PROGRESS REPORT – 2011 PROJECT PERIOD

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Project Title (#2011-853): Deficit Irrigation of Cabernet Sauvignon and Tempranillo: Impacts on vine growth, yield, and berry composition

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Cooperators: The owners and managers of the below listed businesses are site cooperators who have contributed part of their crop and provided operational support which was critical to this project.

Alex Cabrera/Earl Jones	Chris Martin/Brian Gruber	Richard Ellis
Abacela Winery UmpquaValley	Troon Winery Applegate Valley	Ellis Vineyard Rogue Valley

Summary: Due to various reasons the previous investigator decided to pull out the crop level trials from the original experiment designed in 2010 season. However, the irrigation field experiments implemented in the 2010 season continued in 2011, in order to find out the impact of varied deficit irrigation regimes on vine development and fruit composition in Tempranillo and Cabernet Sauvignon cultivars.

Since the number of vines from the crop load trials were not flagged distinctively it is possible that some variation in the yield components between vines across the same treatments in 2011 data, to be a carryover effect of the crop load from the previous season.

The weather pattern in 2011 season was almost similar with that from the previous season. Initiation of irrigation was delayed due to the cool and wet soil conditions. Each cooperator of the project initiated their irrigation trials based on the site specific weekly ETo and

canopy size, and they maintained the following irrigation treatments: (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.

Fruit analyses for the first year of the experiment (2010) were performed in cooperation and support of students, technical, and faculty partners at the Department of Chemistry at Southern Oregon University. Due to various reasons like lack of communication with previous partners from SOU and poor control of the time acquisition and quality of data, I have decided that all the analyses to be performed at the Viticulture Laboratory from SOREC, beginning with 2011. With support from Oregon Wine Research Institute and College of Agriculture Sciences from Oregon State University, a full operational Viticulture Lab was created at SOREC by the end of 2011. Since all the protocols will be the same, not significant variation is expected due to different equipments used in the berry analyses. Due to delays generated by laboratory renovation, the berry analyses started at beginning of January 2012. Moreover, in order to validate the potential outcomes from this research, berry samples (100 berries) were collected from each individual experimental vine. The 600 berry samples are stored in a freezer at -10 ^{o}F until they will be analyzed. All samples are expected to be analyzed for all parameters mentioned in the initial proposal by the end of April 2012. However, the preliminary data is added in this report.

The field data (leaf water potential) included in the present report was collected till August 31 by Dr. Marcus Buchanan and his employee Chris Hubert, and by Dr. Gabriel Balint thereafter.

Yield data for vintage of 2011 was collected from all three experimental sites by Dr. Gabriel Balint and his crew as follow: Tempranillo - Abacela Vineyards (Umpqua Valley; October 22-23rd 2011), Tempranillo - Ellis Vineyards (Rogue Valley, October 25-26th, 2011), Cabernet Sauvignon – Ellis Vineyards (Rogue Valley, November 2-3, 2012), Cabernet Sauvignon – Troon Vineyards (Applegate Valley, November 8-9th, 2011)

According with weather data history, and based on the discussions with all the cooperators of the project, it seems that 2011 was the third year in row which was characterized by atypical weather conditions for Southern Oregon Region. As it was emphasized in the previous reports, this could have a strong influence on the development and degree of water stress imposed in all treatments. The irrigation treatments applied in 2011, indicated to have a significant effect on yield components (yield/vine, number of clusters per vine, cluster and berry weight), berry chemistry (Brix^o, pH, TA) and plant nutritional status at veraison.

The reference evapotranspiration data from 2010 (Fig.1) and 2011 (Fig.2) indicates overall a similar pattern. The highest ET values are found in both years around middle of July. However, an important observation was that in 2010 (Fig. 1) the magnitude of variation between ET values was higher at beginning (May) and the ending of the season (September) while in 2011 (Fig. 2) we had the highest variability at beginning and middle of the season (May to July 15th). This pattern of ET which is directly correlated with the daily temperature and solar radiation had a significant effect on vine development. However, the phenological data is not included in this report. In both years (2010-2011) the soil moisture profile (data not shown) in all sites indicated a good water reserves at the beginning of the season.

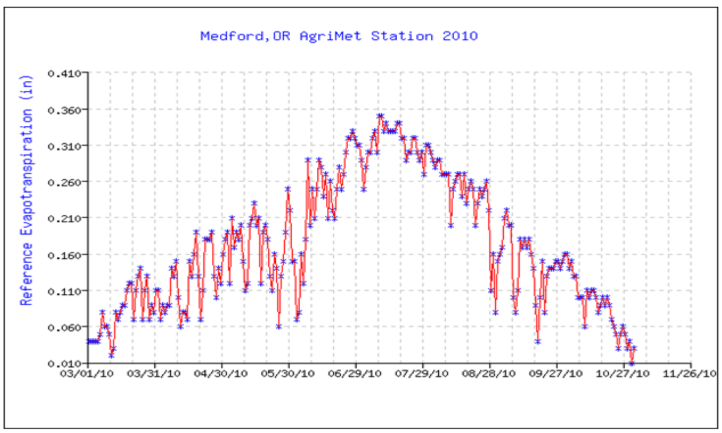

Figure 1. Reference evapotranspiration from March 1 to October 30th, 2010 (Agrimet Station, Medford, OR)

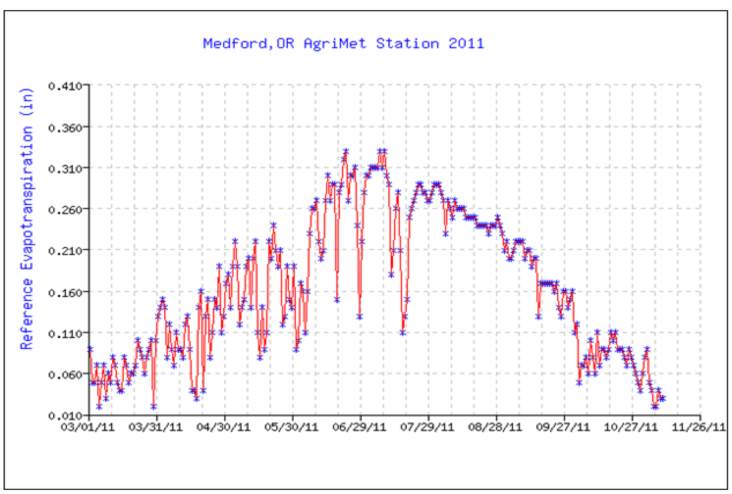

Figure 2. Reference evapotranspiration from March 1 to October 30th, 2010 (Agrimet Station, Medford, OR)

Data presented in Figs. 3 and 4 show that even in these atypical weather conditions an important water deficit built up under Southern Oregon region conditions in each of the experimental year. Data clearly indicates the importance of using irrigation in Southern Oregon vineyards. The pattern of the water deficit (difference between water lost through evapotranspiration and input from precipitation amount) confirms that all the cooperators initiated their irrigation trials earlier in 2010 than in 2011.

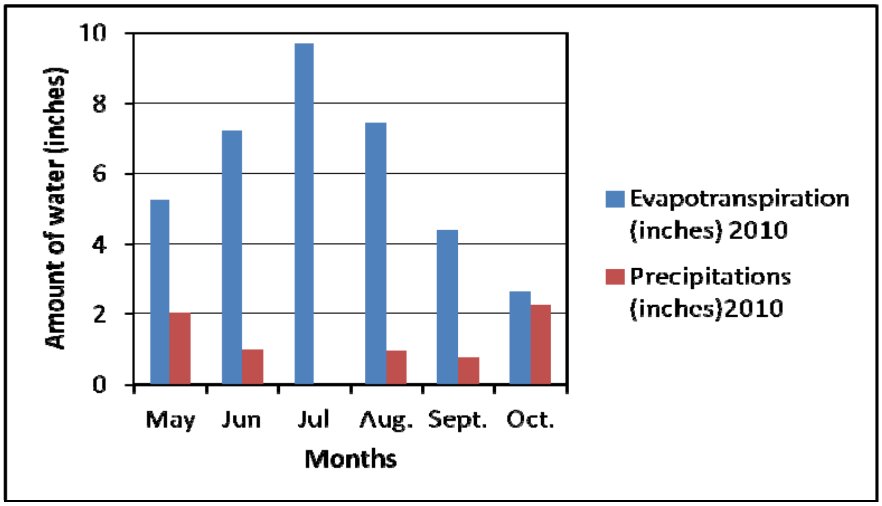

Figure 3. Monthly evaporation and precipitation data, during the growing season – 2010 (Agrimet Station, Medford, OR)

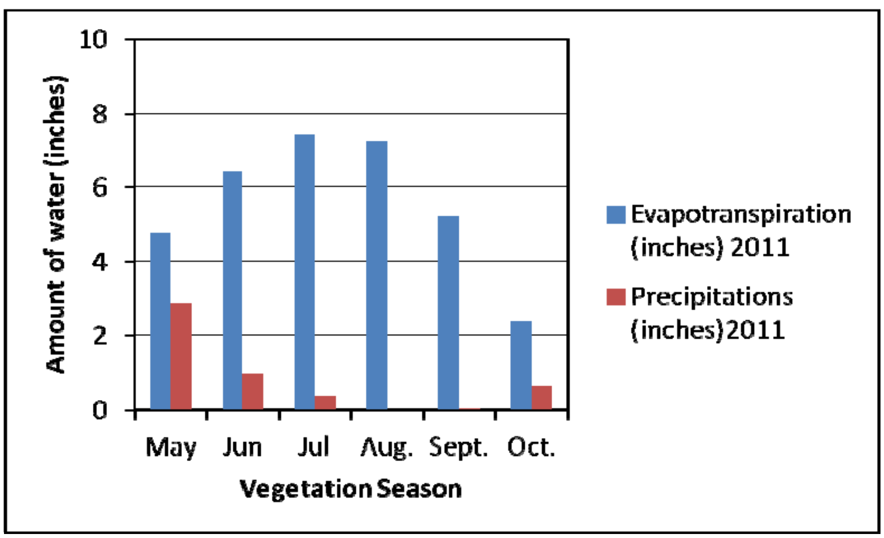

Figure 4. Monthly evaporation and precipitation data, during the growing season – 2011 (Agrimet Station, Medford, OR)

Vine Nutrients Status.

In 2011, leaf samples were collected at veraison for nutritional analysis. One mid-shoot leaf was sampled from each experimental vine, and a total of ten leaves per each treatment replicate were collected. They were analyzed at A&T Western Laboratories (Portland, OR). The petiole was separated from the leaf blade after very gentle washing. Only the leaf blade was submitted to a certified commercial laboratory for analysis. Total N was measured on a LICO CN analyzer and following acid digestion all macro- and micronutrients were determined with ICP-AES.

Irrigation had a significant effect on many vine nutrients, although Tempranillo and Cabernet responded differently. The nutrients data from 2011 was not compared statistically with data from 2010 because I was able to retrieve data from 2011 only from SD treatments. Data presented in table 1 indicate significant variation not only among the irrigation treatments but also from vintage to vintage. In 2011, the highest amount of nitrogen was found in SD1 treatments, much more than in the similar treatment from 2010. The pattern was quite different for nitrogen content from one site to the other. Moreover, Cabernet Sauvignon cultivar grown in shallow soil had much less nitrogen compared to the deep soils. No significant variation was found among treatments for P, Na and S. However, the leaves from the deep site had significant higher values compared to these from the shallow sites. The irrigation treatments had a significant impact on potassium content only on deep soil but not on shallow soils (Table 1). However, a surprising observation was that the amount of potassium in leaves was two to three times higher in 2011 compare to the similar treatments from 2011. This indicates that the vintage has a big impact on the plant nutritional status, and other factors besides soil moisture could affect the potassium uptake into the plant. Magnesium has the same pattern as potassium at both sites and vintages; however the amount found is less than potassium. Calcium was affected by irrigation treatments at both sites, but no significant variation was observed between the sites. Calcium had the same pattern like the others nutrients being found in higher amounts in 2011 compare to 2010.

The micronutrients were also affected by the irrigation treatments. The magnitude of variation was higher for iron in the shallow soil treatments compared to those from the deep soil (Table 2). However, the amount of Fe was higher in leaves from the deep soil and much higher in 2011 compared to 2010 season. Boron and Zinc were also affected by the irrigation treatments. Their pattern was opposite at two sites: boron was higher at Ellis site and lower at Troon while Zinc had and opposite pattern.

Table 1. Impact of irrigation strategy on nutrients status (primary and secondary minerals) in grapevine leaves of Cabernet Sauvignon at veraison, grown on two types of soils (2010-2011)

Treatment	N(%)	S(%)	P(%)	K(%)	Mg(%)	Ca(%)	Na(%)
Ellis (deep soil)							
2010							
SD1	2.19 B	0.23 A	0.12 B	0.490 A	0.18 B	1.17 B	21.6 B
SD2	2.45 A	0.19 B	0.17 A	0.39 B	0.21 A	1.38 A	24.0 A
2011							
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
Troon (shallow soil)							
2010							
SD1	2.30 A	0.20 A	0.16 A	0.34 A	0.40 A	1.46 A	47.0 A
SD2	2.13 B	0.18 B	0.13 B	0.26 B	0.35 B	1.35 B	39.6 B
2011							
SD1	2.12ab	0.19	0.17	0.65	0.69	**2.95a**	0.01
SD2	2.04b	0.20	0.16	0.61	0.69	2.86ab	0.01
RDI1	2.01b	0.20	0.17	0.58	0.75	2.87ab	0.01
RDI2	2.24a	0.20	0.15	0.60	0.69	**2.68b**	0.01

Table 2. Impact of irrigation strategy on nutrients status (micronutrients) in grapevine leaves of Cabernet Sauvignon at veraison, grown on two types of soils (2010-2011)

Treatment	Fe (ppm)	Al(ppm)	Mn(ppm)	B(ppm)	Cu(ppm)	Zn(ppm)
Ellis (deep soil)						
2010						
SD1	124.9 A	-	81.9 A	29.6 A	4.8 A	11.4 A
SD2	120.9 A	-	76.1 A	31.2 A	4.3 B	12.0 A
2011						
SD1	220.0a	102.6ab	86.6a	**46.0b**	8.0	**19.0a**
SD2	217.7b	**96.6b**	84.0ab	50.0ab	7.6	16.6ab
RDI1	**202.7c**	108.6a	80.0b	**58.0a**	7.3	**11.6b**
RDI2	213.4b	102.6ab	83.5ab	51.3ab	7.6	15.7ab
Troon (shallow soil)						
2010						
SD1	121.8 B	-	84.6 A	19.4 A	7.6 A	32.2 A
SD2	135.7 A	-	79.6 B	17.5 B	6.6 B	30.6 B
2011						
SD1	172.6ab	71.6b	**101.3a**	24.6	10.6	35.6ab
SD2	**168.6ab**	79.6ab	84.3ab	22.6	11.0	39.0a
RDI1	201.6a	84.6a	84.3ab	21.3	11.6	32.3b
RDI2	**162.0b**	70.0b	**78.3b**	21.6	12.3	36.6ab

The nutrients status in Tempranillo trials followed almost the same patterns like in Cabernet Sauvignon ones (Tables 3 and 4)

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 (2010-2011)

Treatment	N(%)	S(%)	P(%)	K(%)	Mg(%)	Ca(%)	Na(%)
			Deep soils (Ellis)				
2010							
SD-1	2.26 B	0.24 a	0.13 B	0.44 B	0.14 B	1.00 B	31.5 A
SD-2	2.38 A	0.23 B	0.16A	0.78 A	0.28 A	2.11 A	41.7 B
2011							
SD-1	2.48a	0.18	0.21	1.49b	0.23	2.11b	0.01
SD-2	2.22b	0.17	0.18	1.52b	0.25	2.21ab	0.01
RDI1	2.09c	0.14	0.19	1.84a	0.24	2.20ab	0.01
RDI2	2.34ab	0.15	0.19	1.81ab	0.25	2.29a	0.01
			Shallow Soils (Abacela)				
2010							
SD-1	1.60 B	0.13 B	0.12 A	0.21 B	0.39 A	0.83 A	116.4 A
SD-2	1.87 A	0.14 A	0.12 A	0.27 A	0.33 B	0.75 B	101.8 B
2011							
SD1	1.83a	0.14	0.12	0.84a	0.62b	1.81	0.01
SD2	1.70b	0.14	0.13	0.73b	0.72a	1.81	0.01
RDI1	1.85ab	0.13	0.12	0.68b	0.64b	1.76	0.01
RDI2	1.70b	0.15	0.12	0.74b	0.64b	1.77	0.01

Table 4. Impact of irrigation strategy on nutrients status (micronutrients) in grapevine leaves of Cabernet Sauvignon at veraison, grown on two types of soils (2010-2011)

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	178.00ab	61.67c	71.00b	41.33b	8.67	23.6a
SD2	159.67b	88.33b	77.67a	33.67c	6.67	18.0c
RDI1	160.67b	105.33ab	75.67a	46.67ab	6.33	20.3b
RDI2	181.33a	130.33a	76.66a	58.00a	7.33	21.0b
			Shallow Soils (Abacela)			
2010						
SD1	131.4 A	-	134.8 A	26.9 A	13.5 B	53.8 B
SD2	114.1 B		124.6 B	27.3 A	17.4 A	65.0 A
2011						
SD1	121.00b	41.67	129.67b	19.00	7.67	38.33b
SD2	119.33b	45.33	145.67a	21.33	8.00	38.67b
RDI1	117.00b	40.00	115.67c	21.33	8.33	45.33ab
RDI2	136.33a	43.00	129.00b	21.67	7.33	48.33a

Yield Components and berry composition: As expected vine yields varied between sites (Table 5 and 6). The yield was not significantly different among the irrigation treatments in Cabernet sauvignon block from the deep sites. This might indicate a better buffer affect on the vine compared to the swallow sites. Moreover, we should not neglect the application strategy applied. Due to the fact that the deep soil had a good drainage capacity the cooperator applied the water amount needed it for each treatment in short cycles. No significant variation was observed among the irrigation treatments with respect to yield and berry weight. However, variation was observed in terms of the number of clusters per vine and cluster weight, perhaps due to different number of berries per cluster. The lowest Brix was recorded in RDI2, while the lowest pH was found in SD2 treatment. TA was pretty consistent among the treatments, the highest value was found in RDI1. Contrary to the expectations the yield in all irrigation treatments from the shallow site was much higher compared to the deep site (Table 5). This is mainly due to the higher number of clusters per vine, almost double compared to Ellis site. However the cluster and berry weights were much lower compare to these from the deep site. This might be explained that the shallow site had overall a lower canopy density in the previous year which allowed a better exposure of the basal buds to the solar radiation and a better differentiation of the primordia. In the Cabernet block from the shallow site, Brix and TS were not significantly affected by the irrigation treatments; however the ph showed significant variation among the treatments. The highest pH was found in SD2 treatment while the lowest was found in RDI1 treatment (Table 6).

Table 5. Impact of different irrigation strategies on yield components and berry composition of Cabernet Sauvignon grown on deep soil (Ellis Vineyards, Rogue Valley 2011)

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	pH	Brix	TA (g/L tartaric acid)
SD1	5.8±0.6	26.2±1.8a	214.6±16.9b	137±8	3.600±0.1ab	23.4±0.3a	9.0±0.3b
SD2	5.2±0.7	26.0±3.3ab	214.7±3.1b	139±3.2	3.500±0.1b	23.4±0.1a	9.1±0.2b
RDI1	5.6±0.6	24.3±1.2b	229.0±31a	141±4.6	3.624±0.1ab	23.3±0.3a	10.2±0.5a
RDI2	5.7±0.1	25.9±0.3ab	219.6±4.1ab	136±1.8	3.634±0.03a	22.4±0.8b	9.5±0.1b

Table 6. Impact of different irrigation strategies on yield components and berry composition of Cabernet Sauvignon grown on shallow soil (Troon Vineyards, Applegate Valley 2011)

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	pH	Brix	TA (g/L tartaric acid)
SD1	9.8±1.2	57.4±6.6b	**174±25.3a**	117±5.9	3.400±0ab	21.9±0.8	8.7±0.5
SD2	9.7±1.9	59.2±8.6b	167±13.5ab	112±2.9	**3.600±0.2a**	22.3±0.7	8.4±0.5
RDI1	9.8±2.5	**82.1±42.1a**	167±38.8ab	117±7.7	3.344±0.1b	21.7±0.9	8.3±0.8
RDI2	10±0.9	66±16b	162±21.4b	117±7.3	3.432±0.2ab	22.5±0.3	8.6±0.7

Tempranillo indicated to be more sensitive at water status variation. The magnitude of variation was highest in deep soils. Overall, the shallow soils seem to have slightly lower yield compared to the deep sites. However, the trends are not quite similar. The highest yield was found in SD2 treatment from the deep site while in the shallow site was found in SD1 treatment. The yield components were affected by the irrigation strategy at both sites. Data shows that the yield was affected by the irrigation treatments mainly because of the number of clusters, which overall was higher in the treatments from the deep soil compared to those from the shallow site (Tables 7 and 8). The clusters were much heavier in the shallow sites compared to the deep one.

Table 7. Impact of different irrigation strategies on yield components and berry composition of Tempranillo grown on deep soil (Ellis Vineyards, Rogue Valley 2011)

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)	Berry weight (100 berries)	pH	Brix	TA (g/L tartaric acid)
SD1	7.8±0.8b	26.9±0.6b	291±29.8b	**221±1.1a**	**3.752±0.1a**	25.8±1	7.9±0.6ab
SD2	**9.4±1.2a**	**29.9±1.1a**	**315±34.7a**	206±16.6ab	3.629±0.1b	26.0±1.6	**9.5±3.7a**
RDI1	7.9±1b	26.4±2.4b	297±17.2b	194±14.3b	3.682±0ab	26.1±0.3	7.4±0.8b
RDI2	7.9±0.6b	29.2±1.1ab	269±22c	212±3.7ab	3.629±0.1b	25.8±0.2	7.2±0.5b

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

Treatment	Yield (Kg/vine)	No. Clusters/vine	Cluster weight (g)
SDI1	**8.6±1.2a**	**20.7±1.3a**	**426±12.1a**
SD2	7.5±2.3b	19.3±4.3b	382±34b
RDI1	8.0±0.8ab	19.8±0.4b	411±38.4ab
RDI2	8.1±1.8ab	**20.7±2.7a**	399±17b

Analyses of Tempranillo berries from the shallow site are in progress, and data will be available by the end of March. All others analyses of the grape berries previously conducted at SOU will be done at the Viticulture Lab of SOREC by the end of April.

Vine water status (Leaf water potential). Budbreak and vine development was late and slow, while soil moisture content remained higher than normal. Thus initiation of irrigation at each site was delayed. Harvest of both varieties at all sites was 2 to 3 weeks later than normal, with Tempranillo being harvested at the end of October and Cabernet not harvest until the first week of November.

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). All irrigation treatments follow the same trend at Abacela site. Leaf water potential decreased significantly by the end of the season reaching values about – 1.5 MPa. RDI 1 had consistently lower values compared to the other irrigation treatments (Figure 5).

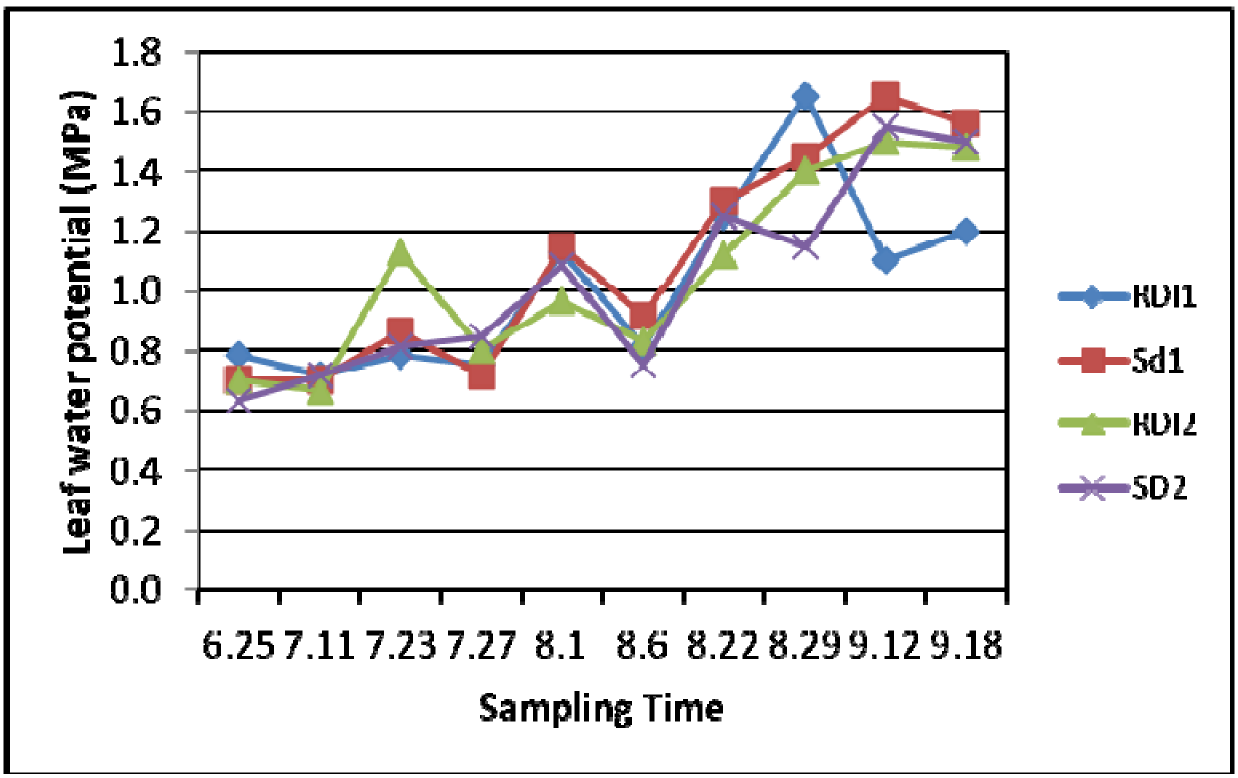

Figure 5. Impact of different irrigation strategies on leaf water potential during the vegetation season in Tempranillo block – Abacela Vineyard (Umpqua Valley)

Contrary to our expectation, Tempranillo had lower LWP values across the entire 2011 season compared to the shallow site (Figure 6) which could indicate a better buffer capacity of the deep soil. LWP data shows little variation among the irrigation treatments in 2011. All the treatments followed the same pattern.

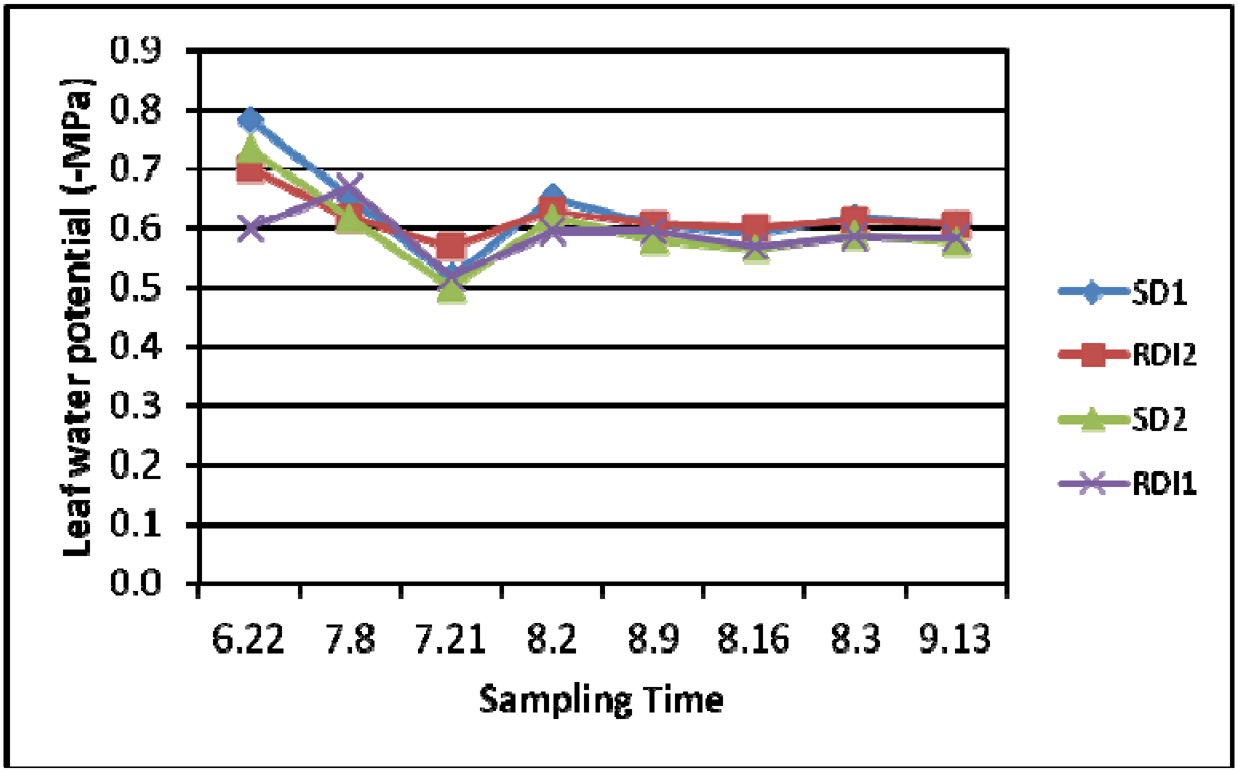

Figure 6. Impact of different irrigation strategies on leaf water potential during the vegetation season in Tempranillo block – Ellis Vineyard (Rogues Valley)

Cabernet Sauvignon had the same trend as Tempranillo in shallow soils (Figure 7). However, the values were higher compared to Tempranillo. LWP reached the lowest value on the last sampling date, which indicates that the water stress build up consistently no matter of the irrigation strategy applied (Figure 7).

In the shallow soils, Cabernet Sauvignon followed approximately the same trend as Tempranillo. However, Cabernet Sauvignon showed more water stress over the entire season (Figure 8). Data indicated a clear separation among the irrigation treatments, which could suggest that the grape varieties react differently at water stress according with the type of soil where they are grown. Also, various irrigation strategies must be used differently according with the stage of development and cultivar.

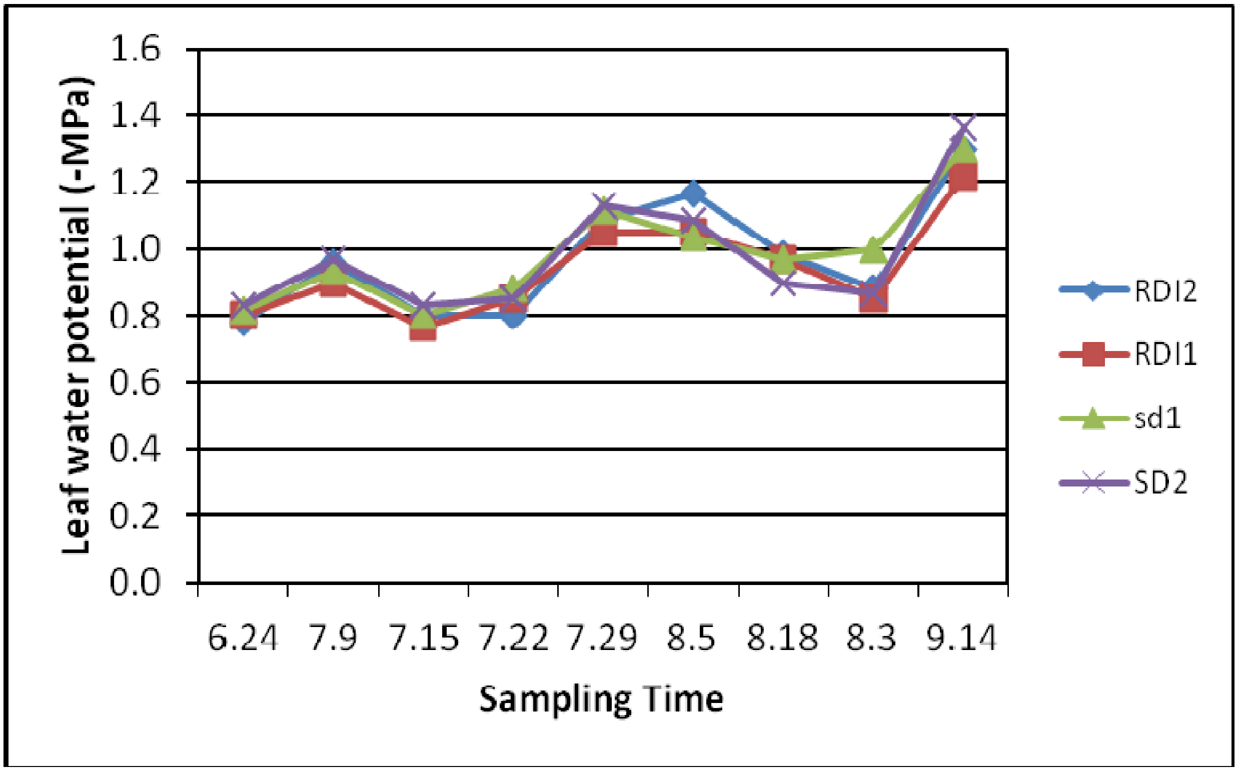

Figure 7. Impact of different irrigation strategies on leaf water potential during the vegetation season in Cabernet Sauvignon block – Troon Vineyard (Applegate Valley) 2011.

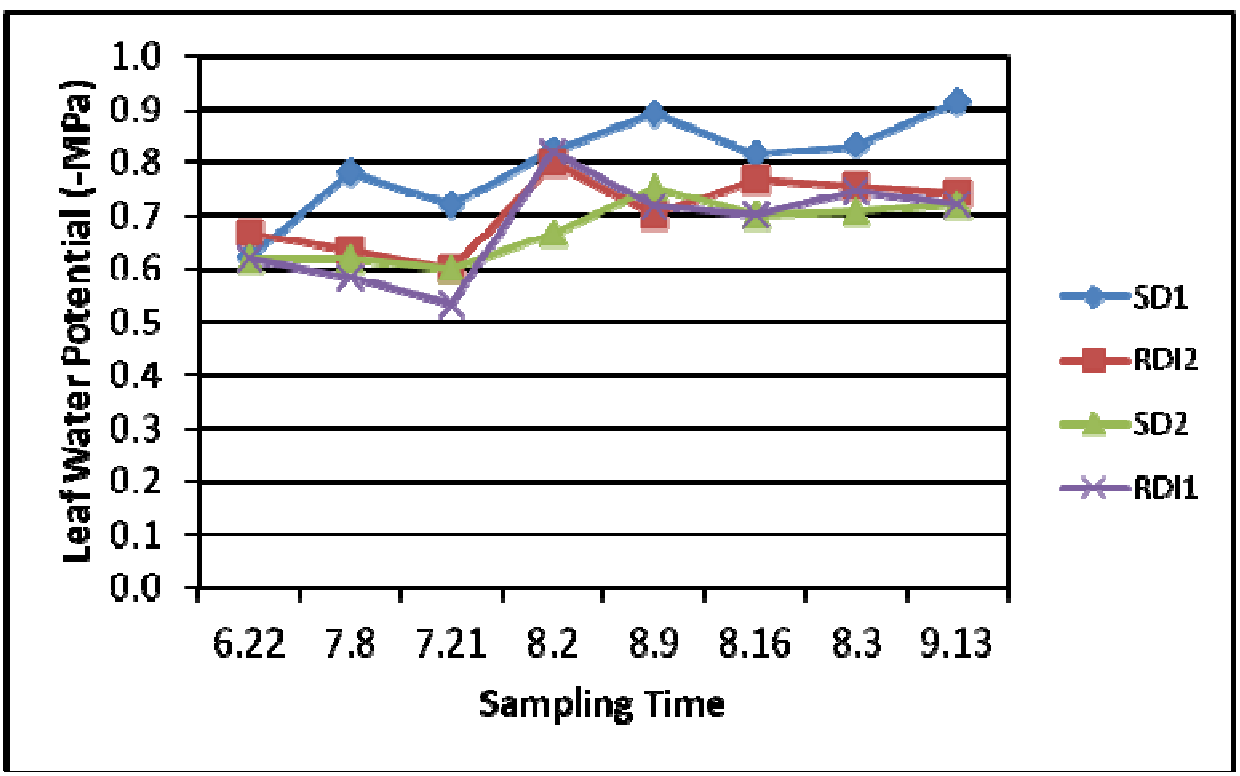

Figure 8. Impact of different irrigation strategies on leaf water potential during the vegetation season in Cabernet Sauvignon block – Ellis Vineyard (Rogue Valley) 2011

Research Success Statements: This project concept was been conceived by interested growers and winery owners in the Southern Oregon region. The results were not consistent from year to year basically due to various weather pattern from year to year.

Moreover, under Southern Oregon climate condition using Cabernet Sauvignon a late grape variety was not one of the best choices in this project. As consequences, in order to get some valid data and consistent trends, I and the research Committee from Rogue Valley decided to replace Cabernet Sauvignon with Syrah in the new irrigation trials. Even if the experimental design decisions and variety targets were largely made by an industry committee process, I believe that the previous PI could have a great impact on the accuracy of data and the outcomes from this project.

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.

Funds Status: Funds provided for 2011 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 missing, as a consequence part of any future funds for this irrigation trials will be used for purchasing field equipments and instruments needed to collect data more accurately. A student intern and part-time technician are supported and have provided assistance in the vineyard and laboratory. Due to the infrastructure created at SOREC, the PI will get a better control on time frame and accuracy of berry data acquisition.