ab	0.01
RDI2	1.87c	0.14	0.14	0.77a	0.61ab	1.65ab	0.01

Tempranillo vines from RDI 1 show higher values at bloom for P, K and Ca in deep soil compared to the other irrigation treatments. However, in shallow soils just a little variation was found across the treatments, K and Mg being the only macro-elements affected. SD2 treatment showed the lowest K concentration. Vines from RDI 2 treatment had also the highest content in Fe, Mn and Zn (table 6). Another important observation was that vines from Ellis (deep soil) had much more P, K , Ca, Fe and less Mg and Mn than those from shallow soils (Table 6).

Table 4. Impact of irrigation strategy on nutrients status (micronutrients) in grapevine leaves of Tempranillo at veraison, grown on two types of soils (2010-2012)

Treatment	Fe (ppm)	Al(ppm)	Mn(ppm)	B(ppm)	Cu(ppm)	Zn(ppm)
			Deep Soils (Ellis)			
2010						
SD1	128.8 a	-	99.4 a	25.2 a	7.1 a	31.4 a
SD2	122.9 a	-	81.3 b	26.1 a	4.5 b	11.7 b
2011						
SD1	178.0ab	61.6c	71.0b	41.3b	8.6	**23.6a**
SD2	159.6b	88.3b	77.6a	33.6c	6.6	18.0c
RDI1	160.6b	105.3ab	75.6a	46.6ab	6.3	20.3b
RDI2	**181.3a**	**130.3a**	76.6a	**58.0a**	7.3	21.0b
2012						
SD1	180.0b	96.3b	67.0b	33.0	8.0	21.0b
SD2	171.0b	97.6b	**87.0a**	33.0	9.0	**25.0a**
RDI1	152.0c	84.0c	67.0b	35.0	9.0	23.0ab
RDI2	**201.0a**	**110.0a**	71.0ab	33.0	9.0	24.0ab
			Shallow Soils (Abacela)			
2010						
SD1	131.4 a	-	134.8 a	26.9	13.5 b	53.8 b
SD2	114.1 b		124.6 b	27.3	**17.4 a**	**65.0 a**
2011						
SD1	121.0b	41.6b	129.6b	19.0	7.6	38.3b
SD2	119.3b	**45.3a**	**145.6a**	21.3	8.0	38.6b
RDI1	117.0b	40.0b	115.6c	21.3	8.3	45.3ab
RDI2	**136.3a**	43.0ab	129.0b	21.6	7.3	**48.3a**
2012						
SD1	108.0b	37.0c	100.0b	22.0b	5.0	19.0b
SD2	102.0b	45.6b	112.0b	22.0b	6.0	20.0b
RDI1	102.0b	41.5b	113.0b	21.0b	5.0	23.0ab
RDI2	**125.0a**	**59.0a**	**117.3a**	**28.3a**	6.0	**25.0a**

Table 5. Impact of irrigation strategy on nutrients status (primary and secondary minerals) in grapevine leaves of Tempranillo, at bloom, grown on two types of soils (2010-2012).

Treatment	N(%)	S(%)	P(%)	K(%)	Mg(%)	Ca(%)	Na(%)
			Deep soils (Ellis)				
2012				**Bloom**			
SD-1	0.83ab	0.14	0.60ab	2.48ab	0.63	**2.60a**	0.01
SD-2	0.87ab	0.13	0.56b	2.53ab	0.58	2.32b	0.01
RDI1	0.83b	0.13	**0.65a**	**2.66a**	0.61	**2.60a**	0.01
RDI2	**0.94a**	0.13	0.54b	2.13b	0.62	2.55ab	0.01
			Shallow Soils (Abacela)				
2012				**Bloom**			
SD-1	0.81	0.09	0.17	**1.58a**	0.78b	1.04	0.03
SD-2	0.75	0.09	0.17	1.07b	**1.10a**	1.1	0.03
RDI1	0.80	0.09	0.18	**1.58a**	0.77b	1.03	0.03
RDI2	0.76	0.09	0.17	**1.59a**	0.77b	1.28	0.03

Table 6. Impact of irrigation strategy on nutrients status (micronutrients) in grapevine leaves of Tempranillo at bloom, grown on two types of soils (2010-2012)

Treatment	Fe (ppm)	Al(ppm)	Mn(ppm)	B(ppm)	Cu(ppm)	Zn(ppm)
			Deep Soils (Ellis)			
2012				**Bloom**		
SD1	27b	7	29b	34	10	29b
SD2	27b	8	31b	31	10	41a
RDI1	33b	9	35ab	35	10	36ab
RDI2	**48a**	7	**48a**	31	10	**41a**
			Shallow Soils (Abacela)			
2012				**Bloom**		
SD1	21ab	6	45b	35	10	42b
SD2	19b	5	57ab	38	9	34c
RDI1	18b	3	51b	38	9	**50a**
RDI2	**24a**	6	**60a**	37	10	44b

Table 7. Impact of irrigation strategy on nutrients status (primary and secondary minerals) in grapevine leaves of Syrah at veraison, grown on deep of soils (2012)

Treatment	N(%)	S(%)	P(%)	K(%)	Mg(%)	Ca(%)	Na(%)
				Ellis (deep soil)			
2012							
SD1	**2.63a**	0.18	0.23	1.26c	0.39ab	2.86ab	0.01
SD2	2.45b	0.21	0.24	1.66ab	**0.42a**	**2.92a**	0.01
RDI1	2.24c	0.16	0.25	**1.70a**	0.32b	2.24c	0.01
RDI2	2.44b	0.18	0.24	1.54ab	0.38ab	2.67b	0.01

Yield Components and berry composition

As expected, vine yields varied between sites and treatments (tables 8 to 11). The yield per vine was much higher compared to that from shallow soils. However, a general observation was that even if we used the same irrigation strategies the yield was much lower in 2012 compared to 2011. However, the irrigation strategy used made the difference in terms of yield in 2012. Tempranillo vines from SD2 treatment had the highest yield, being consistent over the two years of irrigation experiment. However, if in the first year of the experiment was due to the number of cluster per vine in 2012 this happened because of the berry weight. However, in 2012 there is a better separation between treatments based on yield per vine compared to 2011 where no differences were observed among SD1, RDI1 and RDI 2 treatments. RDI 1 treatment had the lowest yield per vine. Since data vantages were not compared statistically we cannot conclude what factor had the biggest effect on treatment differentiation. However, since water flow meters were placed in 2012 at each treatment of one field replicate after the valve, we could have a better control on water applied for each individual treatment.

Another interesting observation was that SD2 treatment had also the highest pruning weight. However, no significant difference was observed among irrigation treatments based on Ravaz Index. According with this index all irrigation treatments were under-cropped. Values of this index were almost 30 % higher in Tempranillo grapes grown on shallow soils compared to these grown on deep soils. Interestingly, the pH was much higher in 2012 compared to 2011, however no effect on pH or TA among the irrigation treatments. However, anthocyanins, total phenols and YAN were affected by our irrigation treatments (table 9). It was not found any difference in terms of Brix among irrigation treatments from the site with deep soils, although fruit from 2012 vintage had slightly higher value.

Yield per vines from shallow soils was much lower compared to that from deep soils, and overall two times less than in 2011. If in 2011 SD1 had the higher yield, in 2012 RDI 2 had the highest crop per vine. An interesting observation is that the number of clusters were much higher in 2012 across the irrigated treatments compared to 2011, while the cluster weight about 2.5 times lower than in 2011. The total yield was diminished in 2012 with almost 50% compared to 2011. Moreover, there is a better separation of treatments based on yield per acre. Fruit from shallow soils had higher pH and Brix in 2012 compared to 2011. Significant variation was found among irrigation treatments for almost all chemical parameters.

Syrah responded at our deficit irrigation treatments in terms of yield components and chemistry. Vines from SD1 treatment responded similar as these from Tempranillo vines, they had the highest yield per vine from all irrigation treatments. Significant variation was observed among treatments for total yield per acre, however the magnitude was much lower compared with that found in Tempranillo trials. The highest pruning weights value was found in SD1 treatment. This indicates that this treatment had the biggest canopy which is explained by continuous and consistent irrigation applied over the entire growing season. Ravaz Index showed values almost similar like those from Tempranillo trials which indicate that plants were under cropped. In Syrah, pH, TA and glucose/fructose ratio did not respond to the irrigation strategies, however sugar, phenols and anthocyanins were affected by the irrigation strategies used (table 12)..

Table 8. Impact of different irrigation strategies on yield components of Tempranillo grown on deep soil (Ellis Vineyards, Rogue Valley 2011-2012).

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	Yield/acre kg	Pruning Wt (Kg)	Ravaz Index
	2011						
SD1	7.8±0.8b	26.9±0.6b	291±29.8b	**221±1.1a**	6286.8±132b	-	-
SD2	**9.4±1.2a**	**29.9±1.1a**	**315±34.7a**	206±16.6ab	**7576.4±68a**	-	-
RDI1	7.9±1b	26.4±2.4b	297±17.2b	194±14.3b	6367.4±111b	-	-
RDI2	7.9±0.6b	29.2±1.1ab	269±22c	212±3.7ab	6367.4±45b	-	-
	2012						
SD1	5.8±0.4b	**41.5±2.1a**	141.7±19b	210.7±9ab	4094.6±145b	2.5±0.1ab	2.5±0.1
SD2	**7.5±0.5a**	39.5±3.2ab	**191.5±14a**	**219.1±6a**	**6045±115a**	**2.8±0.2a**	2.7±0.1
RDI1	4.7±0.3c	33.9±2.6b	124.4±9c	201.9±4b	3788.9±98c	1.7±0.3b	2.5±0.1
RDI2	5.6±02b	36.5±1.9ab	148.4±19b	**219.3±7a**	4513.6±117b	1.9±0.1b	2.9±0.1

Table 9. Impact of different irrigation strategies on berry composition of Tempranillo grown on deep soil (Ellis Vineyards, Rogue Valley 2011-2012)

Treatment	pH	Brix	TA (g/L)	Anthoc. (mg/L)	Total Ph. (mg/L)	DGlucose /DFructose	Yan
2011							
SD1	**3.752±0.1a**	25.8±1	7.9±0.6ab	708±52	937±45c	0.98±0.01	195±6b
SD2	3.629±0.1b	26.0±1.6	**9.5±3.7a**	948±41ab	1245±61ab	**0.99±0.01**	168±9c
RDI1	3.682±0ab	26.1±0.3	7.4±0.8b	**1002±14a**	1175±26b	0.97±0.01	**238±7a**
RDI2	3.629±0.1b	25.8±0.2	7.2±0.5b	669±32	**1296±34a**	0.98±0.01	201±8b
2012							
SD1	3.884±0.01	26.0±0.4	6.9±0.3	1008±43b	1125±23b	0.99±0.01	**286±15a**
SD2	3.900±0.02	26.4±0.3	7.3±0.1	1248±29ab	**1365±31a**	0.99±0.01	196±19c
RDI1	3.908±0.01	26.3±0.4	7.0±0.6	**1562±33a**	1190±19b	0.98±0.01	185±11c
RDI2	3.875±0.01	26.1±0.2	7.3±0.2	869±41c	762±49c	0.98±0.02	245±9b

Table 10. Impact of different irrigation strategies on yield components of Tempranillo grown on shallow soil (Abacela Vineyards, Umpqua Valley 2011-2012)

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	Yield/acre kg	Pruning Wt (Kg)	Ravaz Index
	2011						
SD1	**9.0±0.2a**	**20.4±0.6a**	**432.4±21a**	268.0±21b	**4934.0±123a**	-	-
SD2	7.5±0.3b	19.3±0.5b	381.5±32b	271.3±14b	4047.6±95c	-	-
RDI1	8.0±0.1ab	19.8±0.9ab	411.6±19ab	280.6±15ab	4350.1±69b	-	-
RDI2	7.9±0.2ab	**20.4±1.0a**	387.4±14b	**288.9±19a**	4313.9±76b	-	-
	2012						
SD1	3.6±0.1ab	22.9±0.3b	155.9±11ab	231.1±15	1952.6±26b	1.3±0.1	3.0±0.2ab
SD2	3.4±0.2b	**24.2±0.2a**	141.3±9b	235.1±6	1847.0±32c	1.2±0.1	3.2±0.1ab
RDI1	**4.5±0.4a**	24.0±0.2ab	**184.8±7a**	233.1±11	**2431.5±41a**	1.3±0.2	**3.7±0.3a**
RDI2	3.3±0.8b	**24.2±0.4a**	141.2±14b	235.1±13	1809.5±33c	1.4±0.1	2.5±0.4b

Table 11. Impact of different irrigation strategies on berry composition of Tempranillo grown on shallow soil (Abacela Vineyards, Umpqua Valley 2011-2012)

Treatment	pH	Brix	TA (g/L)	Anthoc. (mg/L)	Total Ph. (mg/L)	DGlucose /DFructose	YAN
2011							
SD1	3.488±0.01a	19.2±0.3b	7.2±0.2	1032±26c	1123±0.01c	1.2±0.01	281±11a
SD2	3.252±0.01b	22±0.2a	7±0.3	945±32b	1113±0.01c	0.99±0.01	181±9ab
RDI1	3.262±0.01b	21.6±0.5ab	7.1±0.4	846±121a	1235±0.01b	0.96±0.01	194±7b
RDI2	3.432±0.01ab	21.4±0.1ab	7.1±0.5	967±32c	1327±0.01a	0.98±0.01	166±11c
2012							
SD1	3.765±0.01b	26±0.2b	6.7±0.2ab	986±b	1201±15a	0.99±0.01	215±11b
SD2	3.757±0.01b	25.7±0.3c	6.3±0.1b	890±c	1136±9b	0.97±0.01	186±6c
RDI1	3.928±0.01a	26.3±0.2a	6.9±0.1ab	1002±b	1009±12c	1.01±0.01	265±9a
RDI2	3.771±0.01b	25.3±0.1b	7.2±0.2a	11327±a	1090±8c	0.98±0.01	198±13c

Table 12. Impact of different irrigation strategies on yield components of Syrah grown on deep soil (Ellis Vineyards, Rogue Valley 2012)

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	Yield/acre (kg)	Pruning Wt (Kg)	Ravaz Index
2012							
SD1	5.2±0.1a	24.9±0.4a	197.4±12b	172.4±8ab	4241±39c	1.95±0.02a	2.69±0.1b
SD2	5.6±0.2a	24±0.2ab	221±21a	179±11a	4225±61c	1.48±0.01c	3.12±0.1a
RDI1	4.1±0.1b	22.3±0.3b	178±7c	163.5±4b	4416±42b	1.48±0.02c	2.79±0.1b
RDI2	4.75±0.3ab	24.3±0.4ab	216.5±16ab	165.5±7b	4530±56a	1.78±0.02b	2.66±0.1b

Table 13. Impact of different irrigation strategies on berry composition of Syrah grown on deep soil (Ellis Vineyards, Umpqua Valley 2011-2012)

Treatment	pH	Brix	TA (g/L)	Anthoc. (mg/L)	Total Ph. (mg/L)	DGlucose /DFructose	YAN (mg/L)
2012							
SD1	3.727±0.01	24.3±0.2ab	8.4±0.3	849±21b	1132±35c	0.98±0.02	237±12a
SD2	3.748±0.01	24.5±0.1a	8.1±0.4	913±35a	1345±26b	0.99±0.01	145±7c
RDI1	3.744±0.01	23.8±0.3b	8.3±0.2	649±29c	1462±42a	0.97±0.01	175±15b
RDI2	3.707±0.01	24.3±0.5ab	8.0±0.1	721±19c	1067±31c	0.98±0.03	201±11ab

Vine water status (Leaf water potential). Budbreak and vine development was earlier with almost one week in 2012 compared to 2011. Precipitation from June delayed initiation of irrigation at each site. Harvest of both varieties at all sites was close to the normal being 10 days earlier than previous seasons.

Measurements of vine leaf water potential were made with a pressure bomb on approximately a bi-weekly basis, beginning approximately two weeks after start of irrigation until middle of September. There were notable differences in vine response to irrigation between sites as well as irrigation treatments. Tempranillo reached moderate water stress at Abacela site earlier than in Ellis site (deep site).

Diurnal patterns all showed a steady decrease throughout the morning hours with a plateau starting at approximately solar noon. The vines measured at Site 1 showed ψpd and ψs-em values opposite of what might be expected, with lower values for vines receiving larger amounts of water. It can be concluded that variation in soil between the two spots or between vines had greater influences on water status than did irrigation treatments in this case. However data presented here indicates that ψs measured between 0700h and 0800h solar time (generally between 0815h and 0915h PDT) on cloudless days at both sites (Figure 1, C and D) showed clear differences between treatments despite different levels of %SUN. On days with cloudy mornings (Figure 1, A and B), ψs-em differences were less clear.

Linear correlation models comparing ψl and ψs measurement methods are presented in **Figures 2 and 3.** Data was pooled across all irrigation treatments and all sunny days. Values generally represent vines ranging from "no water deficit" to "moderate to weak" water deficit. In agreement with previous studies all methods showed statistically significant relationships with all other methods, though relationships between ψs-md and ψl-md were the strongest (r2 = 0.88 in the present study). However, when relating midday measurements to either ψpd (Figure 2, B and C) or ψs-em (Figure 3, B and C), correlations were always stronger for ψs-md compared to ψl-md. When data for relationships involving ψs-em was pooled separately by site, significant differences were seen between linear regression equations (Figure 3, B and C). For a given ψs-em, midday measurements tended to be lower at Site 2 compared to Site 1. In these cases relationships at Site 1 had higher r2 values compared to Site 2. However, this may have been due to the greater number of sunny days at Site 1 which resulted in a larger data set overall for this site.

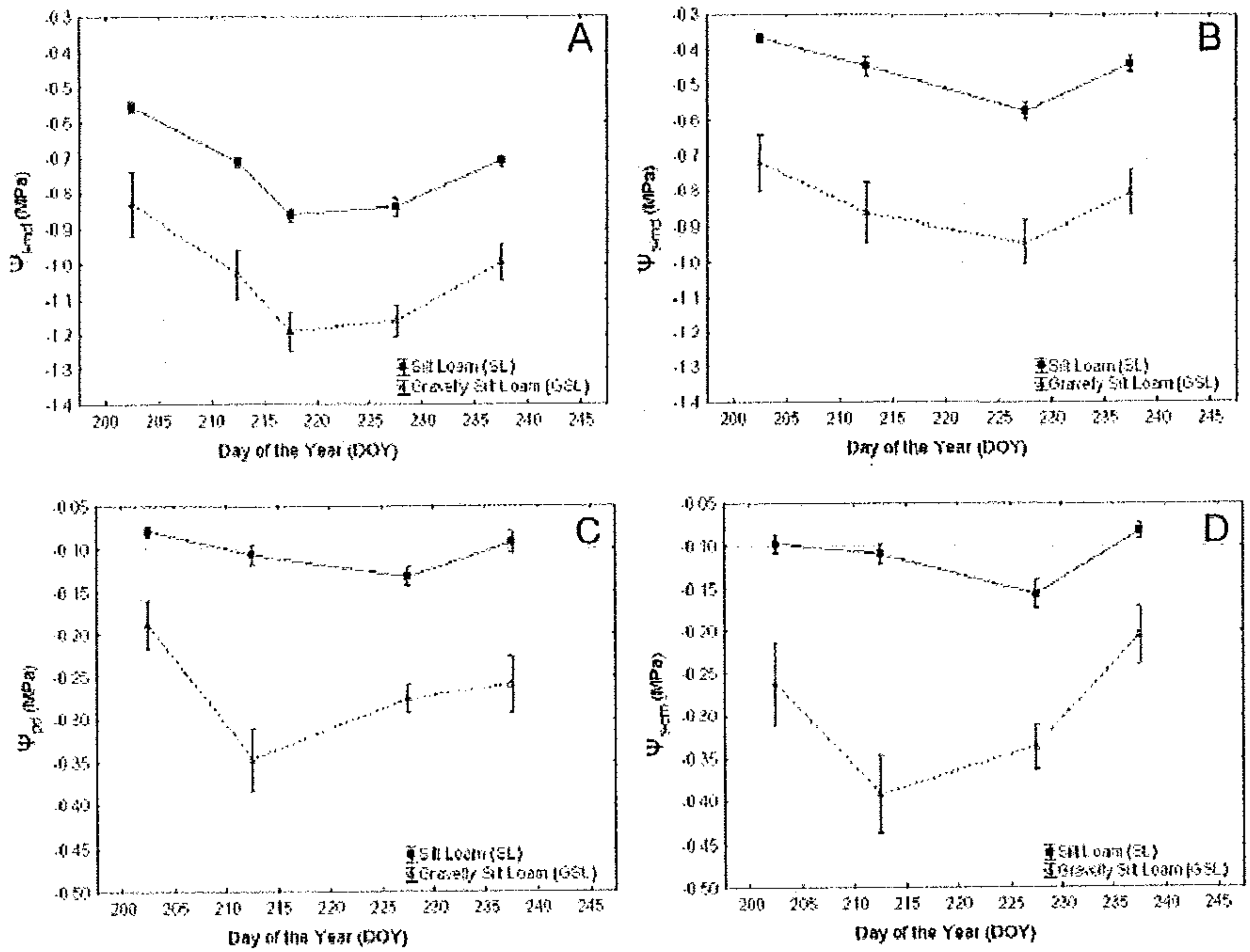

Figure 1. Patterns of diurnal stem water potential (ψs) on cloudy days before veraison (A) and after veraison (B) and on sunny days at Tempranillo site 1 (C deep soils) and site 2 (shallow soils). Vapor pressure deficit (VPD) measured every two hours is presented at the top of each graph.

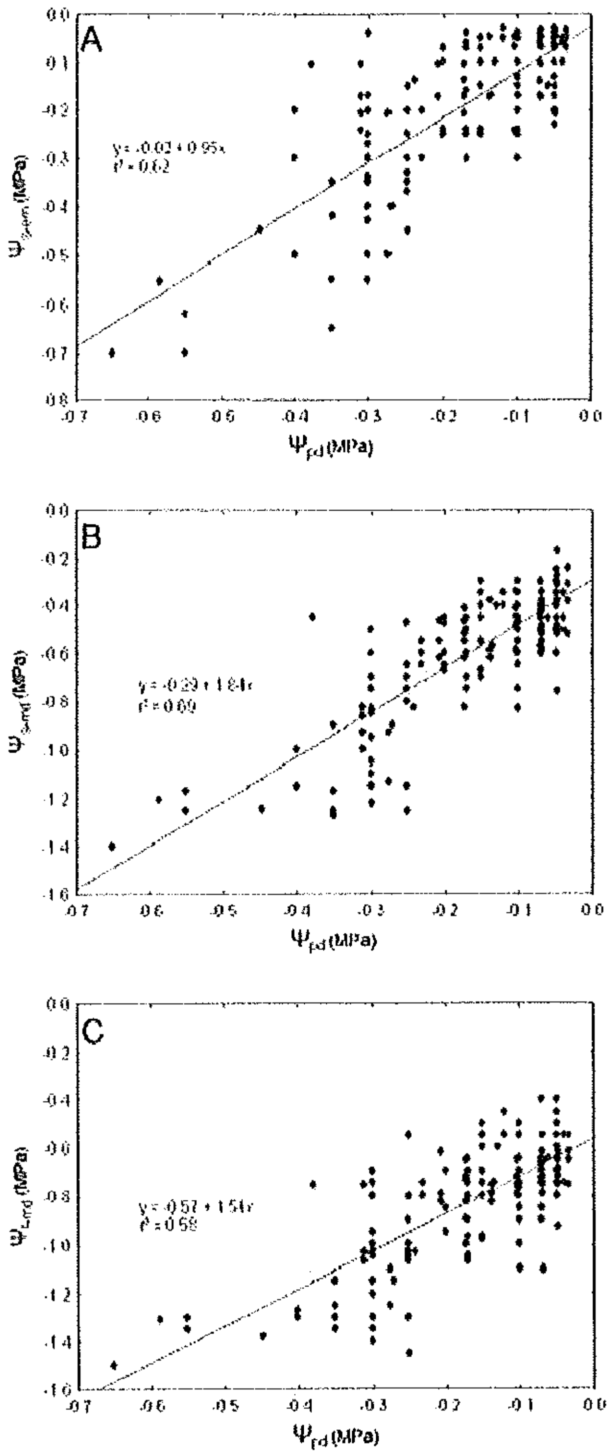

Figure 2 Relationships between (ψpd) predawn leaf water potential,and A) early morning stem water potential ($\psi_{s\text{-}em}$), B) midday stem water potential ($\psi_{s\text{-}md}$ C) midday water potential ($\psi_{l\text{-}md}$) for Tempranillo (site 1 deep soils)

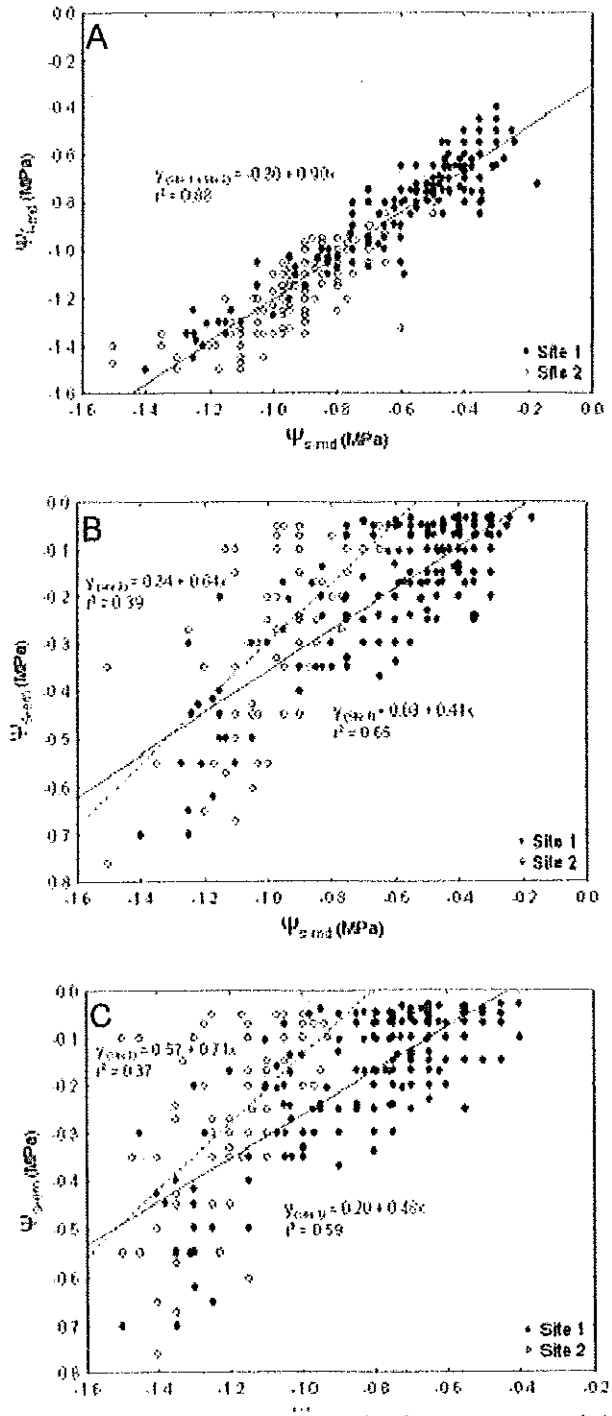

Figure 3. Relationships between (ψpd) predawn leaf water potential, midday stem water potential ($\psi_{s\text{-}md}$), midday water potential ($\psi_{l\text{-}md}$) and early morning stem water potential ($\psi_{s\text{-}em}$) for sunny days at both Tempranillo sites (site 1- deep soils; site 2- shallow soils)

Research Success Statements: The results were not consistent from year to year basically due to various weather pattern from year to year. Under Southern Oregon climate condition, Syrah seems to be responsive to irrigation even from first year of the experiment.

Grape industry from Southern Oregon indicated that trying to find more sustainable strategies to manage water in the vineyard along with validating and optimizing various cheap tools to assess water status might be the most important research project for the region. I am in agreement with many growers and winemakers from the region who feel that irrigation and crop load management are critical factors potentially influencing fruit and wine quality. This irrigation project is a very complex one since is trying to cover the great diversity of mesoclimates and general soil conditions. The preliminary results from this project showed that through a better understanding the interactive effects of weather, soil, and irrigation the Southern Oregon grape and wine industry could improve consistently the grape and wine quality. Part of 2012 data will be presented at Rogue valley Grape Day

Funds Status: Funds provided for 2012 season to support this project were allocated for both components of the project: field work in the vineyard and fruit analysis. Travel is one of the biggest expenses of this research project. One way travel distances between are as great as 95 miles and the research team is at each site on a bi-weekly basis. Moreover, some equipment required by this type of investigations are still missing, and as a consequence part of any future funds for this irrigation trials will be used for purchasing field equipment and instruments needed to collect data more accurately. A student intern and a temporary part-time technician, who provided assistance in the vineyard and laboratory, were supported partially with money from this grant. Even if the infrastructure created at SOREC, partially help the PI to get a better control on time frame and accuracy of berry data acquisition more field equipment is required.