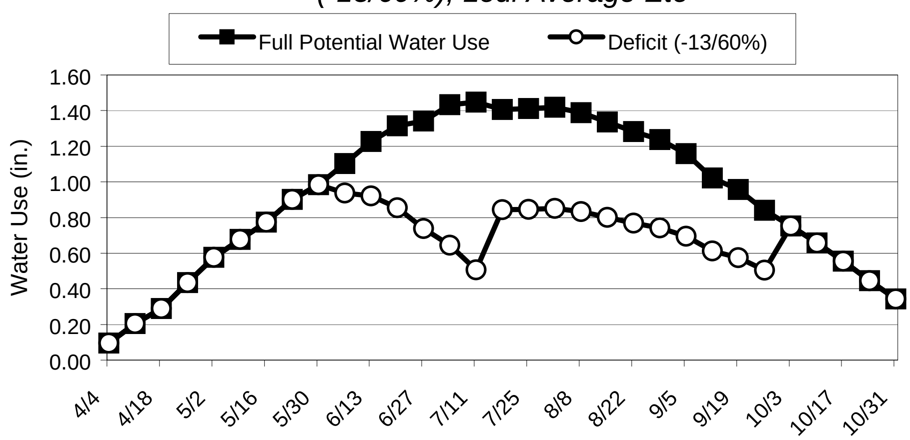
E. **Developing a Deficit Irrigation Strategy**

Regulated Deficit Irrigation

Regulated deficit irrigation (RDI) is a term for the practice of regulating or restricting the application of irrigation water causing the vine water use to be below that of a fully watered vine. By restricting irrigation water volumes, soil water available to the vine becomes limited to a level where the vine cannot sustain the full potential water use. It is at this point that the vine begins to undergo a water deficit. RDI can be a consistent reduction (i.e., consistent reduction of planned irrigation volumes over the entire season) or the reduction can vary over the irrigation season to induce the desired vine response at the appropriate time.

Figure E-1 shows weekly water use for the unrestricted full potential vine water use and the water use of the a deficit irrigation treatment, which produced the best yield/quality relationship in a mature Cabernet Sauvignon vineyard in Lodi, California over five seasons. The upper line represents the full potential water use of a mature vineyard. It is the volume of water consumed by the vineyard that occurs under conditions where soil water availability is not limited and canopy size shades near 50% of the land surface at midday measured at maximum canopy expansion. About 30% less water was consumed by the deficit irrigation regime on a seasonal basis.

Figure E-1. Water Use of Full Potential and Deficit Regime (-13/60%), Lodi Average Eto



Deficit Threshold Irrigation

The Deficit Threshold Method (DTI) relies on a predetermined level of midday water deficit (the threshold) to begin irrigation. After the threshold is reached, a reduced water regime is used based on a portion (RDI %) of full potential vine water use. The goal of the Deficit Threshold Method combined with post threshold Regulated Deficit is to improve fruit quality and minimize yield reductions. As shown in *Figure E-1* water is withheld until -13 bars MDLWP when irrigation commenced on July 11.

This method requires measurements of vine water status. The measurement device is called a pressure chamber often referred to as a pressure bomb. To measure vine leaf water status, a leaf is removed from the vine at midday and placed in the chamber with the petiole through a silicone grommet exposed to the atmosphere. In order to reduce the loss of water from the leaf while making the measurement, the leaf is covered with a plastic bag just prior to removing the leaf from the vine. Pressure is applied inside the chamber until the sap exudes from the petiole. The pressure required to exude the sap is an indication of the level of vine water stress. A measurement made in this fashion is called mid-day leaf water potential (MDLWP).

Experiences with Deficit Threshold Irrigation

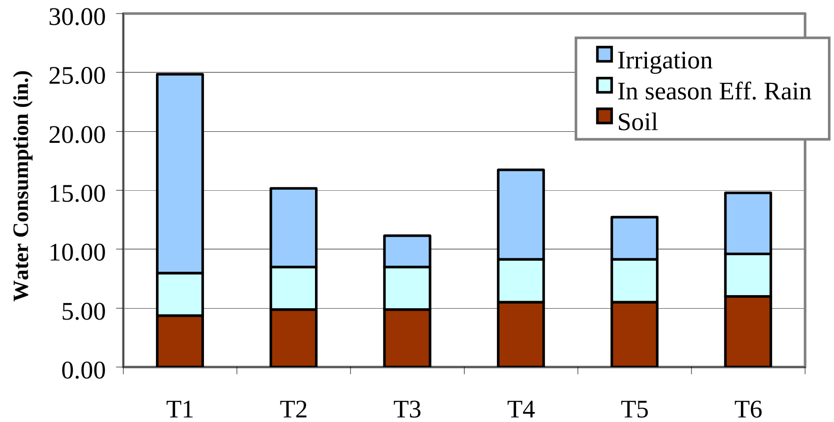
Relying on previous experience gained from the irrigation trials referred to above and work of others, it was thought a midday leaf water potential threshold of -13 to -15 bars was a reasonable place to start.

To establish reasonable RDI values, we again reviewed the trial irrigation volumes to see what percentage of full potential water use after irrigation began produced the "best option." An experimental range was selected of 35 to 60 percent of full potential water use after the threshold was reached. On a seasonal basis, *Figure E-2* shows the typical water sources and amounts consumed for the treatments described in *Table E-1* for cabernet Sauvignon in the North coast in 1999.

Table E-1. Typical irrigation treatments: timing of first application and volume of water to be applied

Treatment Number	Leaf Water Potential Trigger at Which Irrigation Will Begin	Criteria for Subsequent Irrigation (RDI%)
1	no trigger <-10 bars	supply full water
2	-12 bars	supply 60% of daily full water use
3	-12 bars	supply35% of daily full water use
4	-14 bars	supply 60% of daily full water use
5	-14 bars	supply 35% of daily full water use
6	-12 bars	supply 35-60% (variable) of daily full water use

Figure E-2. Water sources and amounts, 1999 Hopland



Experiments of these types were conducted in the Lodi area and North Coast working with Merlot, Cabernet Sauvignon and Zinfandel. Results generally support the –12 bar threshold and 60% post threshold RDI % as successful but conservative. Vigorous vineyards may not be adequately controlled using this conservative threshold and RDI. The effect of both threshold and RDI% is more complex incorporating vine balance, fruit light conditions, and wine character and color. Additionally, the qualities sought after in white varieties support these conservative -12/60% RDI strategies. The qualities sought after in white varieties support these conservative -12/60% RDI strategies. Whereas red varieties, where wine color (phenolics) and character (tannins) are more important, support the more stressed thresholds and lower RDI percent. Even within the red grape varieties differences exist in the response to deficits. Merlot is relatively sensitive while Cabernet Sauvignon and Zinfandel are quite tolerant and produce wines with increased character under more water stress.

The Deficit Threshold Irrigation method is easier to implement, requiring fewer measurements and fewer variables than soil based or volume balance methods and seems to work well in moderate to cool climate regions.

Selecting an Appropriate Deficit Threshold and RDI

Deficit irrigation is not applicable for all vineyards. Young developing vineyards require adequate soil moisture to develop rapid vine structure. Generally deficit irrigation is not practiced until the vineyard is fully developed, usually taking four years or more. Low-vigor vineyards are also not candidates for deficit irrigation as a reduction in vegetative growth is the primary effect of deficit irrigation. Low vigor can occur from pests and diseases as well as nutrient deficiencies and other soil limitations.

All soils and waters contain salts. Some waters are high in salts due to their origin such as groundwater from sediments in coastal ranges of California. Waters originally low in salts can increase as they are used and reused as a consequence of runoff and drainage. Likewise, soils reflect the parent material from which they were developed. Soils which develop from sediments of the ocean floor (coastal and the west side of the valley) tend to be natively high in salts. Soils of east side of the valley are of granitic origin and tend to be low in salts. Soils also accumulate salts from irrigation waters. Even waters relatively low in salts will eventually salt up soils if the salts are not leached out. Leaching can be accomplished by adequate winter rainfall or by excessive irrigation during the season or off season. During season excess irrigation runs counter to deficit irrigation practices. Therefore, if winter rains are not adequate to keep the root zone salts at a level which will not cause damage, off season leaching is the only option.

Selecting a Deficit Threshold

The appropriate Deficit Threshold can be determined through experimentation or experience gained by selecting a relatively safe threshold and observing the results then making adjustments for the next season based on the results. There is an emerging consensus that the severity of the deficit threshold is less important than when the deficits begin to effect vegetative growth. It is known that red varieties are more tolerant of increased deficits and tend to have improved fruit qualities when compared to white grapes.

Experimentation in the Southern Sacramento Valley and in the North Coast indicates the –12 to –15 bars is a reasonable deficit threshold however there are factors which should influence your decision.

Red grapes tolerate and benefit more from a more negative threshold. White and sparkling varieties tend to develop more tannins and more color, which may not be desirable favoring a less negative threshold. Red varieties such as Zinfandel usually benefit from a more negative threshold from a character and bunch rot perspective, Cabernet Sauvignon likewise from a character perspective. Merlot is more sensitive and benefits from a less negative threshold.

Vines in deep soil and high total water holding capacity soils located in a cool may not reach the predetermined threshold by harvest or the threshold may be reached only after a sustained severe climate period. In these cases the soil/water resource is just too large for the environmental demand. The use of a cover crop to extract moisture might be appropriate to reduce the available soil water. In shallow soils, low water holding capacity soils the threshold may be reached too early in the season causing water deficits in berry development Stage I. Water deficits at this time will cause smaller berries, which will reduce yields. To avoid this situation irrigation can forestall the reaching of the threshold until the appropriate time.

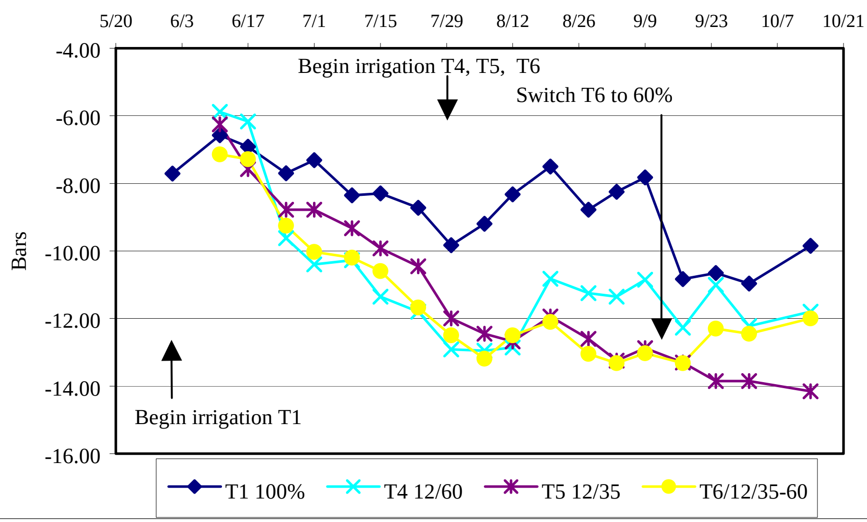
Rootstock differences seem to make no difference in the threshold selected; however, the rate at which the threshold is reached seems to be rootstock dependent. The more vigorous and root extensive rootstocks will be slower and more predictable in the increase in water stress as the approach the threshold. Less vigorous rootstocks and those that have a predominance of shallow roots will increase in water stress in a more rapid fashion especially when climatic conditions are harsher.

Selecting a Post Threshold RDI%

An RDI should be selected to ensure continued photosynthesis, adequate fruit cover to protect from heat and sunburn, and to prevent new vegetative growth.

Trials have been conducted using post threshold regulated deficits (RDI) of 35% and 60% of full potential water use. Varieties include Zinfandel, Cabernet Sauvignon and Merlot on Freedom and 5C rootstocks. Generally, the RDI 35% leads to increased levels of water stress from the threshold level to harvest. The length of time from the threshold to harvest determines the ultimate level of stress using the RDI 35%. *Figure E-3* shows the results of four treatments, two thresholds (-12 and –14) at two RDI percentages. They are denoted as 12/60 and 12/35 with the threshold RDI. Included for comparison is the full potential water treatment. Also included is a treatment, which its RDI received 35% for one half the period from the threshold to harvest, then the RDI was increased to 60%. Generally, the leaf water potential remains at or near the threshold if the RDI% is near 60%. At an RDI of 35%, the stress increases towards harvest. The result of too little water towards harvest can be delayed maturity (sugar accumulation), loss of fruit leaf cover and lower berry size.

Figure E-3. Leaf Water Potentials
Cabernet Sauvignon, Hopland, 2000



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