Project Title:

Deficit Irrigation Management Strategies and the Influence of Extended Maturation on Vine Health, Fruit Yield and Quality: Syrah in Region IV.

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OBJECTIVES*:*

The objective of this study is to determine the effects of irrigation management and extended maturation strategies on Syrah in Region IV. Vines, must, and wine were measured/tested to quantify the effects and any interactions.

TRIAL SITE:

A Syrah vineyard located near Galt in Sacramento County serves as the project site. The vineyard was planted in 1998 using FPMS clone 6 on SO4 rootstock. Vine and row spacing is 5 and 11 feet, respectively, resulting in 792 vines per acre. The irrigation system was designed and installed to facilitate independent water delivery to 32 plots. A plot consists of twenty vines in each of three adjacent vine rows. Data were taken from the 16 central vines located in the center row. Vines are trained to Livingston Divided Canopy (LDC) and are shoot-positioned. The site has a moderate water-holding capacity, increasing in “stoniness” with depth. The well water supply is of good quality delivered via a drip irrigation system. The experimental design is a randomized complete block, split-plot design with eight replications of each of three irrigation strategy treatments. Standard cultural practices were utilized throughout the season provided by the cooperating grower. The total experimental area is about 2.4 acres. All treatments were pruned to 14 two-bud spurs averaging 5.6 primary buds per foot of row. Hail occurred after bloom causing fruit removal as well as shoot tip damage. No cluster removal or shoot removal was performed in light of the hail-reduced crop. Crowns were suckered to remove non-productive shoots.

TREATMENTS:

Irrigation Strategy Treatments:

Irrigation strategies chosen include full potential water use (I-1) and 2 deficit approaches. Both the deficit approaches relied on a level of water stress [-14 bars midday leaf water potential (MDLWP)] to occur prior to the initiation of irrigation. After the leaf water potential was reached irrigation was based on (1) land surface shaded at noon to determine a crop coefficient (Kc), (2) the ETo using the Lodi CIMIS station #166, and (3) a 50% regulated deficit level. The relationship between land surface shaded at midday and Kc was developed by Larry Williams at the Kearney Ag Center using grapevine in a weighing lysimeter. Essentially, shaded area × 1.7 × ETo x RDI % = irrigation volume applied. Treatment I-3 received 50% on a weekly irrigation schedule until harvest of all maturity treatments. Treatment I-2 was irrigated like I-3 until 22 Brix was reached on August 19. At that time, the irrigation volume was increased to 100% based on the canopy size. The irrigation treatments were irrigated at the same level for the 2003 season.

Fruit Maturation Treatments:

Maturity treatment targets were 24, 26, and 28 Brix. Harvest date was determined by sampling berry Brix of each treatment. When the berry samples indicated the Brix treatment level was near, harvest was scheduled for the next day. Harvest began with the treatments I-2, 24 Brix treatments on August 29 and was completed on October 25 with the irrigation treatments I-2, 28 Brix treatments (Table 1).

Table 1. Treatments and Harvest Dates

Irrigation Treatment Number	Brix Strategy	Leaf Water Potential Trigger at Which Irrigation Will Occur	Harvest Date
I-1	24	no trigger/ supply full water	Aug 31
I-1	26	no trigger/ supply full water	Oct 3
I-1	28	no trigger/ supply full water	Oct 5
I-2	24	-14 bars/ 50%-100%	Aug 29
I-2	26	-14 bars/ 50%-100%	Sept 30
I-2	28	-14 bars/ 50%-100%	Oct 25
I-3	24	-14 bars/ 50%	Aug 31
I-3	26	-14 bars/ 50%	Sept 30
I-3	28	-14 bars/ 50%	Oct 14

RESULTS

Water Use:

An evaluation of available stored moisture was made at bud break finding a full moisture profile. Subsequent rainfall continued to replenish the profile at or near the calculated vine water use until May. An irrigation controller and electric solenoids were used to control irrigations. A drip irrigation system with 2 emitters per vine was installed in the experimental area with the application rate of 0.47 gallons per hour per vine at 15-psi operational pressure. All emitters in each plot were tested for emission uniformity with plots averaging 93%. The consumptive use of each plot was measured as a sum of consumed soil moisture volume, applied water volume, and effective in-season rainfall. Soil moisture extraction was measured using a neutron probe to a soil depth of 105 inches. Soil samples were collected from the wells and volumetric water content measured along with the neutron probe count ratio. A calibration was developed between soil volumetric water content and count ratio at the site (Figure 1). In-season rainfall was measured on site. Irrigation volumes were measured using calibrated water meters. Table 2 shows the water consumption components at both harvest and as a seasonal total. The water volumes consumed by the deficit treatments I-2 and I-3 compared to irrigation treatment I-1 was 60% and 47% respectively. Applied water when compared to the full potential treatment (I-1) was 38% for irrigation treatment I-2 and 27% for the irrigation treatment I-3. Essentially, the increase in applied water between the deficit treatments was 2.5 inches applied to treatment I-2 from 22 Brix to harvest.

Figure 1.

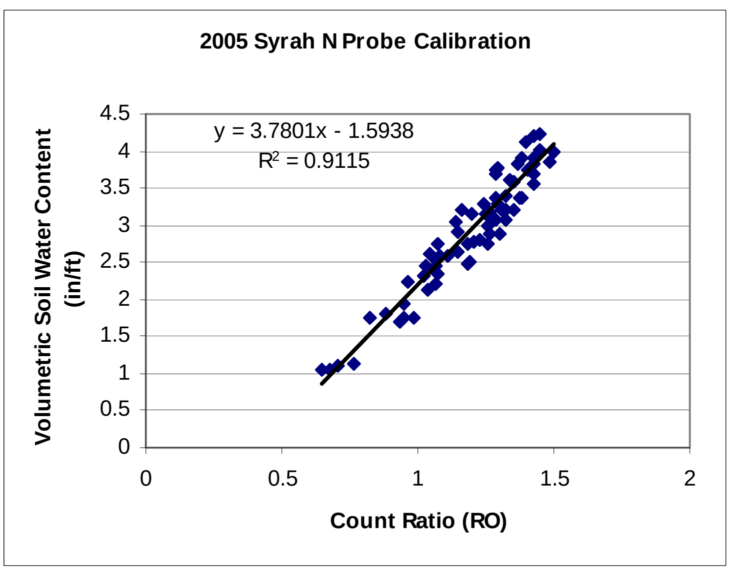
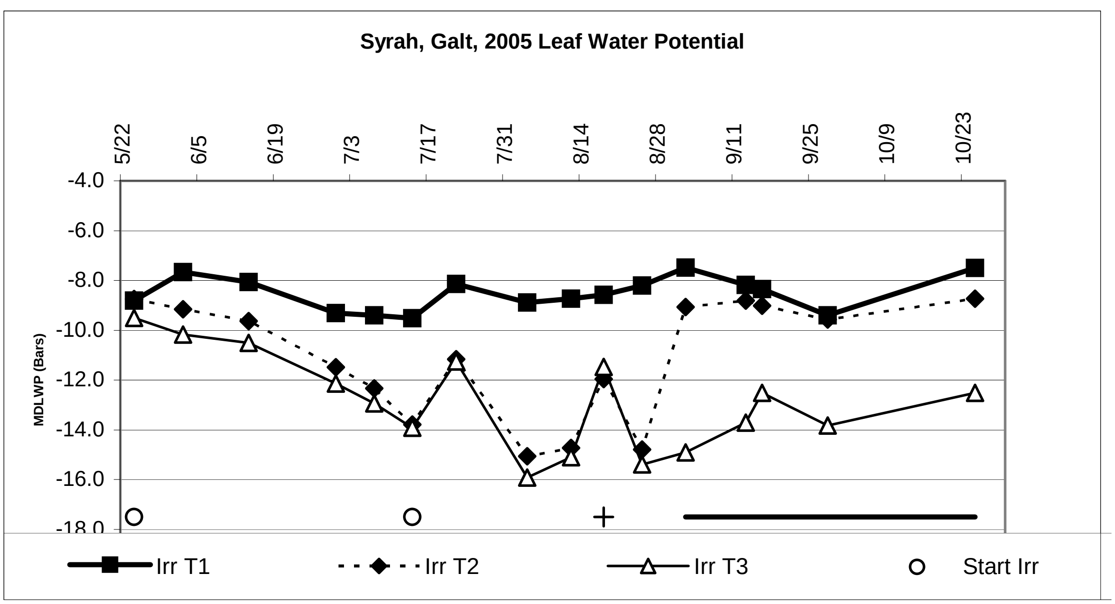


Table 2. Water Consumption Components

Irrigation Treatment	Water Applied (in) Pre harvest	Water Applied (in) Post harvest	Soil Use (in)	Effective In-Season Rainfall (in)	Total Water Consumed (in) Pre harvest	Total Water Consumed (in) Inc. Post Harvest	% of Irrigation Treatment I-1 Pre Harvest	% of Irrigation Treatment I-1 Seasonal
I-1	22.9	2.0	8.3	3.1	34.3	36.3	100	100
I-2	8.6	2.6	10.0	3.1	21.7	24.3	60	64
I-3	6.1	2.6	8.6	3.1	17.8	20.4	47	52

<u>Vine Response to Water Deficits</u>:
The vine response to water deficits was monitored by measuring midday leaf water potential (MDLWP). Irrigation treatment I-1 received irrigation volume to meet full potential water use in combination with stored soil moisture. Weekly irrigations continued until the final harvest. Irrigation began on May 24 at which time leaf water potential was a level of -8.8 bars, indicating a non-stressed condition (Figure 2). The seasonal average (May 20 – October 25) was -8.5 bars ranging from -7.5 to -9.5 bars.

Figure 2.



Irrigation treatment I-2 and I-3 received no irrigation until a MDLWP of -14 was reached on July 15. Irrigation water volumes were then applied weekly at the rate of 50% of calculated full potential continuing to harvest. A week after irrigation, leaf water potential had recovered 2.7 bars to the -11.3 level. MDLWP was measured periodically until harvest with the differences related to climatic conditions and the length of time the measurement was made from the weekly irrigation (note August 18 reading in I-2 and I-3). The seasonal average MDLWP for irrigation treatment I-3 (5/20 – 10/25) was -12.9 bars. Berry sampling and Brix analysis on August 19 indicated the 22 Brix level was reached at which time the volume of irrigation water was increased to full potential as indicated on Figure 1 by an + symbol. Leaf water potential of Treatment 2 continued to track with the irrigation treatment I-3 for a week after the increased water volumes were applied. MDLWP indicated a reduction in water stress of 5.8 bars when compared to the sister Treatment 3. The average MDLWP for Treatment 2 after September 2 was -9.0 bars. The seasonal (5/20 – 10/25) average was -11.1 bars. In the case of Treatments 2 and 3, the volumes of water applied generally stabilized the MDLWP after August 19, for the remainder of the season. The solid bar on Figure 1 indicates the harvest date range. Also see Table 1 for harvest date of each treatment.

Fruit: The extent of veraison was rated visually when 100% of the clusters on the full water treatment (T1) had some color. All plots were rated on July 23 as to the percent of the clusters which had some color. The differences were found between the full potential irrigation strategy and the deficit regimes with T1 at 98% and the defect treatments at 84%. Treatment I-1 had been irrigated since May 24 where as treatments I-2 and I-3 were irrigated on July 15, only a week before the measurement.

<u>Yield</u>:

The fruit weight of each of 15 data vines within each plot was measured. Harvest date was determined by sampling berry Brix of each treatment. When the berry samples indicated the Brix treatment level was near, harvest was scheduled for the next day.

When comparing yield across all Brix treatments, differences were found between the full irrigation Treatment I-1 and the deficit treatments I-2 and I-3 (Table 3). Treatment I-1 at 16.4 pounds per vine (6.5 tons/acre) compared to the deficit treatments at an average of 11.1 pounds per vine, a 32% reduction.

Significant yield differences were also found between the Brix treatments (Table 3). Each of the Brix treatments across irrigation treatments was found to be significantly different from each other in yield. The differences were found in order of increasing Brix with Brix-24 treatment highest at 14.6 lbs/vine, followed by Brix 26 at 12.8 and Brix-28 at 11.3 lbs/vine. The reduction from Brix 24 to 26 and 24 to 28 was 13% and 22% respectively. No interaction between Irrigation and Brix treatments were found to exist.

Yield Components:

Berry size was measured as weight (g) per berry from 5 clusters per plot (40 per treatment). Berry size was found to be significantly larger with both higher level of irrigation and lower Brix (Table 3). Fruit load (number of berries per vine) was found to be significantly higher in the irrigation treatment I-1 than the deficit irrigation levels, about 16% on average. No significant differences in fruit load were found between Brix treatments. Using simple regression, fruit load differences explain 74% of the differences in yield while berry size explains 58%.

Upon further analysis, the number of clusters or the fruit load packets are significantly higher in the irrigation treatment I-1 (Table 3). This is a typical multi-year effect as the irrigation treatments were the same last year. The full irrigation treatments tend to have more clusters in succeeding years. No crop reduction by cluster or shoot thinning was performed. No significant differences were found between Brix treatments across irrigation treatments with respect cluster number. Berry size and cluster size was found to be significantly larger with both higher level of irrigation and lower Brix

Table 3. Yield and Yield Components
2005 Syrah, Galt

	Yield (lb/vine)	Berry Size (g)	Fruit Load (berry/vine)	Cluster No. Cl/vine)	Cluster Wt. Lbs/Cl
Irrigation					
I-1	16.42 a	1.74a	4043a	49.9a	0.328a
I-2	11.46 b	1.45b	3416b	41.7b	0.272b
I-3	10.80 b	1.35c	3455b	43.0b	0.250b
P =	0.0000	0.0000	0.0168	0.0001	0.0000
Brix					
24	14.58a	1.62a	3806	45.0	0.317a
26	12.75b	1.54b	3577	45.6	0.279b
28	11.34c	1.37c	3530	44.4	0.255c
P =	0.0000	0.0000	0.2965	0.4869	0.0003
Interactions					
Irri/Brix P =	0.7677	0.9516	0.9555	0.8140	0.2997

Water Use Efficiency:

The amount of grapes per unit of applied water consumed is termed water use efficiency. The applied water is shown in Table 1 while yield is shown in Table 3. Irrigation treatment I-1, the treatment consuming the most water was least efficient at near 2 lbs of fruit per 100 gallons of applied water (Table 4). Substantial increase in efficiency is possible using the deficit irrigation level I-3 was the highest at near 5 while level I-2 was intermediate at near 4 indicating a much greater water use efficiency using deficit irrigation.

Table 4. Water Use Efficiency
2005 Syrah, Galt

	Lbs Product/100 Gal Applied Water	
Irrigation Treatment	Pre Harvest	Seasonal
I-1	2.1	1.9
I-2	3.9	3.0
I-3	5.2	3.6

Fruit Quality:

One cluster from each vine (40 per treatment) were collected at each harvest and delivered to the laboratory for juice analysis on the day of harvest. The fruit analysis was based on this sample. The juice sugar level was found to significantly vary by irrigation and Brix treatments (Table 5). The highest Brix level was found in irrigation treatment I-3 at 26.7 followed by I-2 and I-1 at 26.0 and 25.8 respectively across Brix treatments. The I-3 treatment was significantly higher than the others. Apparently the small amount of water (2 inches) added to the I-2 treatment over the I-3 treatment had a significant effect in reducing the sugar level across the Brix treatments. The sugar levels in the Brix treatments were all significantly different from each other and serve as the treatment designations by rounding off to the whole number for each treatment.

Comparing the irrigation treatments across the Brix treatments finds potassium content significantly higher (like Brix) in the least water using Treatment I-3, with the others similar.
Comparing the Brix treatments across the irrigation treatments, significantly higher potassium concentrations exist as a function of increasing Brix. A significant interaction between the irrigation treatments and the Brix treatments occurred. Irrigation treatment 1 potassium level did not increase with increasing brix treatments. The potassium level was not significantly different between brix treatments in treatment I-1.

Malate concentration typically decreases as the season progresses and is higher under conditions of abundant vegetative growth. The treatment with the highest water consumption (I-1) was significantly higher in malate than the deficit treatments when compared across all Brix treatments. The Brix treatments followed a significant reduction in malate from the Brix-24 to Brix-28 for a change over time. However, with out explanation the Brix-26 was intermediate.

Significant differences in pH level were found between irrigation strategies and Brix treatments. pH increased from irrigation treatment I-1 and I-2 at an average of 3.76 to 3.86 for the highest level of deficit (I-3). Brix treatments increased in pH at higher Brix levels with 24 Brix harvest being significantly lower at 3.60 than the others averaging 3.88.

Table 5 Juice Analysis
2005 Syrah, Galt

	Brix	K content	Malate	TA	pH
Irrigation					
I-1	25.8b	1881b	2924a	5.08a	3.73b
I-2	26.0b	1869b	2266b	4.38b	3.78b
I-3	26.7a	2044a	2252b	4.43b	3.86a
P =	0.0006	0.0023	0.0000	0.0000	0.0060
Brix					
24	24.3c	1352b	2468b	5.42a	3.60b
26	26.4b	2182a	2683a	4.48b	3.85a
28	27.7a	2260a	2291c	3.99c	3.90a
P =	0.0000	0.0000	0.0008	0.0000	0.0000
Interactions					
Irri/Brix P =	0.2659	0.0067	0.2429	0.2022	0.0164

Summary

Three levels of fruit maturity were compared across three different irrigation strategies in a region IV Syrah vineyard. Significant differences in level of water stress were found between all treatments as measured by seasonal average midday leaf water potential. Water consumption was also significantly different between all irrigation treatments. The deficit irrigation treatments I-2 and I-3 consumed 64% and 52% of the full potential consumptive use treatment I-1.

Significant yield reductions were found with deficit irrigation and increased fruit maturity. Yield reductions of 32% were found due to deficit irrigation across all Brix treatments. Deficit irrigation treatment I-2 received additional water than the I-3 by 2.5 inches as harvest approached. This strategy although numerically higher in yield, was significantly different. Yield component analysis using simple regression revealed fruit load differences explain 74% of the differences in yield while berry size explains 58%. The same irrigation treatments were imposed in the 2004 season which explains the increased cluster number and fruit load in the full irrigation treatment (I_1).

Significant yield reductions were also found in Brix treatments across irrigation treatments. The yield reduction from Brix 24 to 26 and 24 to 28 was 13% and 22% respectively. Using simple regression, berry size differences explain 80% of the differences in yield. No interaction between Irrigation and Brix treatments were found to exist.

Juice potassium levels were significantly higher comparing the full irrigation I-1 and the largest deficit treatment I-3. Additionally potassium levels increased progressively with higher Brix. Essentially the same was true for juice pH. Titratible acidity declined with deficits and increasing Brix**.**