Irrigation Scheduling

Use of reference ET (ET_o) and crop coefficients (K_c)

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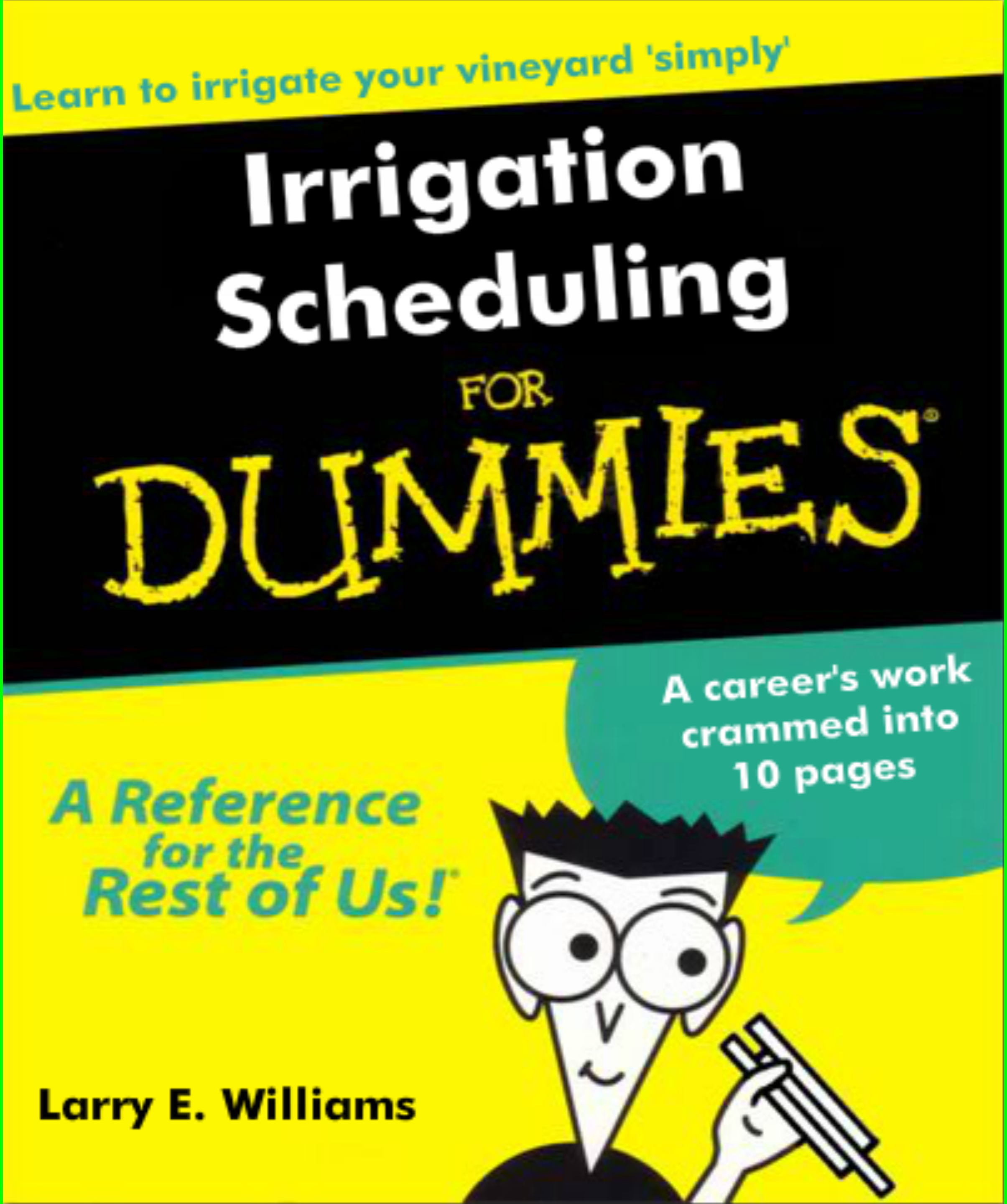
My Retirement Project



Important irrigation management decisions

- When should one initiate irrigations at the beginning of the season?
- How much water should one apply?
- How does the design of your irrigation system affect the ability to irrigate your vineyards?
- Are there deficit irrigation practices to minimize production loss and maximize fruit quality?

Summary: When to start irrigating

- In general, most of the physiological methods one can use are highly correlated with one another and with soil water content. I would use the one that is most convenient and that a person feels most comfortable with.
- I am of the opinion that any of methods (plant or soil based or even water budgeting based) could be used to determine when to initiate irrigation early in the season.
- Once the decision to irrigate has been made I would calculate ET_c using the product of ET_o and K_c.
- I would then irrigate at some fraction of ET_c using sustained deficit irrigation or regulated deficit irrigation.
- The fraction of ET_c used would be based upon previous experience in a particular vineyard and production goals.

Factors affecting vineyard water use (per land area).

- Evaporative demand
- Seasonal growth of the vine (function of temperature, i.e. degree days)
- Ultimate canopy size (trellis type)
- Spacing between rows
- Amount of water in the soil profile

Evaporative Demand

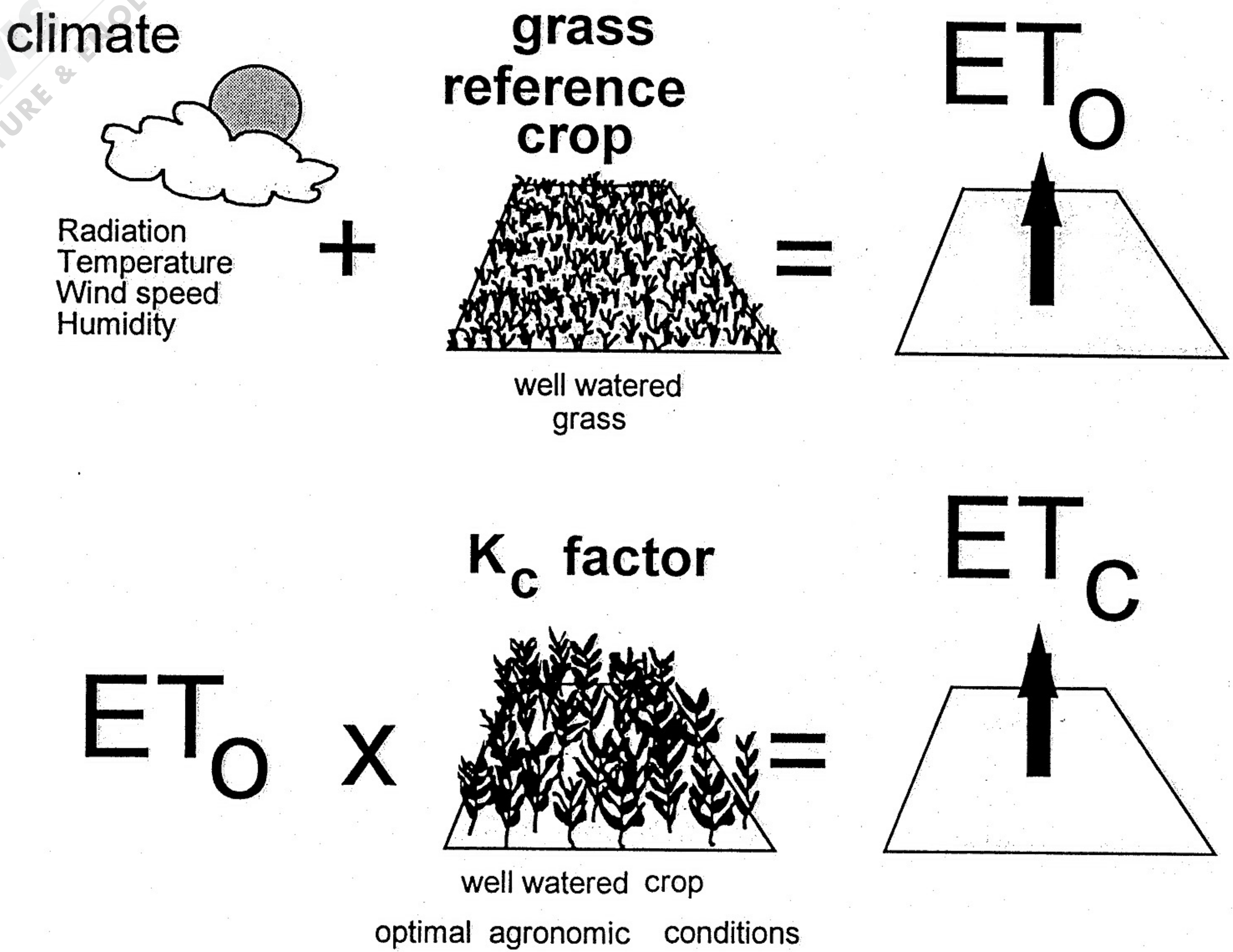
- It is a function of net radiation, vapor pressure deficit and wind.
- Reference evapotranspiration (ET_o) is used as a measure of evaporative demand.
- ET_o can be obtained from a CIMIS weather station or by other means.

The following equation can be used to calculate vine water requirements:

$$ET_c = ET_o \times K_c$$

where ET_c = vineyard evapotranspiration, ET_o = reference evapotranspiration (from CIMIS or elsewhere) and K_c = crop coefficient. It predicts ET of a **non-stressed crop** growing under optimum conditions.

The above equation will give water requirements in inches (one, acre inch = ~ 27,500 gallons per acre [43,560 ft^2]) (one mm covering one hectare = 10,000 L)



climate
Radiation
Temperature
Wind speed
Humidity
+
grass
reference
crop
well watered
grass
=
ET_O
ET_O
X
K_c factor
well watered crop
optimal agronomic conditions
=
ET_C

Crop Coefficient (K_c)

- The fraction of water used by a specific crop compared to that of ET_o at a given location
- $K_c = ET_c / ET_o$
- The K_c depends upon stage of crop development, degree of cover, crop height and canopy resistance.

Crop Coefficient (K_c)

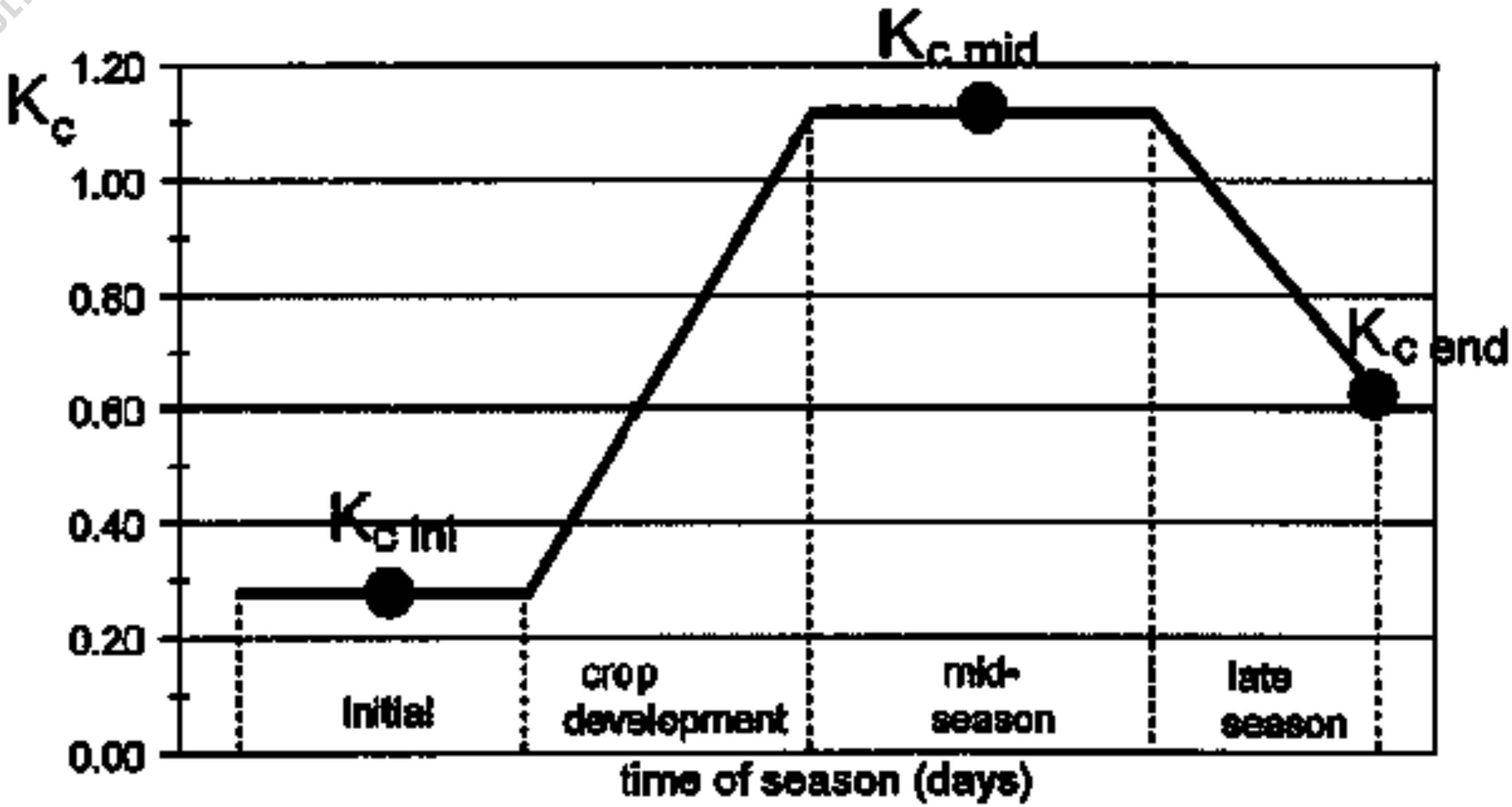
“The K_c value relates evapotranspiration of a disease-free crop grown in large fields under optimum soil water and fertility conditions and achieving full production potential under the given growing conditions.”

Doorenbos and Pruitt: Guidelines for predicting crop water requirements (FAO Irrigation and Drainage Paper, 24 (revised 1977))

Reliable crop coefficients should take the following into account:

- Seasonal growth of grapevines
- Final canopy size, which is a function of trellis design
- Row spacing (the closer the row spacing the greater the water use per acre)
- Possible differences in growth (canopy size) due to cultivar and/or rootstock

FIGURE 34. Crop coefficient curve



‘Using reference evapotranspiration (ET_o) and crop coefficients to estimate crop evapotranspiration (ET_c) for trees and vines’
Cooperative Extension, UC DANR
Leaflet 21428 (1987)
Synder et al.

SJV Grapes	------- Crop Coefficient --------		
Date of budbreak	K_c1	K_c2	K_c3
1 March	0.06	0.78	0.20
16 March	0.07	0.80	0.30
1 April	0.07	0.76	0.12

Note: Crop coefficients (K_c 1, 2 and 3) are based upon growth dates. The K_c values don’t differentiate among raisin, table grapes or wine grapes.

It was also stated in Leaflet 21428 that:

“Evapotranspiration rates depend on the percentage of ground shaded by a crop, and immature crops use less water. Ground shading is determined by subjectively estimating the percentage of ground area shaded by the crop canopy at midday during the midseason.”

Allen, Pereira, Raes and Smith (1998) Irrigation and Drainage Paper 56, United Nations FAO, Rome
'Crop evapotranspiration: guidelines for computing crop water requirements'

Grape Type	------- Crop Coefficient -------- $K_{c\ ini}$	$K_{c\ mid}$	$K_{c\ end}$ --------	height (m)
Table or raisins	0.30	0.85	0.45	2.0
Wine grapes	0.30	0.70	0.45	1.5 – 2.0

Doorenbos and Pruitt: Guidelines for predicting crop water requirements (FAO Irrigation and Drainage Paper, 24 (revised 1977))

"The K_c value for grapes will vary considerably with cultural practices such as vine and row spacing, pruning, trellising height and span and with extreme varietal differences in vine growth. Grapes are normally clean cultivated, use less water than many other crops due to cultural practices resulting in a 30 to 50 percent cover. Also there may be a somewhat greater degree of stomatal control of transpiration compared to many other crops."

My estimate of a maximum K_c based on a ground cover of 30 to 50% would be 0.51 to 0.85.

Allen and Pereira (2009) Irrigation Science 28:17-34 'Estimating crop coefficients from fraction of ground cover and height'

Grape Type	Ground Cover	--------- Crop Coefficient ----------		
Table or raisins		$K_{c\ ini}$	$K_{c\ mid}$	$K_{c\ end}$
High density*	0.70	0.30	1.10 (1.19)***	0.85
Medium density	0.50	0.30	0.70 (0.85)***	0.45
Low/young	0.25	0.30	0.60 (0.43)***	0.50
Wine grapes**		$K_{c\ ini}$	$K_{c\ mid}$	$K_{c\ end}$
High density	0.70	0.30	0.75	0.60
Medium density	0.50	0.30	0.70	0.55
Low/young	0.25	0.30	0.45	0.40

* Values in this row are from vines in the lysimeter at Kearney

**The $K_{c\ mid}$ and $K_{c\ end}$ values include an implicit K_s (stress) factor of about 0.7

***My estimates of K_{cmid} based upon ground cover.

Methods to measure ET in the vineyard

Micro-meterological and other techniques are used to calculate ET:

a.) Bowen ratio

b.) Surface renewal

c.) Eddy covariance

d.) Soil water budget

e.) Lysimeter


Access tubes

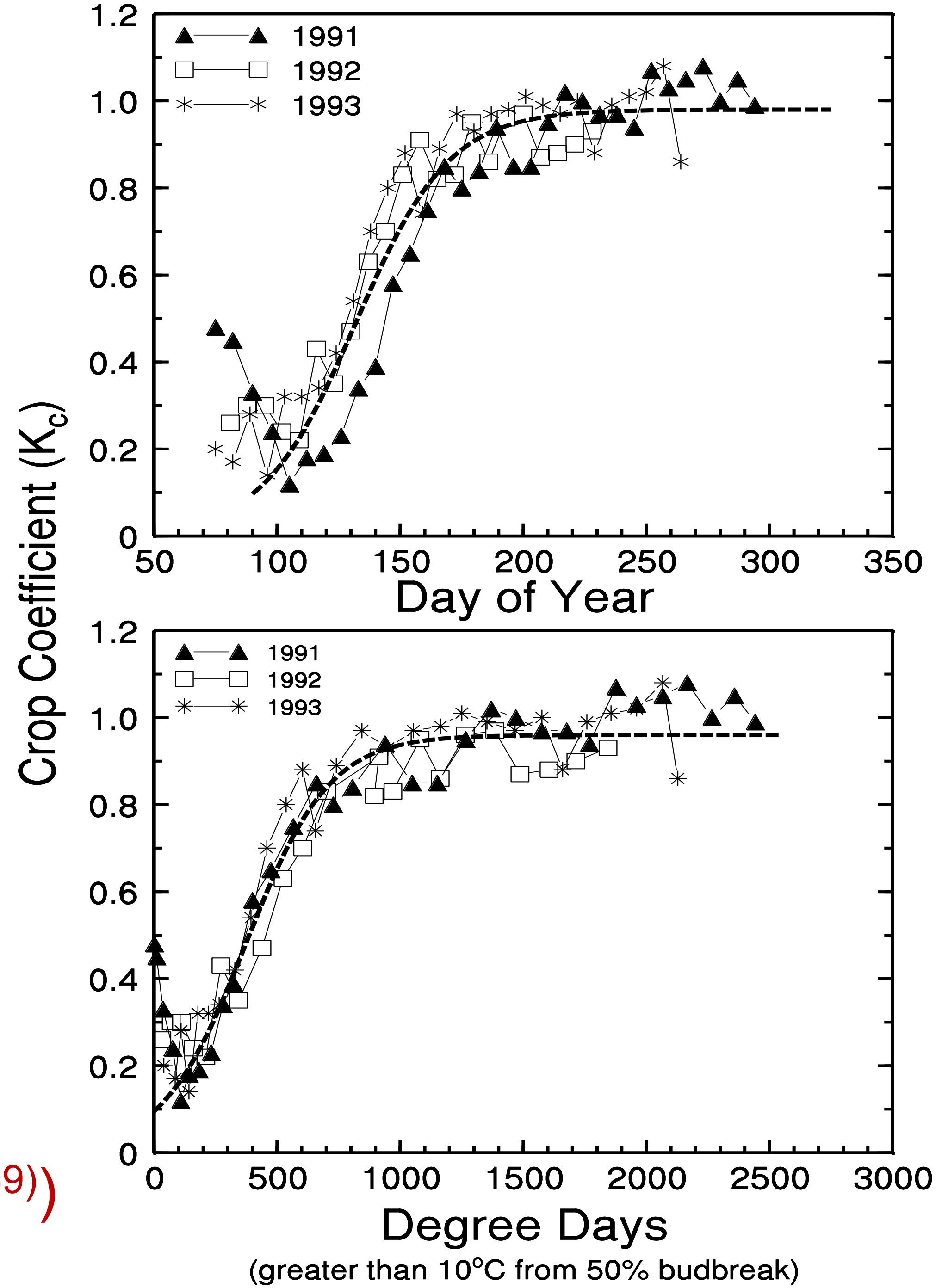
ET_c determined with a weighing lysimeter.
ET_o obtained from CIMIS station at KARE Center.

$$K_c = ET_c / ET_o$$

Leafhopper populations were not controlled in the vineyard and the vines were almost defoliated by the end of September the last year of the study.

$$y = 0.96/(1 + e^{(-(x - 373/169))})$$

where x = degree days



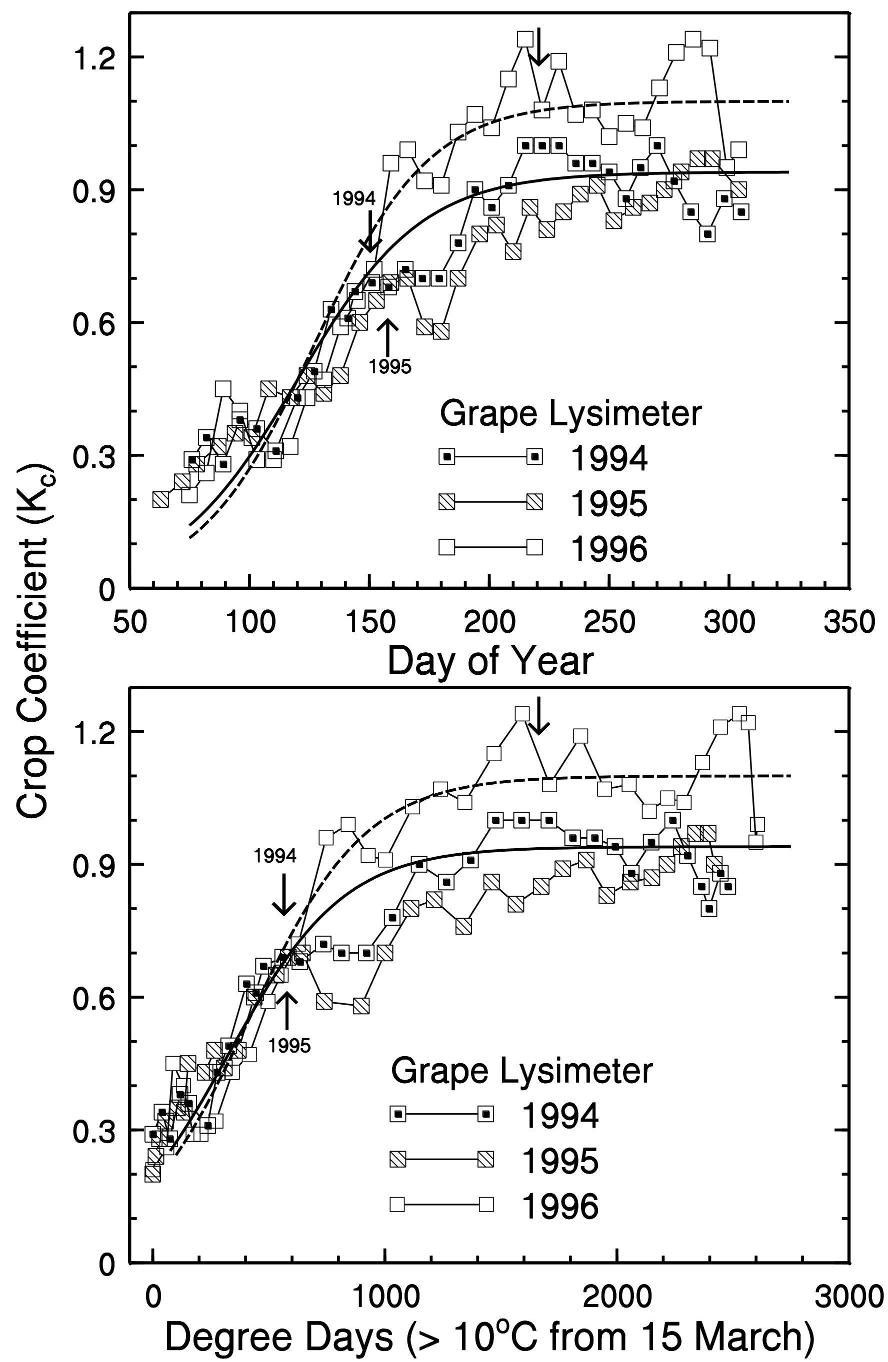
ET_c determined with a weighing lysimeter.
ET_o obtained from CIMIS station at KARE Center.

$$K_c = ET_c / ET_o$$

Leafhopper populations were controlled in the vineyard all three years and the K_c remained high until the end of the irrigation season.

$$y = 0.94/(1 + e^{(-(x - 325/250))})$$
$$y = 1.10/(1 + e^{(-(x - 415/2500))})$$

where x = degree days

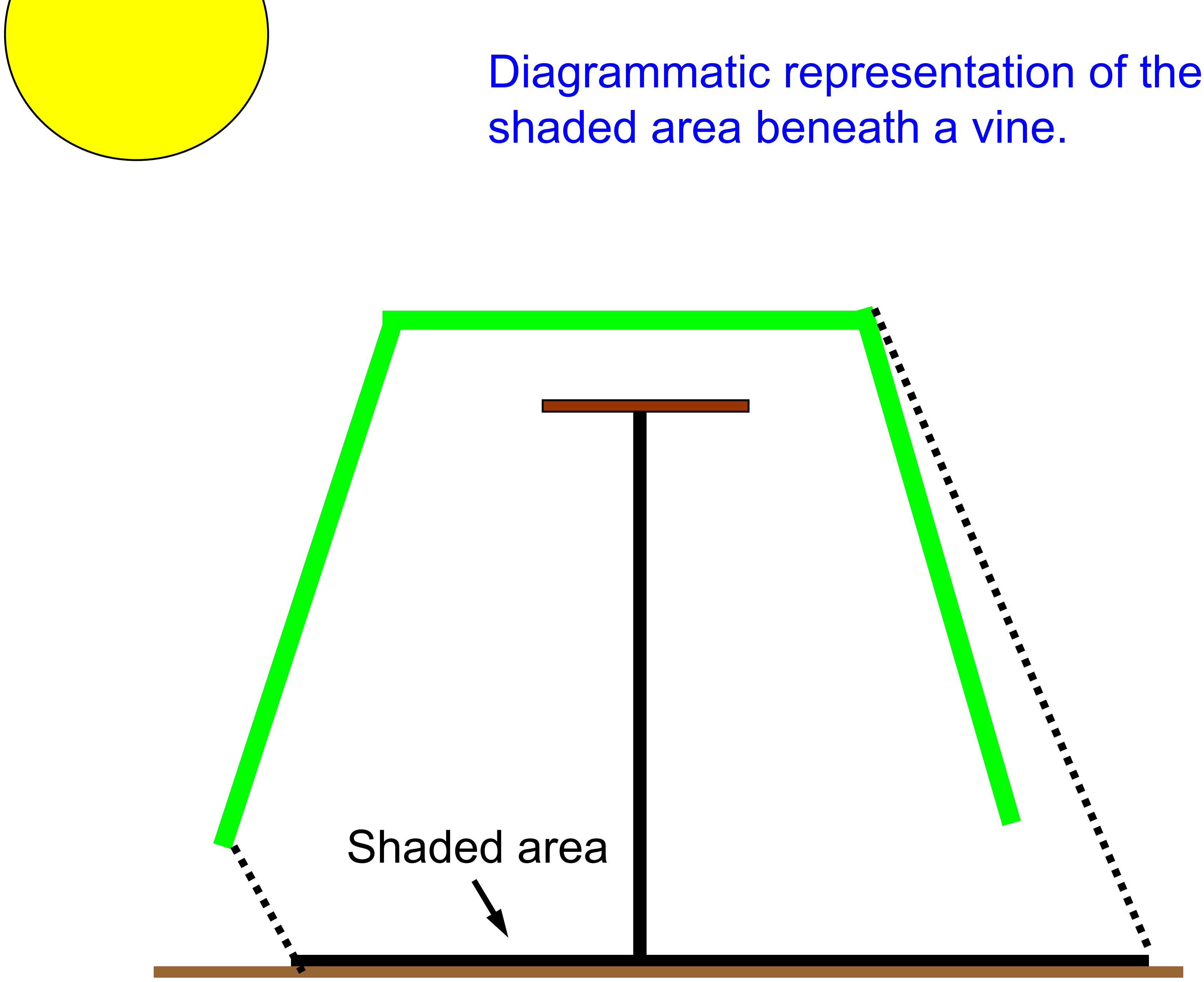


Based upon the previous slide and data collected on Chardonnay grown in the Carneros region, the K_c does not decrease from harvest to the end of the irrigation season (30 October) if the vines are being irrigated with applied water amounts close to 100% of ET_c.

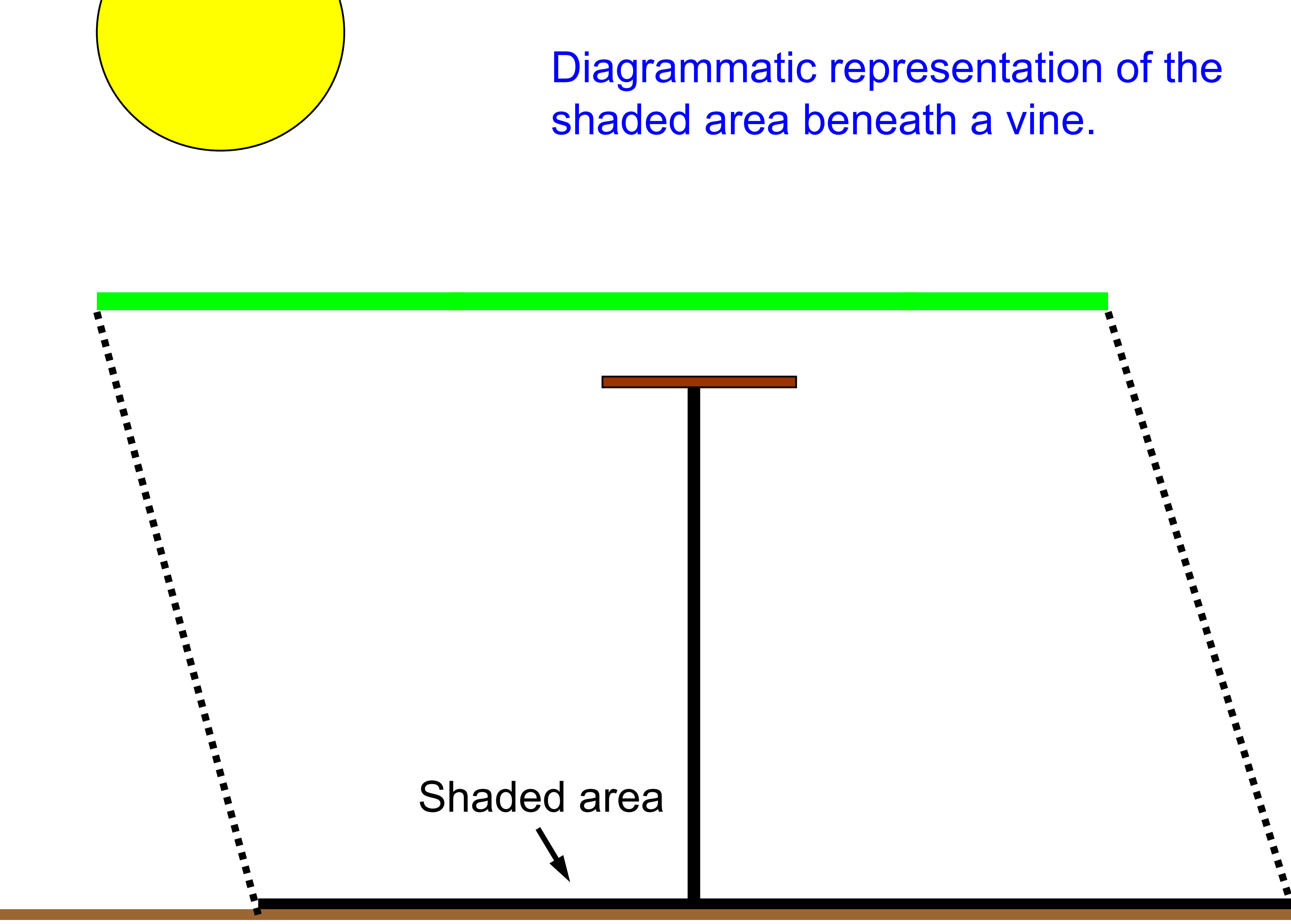
Technique for estimating crop coefficients (K_c) for vineyards. Using data from a weighing lysimeter at the Kearney Agric. Research and Extension Center.

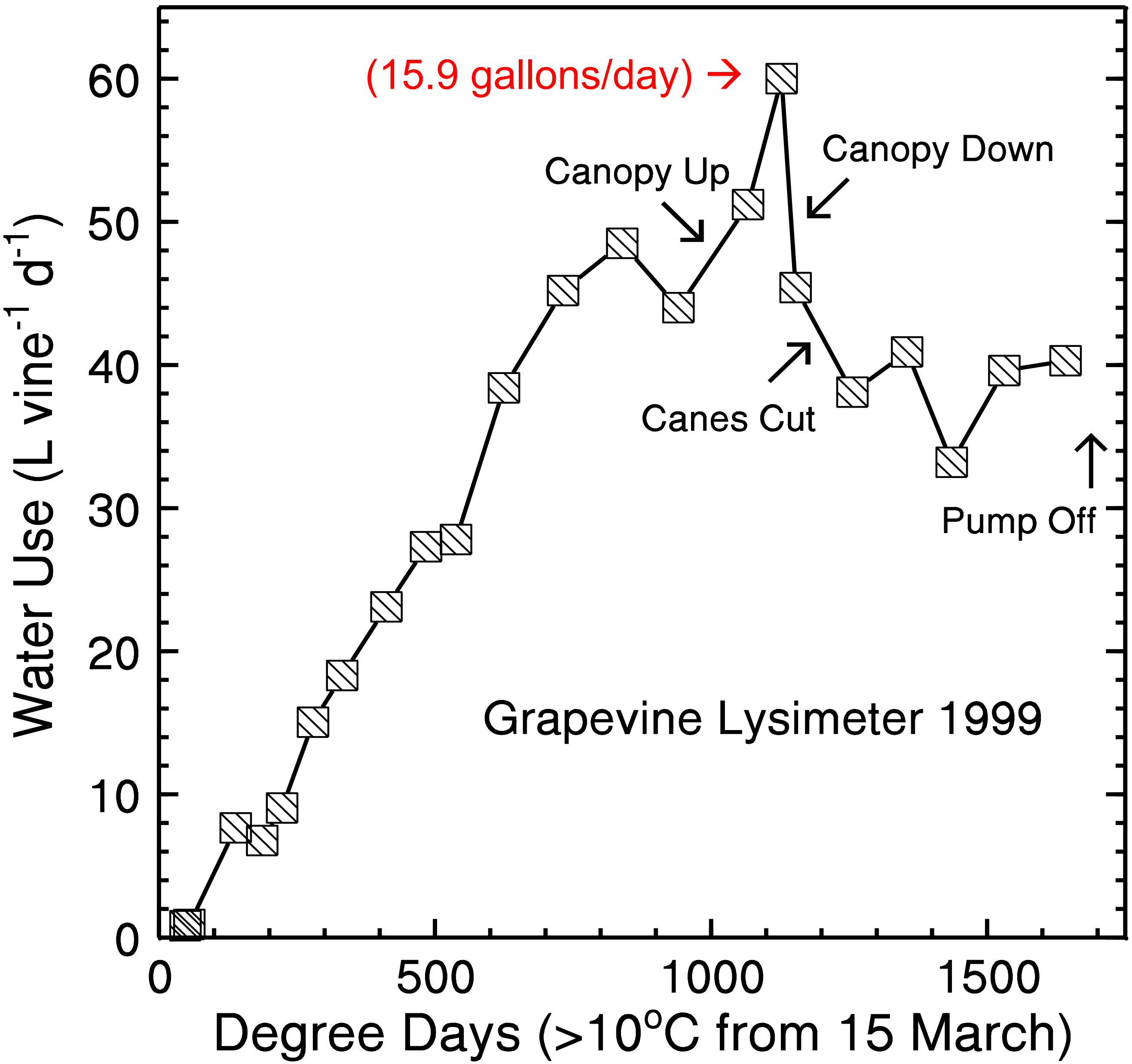
Williams and Ayars (2005) Agric. For. Meteor. 132:201-211.

Diagrammatic representation of the shaded area beneath a vine.

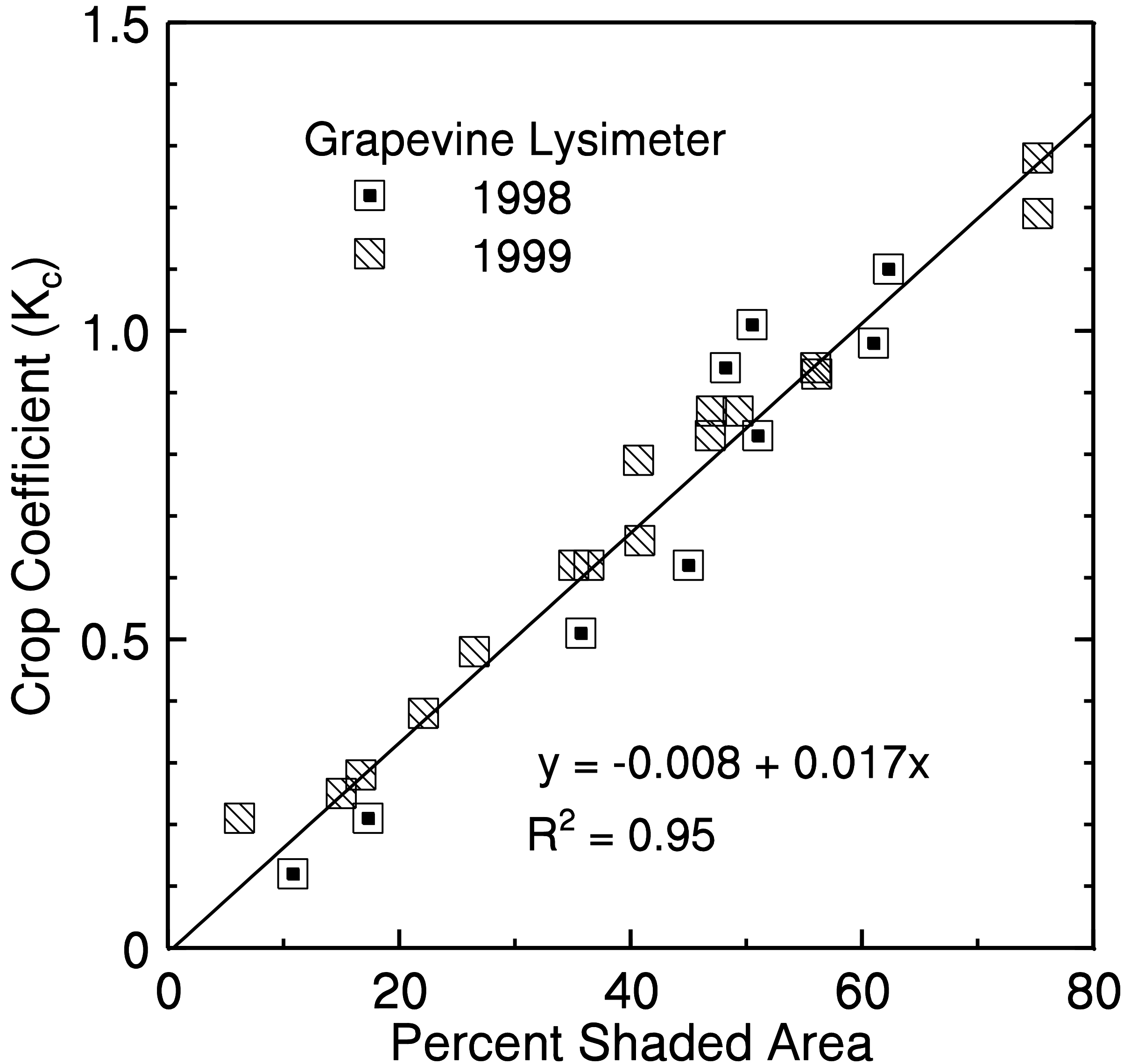


Diagrammatic representation of the shaded area beneath a vine.

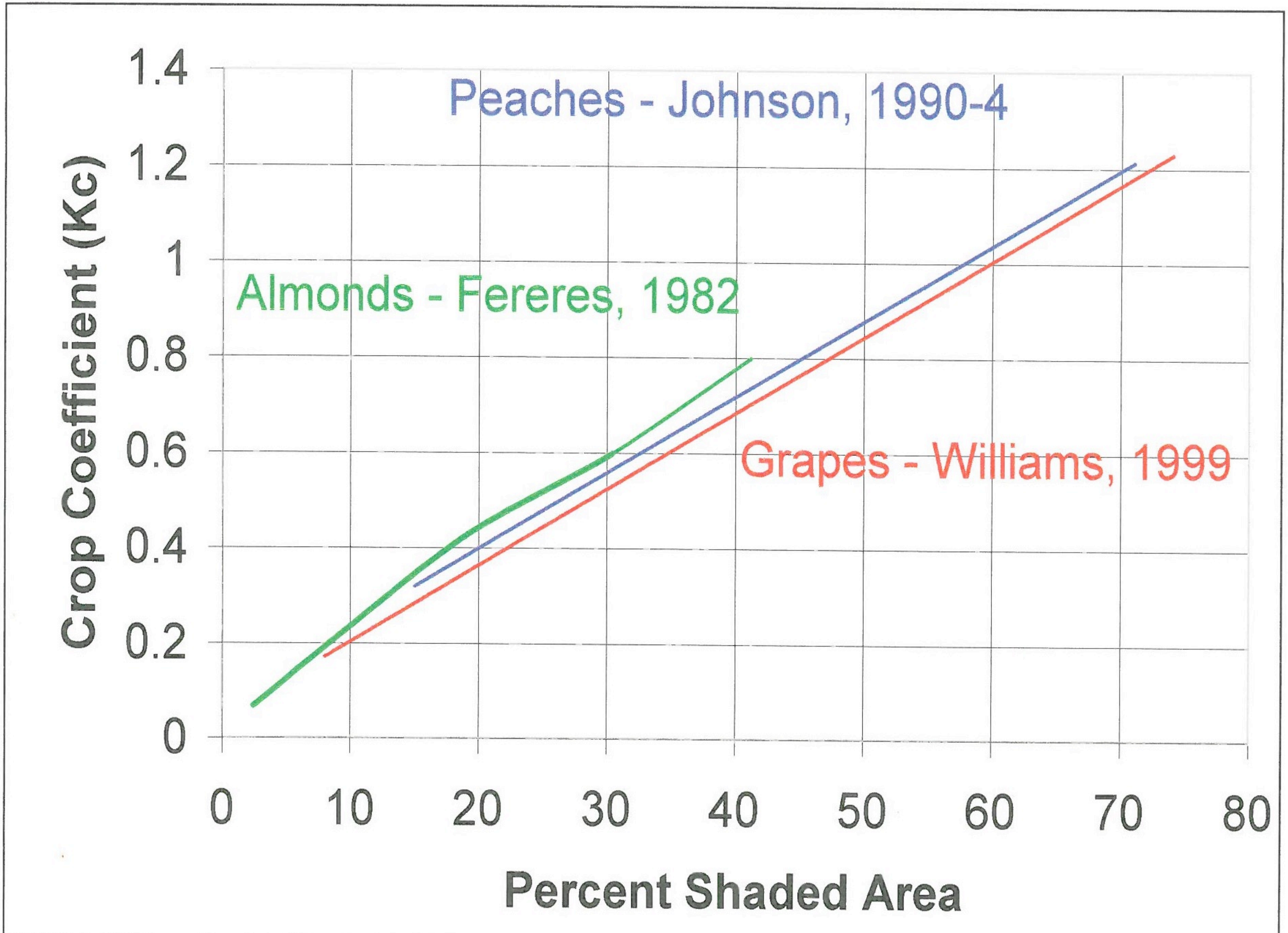




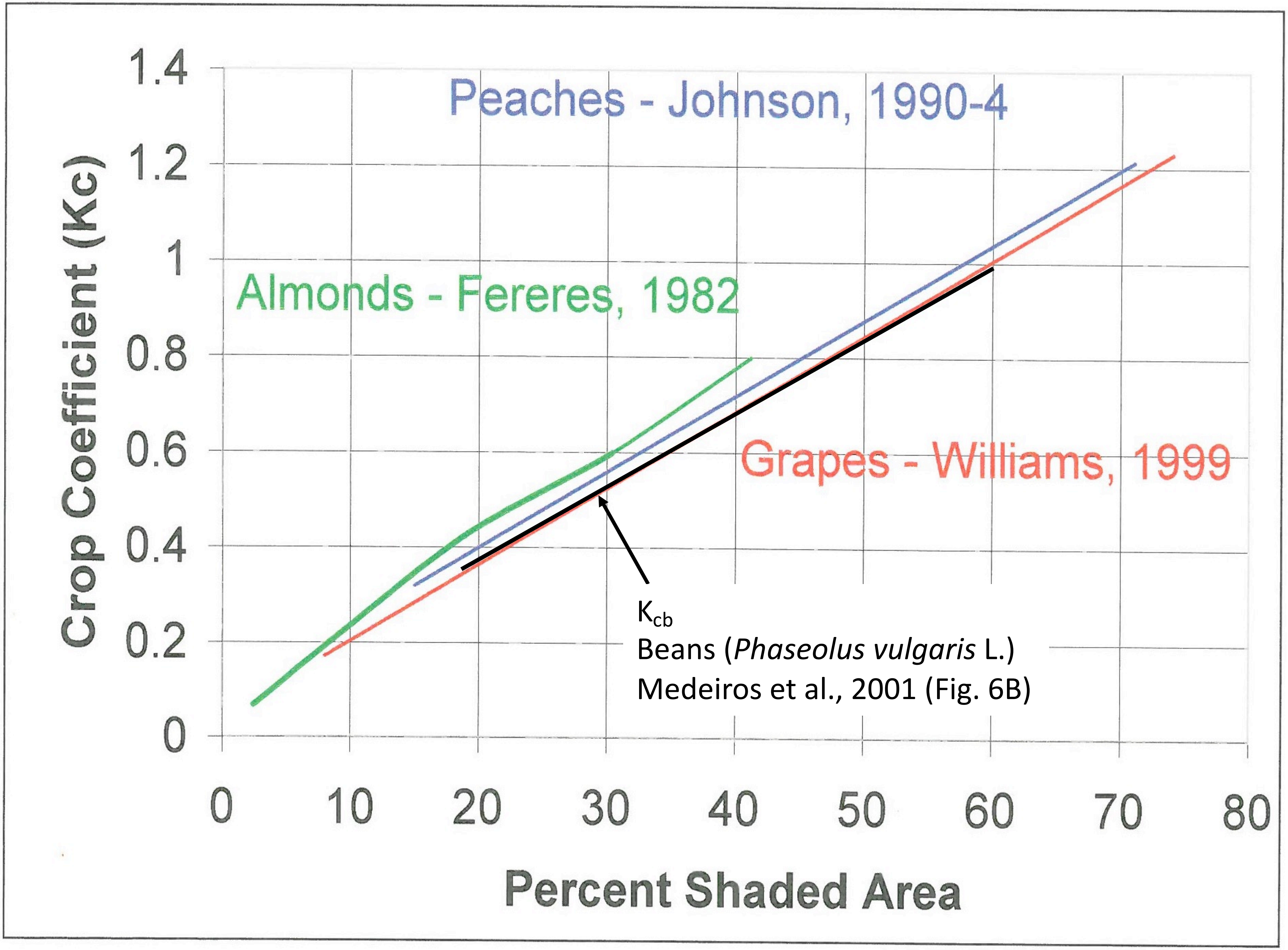
Conclusion: It is the orientation of the canopy and not leaf area or LAI per se that determines grapevine water use under these conditions



Williams and Ayars (2005) Agric. For. Meteor. 132:201-211.



Peaches - Johnson, 1990-4
Almonds - Fereres, 1982
Grapes - Williams, 1999
Crop Coefficient (Kc)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
Percent Shaded Area



Crop Coefficient (Kc)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Peaches - Johnson, 1990-4
Almonds - Fereres, 1982
Grapes - Williams, 1999
K_{cb}
Beans (*Phaseolus vulgaris* L.)
Medeiros et al., 2001 (Fig. 6B)
0
10
20
30
40
50
60
70
80
Percent Shaded Area

Other estimates of K_cs using ground cover

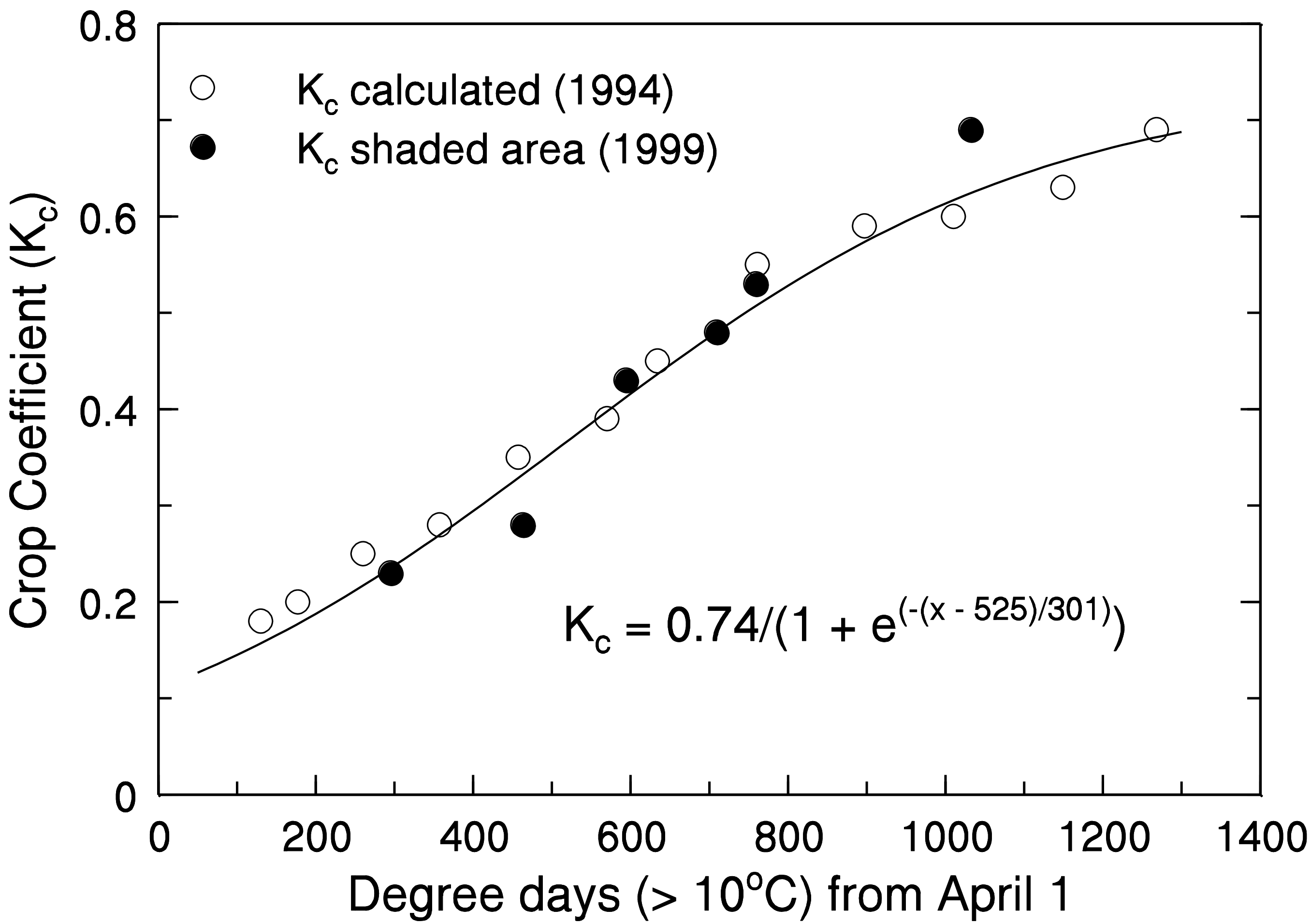
- Ayars et al. (2003) Irrig. Sci. 22, 187–194. The estimated slope would be 0.0159. (peach trees with weighing lysimeter)
- Stevens and Harvey (1996). Aust. J. Grape Wine Res. 2, 155–162. The estimated slope would be 0.018. (Colombard using water balance technique)
- Picón-Toro et al. (2012) Irrig. Sci. 30:419-432; $K_c = 0.07 + 0.02x$; $R^2 = 0.88$) (weighing lysimeter)
- López-Urrea et al. (2012) Agric. Water Man. 112:13-20; $K_c = -0.024 + 0.017x$; $R^2 = 0.99$ in 2007 and $-0.088 + 0.017x$; $R^2 = 0.97$ in 2009) (weighing lysimeter)
- Ferreira et al. (2012) Irrig. Sci. 30:433-447; $K_c = 0.076 + 0.019x$.

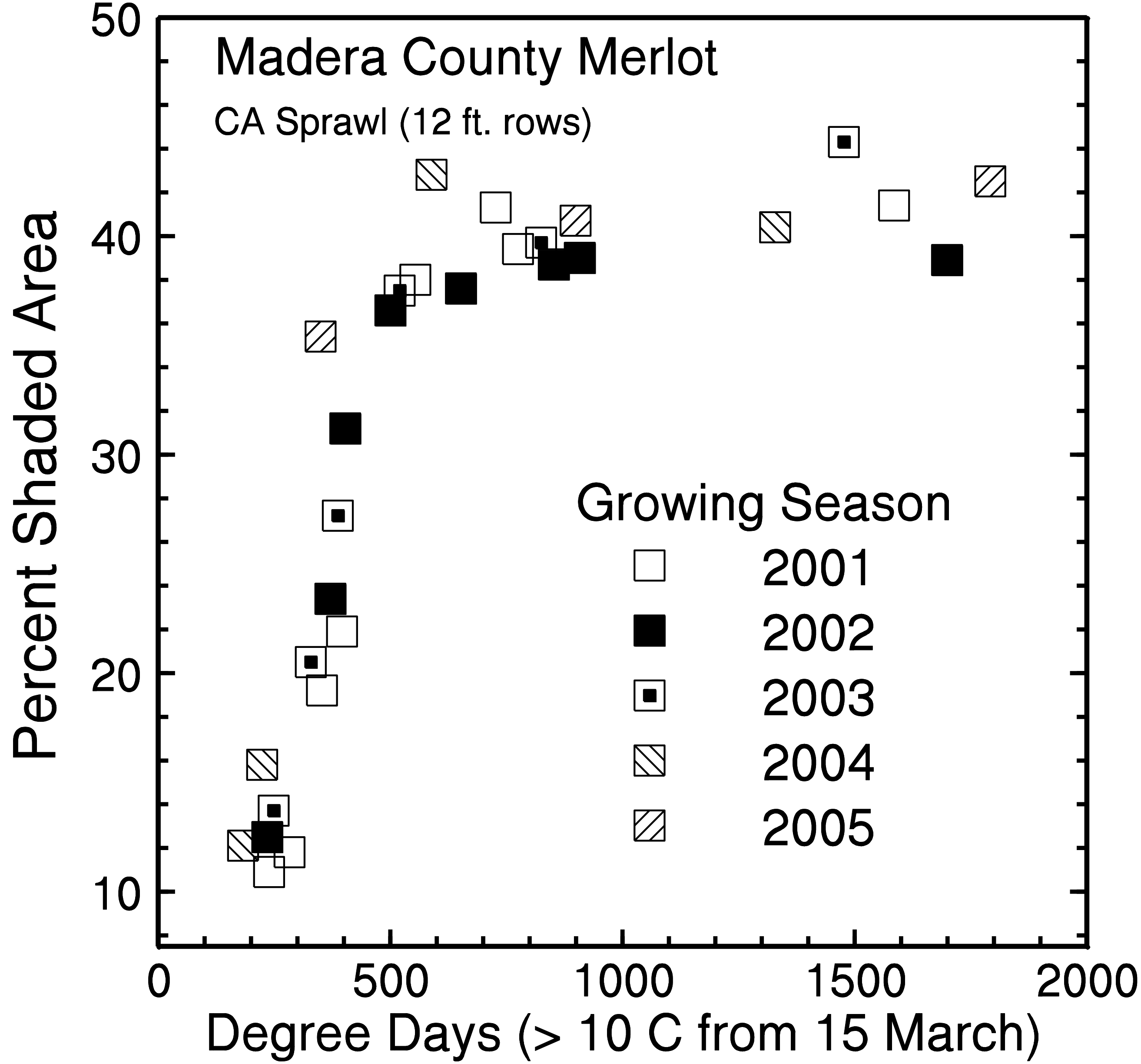
"It can be concluded that measuring canopy cover is a reliable approach to estimate K_c values in grapevines. The use of growing degree-days should improve the precision of the estimate by removing year to year variation in crop development."

López-Urrea et al. (2012) Agric. Water Man. 112:13-20.

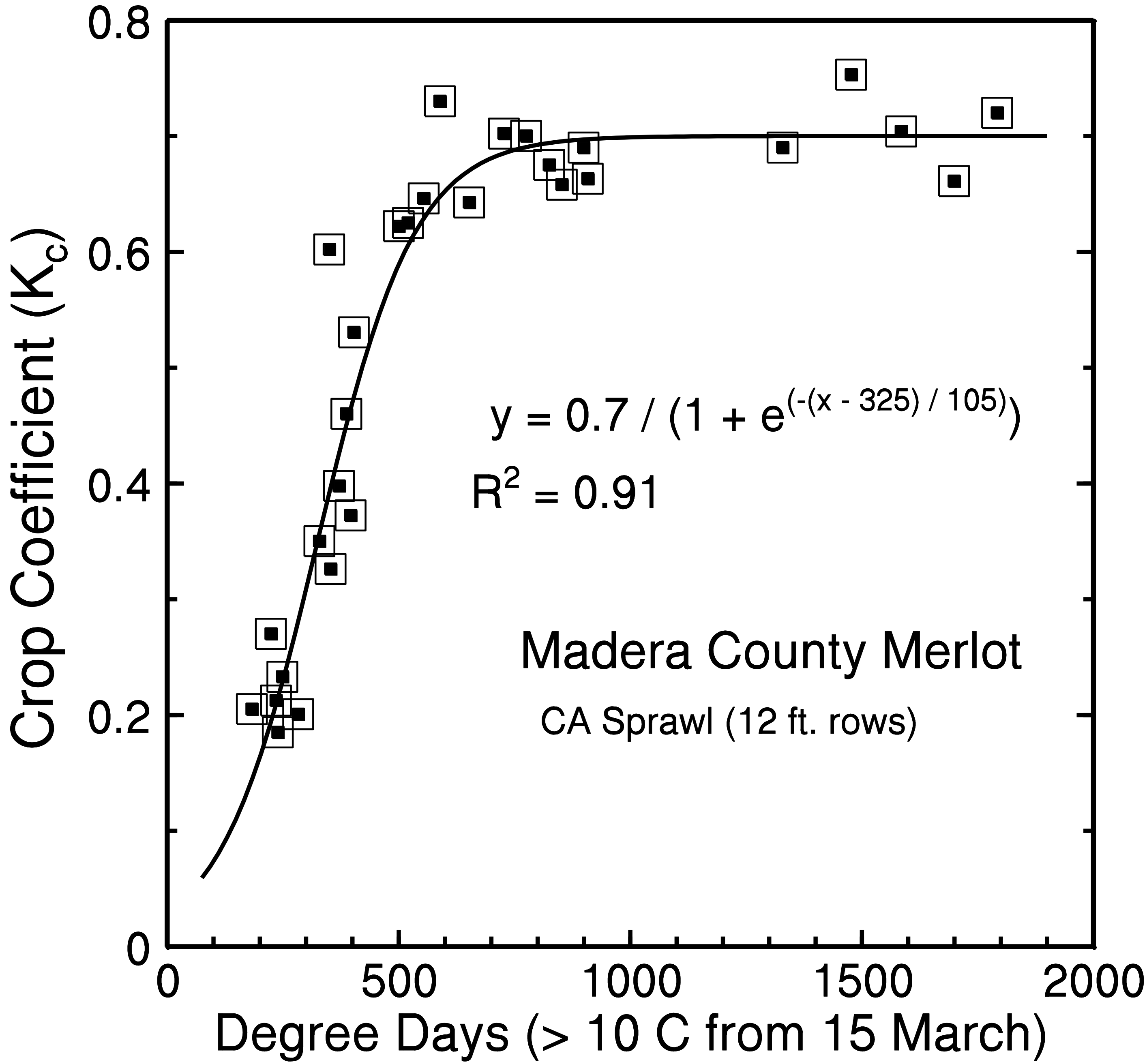
Maybe you don't actually need to measure ET_c to come up with reliable estimates of crop coefficients in vineyards!

Seasonal crop coefficient developed in Carneros using the soil water budget method for VSP trained Chardonnay vines in 1994 on a 2.13 m row spacing. The black circles represent K_cs calculated from shaded area. Note that the maximum K_c is 0.74. The line represents a regression through the data points from 1994. Starting date is 1 April.





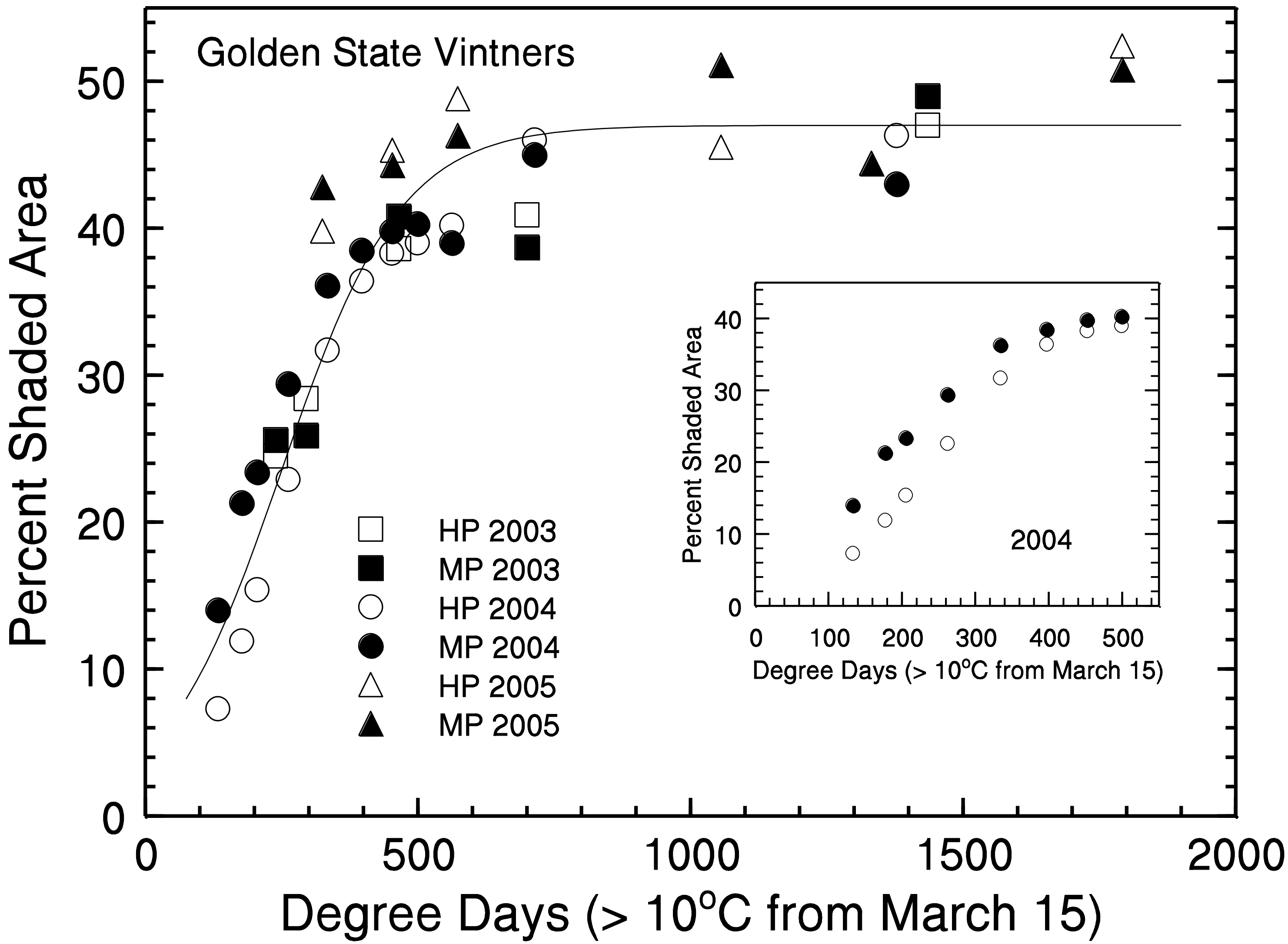
Shaded area measured under vines that were irrigated at 1.2 of estimated ET_c.
Based upon measurements of g_s and Ψ_{leaf} vines were not stressed for water.



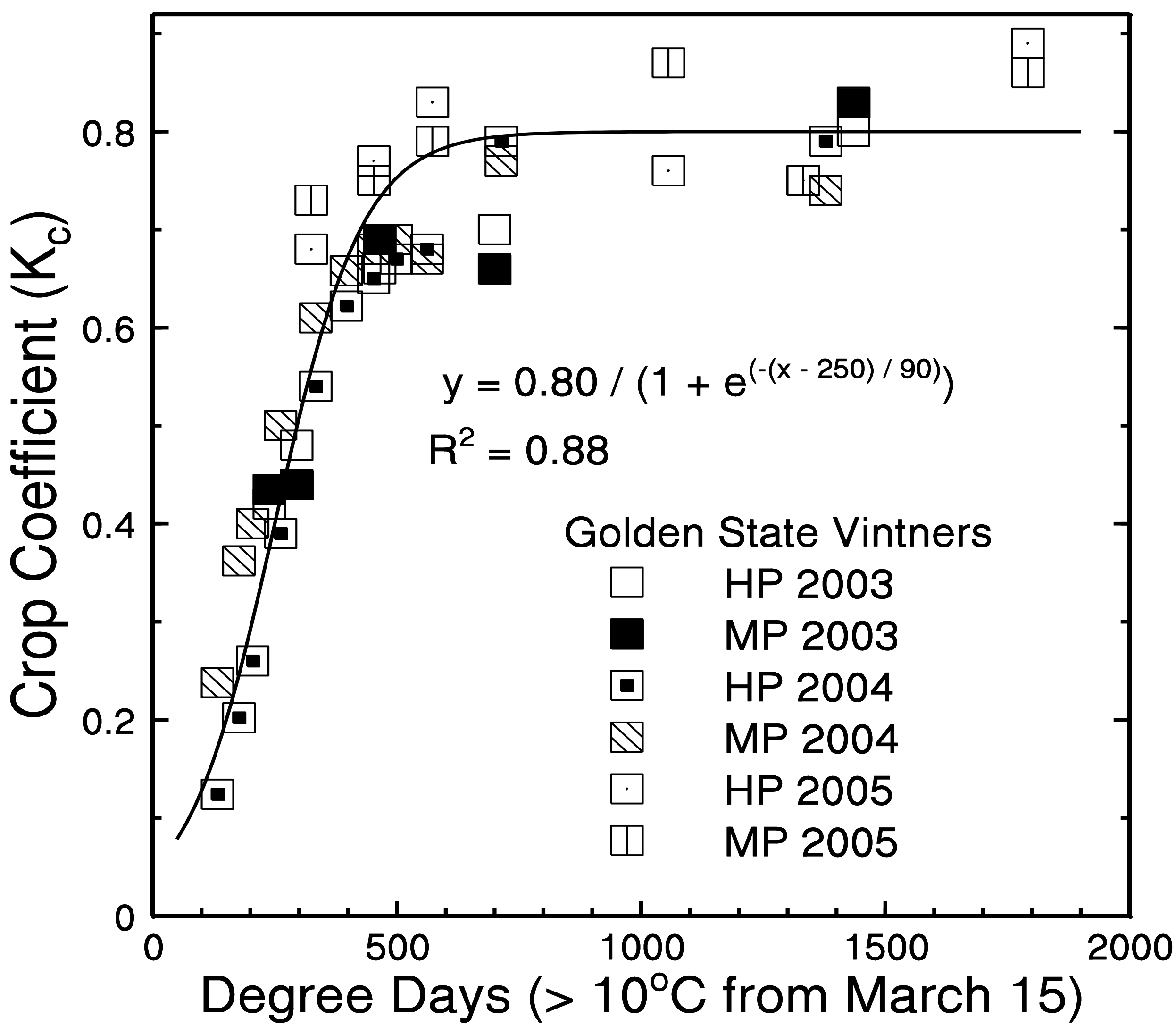
Max K_c:
11 ft row = 0.76
10 ft row = 0.84

Cultural practices that may affect vine water use:

Differences in pruning type (hand vs. minimal) – any practice that affects the rate of canopy development or total amount of canopy will affect water use.



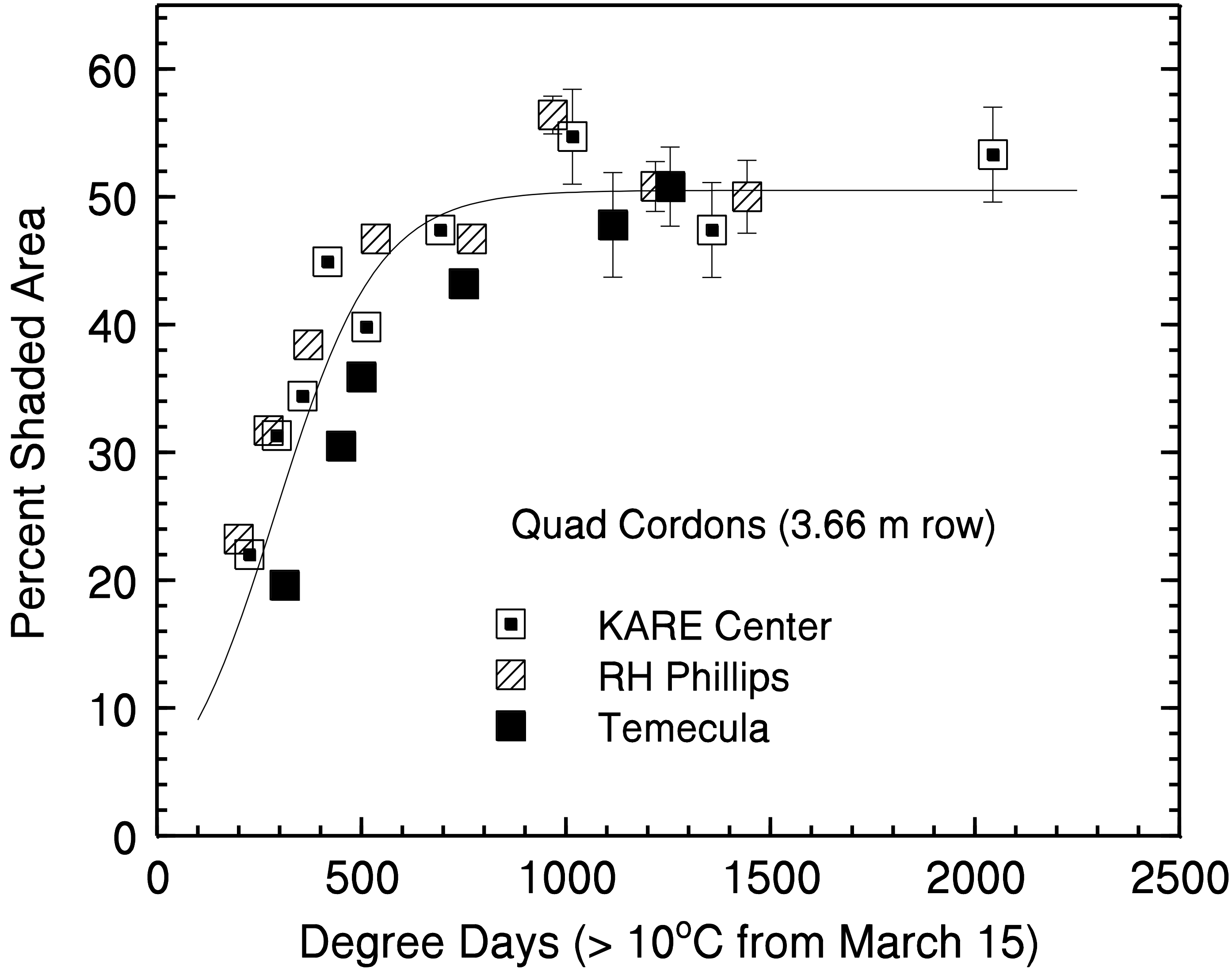
Percent shaded area as a function of degree days for Syrah grapevines grown near Fresno for 3 years. HP and MP refer to vines either hand or machine pruned, respectively.



Estimated seasonal K_c as a function of degree days for Syrah grapevines grown near Fresno for 3 years. HP and MP refer to vines either hand or machine pruned, respectively.

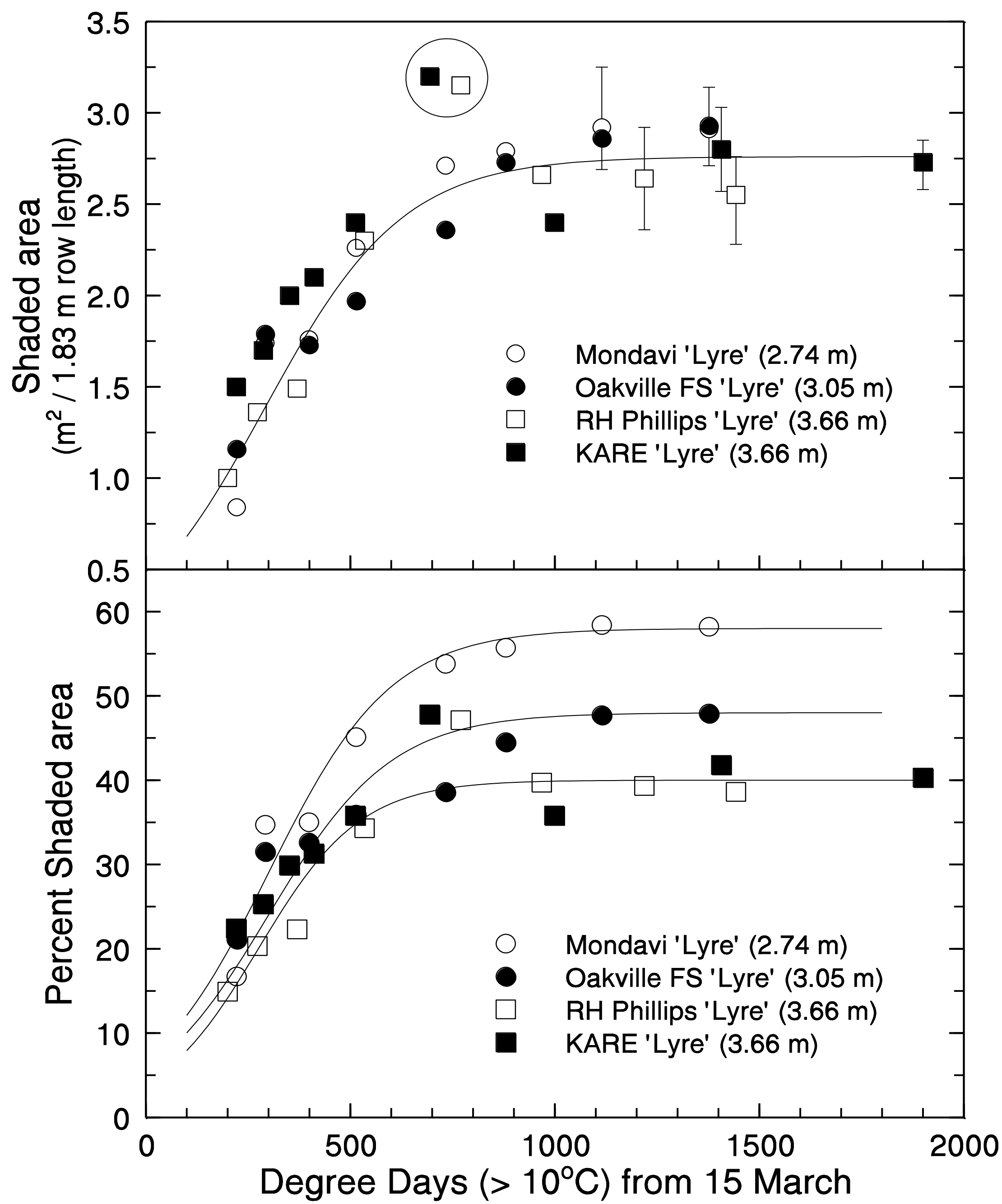
Cultural practices that may affect vine water use:

How great are differences in canopy coverage among vineyards as a function of location and/or owner with the same trellis and training system?



The percent shaded area measured beneath vines in three vineyards trained to quadrilateral cordons on 3.66 m rows. Data were collected in 2000 in the KARE and RH Phillips vineyards and in 1998 and 1999 at Temecula. The data were fit to the following equation: $y = 50.5/ (1 + e^{(-(x-290)/125)})$, $R^2 = 0.79^{***}$. Bars represent one SD.

The amount of shade measured beneath grapevines at solar noon trained to a Lyre trellis at four locations across the growing season (2000) and normalized for a vine spacing down the row of 1.83 m (upper graph). The lower graph is the seasonal progression of the percent shaded area in each vineyard as a function of row spacing (row width in parentheses). The circled data points (upper graph) were measurements taken before the vines were hedged and not included in the regression. The equation for the shaded area: $y = 2.76/(1 + e^{(-(x-290)/170)})$, $R^2 = 0.90$***.



Lysimeter covered with plastic to minimize soil water evaporation.

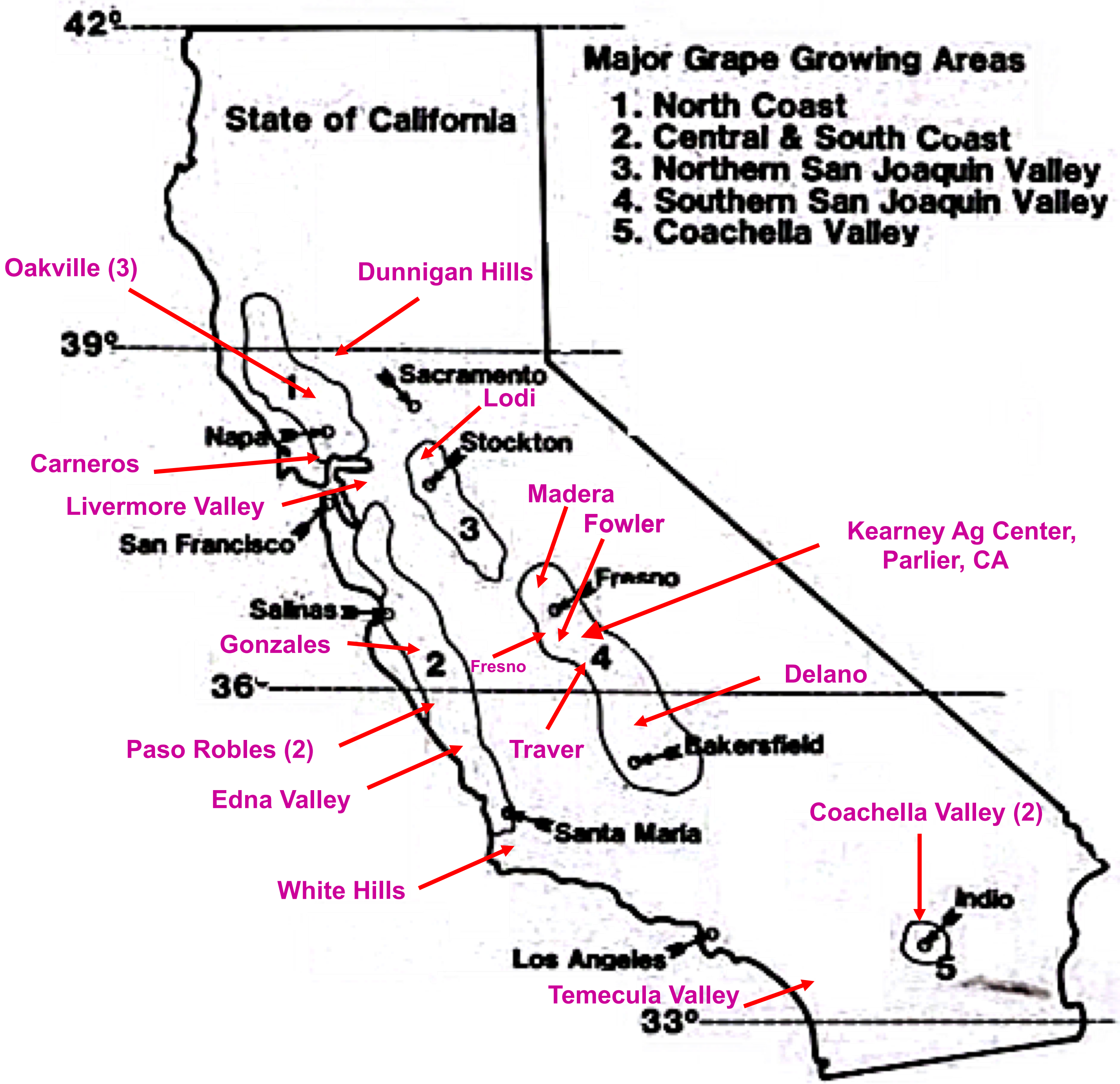
Also measured sap flow.

What percentage of ET_c is E or soil evaporation?

What percentage of ET_c is E or soil evaporation?

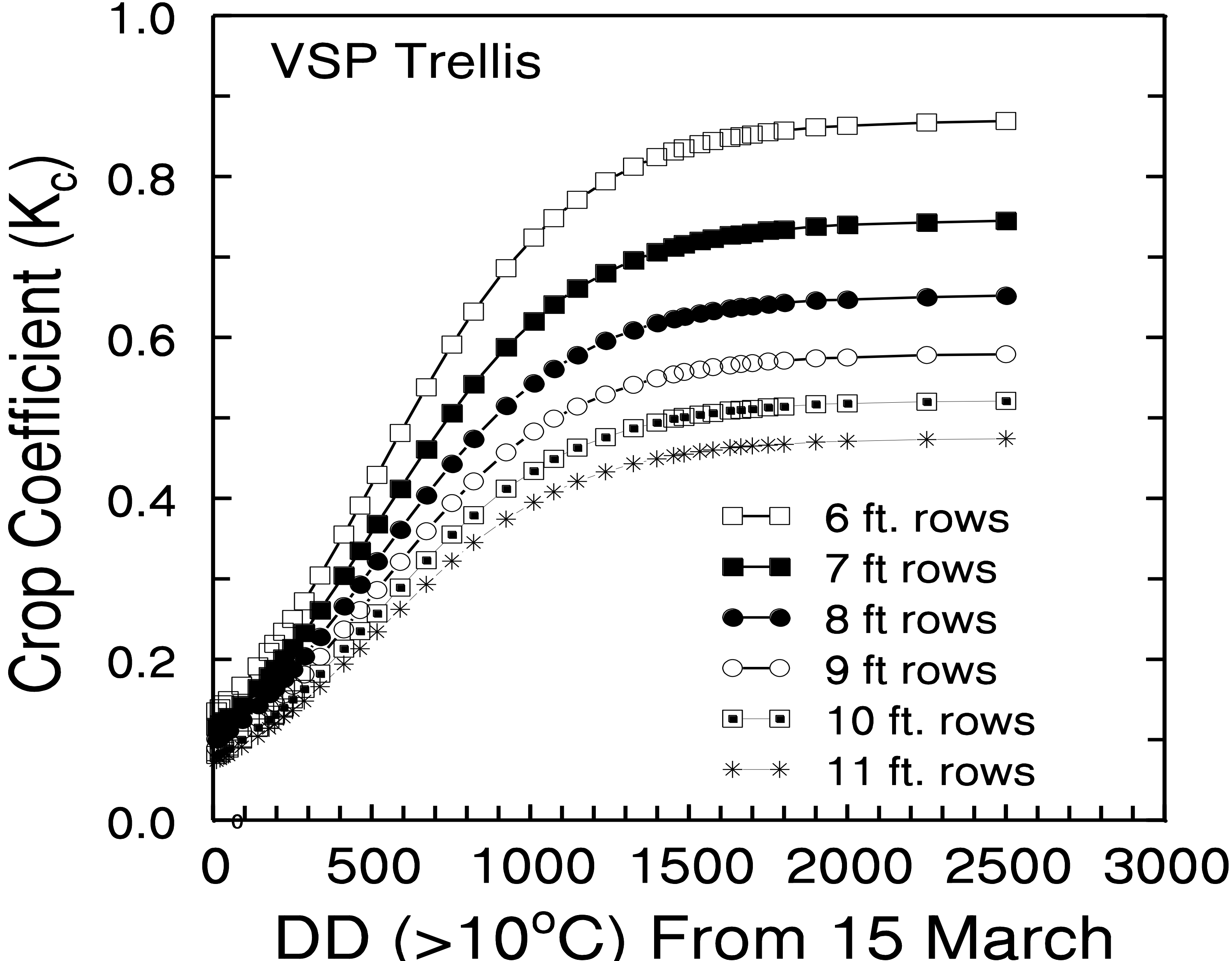
- Lysimeter's soil surface was covered with plastic numerous times during the 2009 growing season (6 June to 14 Sept.).
- Grapevine water use was reduced ~ 11% when the soil was covered with plastic compared to bare soil (5.64 vs. 6.36 mm/day).
- The K_c was reduced from an average of 1.07 to 0.93 (13% reduction) over the 100 day period mid-season.
- This would be called the K_{cb} (basal crop coefficient).

Once you have measured shaded area throughout the growing season, you shouldn’t have to measure it each year if it is plotted versus thermal time (degree-days).



State of California
Major Grape Growing Areas
1. North Coast
2. Central & South Coast
3. Northern San Joaquin Valley
4. Southern San Joaquin Valley
5. Coachella Valley
42°
39°
36°
33°
Oakville (3)
Dunnigan Hills
Sacramento
Lodi
Stockton
Napa
Carneros
Livermore Valley
San Francisco
Madera
Fowler
Fresno
Kearney Ag Center, Parlier, CA
Salinas
Gonzales
Fresno
Delano
Paso Robles (2)
Traver
Bakersfield
Edna Valley
Santa Maria
Coachella Valley (2)
White Hills
Indio
Los Angeles
Temecula Valley
1
2
3
4
5

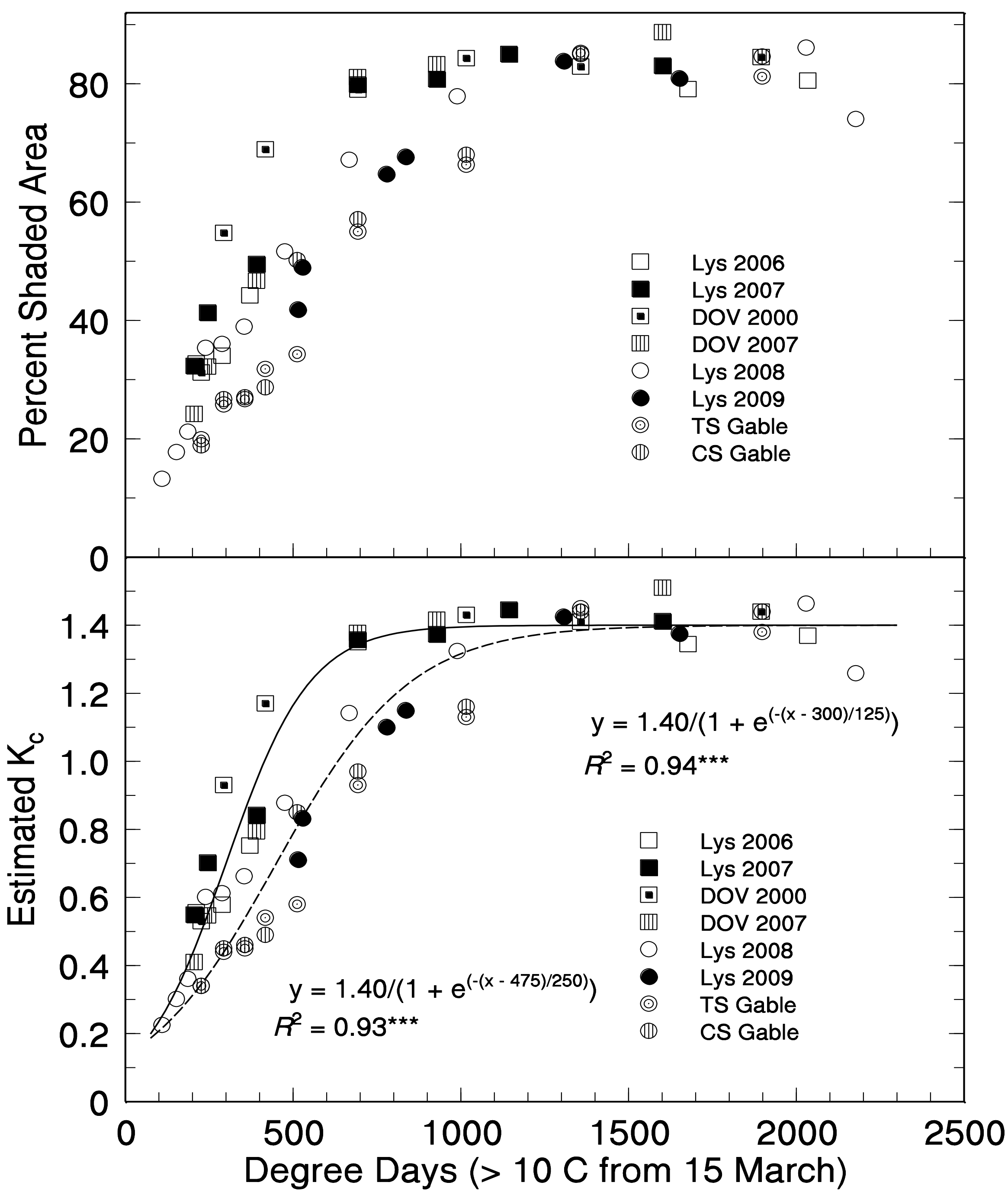
Several canopy types in Viticulture



VSP Trellis
Crop Coefficient (K$_c$)
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
2000
2500
3000
DD (>10^{o}C) From 15 March
6 ft. rows
7 ft rows
8 ft rows
9 ft rows
10 ft. rows
11 ft. rows

The effect of row spacing on estimated seasonal K_c values for a VSP trellis system, a California Sprawl type canopy, quadrilateral cordon trained vines and Lyre (or 'V') type canopies. The x value in the equation is degree-days (base of 10°C) from a starting point. The 'e' value in the equation is 2.71828. Note that row spacing only changes the numerator in the equation, the maximum K_c value.

Trellis/ Canopy type	Row Spacing m (ft.)	Crop coefficient equation
VSP	1.83 (6 ft.)	$K_c = 0.87/(1+ e^{(-(x - 525)/301)})$
	2.13 (7 f.t)	$K_c = 0.74/(1+ e^{(-(x - 525)/301)})$
	2.44 (8 ft.)	$K_c = 0.65/(1+ e^{(-(x - 525)/301)})$
	2.74 (9 ft.)	$K_c = 0.58/(1+ e^{(-(x - 525)/301)})$
	3.05 (10 ft.)	$K_c = 0.52/(1+ e^{(-(x - 525)/301)})$
CA Sprawl	3.05 (10 ft.)	$K_c = 0.84/(1+ e^{(-(x - 325)/105)})$
	3.35 (11 ft.)	$K_c = 0.76/(1+ e^{(-(x - 325)/105)})$
	3.66 (12 ft.)	$K_c = 0.70/(1+ e^{(-(x - 325)/105)})$
Quad-cordons (or GDC/Wye)	3.35 (11 ft.)	$K_c = 0.93/(1+ e^{(-(x - 300)/175)})$
	3.66 (12 ft.)	$K_c = 0.85/(1+ e^{(-(x - 300)/175)})$
Lyre Types or 'V'	2.74 (9 ft.)	$K_c = 0.93/(1 + e^{(-(x - 300)/150)})$
	3.05 (10 ft.)	$K_c = 0.84/(1 + e^{(-(x - 300)/150)})$
	3.35 (11 ft.)	$K_c = 0.76/(1 + e^{(-(x - 300)/150)})$
	3.66 (12 ft.)	$K_c = 0.70/(1 + e^{(-(x - 300)/150)})$



Estimated seasonal K_c for overhead DOV and gable table grape trellis systems.

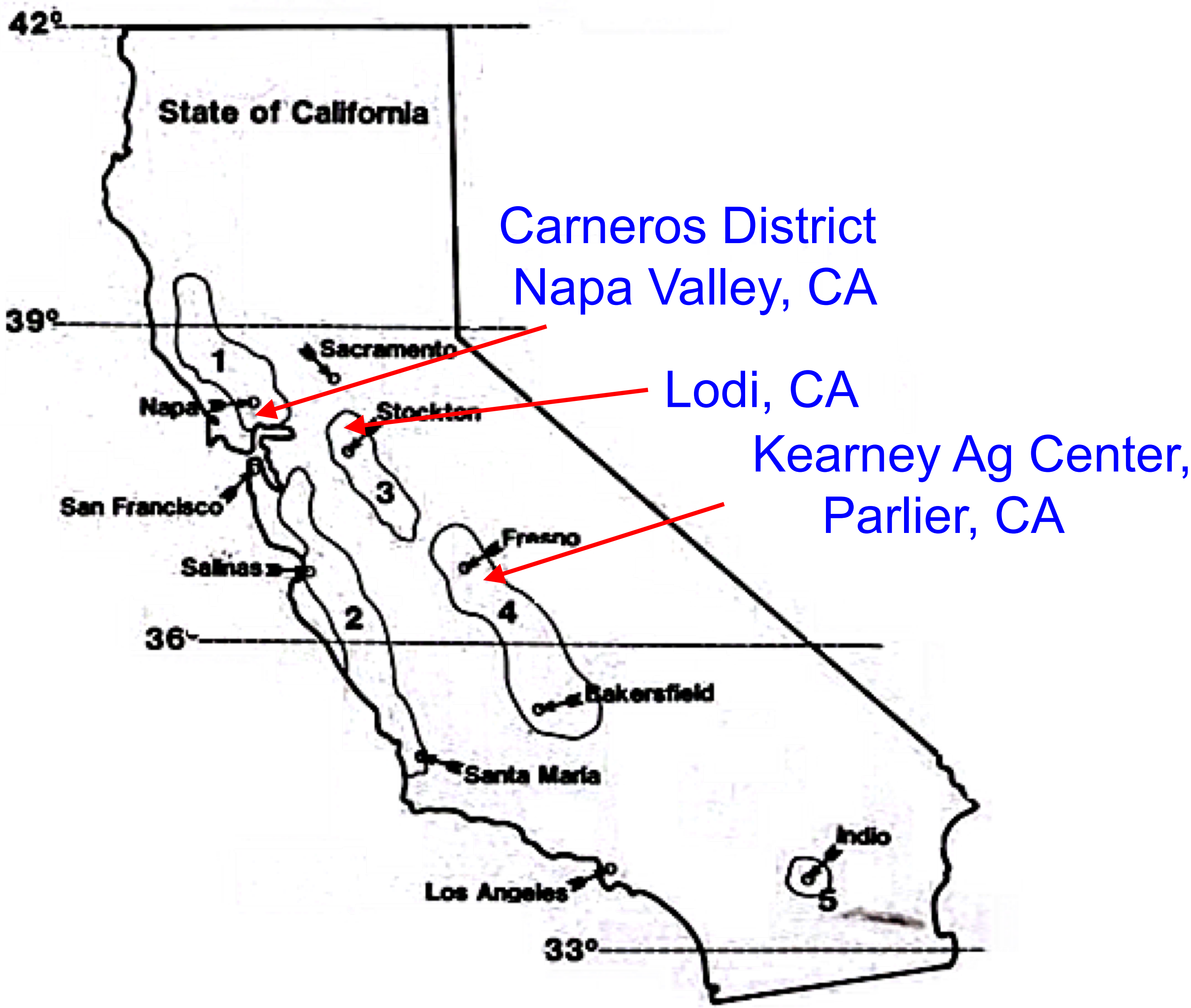
Estimated ET_c for:

DOV = 950 mm

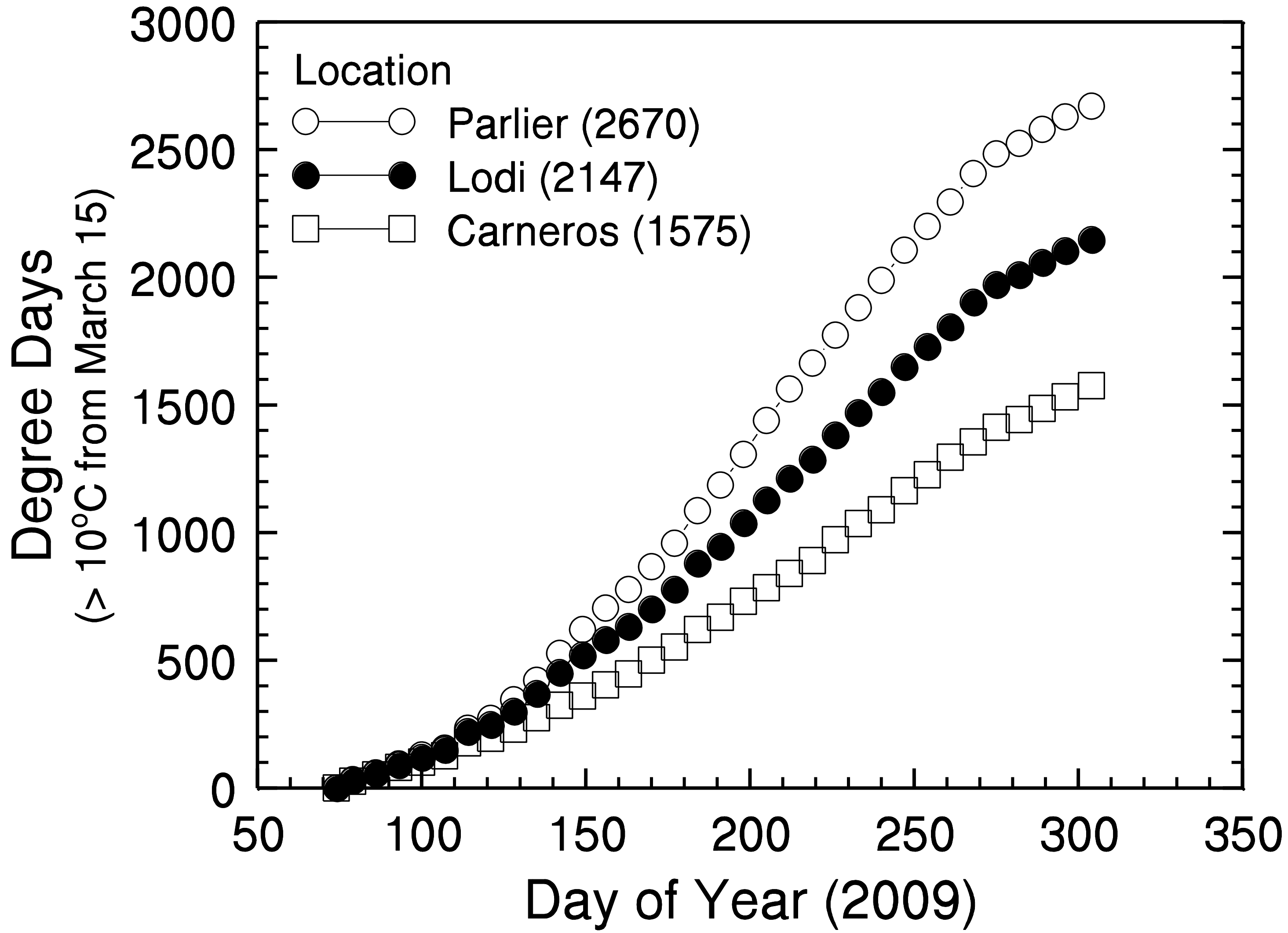
Gable trellis = 1200 mm

Question: How much is estimated vineyard ET affected by location in California?

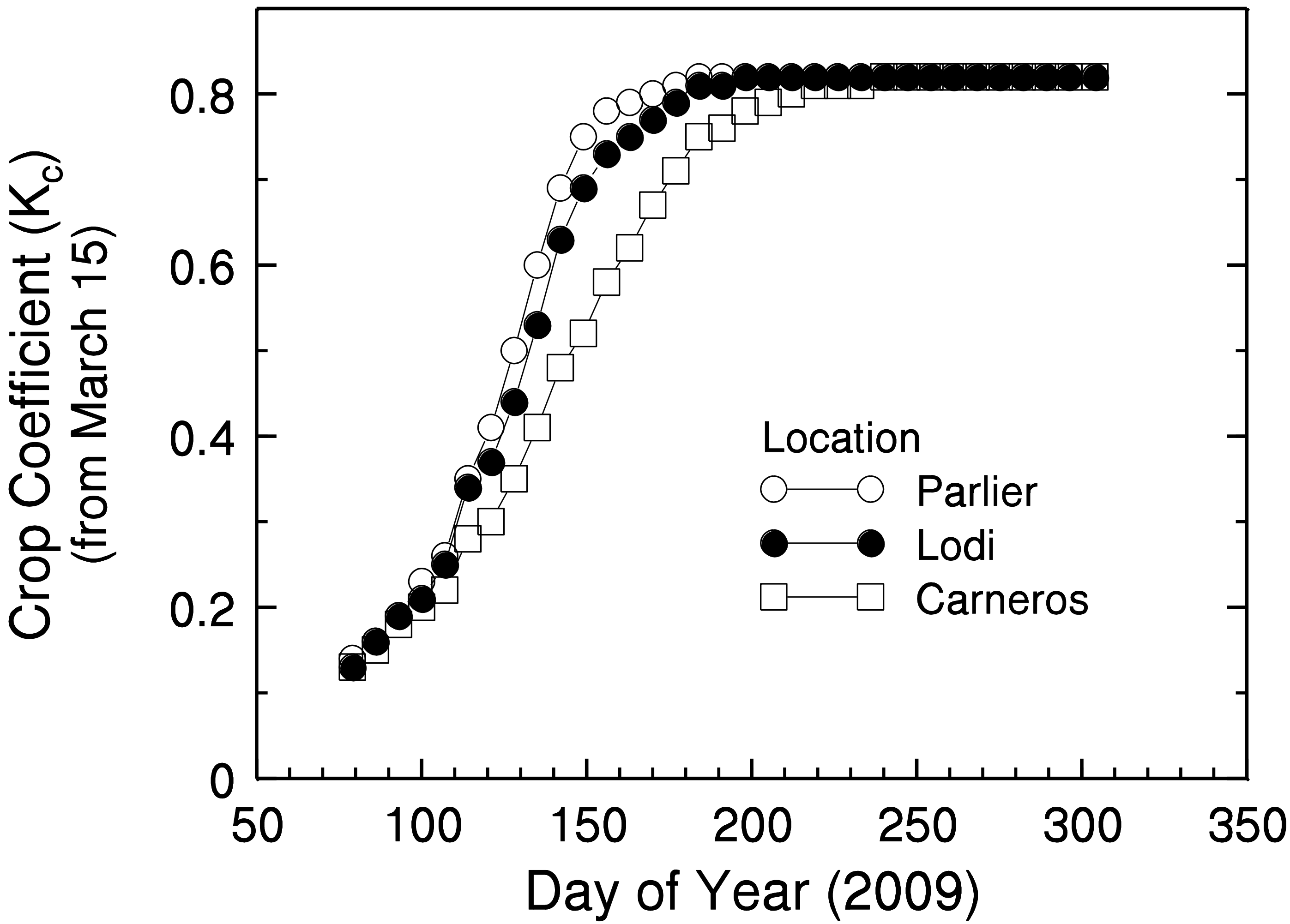
- Grapevine water use was estimated at three locations in California using weather data obtained from the particular locale.
- The vines were assumed to be trained as a CA sprawl and row spacing was 11 feet.
- The crop coefficient at each location was estimated using degree days (> $10^{o}C$) from March 15^{th}.



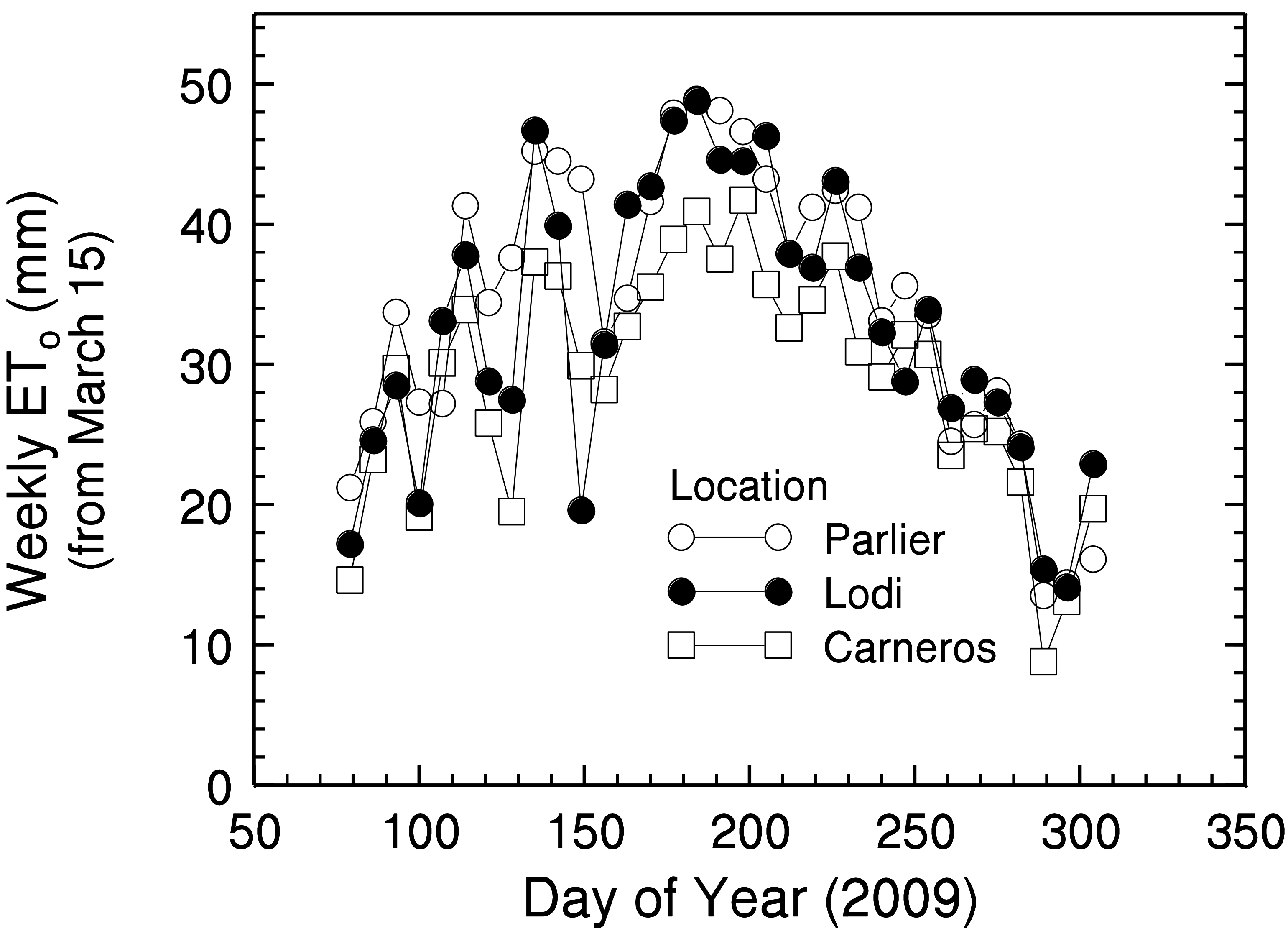
42°
State of California
Carneros District
Napa Valley, CA
39°
1
Sacramento
Lodi, CA
Napa
Stockton
Kearney Ag Center,
Parlier, CA
3
San Francisco
Fresno
Salinas
4
2
36°
Bakersfield
Santa Maria
Indio
Los Angeles
5
33°



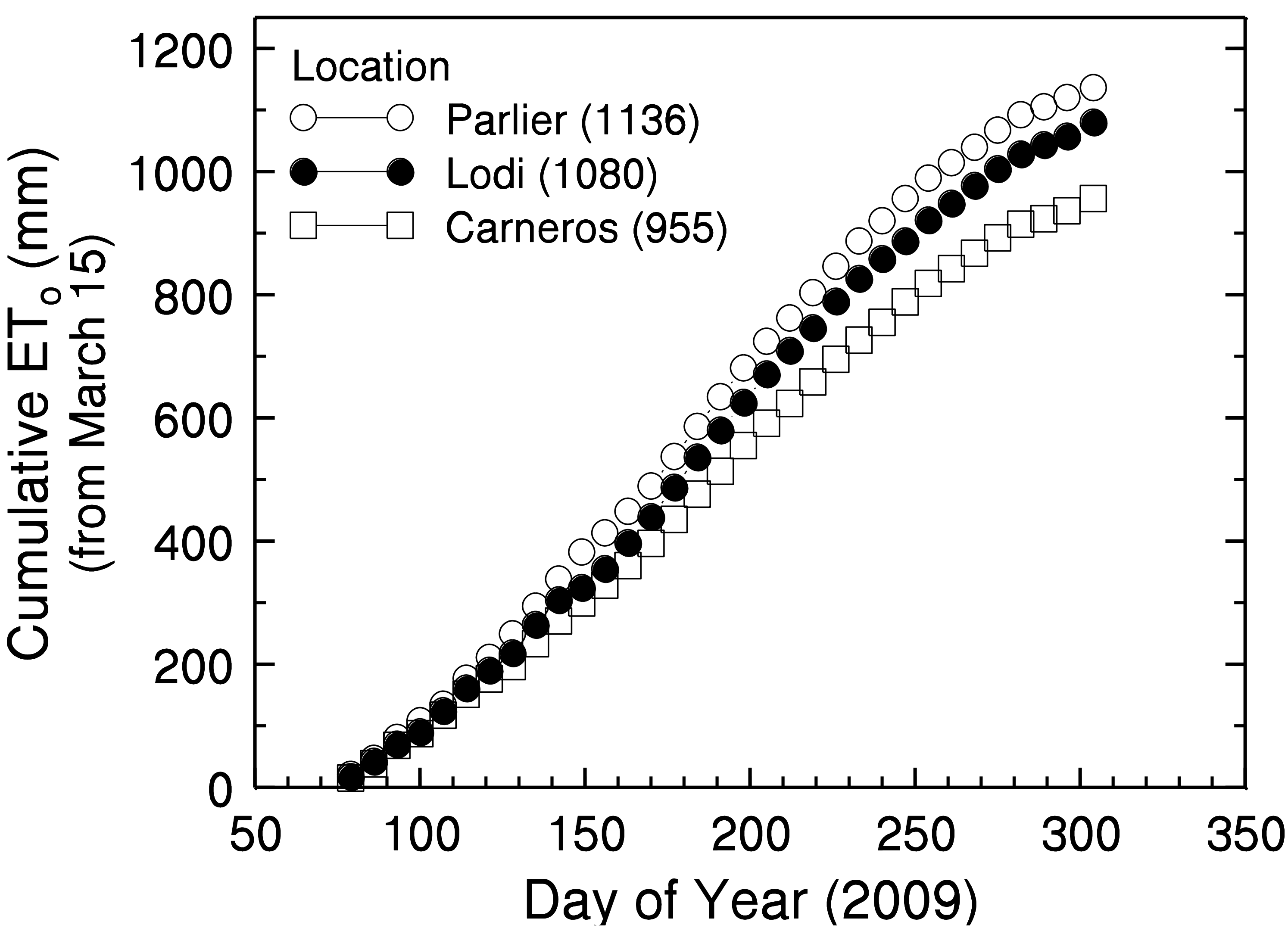
Cumulative DDs from March 15 to October 31. Cumulative DDs at Carneros and Lodi are 59 and 80%, respectively, those at Parlier



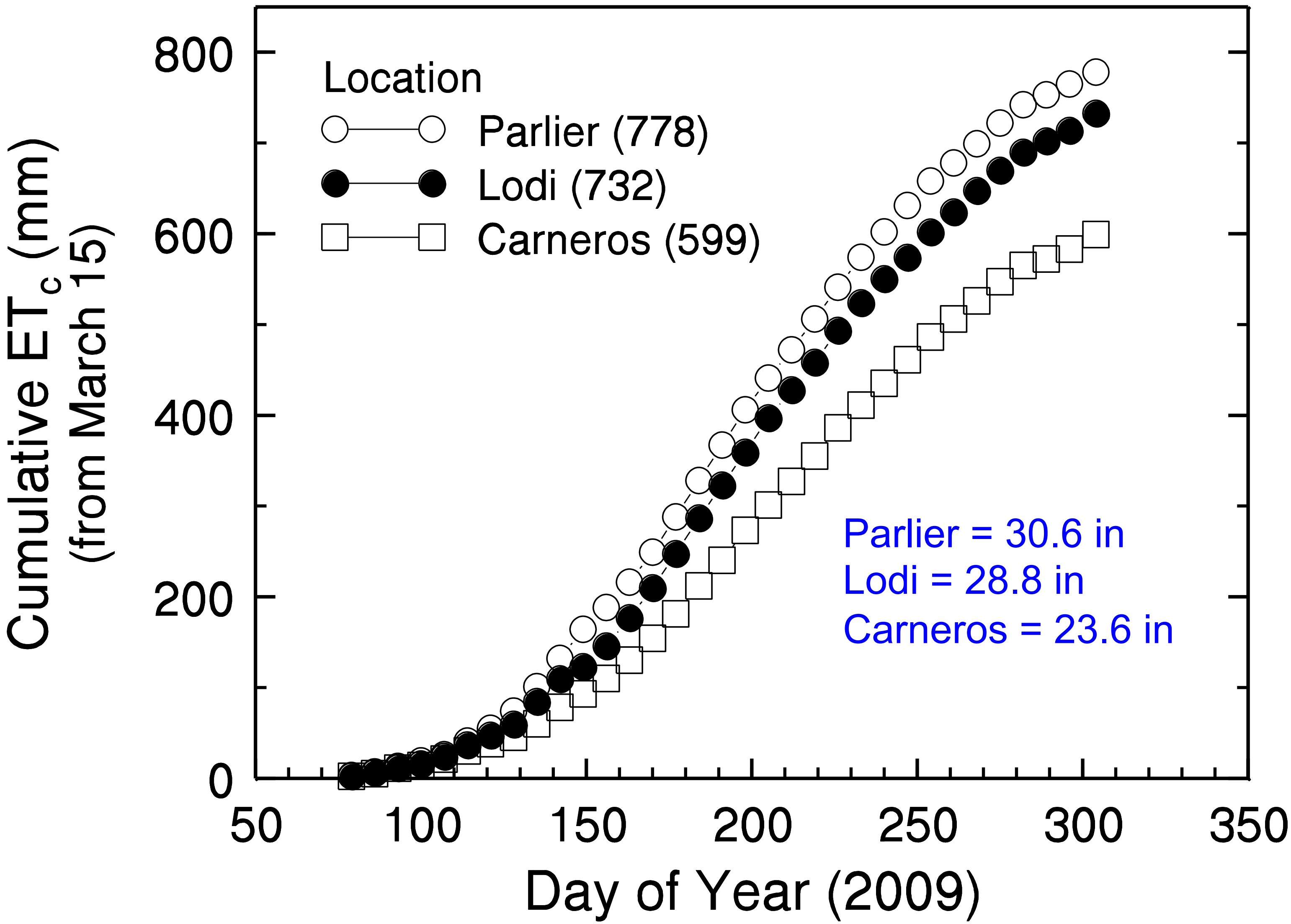
Note: 1.) Delay in reaching the maximum K_c at Carneros compared to the other two locations and 2.) the K_c does not decrease after the maximum has been reached.



Weekly reference ET at three locations in California

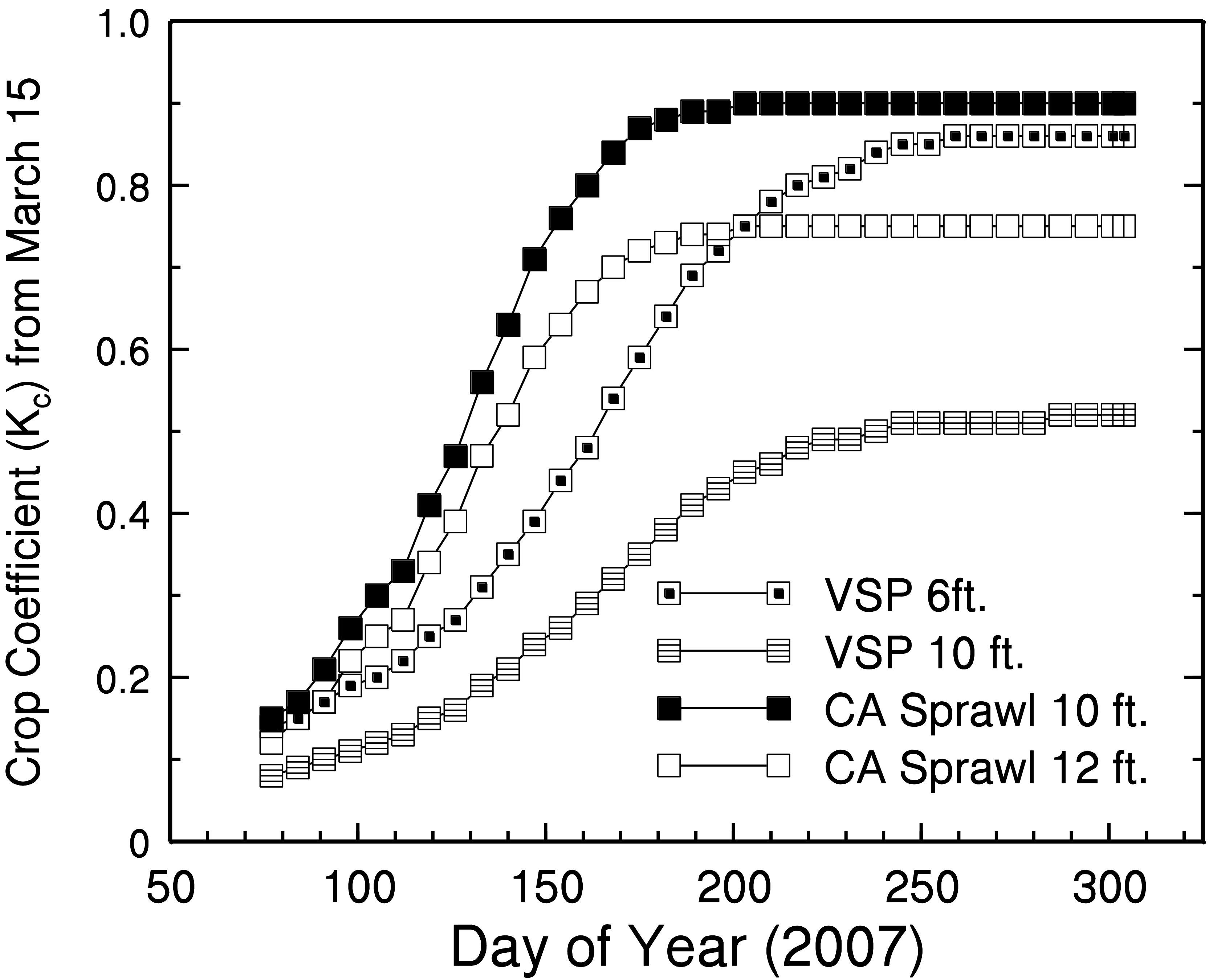


Cumulative ET_o from <u>March 15 to October 31</u>. ET_o values at Carneros and Lodi are 84 and 95% that at Parlier.

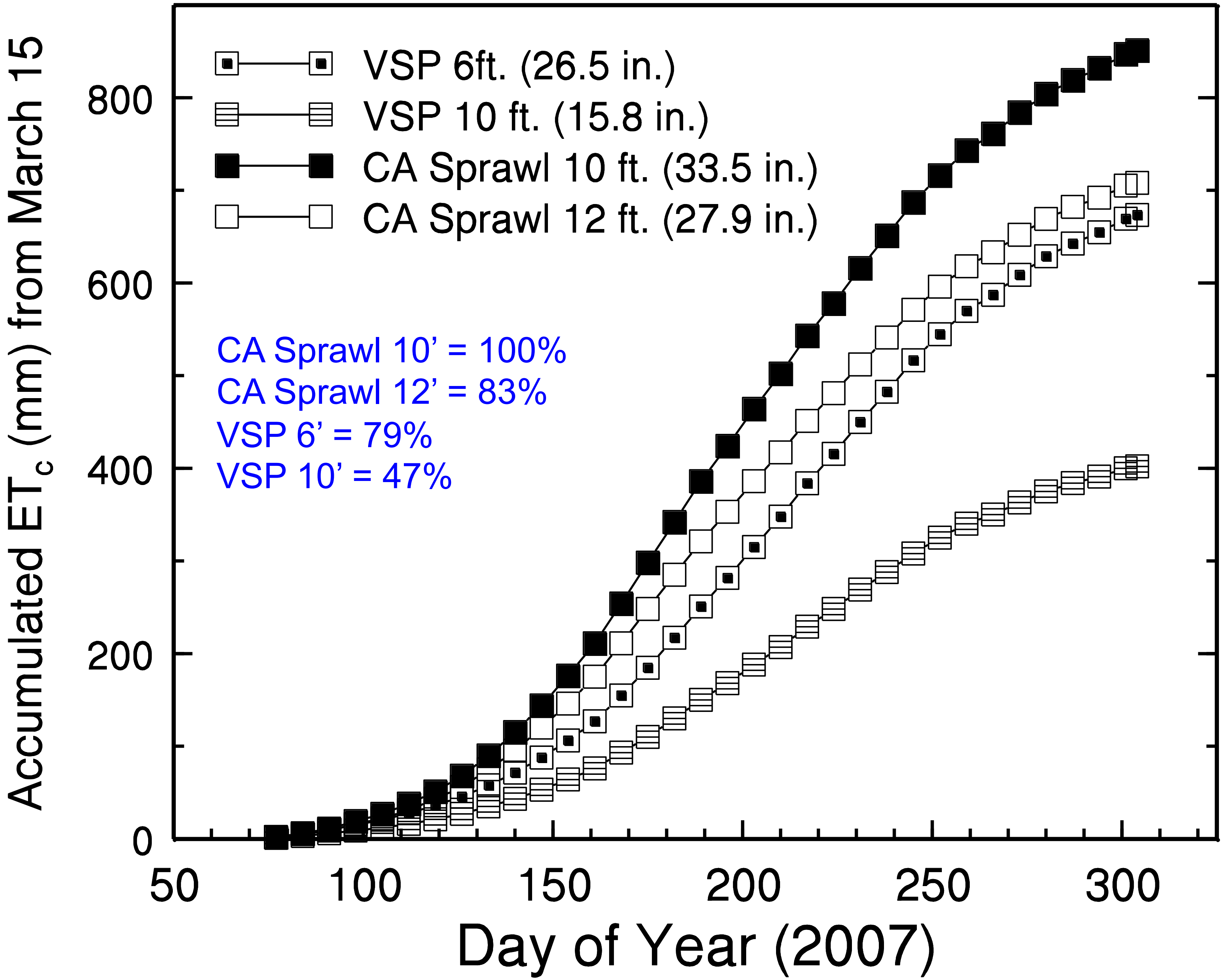


Cumulative estimated vineyard ET from March 15 to October 31. ET_c values at Carneros and Lodi are 77 and 94%, respectively, that at Parlier.

Question: How much is estimated vineyard ET affected by trellis type and row spacing at one location?



1.0
0.8
0.6
0.4
0.2
0
50
100
150
200
250
300
Crop Coefficient (K_c) from March 15
Day of Year (2007)
VSP 6ft.
VSP 10 ft.
CA Sprawl 10 ft.
CA Sprawl 12 ft.



Accumulated ET_c (mm) from March 15
Day of Year (2007)
VSP 6ft. (26.5 in.)
VSP 10 ft. (15.8 in.)
CA Sprawl 10 ft. (33.5 in.)
CA Sprawl 12 ft. (27.9 in.)
CA Sprawl 10' = 100%
CA Sprawl 12' = 83%
VSP 6' = 79%
VSP 10' = 47%
0
200
400
600
800
50
100
150
200
250
300

One can also take historical ET_o and degree days from estimated budbreak and devise a seasonal irrigation regime using the equation: $ET_c = ET_o \times K_c$.
Weekly irrigations throughout the current growing season would then be revised if needed. This works well for the San Joaquin Valley.
(see Raisin Production Manual)

How would one calculate weekly water requirements for a vineyard?

- Monday morning obtain the current value of degree-days (UC IPM website with most recent from Sunday) from a starting point.
- This value would then be used to calculate the appropriate K_c for the coming week.
- Obtain historical ET_o for the week and multiply by the K_c or take the previous 7 days ET_o value and multiply by the K_c. This will give you inches or mm/week.
- I usually use mm which converts directly to L for the week (1 mm covering 1 m^2 = 1 L).

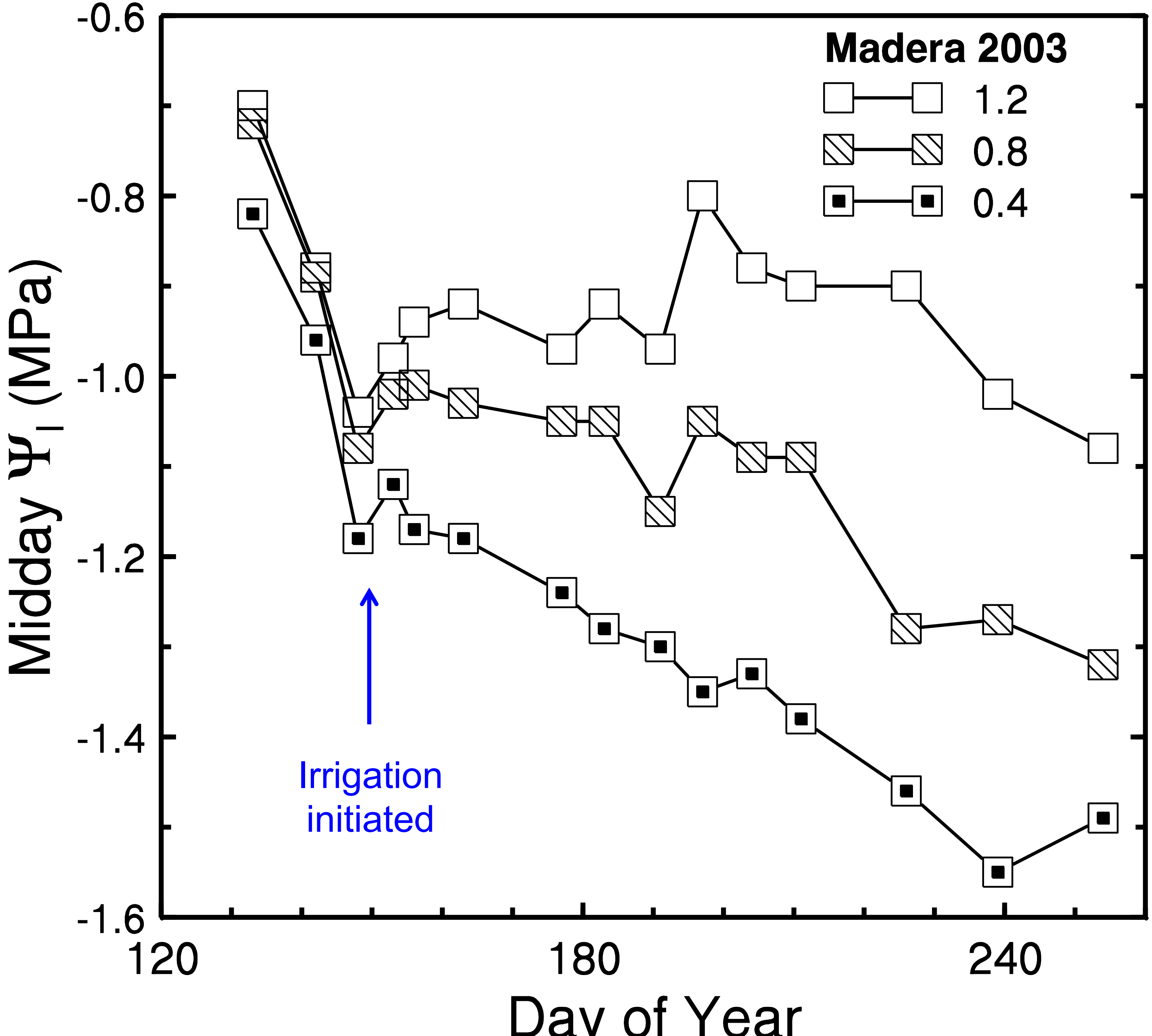
“Goal of irrigation management”

Mark Battany

- Your goal should be to grow vines with a uniform degree and pattern of water stress every season (the degree of stress determined by the grower).
- To do this, you need to adjust irrigation timing and amounts to take into account unique growing conditions in any given season.
- Weather (evaporative demand and temperature) is the variable component that exerts the most influence on irrigation requirements during the season.

How does one use the calculation of vineyard ET_c to assist in a deficit irrigation management strategy?

Leaf water potential was measured at different locations, using different cultivars as a function of applied water amounts at various fractions of estimated ET_c.



Madera 2003
1.2
0.8
0.4
Irrigation initiated
Midday Ψ$_l$ (MPa)
Day of Year
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
120
180
240

Seasonal precipitation, degree days (DDs) from 1 April and reference ET (ET_o) and estimated ET_c (1 April to 1 Nov.) of a Chardonnay vineyard in Carneros. VSP trellis w/vine x row spacing of 5' x 7')

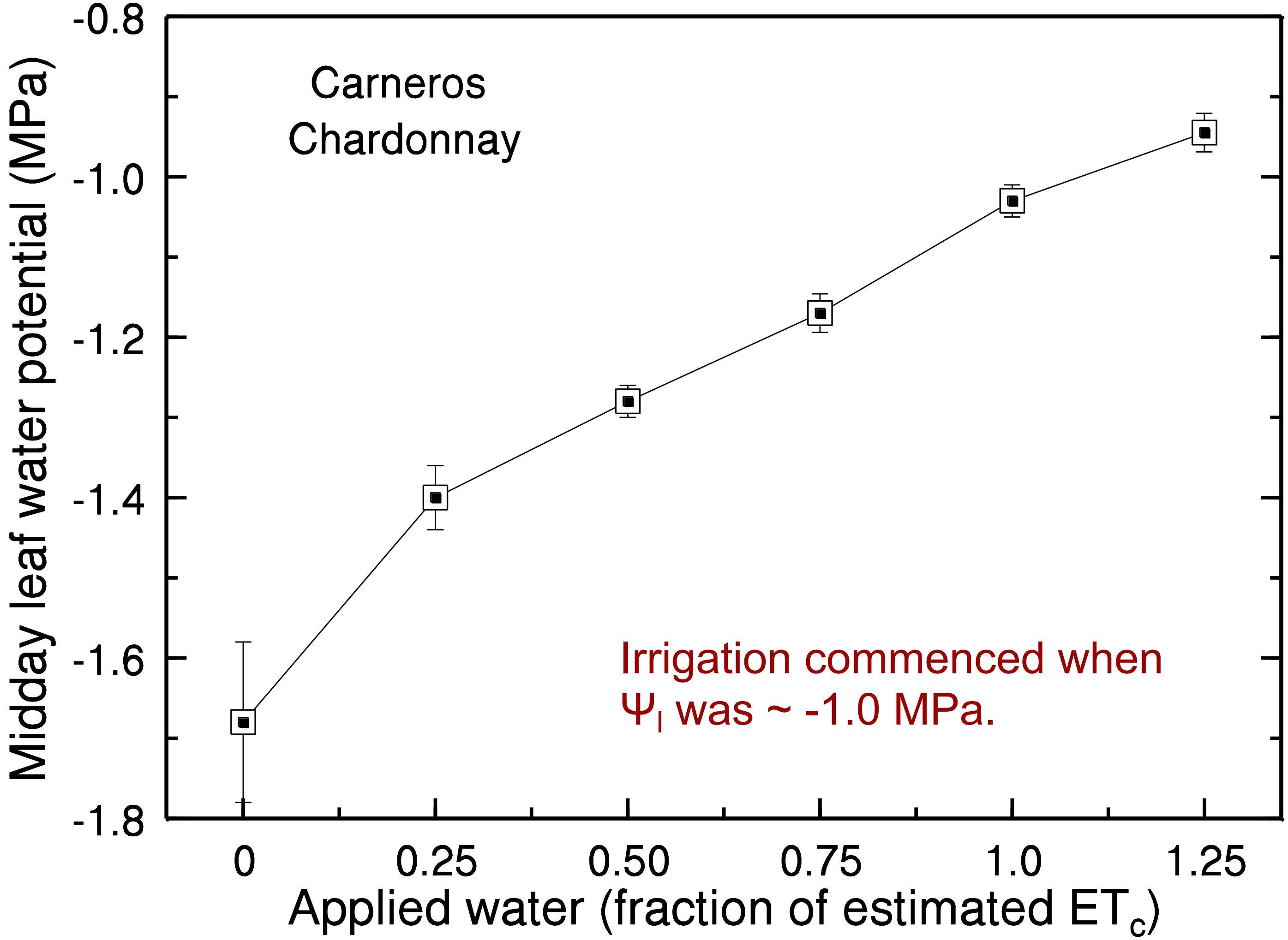
Year	Seasonal Precipitation Nov - Mar	From 1 Apr	DDs	ET_o	Estimated ET_c
	---------- (mm)	----------	(> 10 C)	---------- (mm)	---------
1994	192 (7.6 in)	61 (2.4 in)	1408	1067	432 (17.0 in)
1995	843 (33.2 in)	47 (1.9 in)	1522	1032	447 (17.6 in)
1996	480 (18.9 in)	139 (5.5 in)	1548	1009	455 (17.9 in)
1997	522 (20.6 in)	38 (1.5 in)	**1675**	**1066**	**503 (19.8 in)**
1998	819 (32.2 in)	85 (3.3 in)	**1369**	**885**	**346 (13.6 in)**
1999	436 (17.2 in)	53 (2.1 in)	1357	988	378 (14.9 in)
2000	427 (16.8 in)	72 (2.8 in)	1446	975	410 (16.1 in)
2001	308 (12.1 in)	19 (0.7 in)	1519	1057	462 (18.2 in)
			1481	1009	429 (16.9 in)

Available water to a depth of 2.75 m was estimated to be 275 mm (10.8 in) in this vineyard (or 891 L/vine or 236 gal/vine).

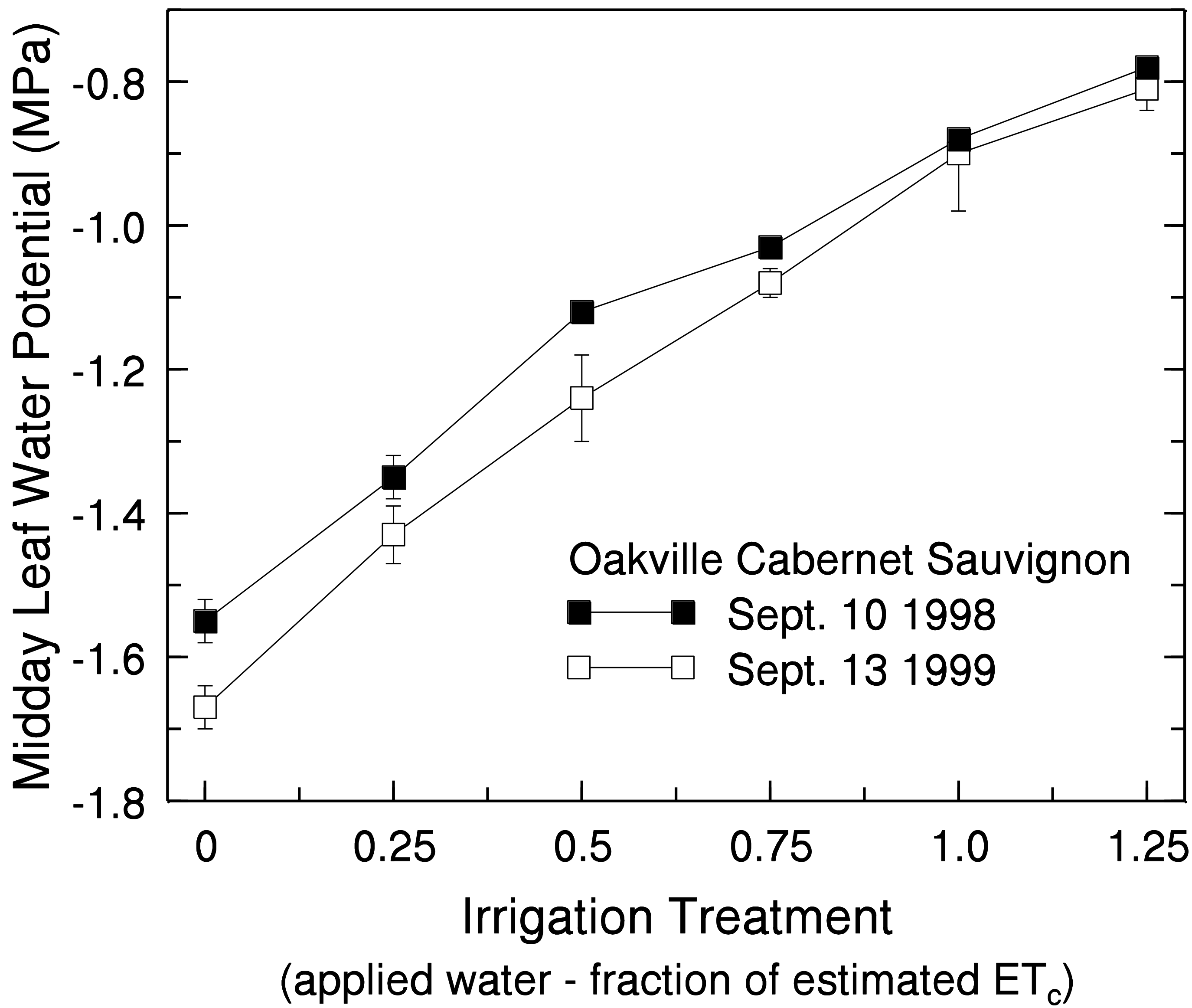
ET_c of 429 mm (16.9 in) is equivalent to 1390 L/vine or 368 gal/vine in this vineyard.

Non-water stressed Ψ values:

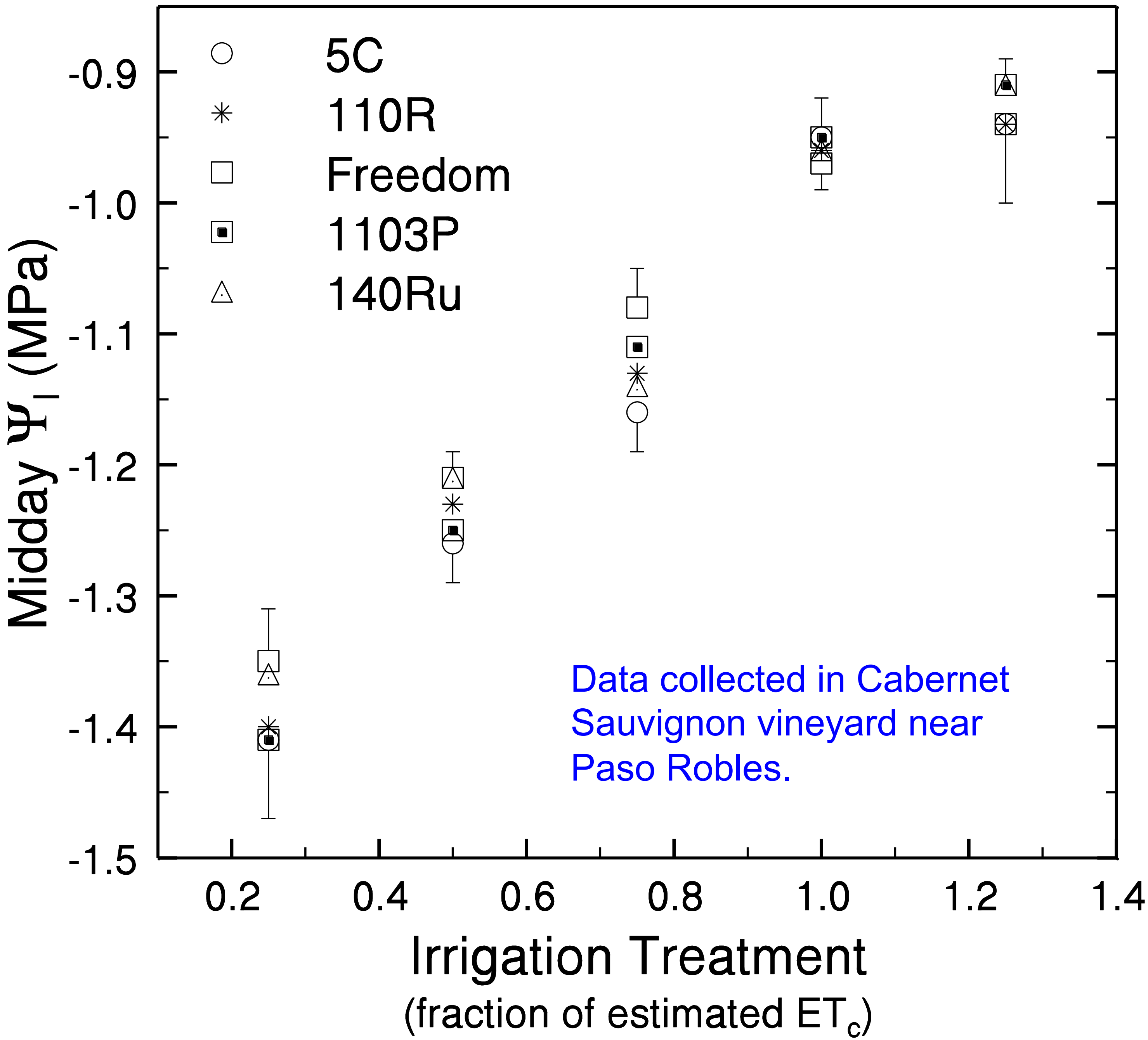
- The following values of vine water status would represent a non-water stressed vine under hot, dry conditions in California:
- Pre-dawn water potential: $\geq$ -0.1 MPa
- Midday leaf water potential: ~ $\geq$ -1.0 MPa
- Midday stem water potential: ~ $\geq$ -0.6 MPa
- The values for midday stem and leaf water potential are a function of VPD at the time of measurement for non-water stressed vines.

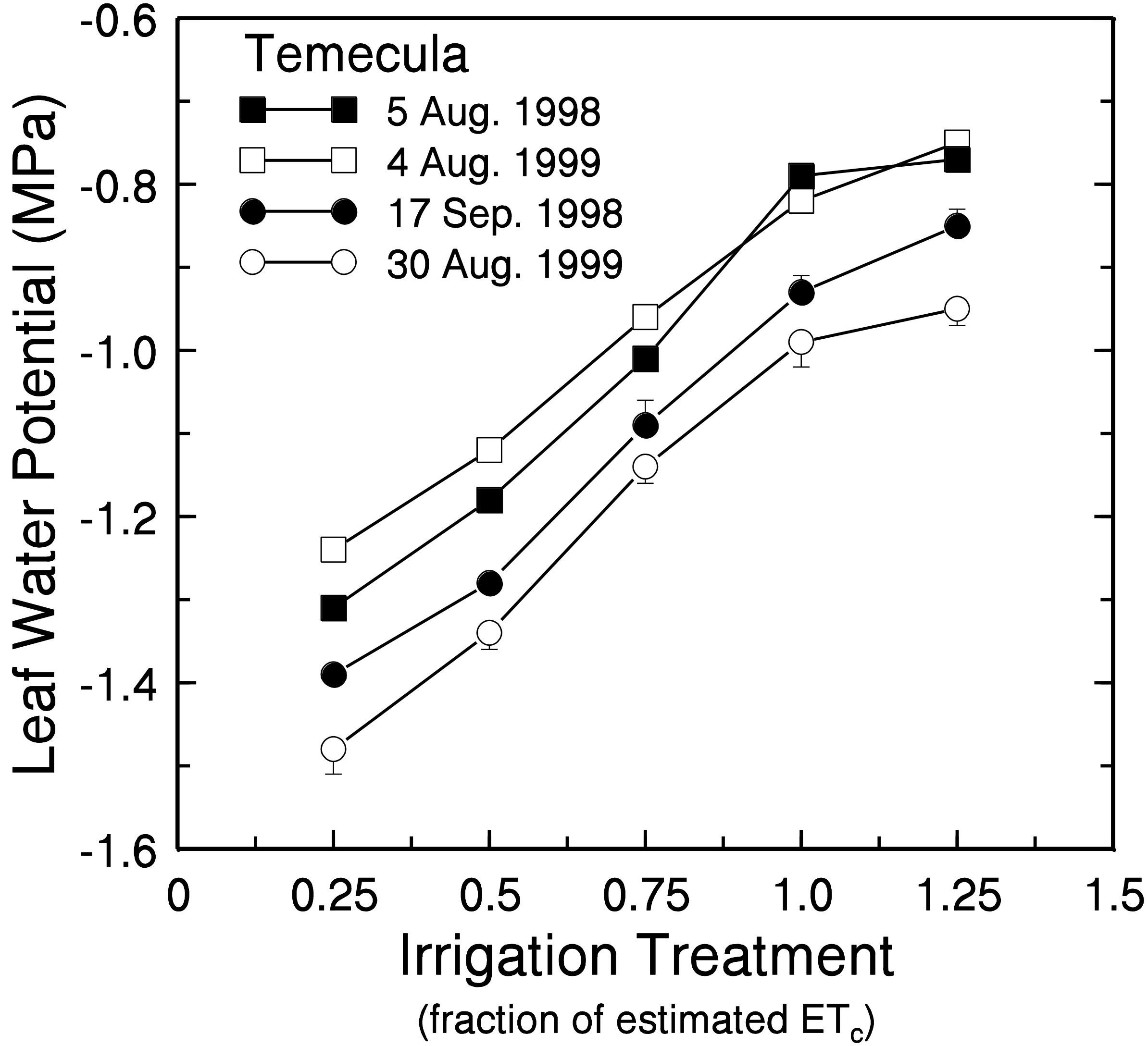


Leaf water potential measured across 8 growing seasons (1994 – 2001). Values are those taken close to harvest each year (dates varied from 28 Aug. to 21 Sept. Values are the means across years (vines on 5C and 110R) ± SE (n = 4 for the 0, 0.25, 0.75 and 1.25 treatments and 8 for the 0.5 and 1.0 treatments.

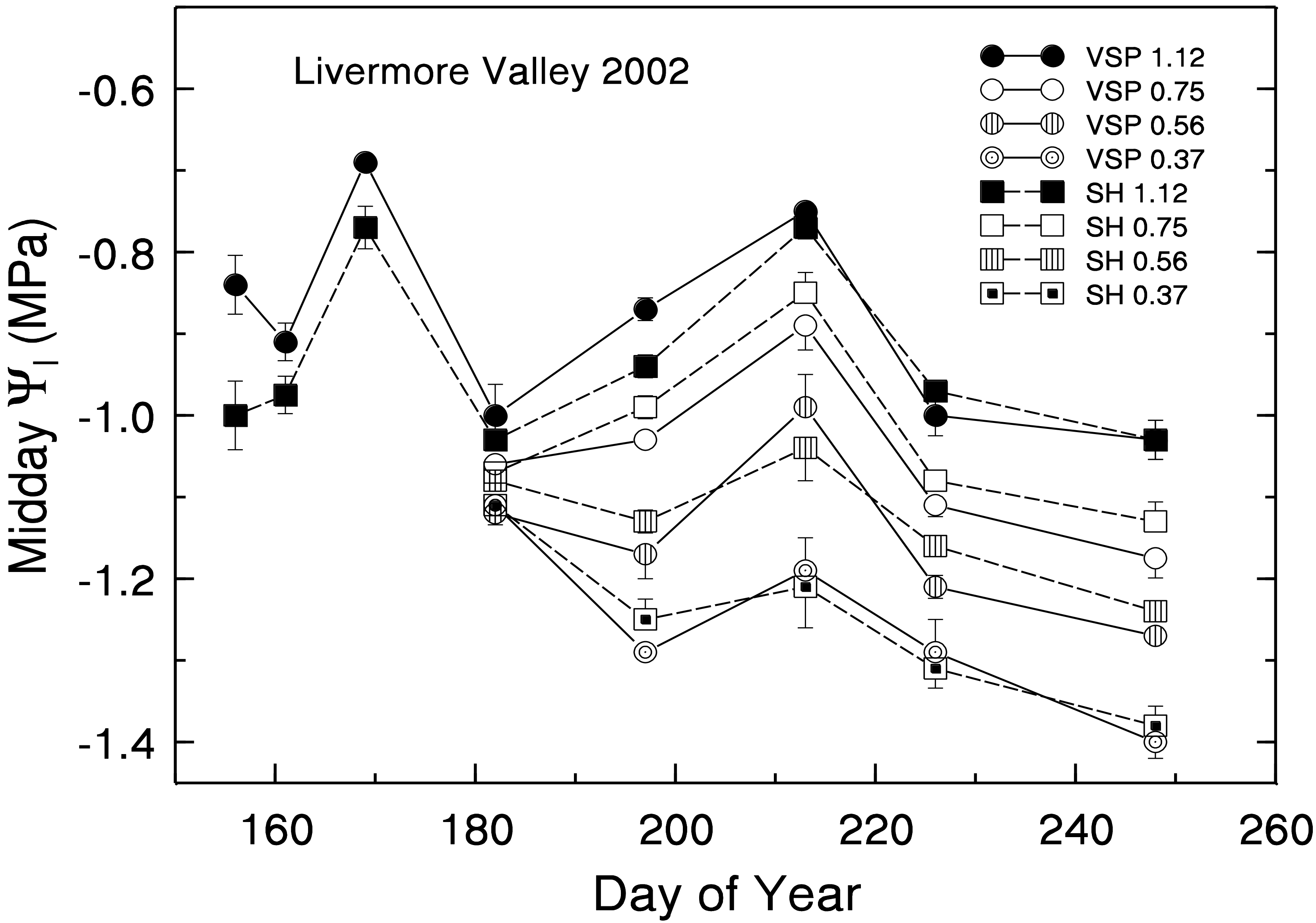


Values averaged across rootstocks – 110R, 5C, 3309


5C
110R
Freedom
1103P
140Ru
Data collected in Cabernet Sauvignon vineyard near Paso Robles.
Midday Ψl (MPa)
-0.9
-1.0
-1.1
-1.2
-1.3
-1.4
-1.5
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Irrigation Treatment
(fraction of estimated ETc)



Midday Ψ_l of Chardonnay as a function of applied water amounts close to harvest in 1998 and 1999.



Prior to harvest (2001) midday leaf water potentials for the 0.375, 0.56, 0.75 and 1.12 irrigation treatments for the VSP trellis averaged -1.42, -1.23, -1.10 and -0.88 MPa, respectively, and for the SH trellis averaged -1.37, -1.19, -0.92, and -0.88 MPa, respectively.

How much water is used by vines as a function of phenology throughout the growing season?

Water use as a function of phenology (% of total use).

Cultivar	BB → Bloom	BB → Veraison	BB → Harvest	Total
Thompson Seedless	**10**	**38**	**89**	825 mm (32.5 in)
Chardonnay (Carneros)	**10**	**38**	**78**	429 mm (16.9 in)
Merlot (SJV)	**10**	**52**	**82**	716 mm (28.2 in)
Red Cultivars (SJV)	**10**	**48**	**78**	>828 mm (32.6 in)

TS – 11 ft. rows, CA Sprawl; **Chardonnay** - 7 ft. rows, VSP;
Merlot – 12 ft rows, CA Sprawl; **Red Cultivars** – 10 ft. rows, CA Sprawl.

Estimated water use of Cabernet Sauvignon grapevines from March 15th until bloom, veraison, harvest and the end of the season (Oct. 31).

Year	ET_c to Bloom	ET_c to Veraison	ET_c to Harvest	ET_c all Season (ET_o)
Cabernet (OV)	------------------------- (mm)	---------------------------		
2000	**71 (16%)** **(2.80 in)**	**262 (59%)** **(10.3 in)**	**379 (85%)** **(14.9 in)**	**444 (909)** **(17.4 in)**
Cabernet (OV)				
2003	**106 (16%)** **(4.17 in)**	**386 (58%)** **(15.2 in)**	**573 (86%)** **(22.6 in)**	**666 (1053)** **(26.2 in)**
Cabernet (PR)				
2006	**87 (18%)** **(3.4 in)**	**266 (56%)** **(10.5 in)**	**437 (92%)** **(17.2 in)**	**475 (1065)** **(18.7 in)**

Cabernet OV (Oakville): spacing 3.28 x 6 ft, VSP (215 gallons)
Cabernet OV (Oakville): spacing 6 x 9 ft, Lyre trellis (883 gallons)
Cabernet PR (Paso Robles): spacing 6 x 10 ft, modified VSP trellis (701 gallons)

Things you can do to simplify irrigation management.

- Collect degree days from budbreak each year and determine DDs as a function of phenological events.
- Download ET_o data from closest CIMIS station (or by other means).
- Download or record rainfall amounts and events (estimate soil water availability).
- **Measure applied water** amounts and record as a function of time (DDs).

Irrigation management and Vineyard Sustainability

- Maintain productivity over time
- Maximize fruit quality
- Increase vineyard water use efficiency (in general, if the vineyard is irrigated any reduction in applied water will increase WUE).
- Minimize/maximize soil water depletion (function of soil type and rooting depth, cover crop management)
- Some of the above factors will be a function of location in California and price of grapes

Mark Matthews:

“I taught an extension irrigation course for many years with Mike Anderson – in which we discussed several technologies and always taught that you could make any of them work if you invested yourself in it – pay attention, impose some different irrigation regimes, and take notes/data for later review. At the time, we knew that there were folks making each of them work –”