FIRST YEAR RECOVERY OF WALNUT TREES FROM SUSTAINED DEFICIT IRRIGATION

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ABSTRACT

Hedgerow walnut trees (cv. Chico) that were irrigated at 33, 67, and 100% ETc for the past three years were returned to full irrigation in 1989. Tree water status and stomatal opening immediately recovered indicating no tree "memory" of stress history. Trunk growth rates also completely recovered. Rapid shoot growth (primarily in response to pruning cuts) in the previously stressed trees narrowed differences in canopy size relative to the control.

Harvest yields were significantly different between the previous irrigation regimes although the differences were less than last year. Individual nut size was significantly greater in both previous stress treatments due to the compensatory effect of reduced nut load on nut growth.

Three dimensional displays of tree performance parameters (yield, nut load, nut size, and canopy size) vs. time vs. stress history are used to illustrate tree recovery rates.

OBJECTIVES

To return hedgerow walnut trees to full irrigation following three years of sustained deficit irrigation and evaluate their recovery in terms of growth, productivity and tree water relations.

PROCEDURE

Hedgerow trees (cv. Chico) at the Kearney Ag. Center have been irrigated at 33, 67, and 100% of ETc for the past three years (1986-88, inclusive). These irrigation regimes were applied to plots that contained 16 trees each including borders that were replicated three times. Eight trees in each plot were monitored. During that time, production-related effects of the deficit irrigation were evaluated each year as well as changes in tree growth and water status. In 1989, these trees were returned to full irrigation (100% ETc) based on previously determined crop coefficients (Kc) and reference crop water use (ETo).

Irrigation is accomplished with low volume sprinklers located in the tree row 5.5 ft from each tree. Water is applied from two to four times per week. In 1989, 38.7 inches of water were applied. The orchard received 1.0 lb N/tree as UN32 through the irrigation system in mid May.

To determine tree water status, periodic measurements of predawn and midday leaf water potential were made with a pressure chamber. Single leaves on each of four trees per plot for a total of 12 per former irrigation regime were monitored.

Stomatal behavior was assessed periodically with midday porometer measurements taken on three leaves on each of three trees per plot (36 per former irrigation regime).

Trunk growth was monitored periodically on eight trees per replication with a dendrometer. Canopy size was assessed by determining the shaded area of the orchard floor at 1:00 p.m. in late August. Measurements were made by counting the shaded squares of a grid drawn on a tarp and placed beneath one tree per replication.

Harvest took place on September 7 with a commercial shaker and individual tree weights were determined. Composite nut samples (one per replication) were collected, hulled, and dried. These samples were analyzed by Diamond Walnut Growers, Inc. to determine individual nut weights, component weights (shell and kernel), and commercial nut size and quality breakdowns.

RESULTS AND DISCUSSION

Plant water status and stomatal conductance

Predawn leaf water potential over the season (Figure 1) for all treatments (100% ETc and the former 33 and 66% ETc) generally did not exceed -0.2 MPa (1 MPa is 10 bar). An exception occurred in late May and early June when a break in the field station's supply line resulted in temporarily lowered predawn values. There were no statistically significant differences in predawn leaf water potential between any of the irrigation treatments over the season indicating that the previously stressed trees had no "memory" of their stress history in terms of predawn plant water status.

Midday measurements of leaf water potential and stomatal conductance also showed no significant differences between treatments over the season (data not shown). This occurred despite the short-term stress imposed in late May and suggests that the previous stress history of the severely stressed (33% ETc) trees, including possibly smaller root zones, did not impair their ability to extract limited soil water.

Trunk growth

Radial trunk growth rates peaked in late June for all irrigation treatments (Figure 2). The decline in growth rates in late May and early June may be due to the previously-mentioned irrigation system breakdown. Peak growth rates were inversely proportional to the degree of deficit irrigation from previous years (0.031, 0.033, and 0.046 mm/day for the 100, 66, and 33% ETc regimes of '86-'88, respectively). While these differences were not significant, they indicate that the lighter nut loads in 1989 of the previously stressed trees resulted in greater assimilate allocation to vegetative growth. Clearly, the large reductions in trunk growth rate observed in '86-'88 due to the water deprivation were immediately halted in this first year of full irrigation.

It should also be noted that relatively high shoot and branch growth in response to pruning cuts on the previously stressed trees occurred on the side of the trees that received mechanical hedging. Shoot and branch growth was much less noticeable on the unpruned side (alternate sides of the hedgerow are pruned each year).

Nut yield

While harvest yields were significantly different between treatments (Table 1), these differences narrowed from those observed last season. Yields of dry (8% water content) in-shell nuts were 20.8% less for the past 66% ETc trees and 36.8% less for the past 33% ETc trees (2.7, 3.3, and 4.2 tons/acre for the previously 33, 66, and 100% ETc irrigation treatments, respectively). Last season, the yield reductions were 32 and 50% for the 66 and 33% ETc regimes, respectively. To facilitate comparison of the influence of the previous three years of water deprivation and this year's return to full irrigation on relative yield, a three dimensional response surface (relative yield vs. time vs. irrigation) is shown in Figure 3.

Fruit load

As was the case last year, fruit load (Table 1) was significantly lower for the previous stress treatments (24.4 and 47.5% less for the 33 and 66% ETc regimes, respectively). The differences in the relative number of nuts per tree were virtually identical to those of the previous year (Figure 4). Our work to date has shown that nut load is the primary yield component affected by tree water stress. While this observation is again confirmed in this first recovery year, it is important to note that yield recovery has begun in the absence of nut load recovery. Since nut load largely depends on vegetative growth the previous year, it is not surprising that this parameter is unchanged this season.

Nut size

In the absence of nut load improvement, partial yield recovery in response to year one of full irrigation was due entirely to increased nut size and weight (Table 1). Whereas individual nut weights were always less for the stress treatments during the years of water deprivation, nut weights were greater for the previously stressed trees this year (Figure 5). In other words, individual nut weight was inversely related to the severity of the previous water stress. The fact that individual nut weights were 5.2 and 20.2% greater than the control for the past 66 and 33% ETc regimes, respectively, was due to the compensatory effects of nut load on fruit size. Indeed, Jumbo and Large nuts accounted for 67.3, 29.4, and 12.4% of the tree nut load for the previous 33, 66, and 100% ETc treatments, respectively.

Nut quality

Commercial nut quality parameters were generally not significantly different for the previous irrigation regimes (Table 3). One clear exception is in large sound nuts which was much greater for the past 33% ETc treatment due to the previously-discussed nut load effect on fruit size. As in previous years, kernel percentage was not significantly different (Table 1).

Canopy size

The recovery of vegetative growth is evident by the narrowing of canopy cover differences, as shown in Table 1 and Figure 6. Last year, the 33 and 66% ETc regimes had 36.1 and 30.6% less shaded orchard floor than the control, respectively. This season, the differences were 22.2 and 3.7%, respectively. This rapid recovery in canopy size in these hedgerow trees resulted in relatively

large differences in the harvest index of nuts per unit of canopy size (Table 1). Lower harvest index values for the previous stress treatments allowed fewer nuts to be supported by each unit of the canopy and this enhanced nut size.

CONCLUSIONS

Upon renewal of full irrigation following three years of water deficits, walnut trees showed immediate recovery of tree water status and stomatal opening. Trunk growth rates completely recovered and canopy size differences relative to never-stressed trees narrowed.

While harvest yields were significantly different, these differences narrowed from last year. This was due entirely to larger nuts in the previously-stressed trees as relative fruit load differences were virtually identical to last year. Greater harvest index values (nuts per unit of canopy area) and the compensatory effect of nut load on nut size were responsible for the partial recovery.

Table 1. Harvest, fruit load, and canopy-growth related data.

Former Treatment	Yield dry in-shell[1] (lbs/tree)	Fruit load (nuts/tree)	Nut weight[2] (gm/nut)	% Kernel	Shaded area[3] (%)	Harvest index[4/] (nuts/ft^2)
100% ETc	46.7 a	2437 a	8.06 a	49.3	64.1 a	15.7 a
66% ETc	37.0 b	1843 b	8.48 a	50.2	61.7 a	12.4 ab
33% ETc	29.5 b	1280 c	9.69 b	49.3	49.9 b	10.6 b
	*	*	*	NS	*	*

1/ 8% water content by weight.
2/ Oven dry.
3/ Orchard floor measurements on Aug. 30, 1989.
4/ Nuts per ft^2 of shaded area per tree.

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

Table 2. Commercial nut size categories.

Treatment	Jumbo	Large	Medium	Baby
	---------- % ----------			
100% ETc	2.6 a	9.8 a	35.6	52.0 a
66% ETc	6.1 a	23.3 ab	47.0	23.5 b
33% ETc	32.4 b	34.9 b	22.7	10.0 c
	*	*	NS	*

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

Table 3. Commercial harvest quality parameters.

Treatment	Edible yield[1/]	Large sound[1/]	Off-grade[2/]	Internal damage[3/]	Insect damage[1/] (% by #)	RLI #1[4/]
	% by weight					
100% ETc	48.7 a	11.6 a	0.5	1.9	0.4	37.9 ab
66% ETc	49.5 b	27.0 a	0.9	1.7	0.3	38.7 b
33% ETc	48.1 a	62.1 b	2.1	2.2	0.5	35.5 a
	*	*	NS	NS	NS	*

1/ of tree nut load.
2/ of kernels.
3/ of large externally sound nuts.
4/ Reflective Light Index. The higher the RLI, the lighter the kernel color.

* Asterisk beneath columns indicates significant differences at the 5% confidence level between numbers followed by different letters. NS indicates no significant differences in the column.

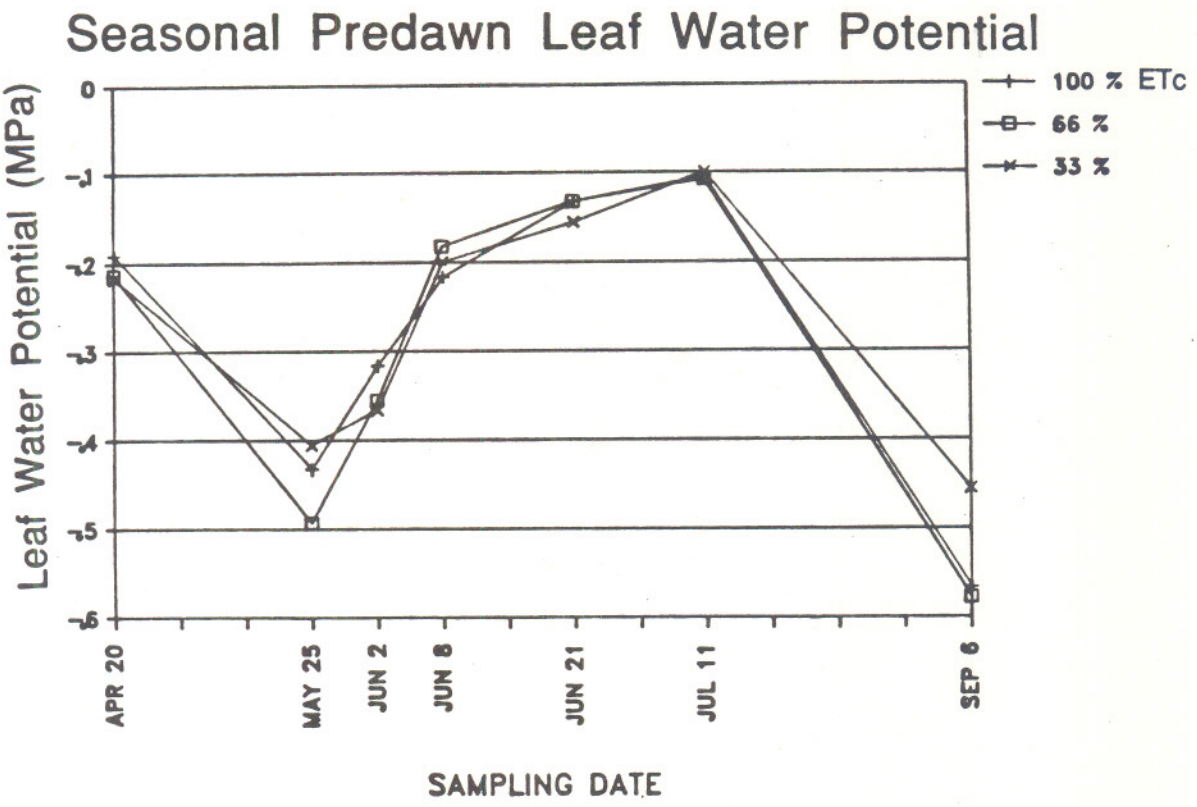

Figure 1. Predawn leaf water potential over the season for the old ETc regimes.

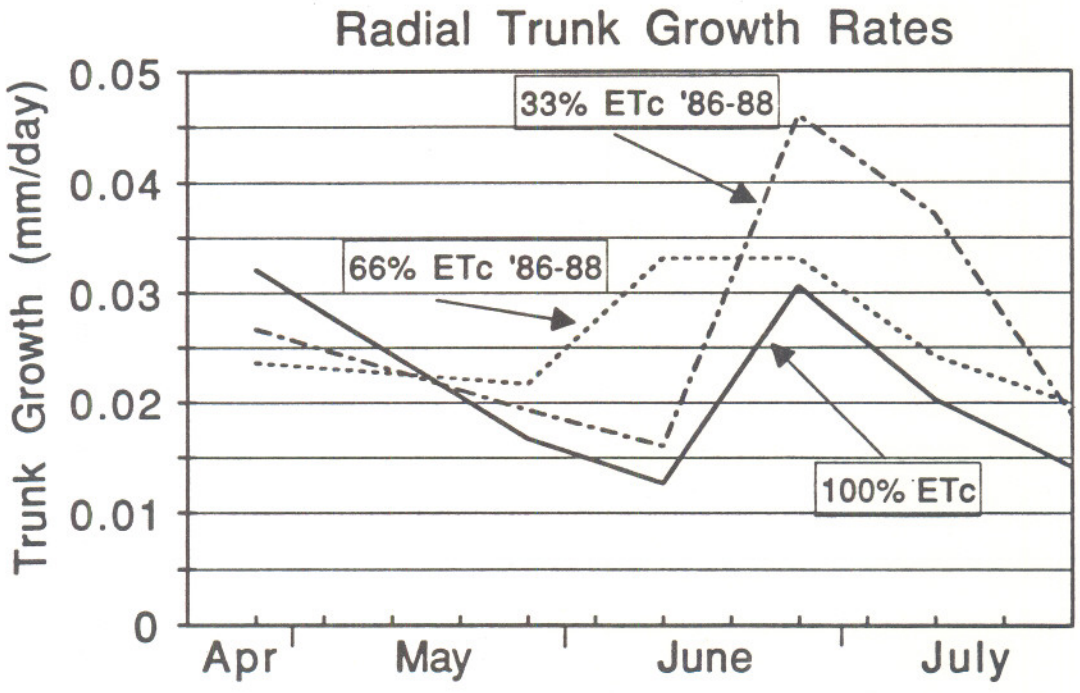

Figure 2. Radial trunk growth rate over the season for the old ETc regimes.

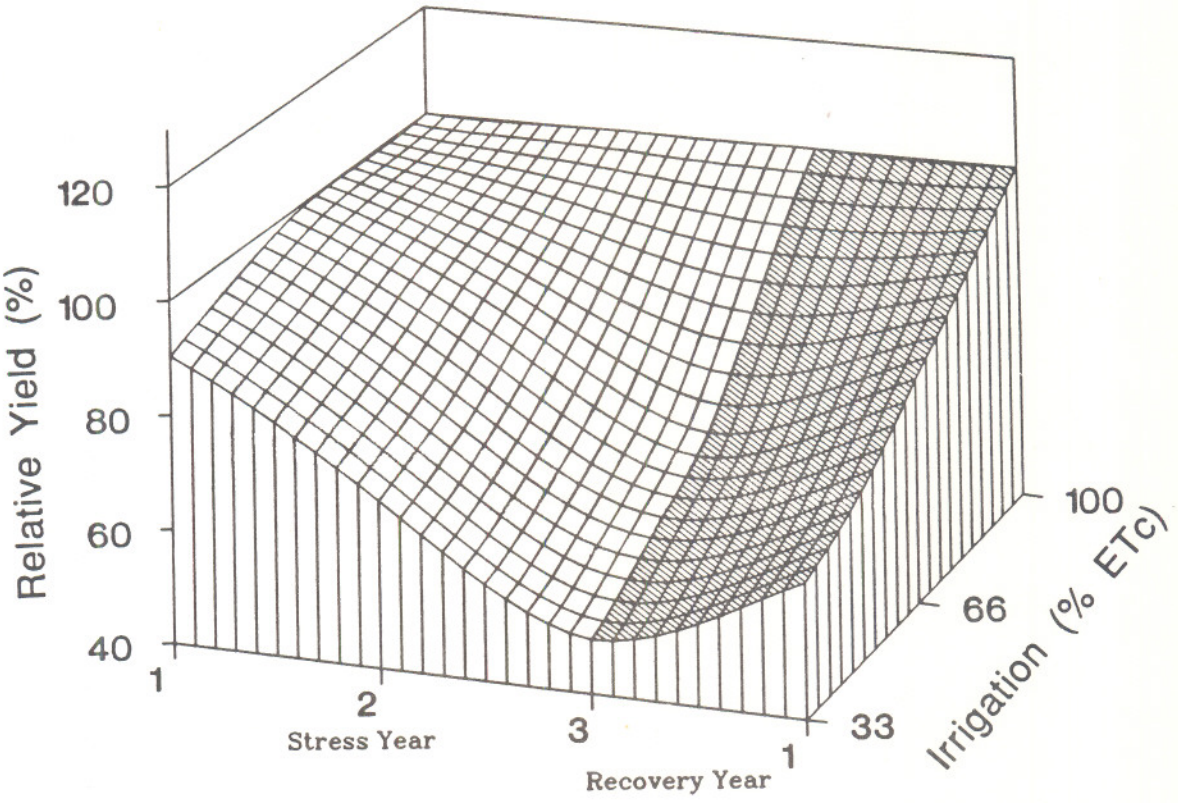

Figure 3. Relationship between relative yield (dry in-shell), time, and irrigation level.

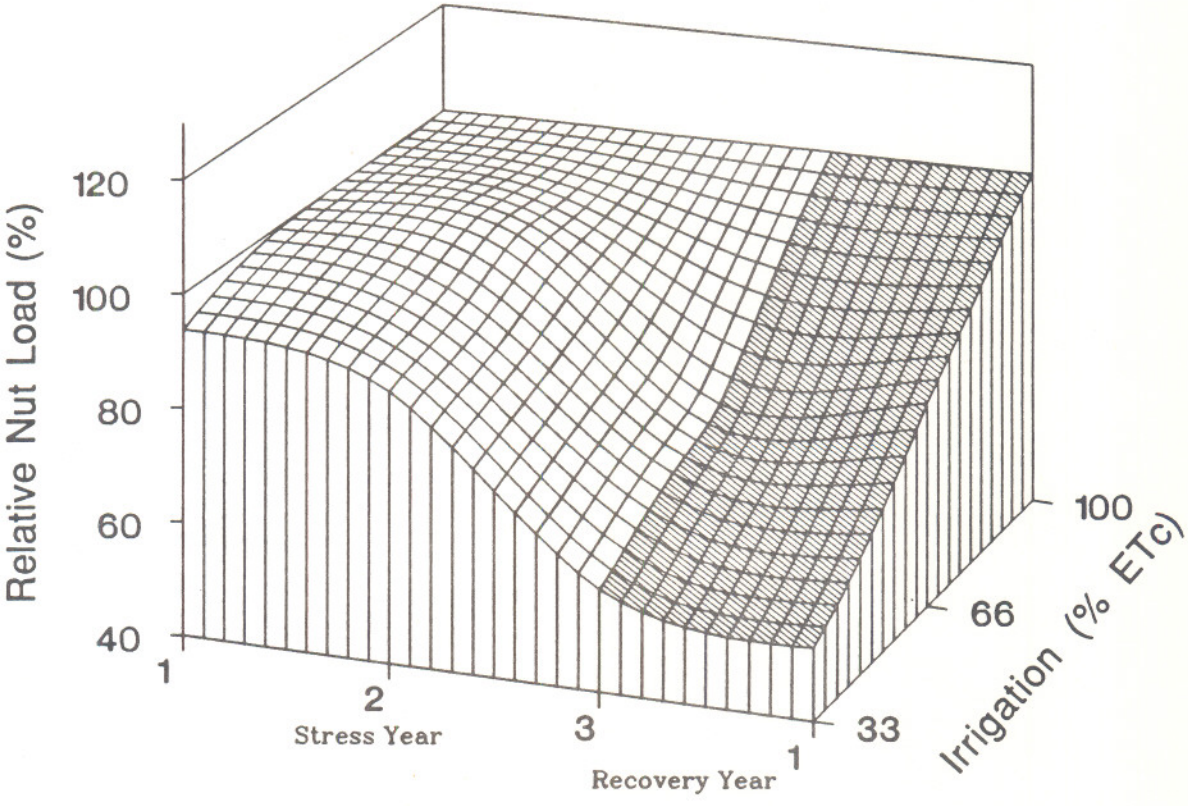

Figure 4. Relationship between relative tree nut load (number per tree), time, and irrigation level.

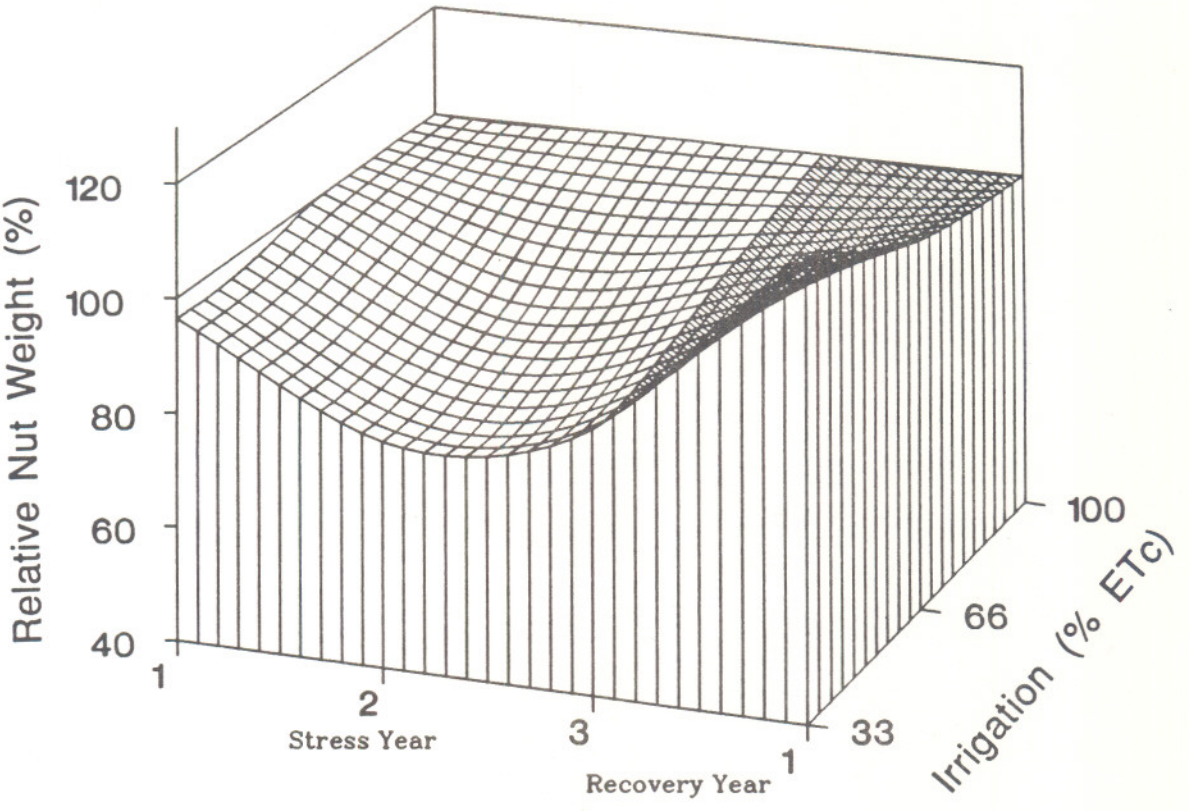

Figure 5. Relationship between relative individual nut weight, time, and irrigation level.

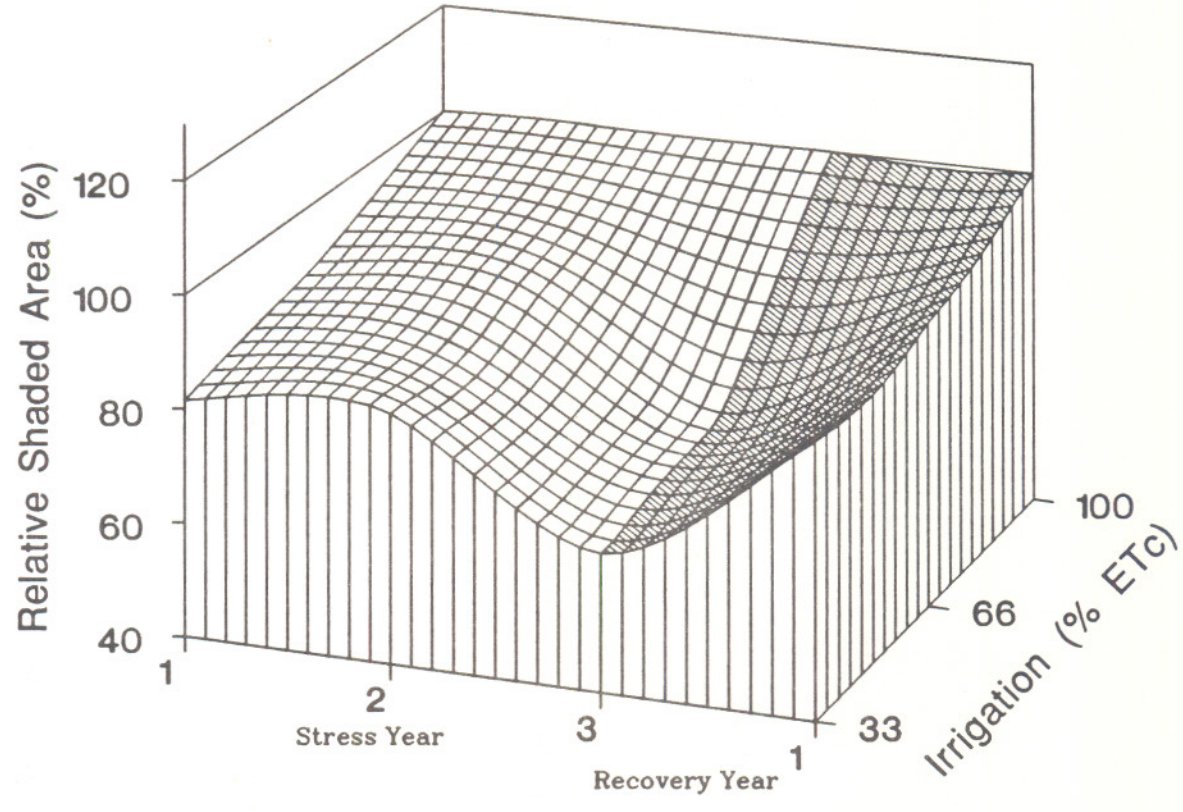

Figure 6. Relationship between relative canopy shading of the orchard floor, time, and irrigation level.