

Table 3. The effect of number of kiwifruit fruits per vine and of thinning date on the fruit number per vine in the following year.

Treatment	Fruit number per vine, 1985	Fruit number per vine, 1986		Average fruit number		
		Bud swell	Stage at thinning ^z		Bud swell	Fruit-set
			Fruit-set			
Thinned ^y	700–1055	4464 a	4165 a	2660 a	2538 a	
	1055–1500	2798 bc	3100 b	2090 a	2213 a	
	1500–2120	2736 bc	2161 bcd	2173 a	2044 a	
	2120 +	---	1866 cd	---	2299 a	
Unthinned ^y	3240–4700	1663 d		2748 a		
Unsprayed	590–1145	1312 d		1045 b		
SE		339		235		

^zFor each characteristic, values followed by a common letter do not differ significantly at $P = 0.01$ by Duncan's multiple range test.

^ySprayed with Alzodef to break dormancy.

(Fig. 2). The first phase, 0 to 9 weeks after anthesis, has an initial rapid rate of growth characterized by intensive cell division in the pericarp in addition to cell enlargement, while the other one or two growth phases are characterized mainly by cell enlargement (4, 6). The first growth phase is known also for a) intensive buildup of total solids and ash (9), b) development of the seeds and nucellus (4), c) promotion of fruit cell growth by some seed-elicited hormonal factors (5), and d) accumulation of minerals (1).

Thinning after the fruit-set stage was performed when one-third of the first growth phase was through and some of the influences noted above already had been exerted. Therefore, the response of fruit growth to thinning after fruit-set was reduced relative to the intensive growth response of fruit that remained on the vines after thinning at bud swell. This rapid growth undoubtedly was related to the reduced competition from other fruit. It is also probable that the initial thinning by pruning resulted in increased exposure of the fruit to sunlight and hence to increased fruit size (3).

It is known that the result of any delay in fruit thinning is reduced growth of the remaining fruit on the tree. However, since all kiwifruit flowers set fruit, and since manual thinning takes a long time, it is possible to start thinning at the bud swell stage and continue until the fruit-set period, although with somewhat reduced results because of the partial delayed thinning.

The use of Alzodef spray to break dormancy under Israeli conditions did not change the alternate-bearing habit of the vine (Table 3). Vines yielding 3240 to 4700 fruits in 1985 set only 1663 fruits/vine the following year. Since Alzodef had a strong influence on productivity and since flowering intensity even 2 years after spraying was high, it is presumed that the use of this compound will increase the need for regular fruit thinning in kiwifruit. However, better control of Alzodef spraying dates and concentrations might reduce the necessity for thinning. Controlled pruning with fewer flowering buds left on each vine might bring about the same result.

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Soil Moisture and Water Use in Lysimeter-grown Peach Trees

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Abstract. Mature peach trees [*Prunus persica* (L.) Batsch] grown in weighing lysimeters were subjected to soil moisture stress. Evapotranspiration (ET) was not affected by rapid changes in soil moisture until soil matric potential reached -1500 kPa. When the trees reached permanent wilt, there was a sharp decline in water use.

Fruit trees are subjected to water stress when irrigation systems fail or prolonged drought occurs in the absence of irrigation. Proebsting and Middleton (1980), reporting on behavior of stressed trees, indicated that

symptoms that lead to tree death began about the time the entire rooting volume reached the permanent wilting point. At permanent wilt, leaf water potentials were between -2700 and -3200 kPa, leaves wilted, turned yellow, and fell from the trees. In terms of soil matric potential, -1500 kPa is considered the permanent wilting point for most plants (Wilkins, 1984; Kramer, 1983); but, in the work by Proebsting and Middleton (1980), soil matric potentials as low as -3200 kPa were reported.

In a review of plant responses to stress,

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WATER USED (LITERS)

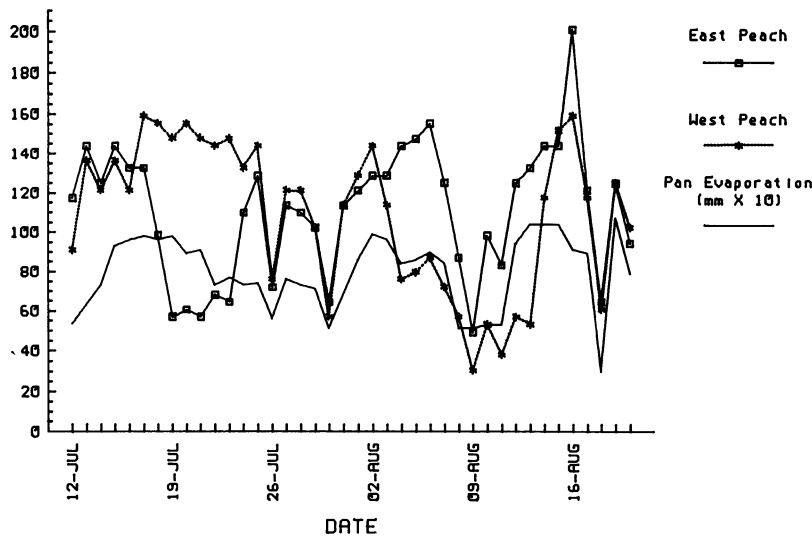


Fig. 1. Water use and pan evaporation as a function of time for two peach trees grown in weighing lysimeters.

PERCENT MOISTURE

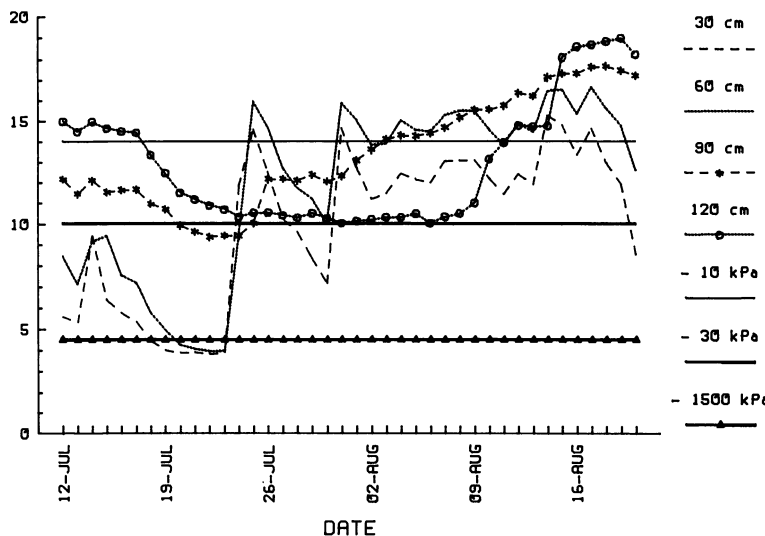


Fig. 2. Soil moisture (%) in east lysimeter as a function of time. (Distance from soil surface in centimeters; soil matric potential in kiloPascals.)

Table 1. Correlations between water use, soil moisture, and pan evaporations for lysimeter-grown trees during stress and non-stress periods.

Parameter ²	Parameter ²				
	EUSE	WUSE	ESOIL	WSOIL	EVAP
EUSE	1.000				
WUSE	0.158	1.000			
ESOIL	0.458**	-0.458	1.000		
WSOIL	-0.152	0.669**	-0.189	1.000	
EVAP	0.527**	0.681**	-0.166	0.333	1.000

²EUSE = east water use; WUSE = west water use; ESOIL = east soil moisture; WSOIL = west soil moisture; EVAP = pan evaporation.

**Significantly different than zero at the 99% confidence level.

Hsiao (1973) indicated that stomatal closure is the main cause for transpiration decline as water stress develops. He postulated a threshold value of leaf water potential above which leaf resistance, and therefore stomatal opening, remained constant. Below this threshold, stomatal closure was almost com-

plete. Stomata regained most of their ability to open within 1 day of rewatering. In some cases, 5 to 7 days were required for full recovery.

Declining soil matric potential caused a decrease in leaf water potential in peach seedlings that was accompanied by a decline

in stomatal conductance, transpiration, and photosynthesis (Tan and Buttery, 1982a, 1982b, 1986). In studies of peach trees under various irrigation regimes, Punthakey et al. (1984) found that stomatal conductance increased exponentially as light levels increased. Where soil water availability was limiting, stomatal conductance decreased rapidly as leaf water potential decreased below -1800 kPa for shaded leaves and -2100 kPa for exposed leaves. Stomata of stressed trees responded more slowly than those of unstressed trees.

The research reported here evaluated the influence of moisture stress on evapotranspiration (ET) in mature peach trees as measured by weighing lysimeters. Two 5-year-old 'Redglobe' trees on Nemagard rootstock were dug with a ball 1.2 m in diameter and 1 m deep and transferred to the lysimeters in Spring 1981. Trees grew for one full season before this study, which took place in July and August 1982. The soil in the root ball and the lysimeters was a Windthorst fine sandy loam (thermic Udic Paleustalf) (Wagner et al., 1973). Details of transplanting and lysimeter construction and sensitivity have been reported previously (McFarland et al. 1983; Worthington et al. 1984).

To monitor soil moisture levels, readings were taken daily at 30, 60, 90, and 120 cm with a Campbell Pacific Model 503 neutron probe (Campbell Pacific Nuclear Corp., Pacheco, Calif). Calibration was based on gravimetric water-content determinations of the soil that was added to the lysimeters when the trees were transplanted. The soil water extraction curve relating soil water potential to percent water was determined by pressure plate and pressure membrane techniques. This soil contained 15% water at field capacity and 4.8% at permanent wilt (-1500 kPa).

Evaporation from a Class A pan (E_{pan}) is a reasonably good predictor of water use by plants (Doorenbos and Pruitt, 1977; Worthington et al. 1984). Daily E_{pan} data were collected along with lysimeter weights. Effects of both E_{pan} and soil moisture were used in evaluation of tree response to water stress.

Lysimeters were labeled east and west based on their relative site location. Stress studies were initiated in mid-July 1982. The west lysimeter was maintained at field capacity, and the east lysimeter was allowed to dry. The two trees maintained similar daily ET values until the soil at the 30- and 60-cm levels reached the theoretical point of permanent wilt (Figs. 1 and 2). At this level of soil moisture, water use by the stressed tree dropped abruptly to $\approx 36\%$ that of the nonstressed tree. For the period of 19 to 23 July, the stressed tree was watered each night with an amount of water equal to its daily use to prevent possible loss of the tree. Little or no recovery from wilting was observed during the period of stress, even at dawn, and the trees were assumed to be at permanent wilt as defined by Brady (1984). By the 5th day of this stress period, many leaves had begun to yellow, and considerable exudation of gum appeared along the main scaffold branches.

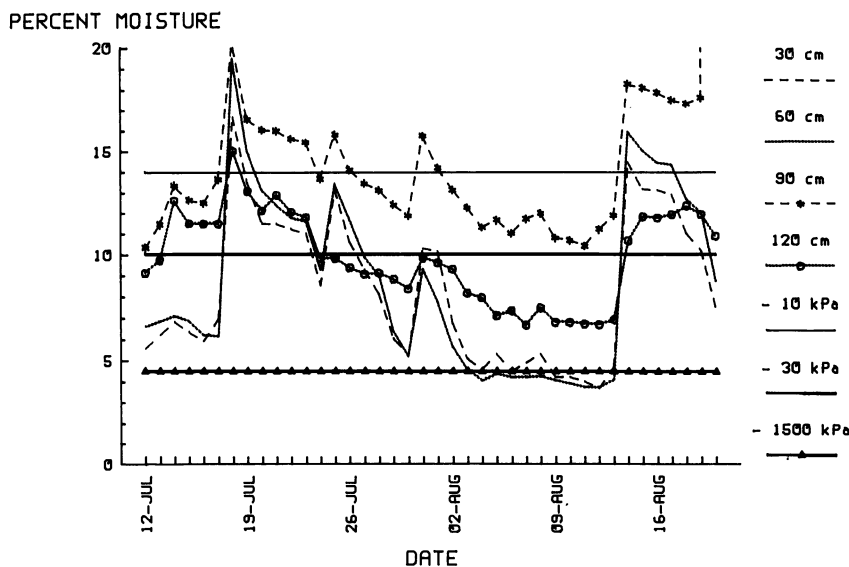


Fig. 3. Soil moisture (%) in west lysimeter as a function of time. (Distance from soil surface in centimeters; soil matric potential in kiloPascals.)

Table 2. Correlations between water use, soil moisture, and pan evaporation for lysimeter-grown trees during non-stress periods.

Parameter ^a	Parameter ^a				
	EUSE	WUSE	ESOIL	WSOIL	EVAP
EUSE	1.000				
WUSE	0.764**	1.000			
ESOIL	0.105	-0.067	1.000		
WSOIL	0.123	0.272	0.471	1.000	
EVAP	0.750**	0.803**	0.067	0.232	1.000

^aEUSE = east water use; WUSE = west water use; ESOIL = east soil moisture; WSOIL = west soil moisture; EVAP = pan evaporation.

**Significantly different than zero at the 99% confidence level.

Table 3. Correlations between water use, soil moisture, and pan evaporation for lysimeter-grown trees during stress periods.

West-stressed parameter	Parameter ^a					East-stressed parameter
	EVAP	WSOIL	ESOIL	WUSE	EUSE	
	1.000	0.845	0.915	-0.002	-0.715	EVAP
		1.000	-0.675	0.167	-0.675	WSOIL
EUSE	1.000		1.000	0.145	-0.673	ESOIL
WUSE	0.897**	1.000		1.000	-0.385	WUSE
ESOIL	-0.300	-0.027	1.000		1.000	EUSE
WSOIL	0.295	0.499	0.334	1.000		
EVAP	0.835**	0.611	-0.203	-0.018	1.000	
	EUSE	WUSE	ESOIL	WSOIL	EVAP	

^aEUSE = east water use; WUSE = west water use; ESOIL = east soil moisture; WSOIL = west soil moisture; EVAP = pan evaporation.

**Significantly different than zero at the 99% confidence level.

This treatment was terminated on the 5th stress day because the tree was beginning to shed leaves, and we believed that continued stress would jeopardize future tests.

To verify results of this test, both trees were watered on 24 July to eliminate stress and assure that both trees were again using comparable amounts of water. On 31 July, the west lysimeter was allowed to dry, while the east was watered daily to prevent stress (Figs. 1 and 3). By 4 Aug., soil matric potentials at 30 and 60 cm in the west lysimeter had reached -1500 kPa, and water use of the stressed tree dropped to about one-half that of the watered tree. For the duration of this study, water was applied to each tree

each evening to replace that day's use. During this stress period, there were several days of rainy, humid weather, during which neither tree used much water. The low evaporative demand permitted maintenance of the low soil moisture level for 10 days. Leaves yellowed as before, and were beginning to fall by the end of the stress period. This tree also began to exude sap from the main scaffolds.

Statistical evaluations of the data were made using the Systat program (Systat Inc., Evanston, Ill.). When all data points (stressed and nonstressed period) were included, correlation analysis (Snedecor and Cochran, 1973) indicated that ET was dependent on

both E_{pan} and soil moisture ($P = 0.01$). The value of r for the east lysimeter was 0.527 and 0.681 for the west (Table 1). When the period of severe stress was left out of the analysis, the dependence of ET on soil moisture was no longer significant, although it remained significantly dependent ($P = 0.01$) on E_{pan} (Table 2). During the period of stress for the east lysimeter, ET was not dependent on either soil moisture or E_{pan} (Table 3). During the second stress period (west lysimeter), ET was significantly affected by changes in E_{pan} , but not in soil moisture. During the second stress period (9 Aug.), there was a comparatively large change in evaporative demand brought on by a 9.6-mm rain. No comparable, large shift in pan evaporation occurred during the first stress period. Because we were able to extend the second stress period, and since we found a significant correlation between water use and pan evaporation in this second stress period (Table 3), we believe that even severe stress can be moderated by reduced evaporative demand.

One advantage of lysimeter studies is that the moisture status of the system can be changed quickly. On the other hand, there is little time for the trees to adapt to rapidly changing soil water status, either by the formation of new roots or physiological change, such as an adjustment in osmotic potential. While the trees went into severe stress about the time that soil moisture at the 30- and 60-cm levels reached permanent wilting point, there was still available moisture at 90 and 120 cm. Over the season, there were changes in the moisture levels at the 90- and 120-cm depths, and we assume that the tree roots had exploited these levels. With a more gradual decline in soil moisture, as might be expected in the field, trees could probably make better use of this available moisture.

Soil moisture at the 120-cm level was lower than that at 90 cm (Fig. 3). Readings from other access tubes used after this study was completed did not show this trend. Some of the pea gravel used to line the bottom of the lysimeter may have been inadvertently mixed into this profile, producing atypical readings.

In view of the work by Tan and Buttery (1982a, 1982b, 1986), there seems little doubt that under controlled-environment conditions, transpiration is reduced by declining soil moisture levels, even above the threshold of stomatal closure. This may be caused by sluggish opening of stomata in stressed trees (Punthakey et al., 1984). Under the conditions that prevailed for the duration of our study, other factors governing ET were so great that the influence of soil moisture was not significantly correlated to water use when matric potentials were above the permanent wilting point.

The data presented here indicate that, under rapidly changing soil moisture conditions, peach tree water use was relatively unaffected by availability of soil moisture until a distinct threshold (-1500 kPa soil matric potential) was reached. Once the soil matric potential went below this point, tran-

spiration was abruptly and drastically reduced. The effect of soil moisture stress on ET is probably an indirect effect of stomatal closing. This would be in keeping with the arguments for stomatal control of transpiration as outlined by Hsiao (1973) and Kramer (1983). The case for stomatal control of water use can also be made based on nighttime ET. While pan evaporation continues through the night at nearly the same rate as it does during daylight hours (Doorenbos and Pruitt, 1977), little if any water is lost to ET at night (Worthington et al., 1984). Even under the stress conditions reported here, when the stomata were closed at night, transpiration virtually stopped, regardless of the soil moisture status.

In this study, there was no indication of any lasting effect of stress, since both trees used similar amounts of water both before and after they were subjected to stress. The sap exuded as a response to stress weathered off during the dormant season, and trees in the lysimeters foliated and grew normally the 2 years following this study and symptoms were not observed again.

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Solar Heating Reduces Insect Infestations in Ripening and Drying Figs

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Additional index words. nitidulidae, *Carpophilus hemipterus*, Adriatic figs, Calimyrna figs, *Ficus carica*, disease

Abstract. Several experimental procedures were used to evaluate the influence of solar radiation on insect infestations in Calimyrna and Adriatic variety figs (*Ficus carica* L.). Direct sunlight eliminated infesting insects and prevented further infestation of ripe figs drying on the ground for at least 10 days. Placement in the shade resulted in 12% insect infestation in figs within 3 days. Figs that fell naturally into sunlit areas contained almost no insects, whereas 31% of figs that fell into dense shade were infested. While ripening figs were still attached to trees, the level of insect infestation was 50% higher on the shady north side than the sunny south side. The insect pests most frequently encountered in these experiments were nitidulid beetles and their larvae. Disease incidence was not affected by degree of exposure. We propose that cultural techniques to maximize exposure of ripening and drying figs to solar radiation could be developed as important pest management tools.

Commercial figs are attacked by a wide variety of insects and microorganisms. In the United States, most commercial figs are grown within a 200-km radius of Fresno, Ca., in the San Joaquin Valley. Figs ripen during July, August, and September under weather conditions that are favorable for rapid development of large populations of pest organisms.

The most commonly produced fig cultivar is Calimyrna. 'Calimyrna' figs are noted for high susceptibility to attack by many insect species and disease-inducing microorganisms. This susceptibility is due primarily to the prominent ostiole. The ostiole opens between mid-July and mid-August, allowing access to the ovule-packed interior of the fig syconium at a time when the fig is rapidly enlarging and undergoing final ripening.

Several fig cultivars in addition to 'Calimyrna' are grown. Many have less well developed ostioles than 'Calimyrna' and, presumably due to more effective blocking of insect and microorganism entry, less severe pest problems. However, in 'Adriatic'

figs, a prominent ostiole opens during the latter part of the ripening cycle and provides an entry port for pest organisms, giving rise to similar serious pest-invasion problems. Both types were studied in this investigation.

Problems attributable to insects and microorganisms are found not only during the time that figs are ripening on trees. Most figs are dried before sale. The first stage of this drying typically occurs on the ground beneath fig trees. Fig-harvesting operations differ widely in detail from ranch to ranch, but fully ripe figs typically are allowed to drop naturally from trees. The ripe figs usually dry under the trees for a week or more before being picked up by hand or machine. During this ground-drying period, the ostiole remains open allowing entry of insects and microorganisms.

Various investigators have catalogued pests that attack figs ripening on trees or drying on the ground. The most prominent insect species are nitidulid beetles, of which the most common are dried-fruit beetles, *Carpophilus hemipterus* (L.); confused sap beetles, *Carpophilus mutilatus* Erichs.; and yellow-brown sap beetles, *Haptoncus luteolus* Erichs. (11, 17). In addition to several other species of nitidulid beetles, frequently encountered insect pests of figs include flies of the genus *Drosophila*; the navel orange worm, *Paramyelois transiella* (Walker); and darkling beetles of the genus *Blapsitinus*. Disease-inducing microorganisms that attack figs include many different species of fungi, yeasts, and bacteria (8-10, 12). The diseases that develop are separated into two general categories by official inspectors of the industry-overseeing Dried Fig Advisory Board

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