Applying Crop Coefficients at a Landscape Scale

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ARS

Outline

- Introduction
- Review of Development of Crop Coefficients
- Example of application at landscape scale
- Example of application from Australia

Introduction

- Why a landscape scale?
  - District wide analysis of crop water use
  - Water delivery
  - Irrigation scheduling

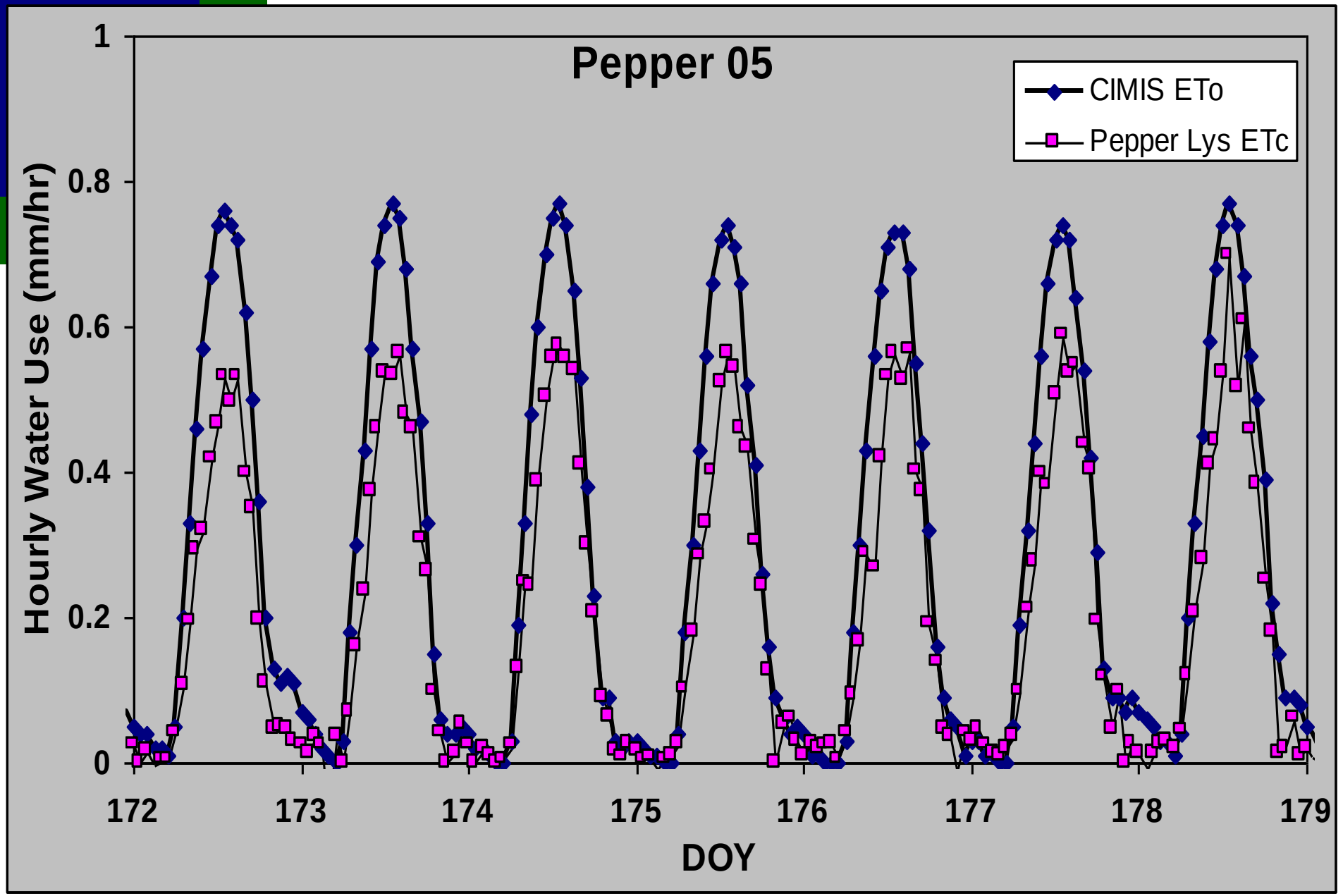
Climatic Irrigation Scheduling

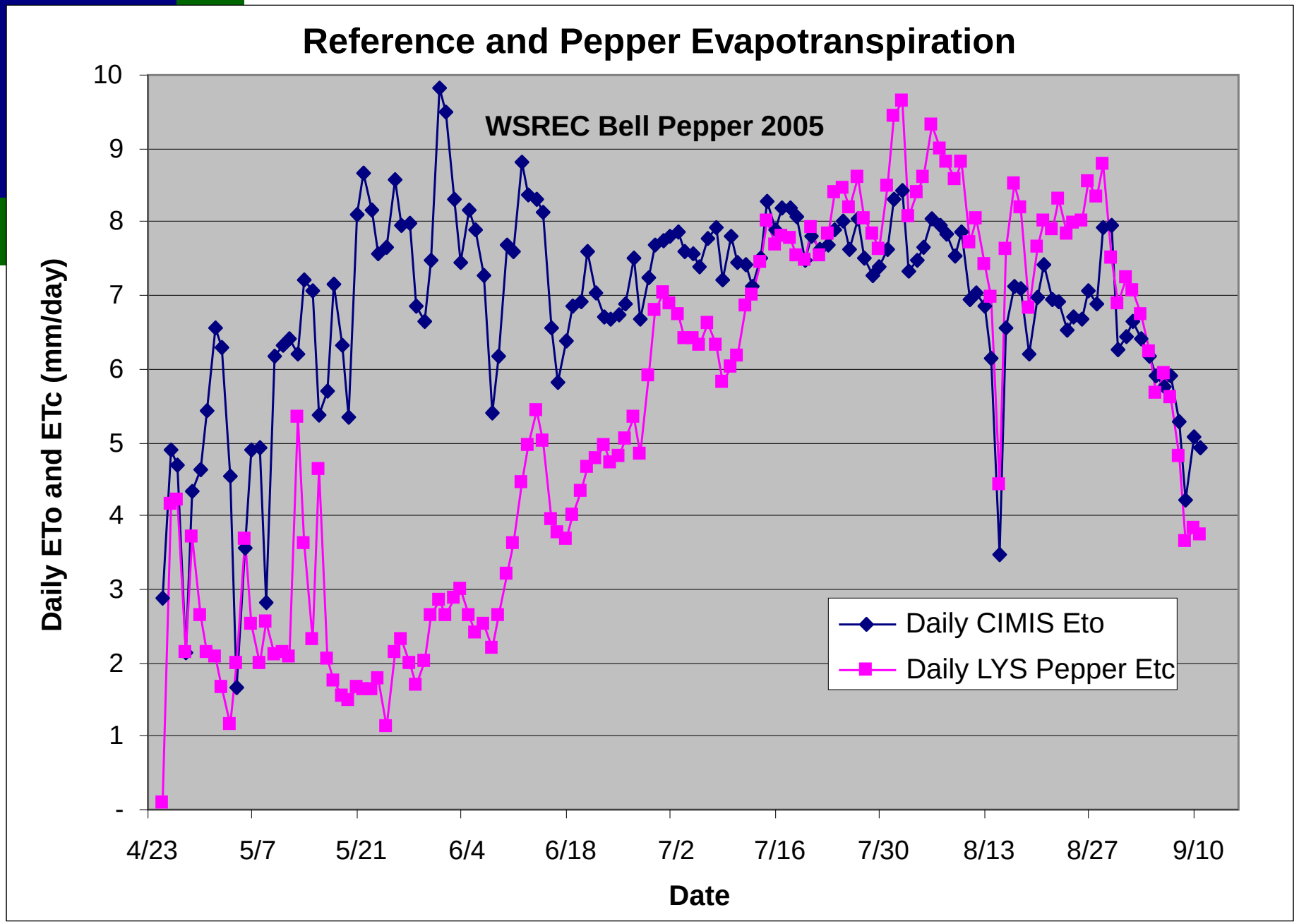
$$ET_c = K_c * ETo$$

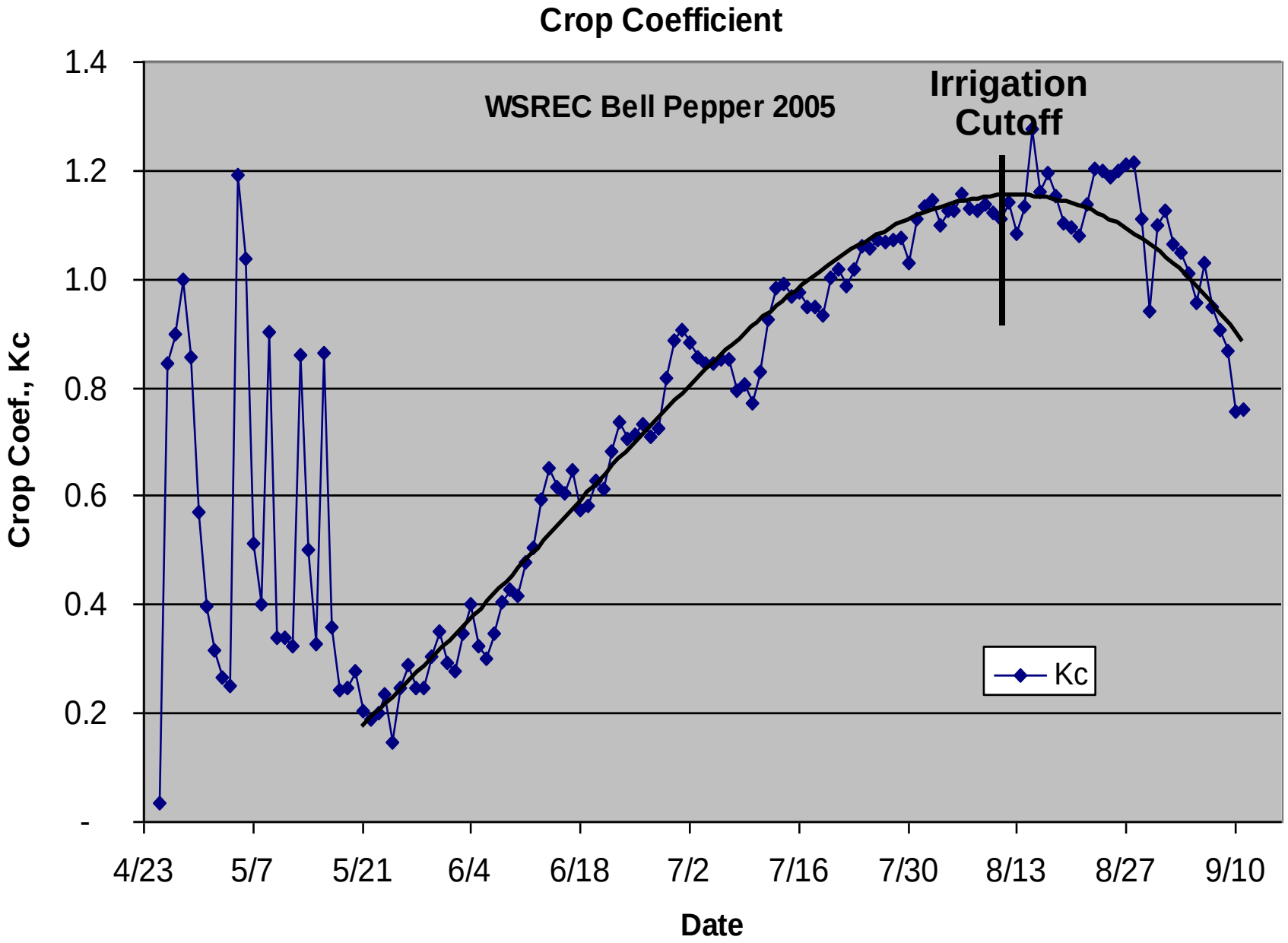
ET_o = reference evapotranspiration (CIMIS) or Grass Lysimeter

K_c = crop coefficient

CIMIS #2 (WSREC) and Grass Lysimeter

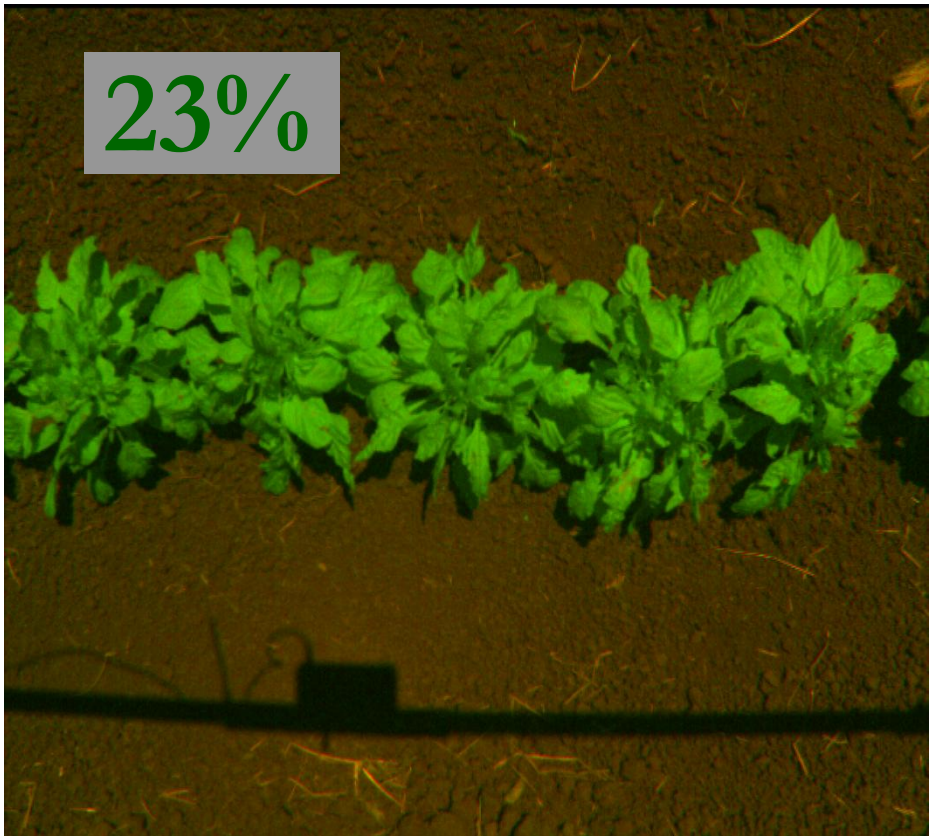

Pepper 05
CIMIS ETo
Pepper Lys ETc
Hourly Water Use (mm/hr)
1
0.8
0.6
0.4
0.2
0
172
173
174
175
176
177
178
179
DOY

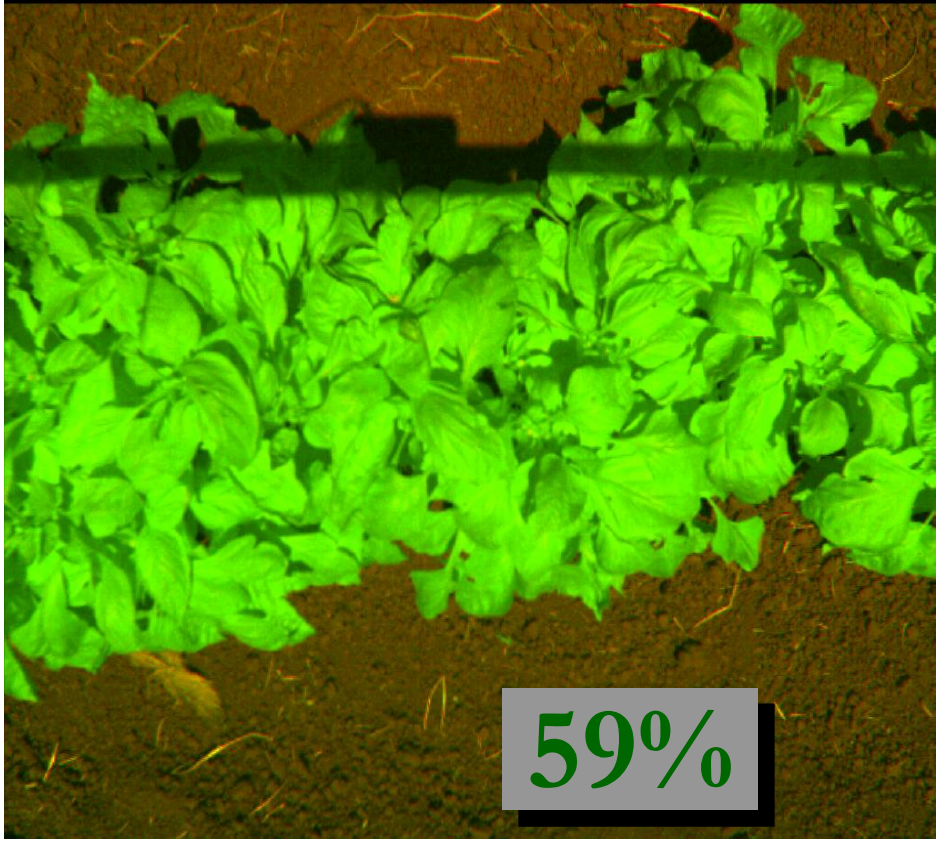

Reference and Pepper Evapotranspiration
WSREC Bell Pepper 2005
Daily ETo and ETc (mm/day)
10
9
8
7
6
5
4
3
2
1
-
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
8/13
8/27
9/10
Date
Daily CIMIS Eto
Daily LYS Pepper Etc

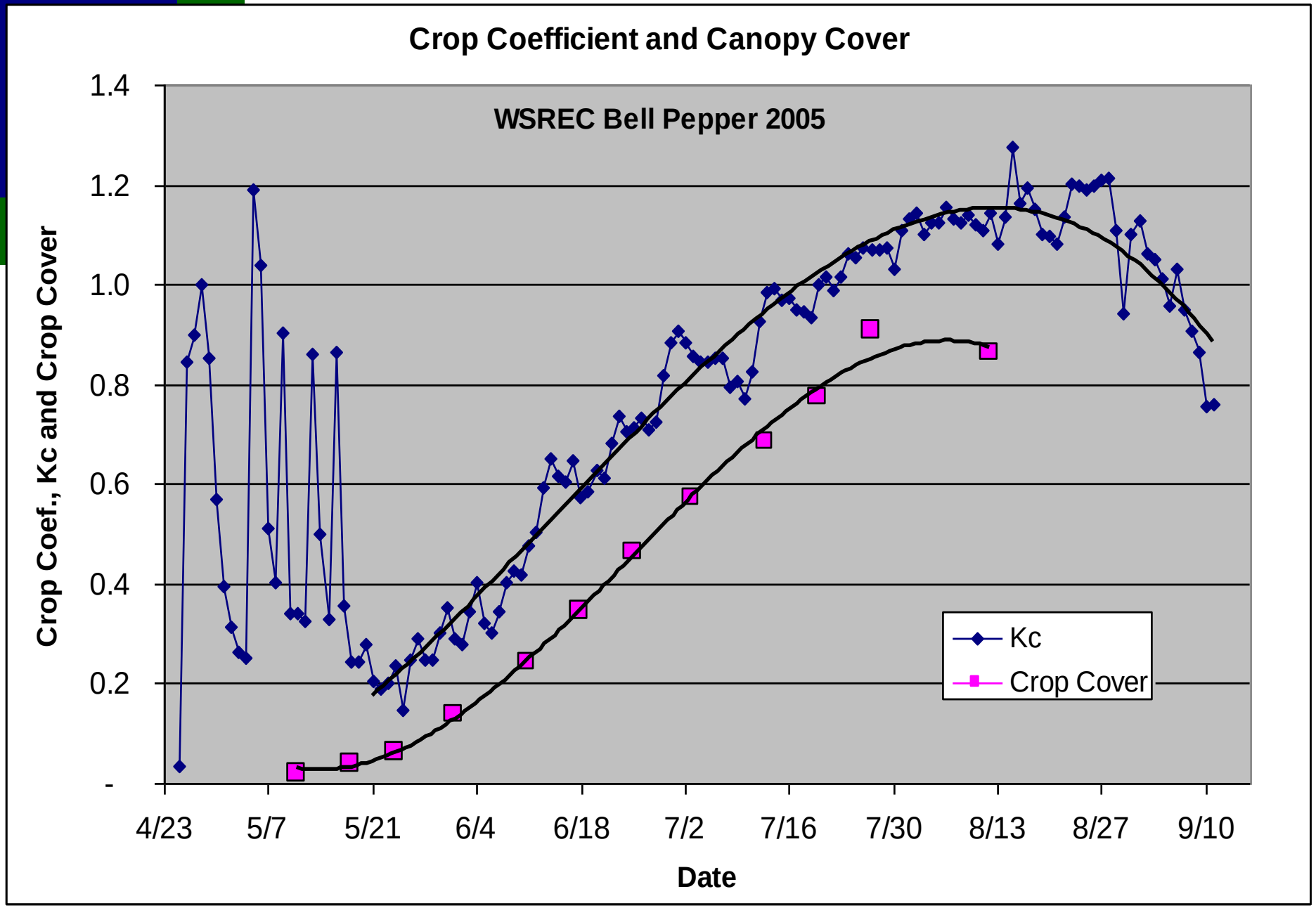

Crop Coefficient
WSREC Bell Pepper 2005
Irrigation Cutoff
Crop Coef., Kc
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
8/13
8/27
9/10
Date
Kc

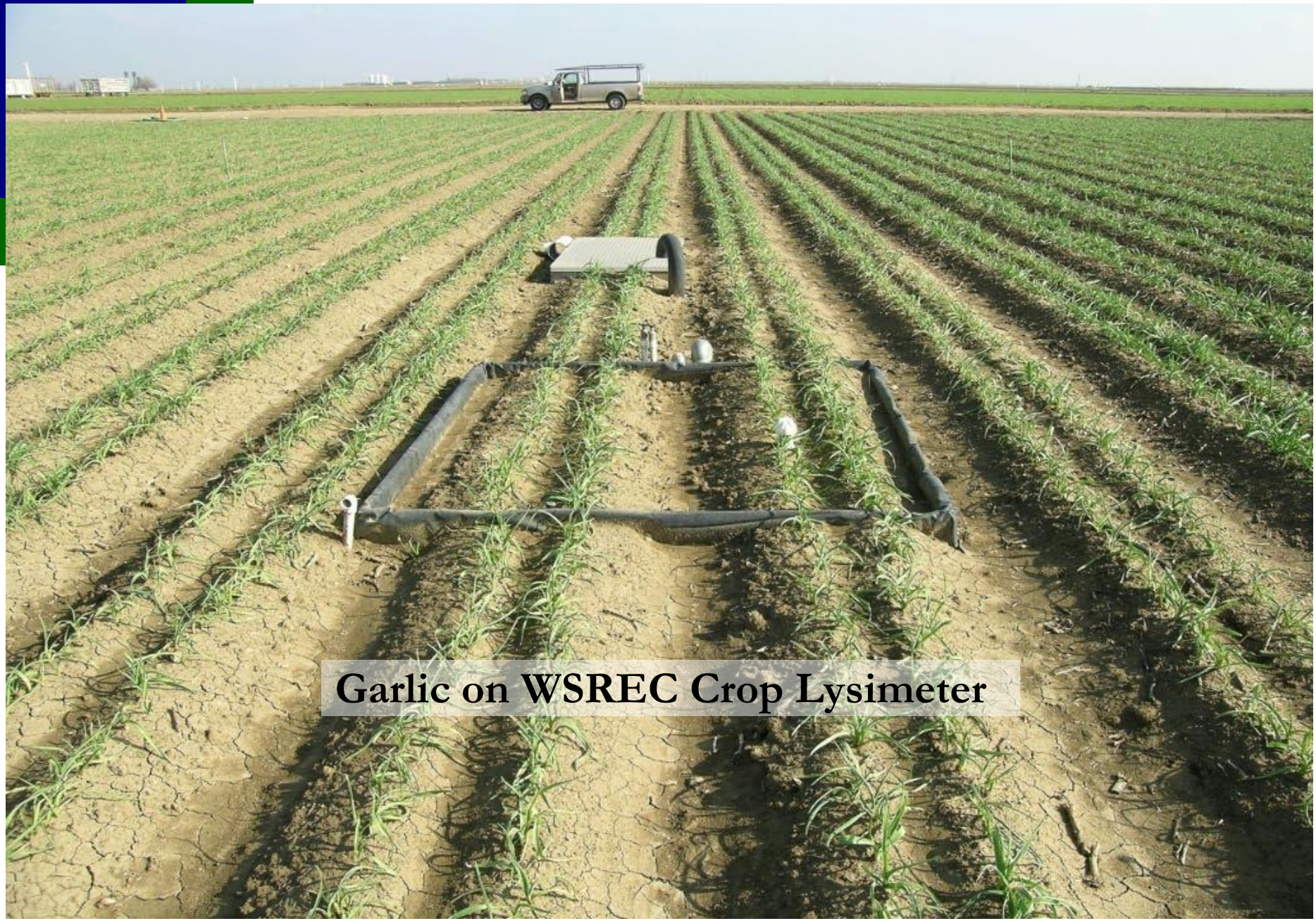
Measuring Crop Canopy Cover - Onions

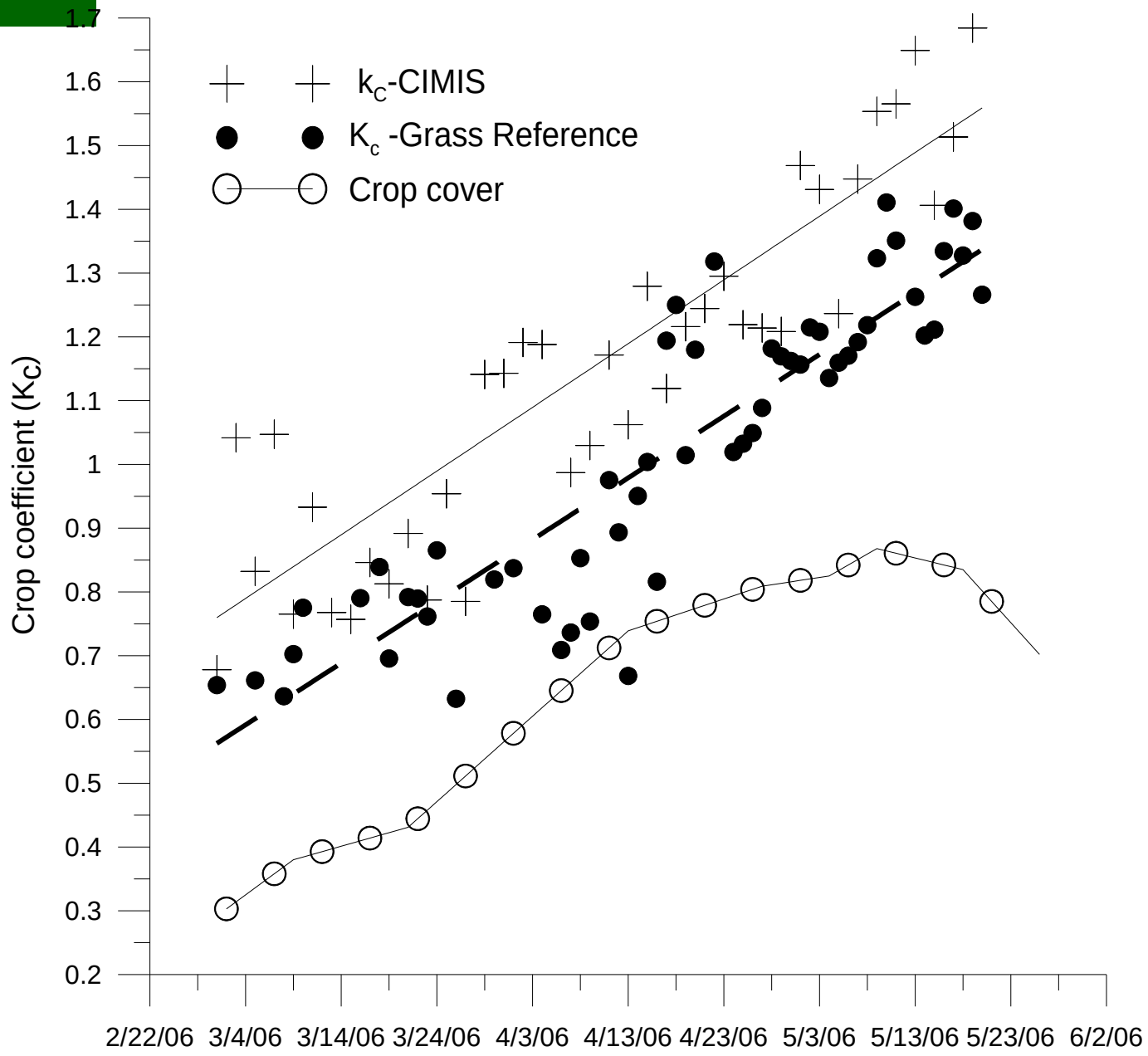
Pepper Canopy Cover

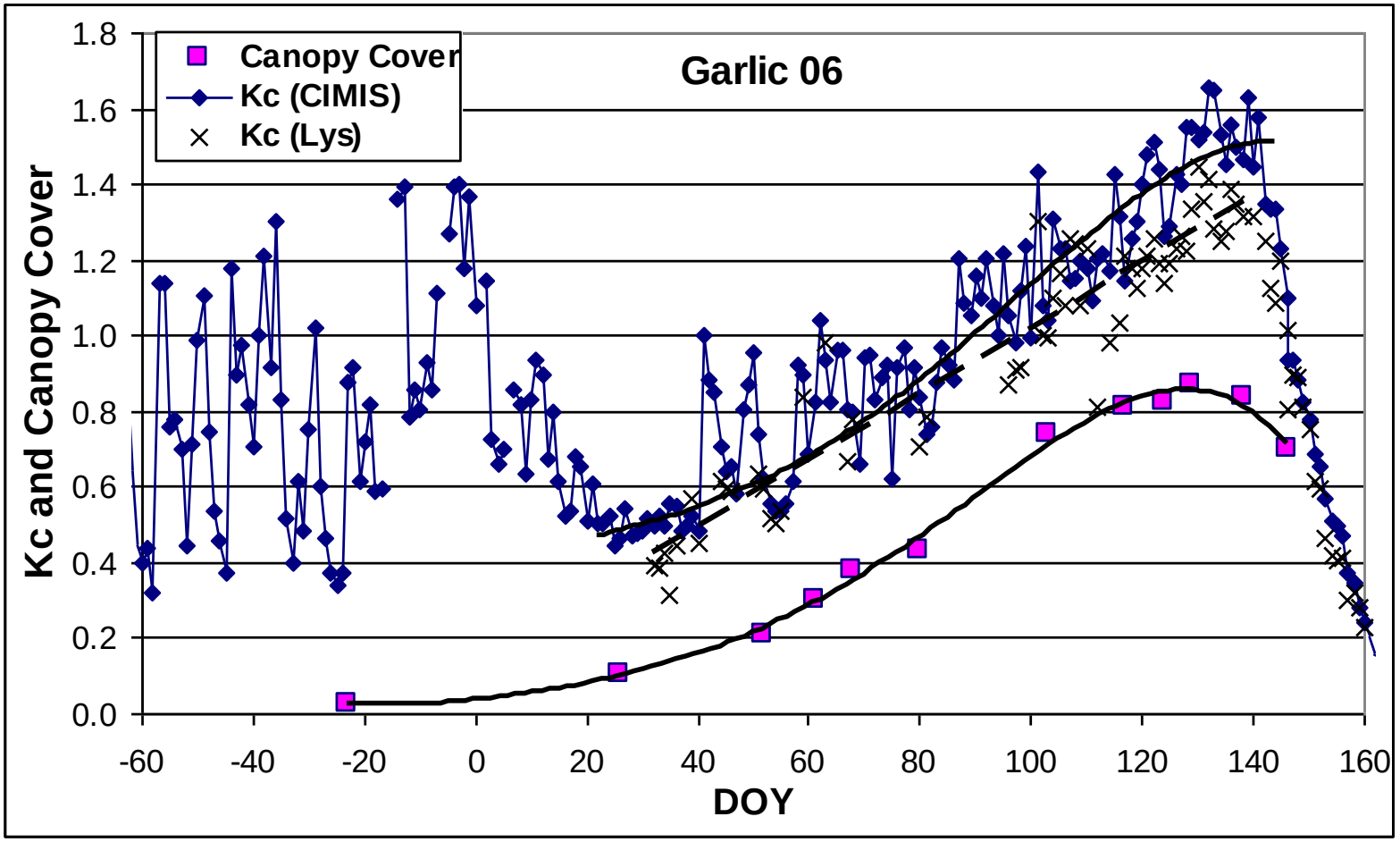


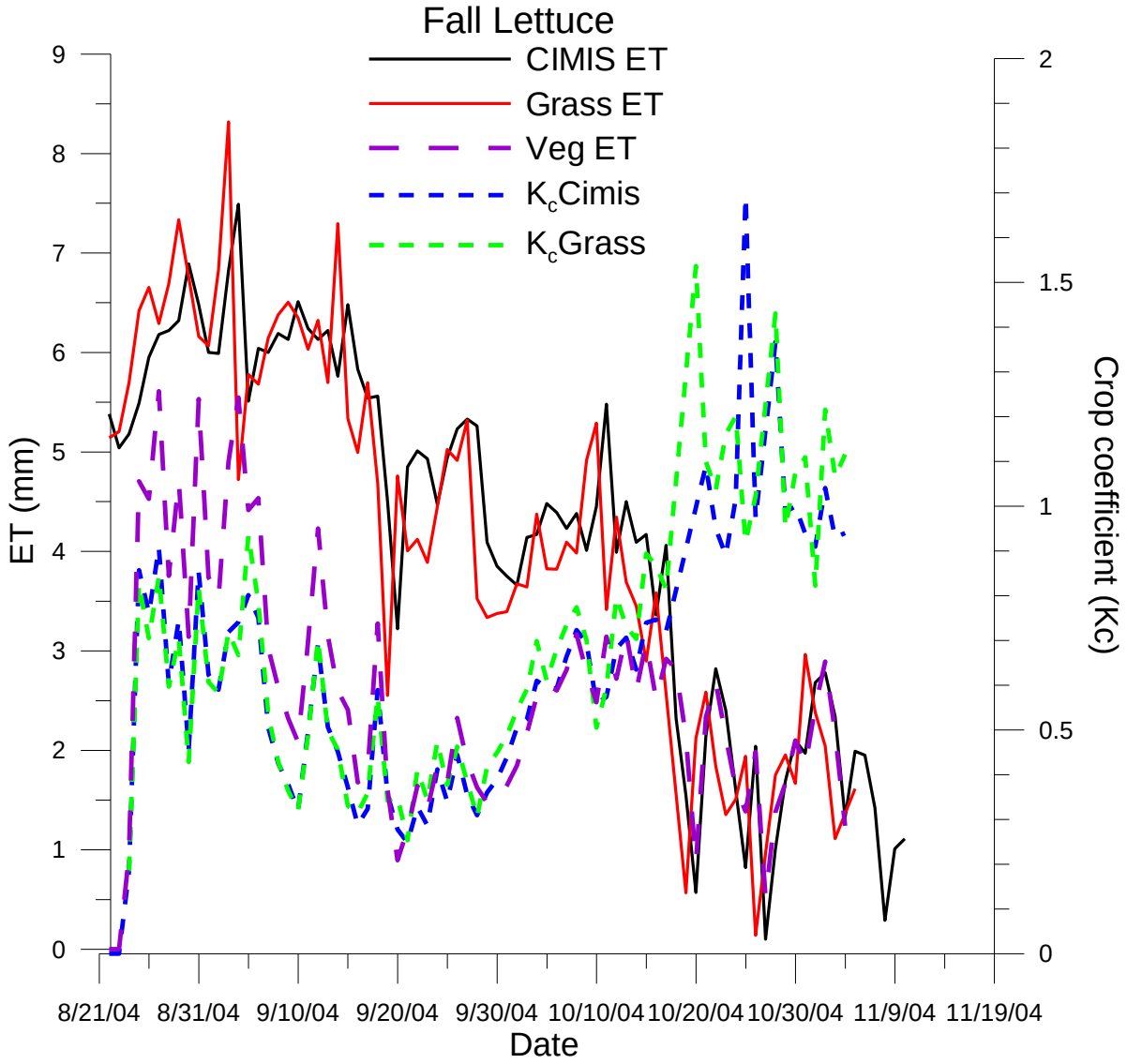


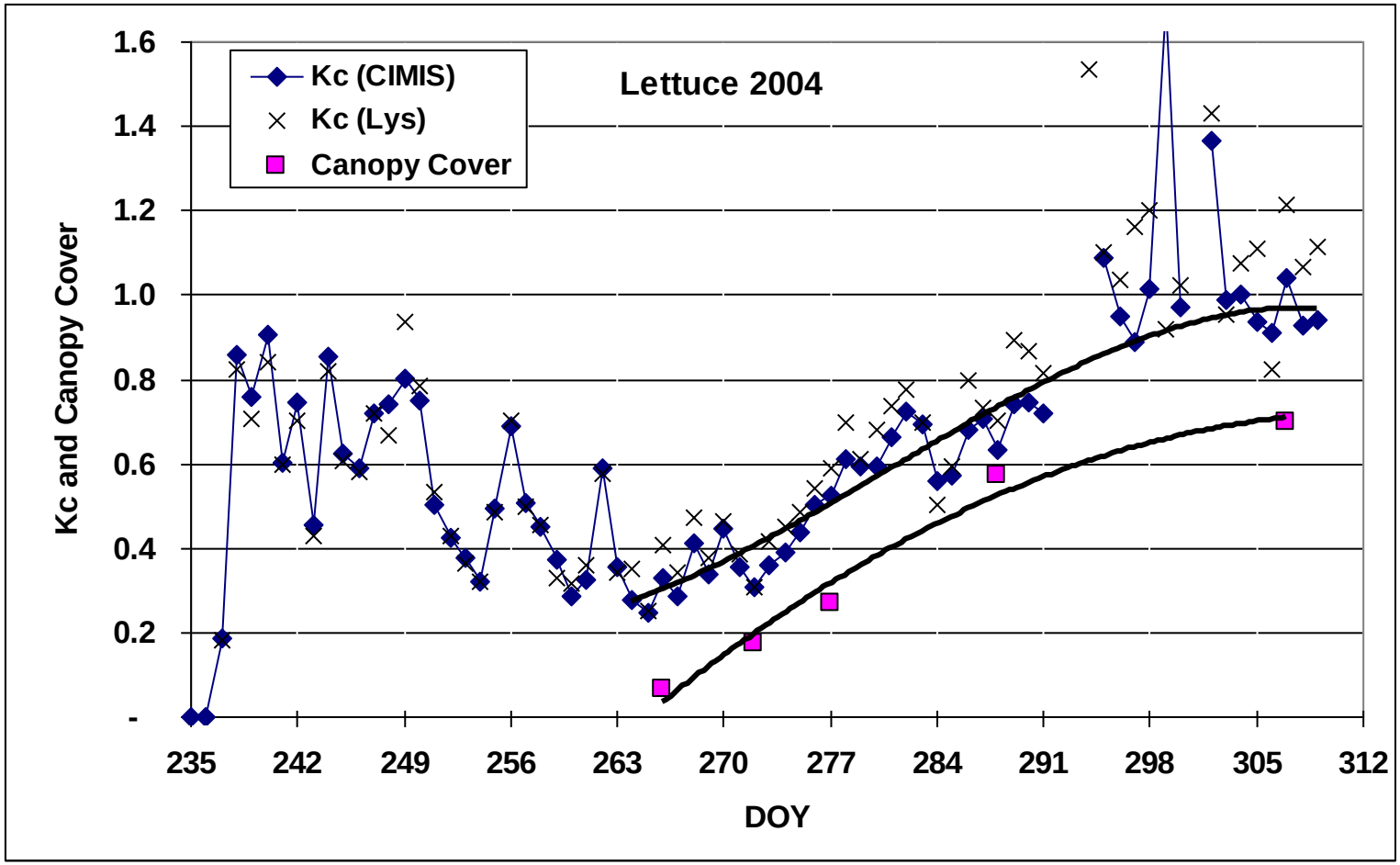

Crop Coefficient and Canopy Cover
WSREC Bell Pepper 2005
Crop Coef., Kc and Crop Cover
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-
4/23
5/7
5/21
6/4
6/18
7/2
7/16
7/30
8/13
8/27
9/10
Date
Kc
Crop Cover

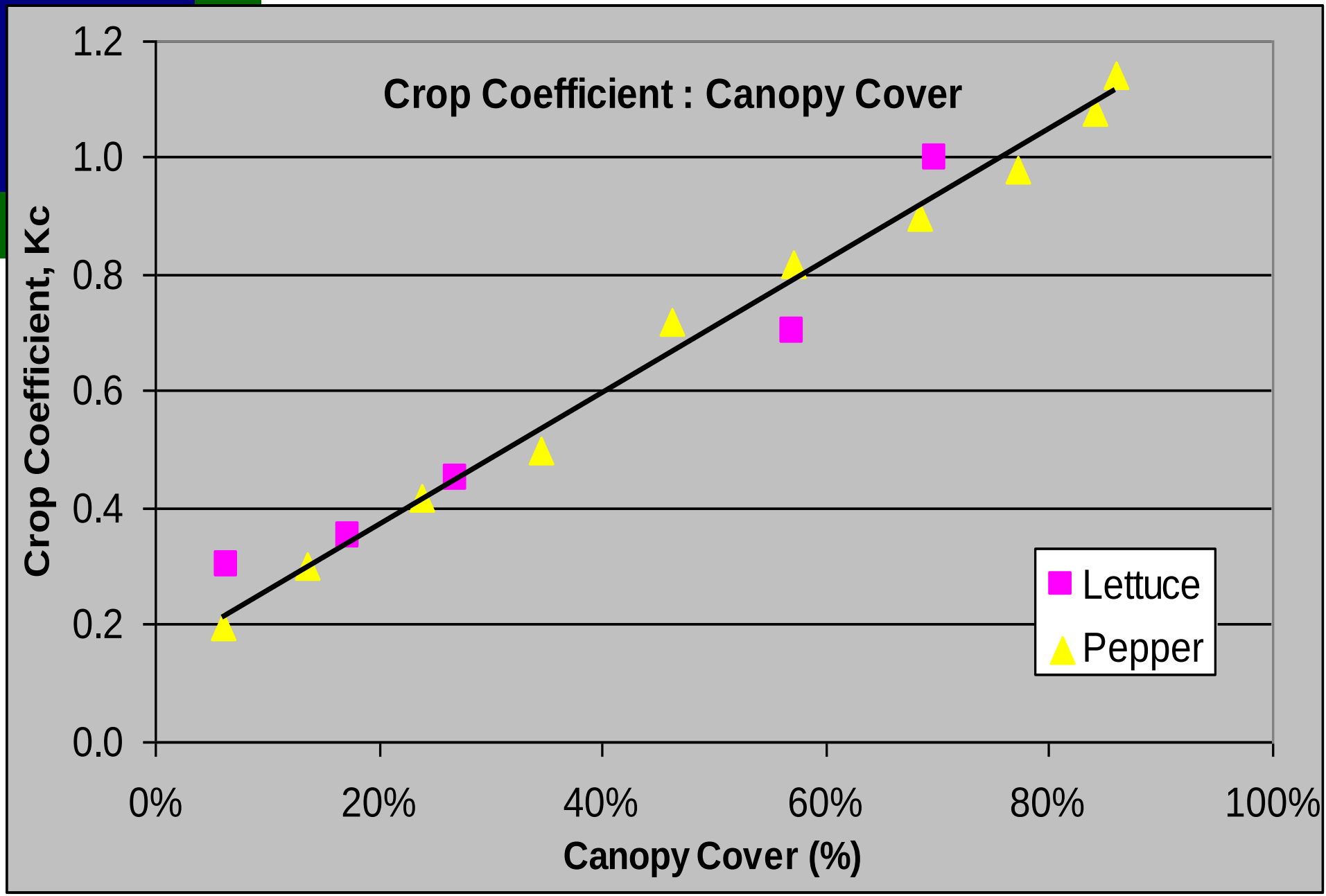

Garlic on WSREC Crop Lysimeter

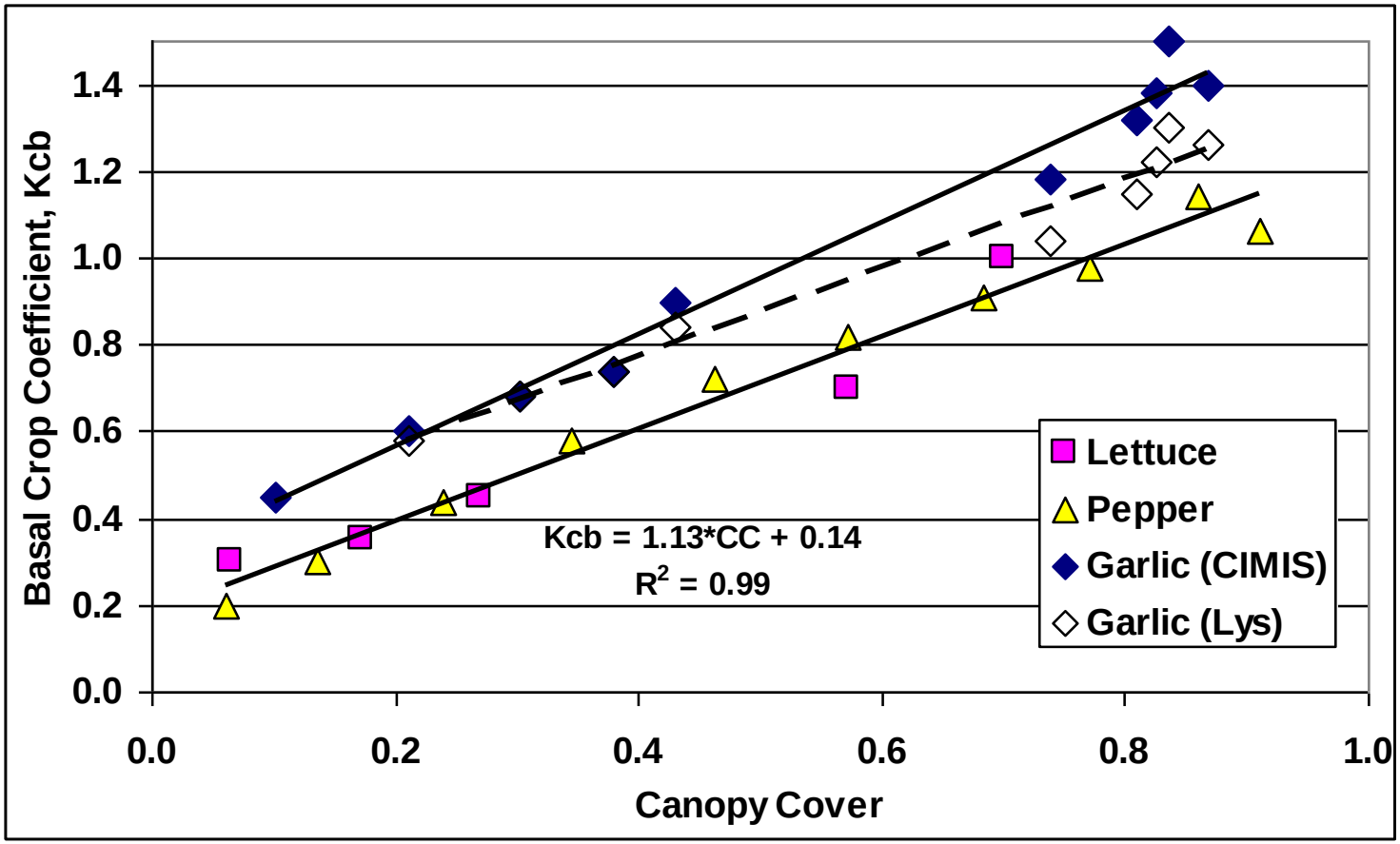

k_c-CIMIS
K_c -Grass Reference
Crop cover
Crop coefficient (K_C)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
2/22/06
3/4/06
3/14/06
3/24/06
4/3/06
4/13/06
4/23/06
5/3/06
5/13/06
5/23/06
6/2/06
Date

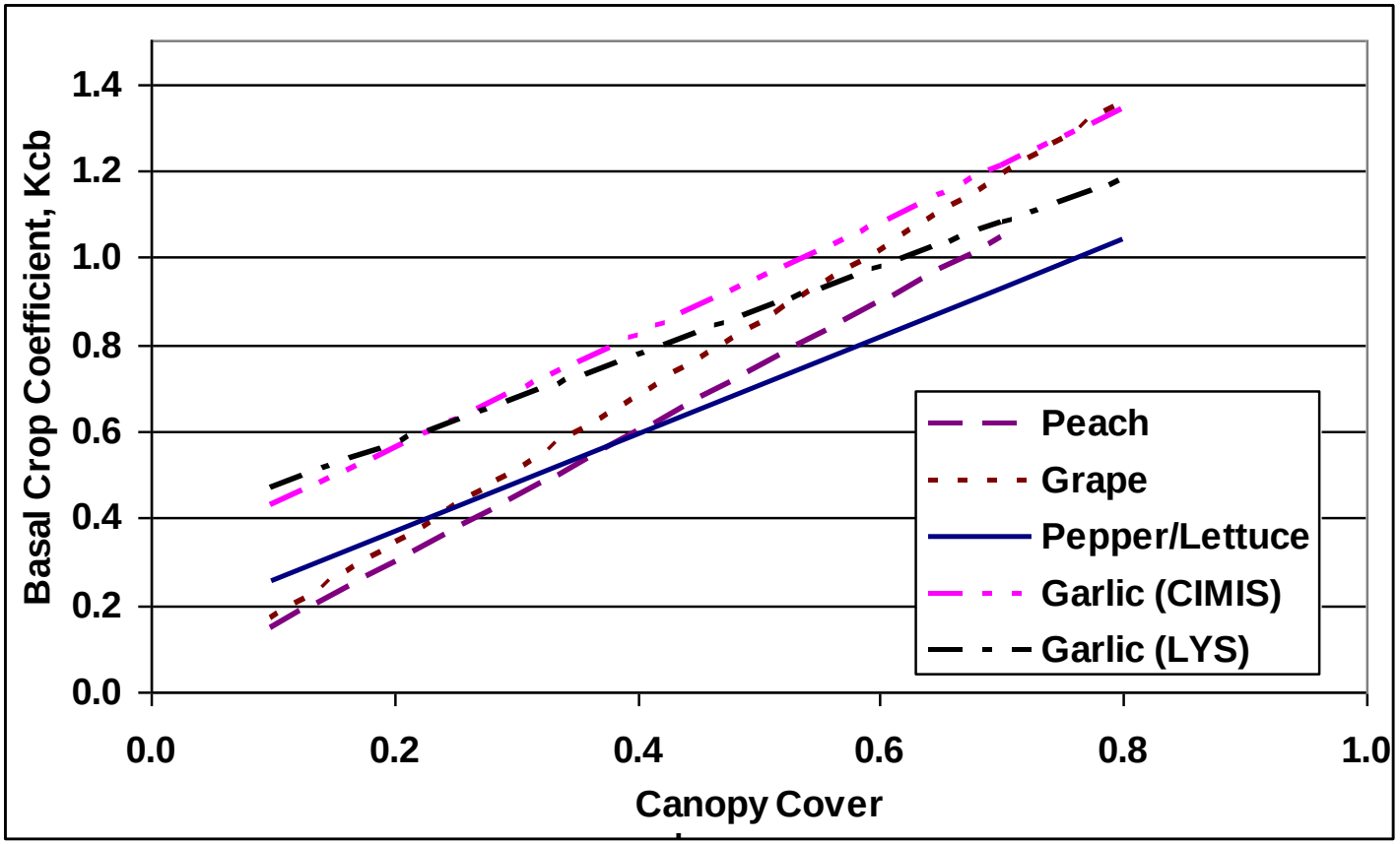

Garlic 06
Canopy Cover
Kc (CIMIS)
Kc (Lys)
Kc and Canopy Cover
DOY
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-60
-40
-20
0
20
40
60
80
100
120
140
160


Fall Lettuce
CIMIS ET
Grass ET
Veg ET
K_cCimis
K_cGrass
ET (mm)
Crop coefficient (Kc)
Date
0
1
2
3
4
5
6
7
8
9
0
0.5
1
1.5
2
8/21/04
8/31/04
9/10/04
9/20/04
9/30/04
10/10/04
10/20/04
10/30/04
11/9/04
11/19/04

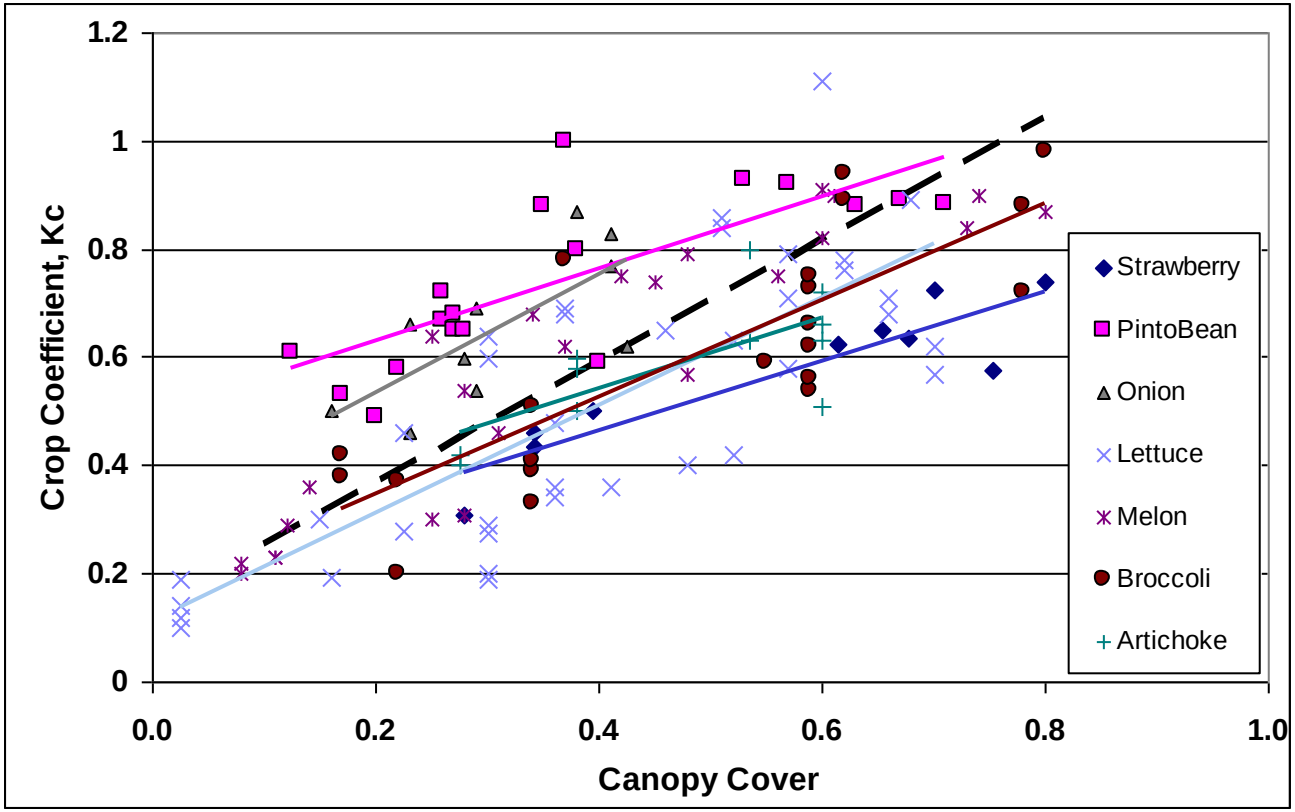

Lettuce 2004
Kc (CIMIS)
Kc (Lys)
Canopy Cover
Kc and Canopy Cover
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-
235
242
249
256
263
270
277
284
291
298
305
312
DOY


Crop Coefficient : Canopy Cover
Crop Coefficient, Kc
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0%
20%
40%
60%
80%
100%
Canopy Cover (%)
Lettuce
Pepper


Basal Crop Coefficient, Kcb
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Canopy Cover
Kcb = 1.13*CC + 0.14
R2 = 0.99
Lettuce
Pepper
Garlic (CIMIS)
Garlic (Lys)



Linear relationships between basal crop coefficient and canopy cover for Peach (Johnson et al. (2004)), Grape (Williams and Ayars, 2005) compared to the Pepper/Lettuce and Garlic relationships from this study.

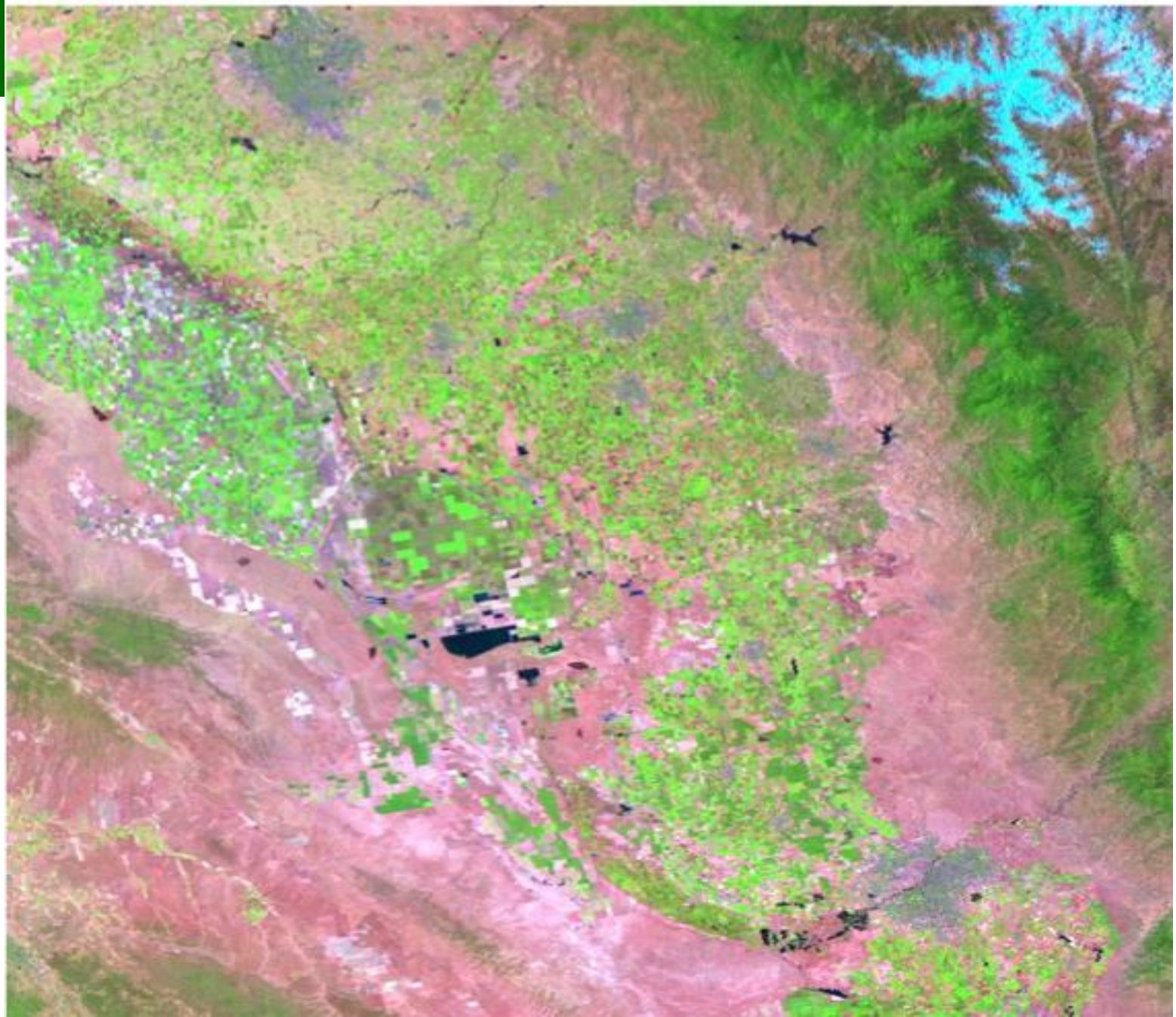


Grattan et al. (1998) crop coefficient (with a visibly dry soil surface) versus canopy cover for 7 annual horticultural crops and out linear best fit relationships for each crop. The dashed line is our lettuce/pepper relationship.

District Level

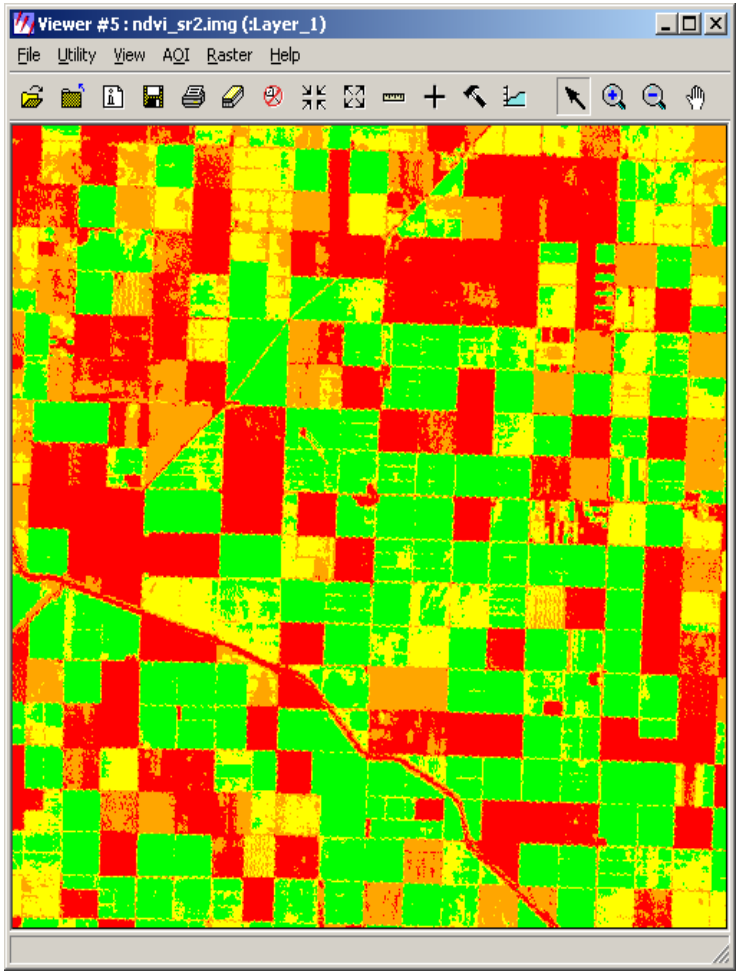
- Remote Sensing canopy cover

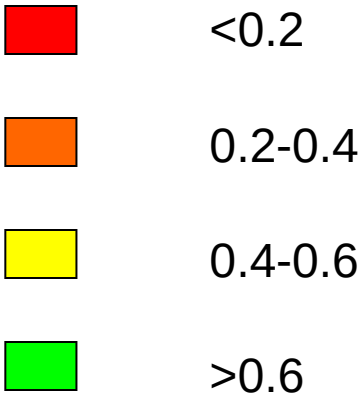
Item 4: Landsat 4-5 TM (July 1982 - present) search results, Preview Image



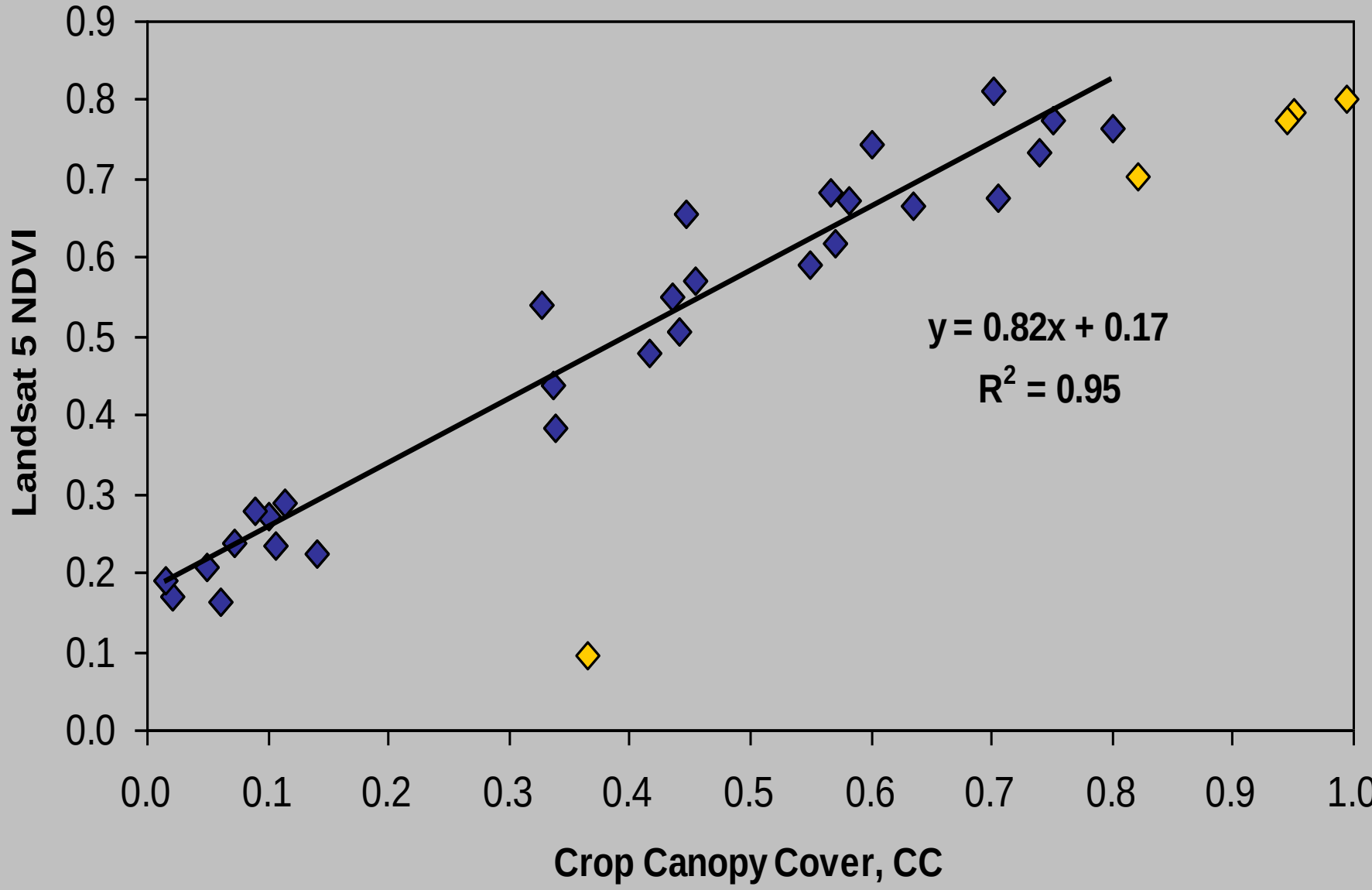
Landsat 5 Thematic Mapper

NDVI





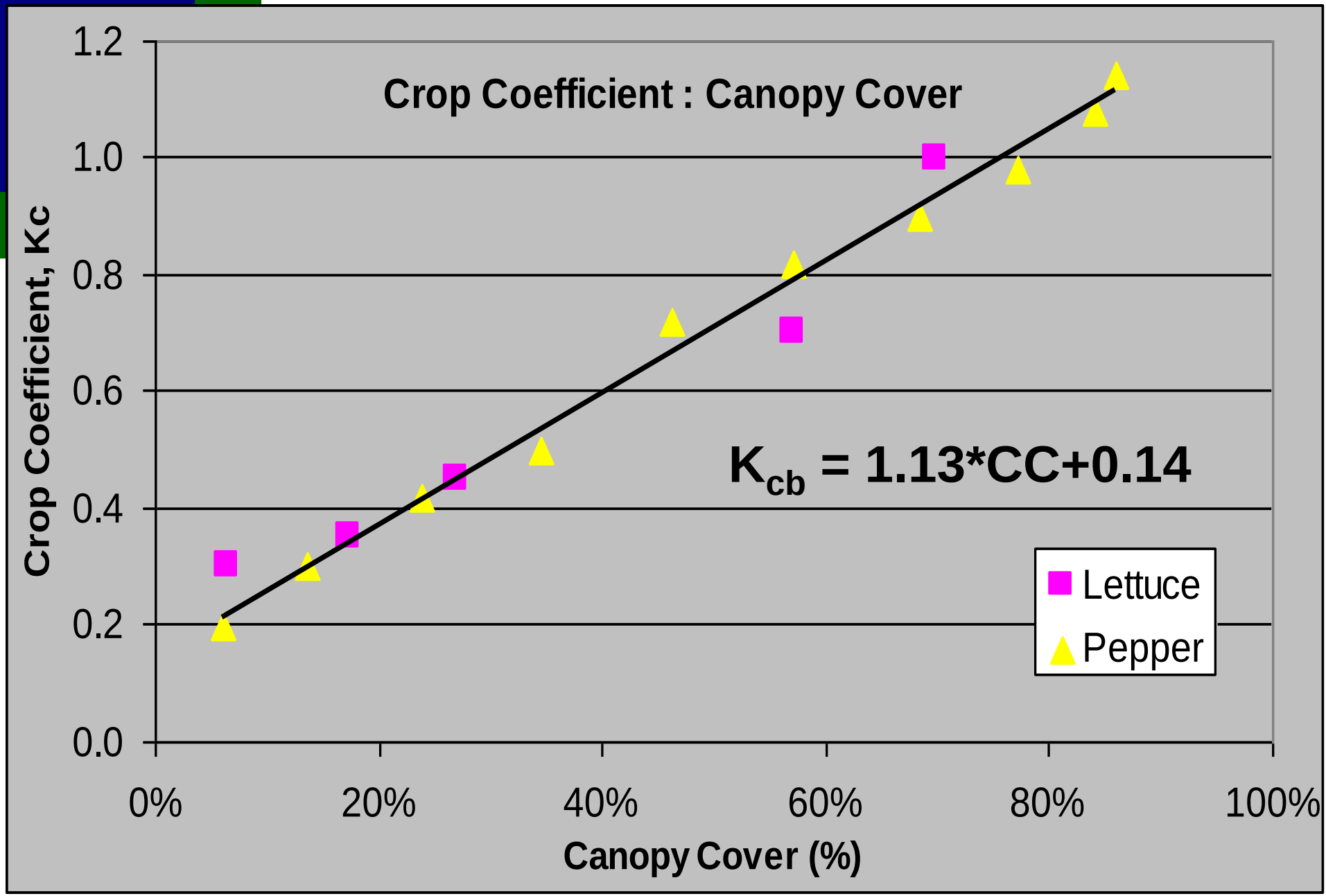
NDVI vs CC


Landsat 5 NDVI
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Crop Canopy Cover, CC
y = 0.82x + 0.17
R2 = 0.95

CC = 1.22*NDVI – 0.21

Canopy Cover

- <20%
- 20%-40%
- 40%-60%
- >60%

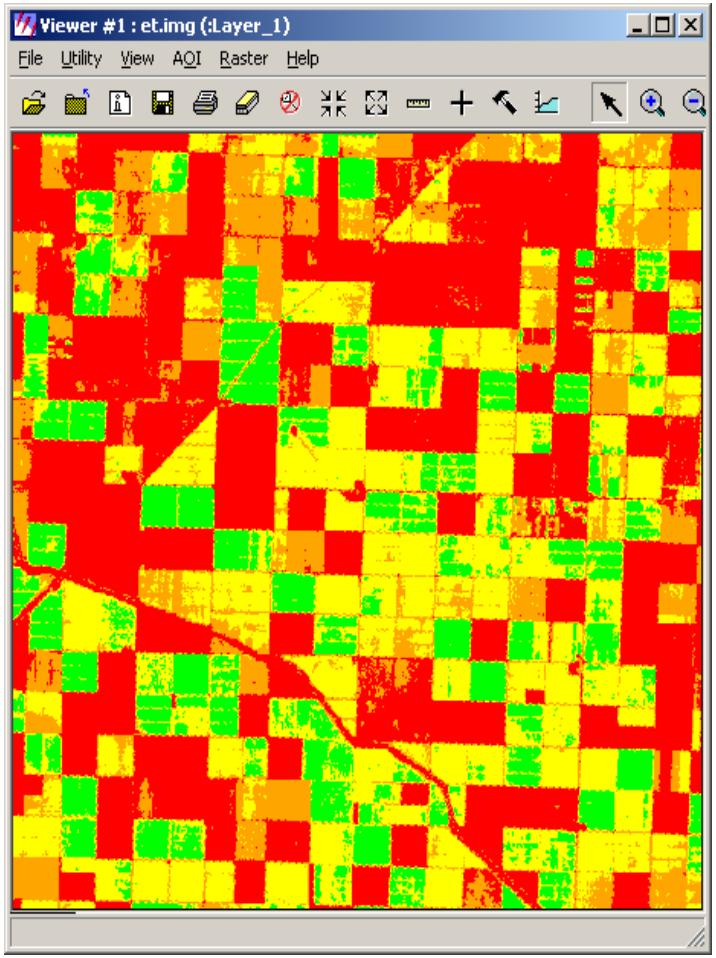

Crop Coefficient : Canopy Cover
Crop Coefficient, Kc
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0%
20%
40%
60%
80%
100%
Canopy Cover (%)
K_{cb} = 1.13*CC+0.14
Lettuce
Pepper

Kcb = 1.13*CC + 0.14

Kcb

- <0.3
- 0.3-0.6
- 0.6-0.9
- >0.9

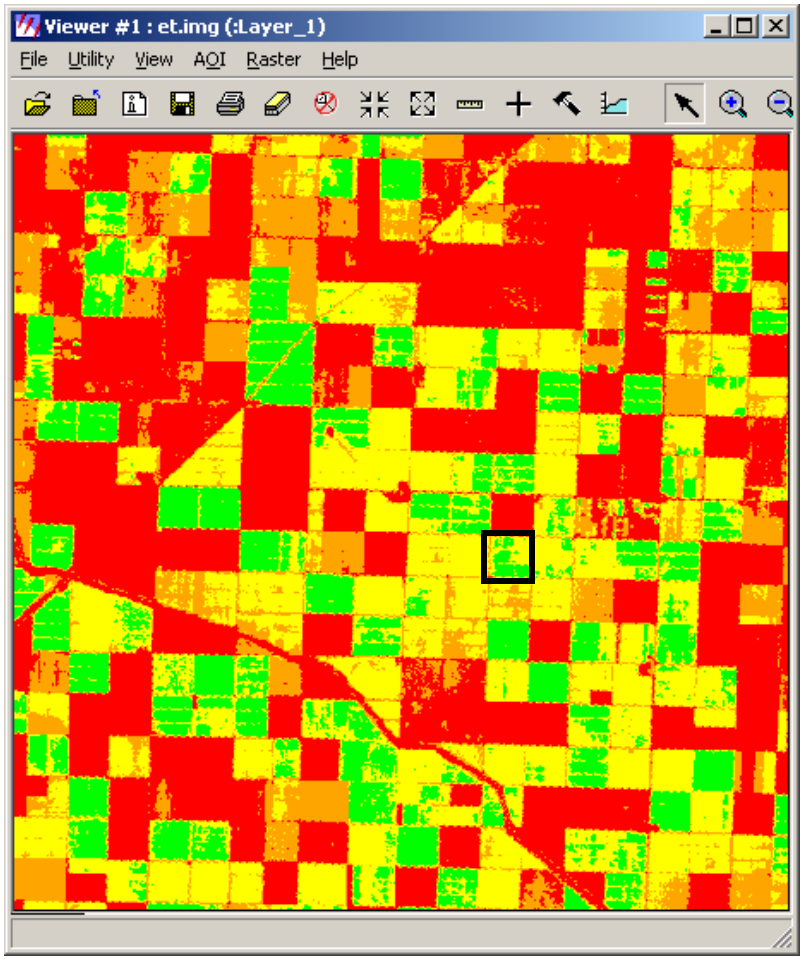
ETc = Kc * ETo (6 mm)



ETc

- <2 mm
- 2-4 mm
- 4-6 mm
- >6 mm

Field Water Use



Daily Water Use

Crop: Corn

Irrigation Method: Furrow

Previous Irrigation (days): 7

DOY: 160

ETo: 6.3 mm

CC: 75%

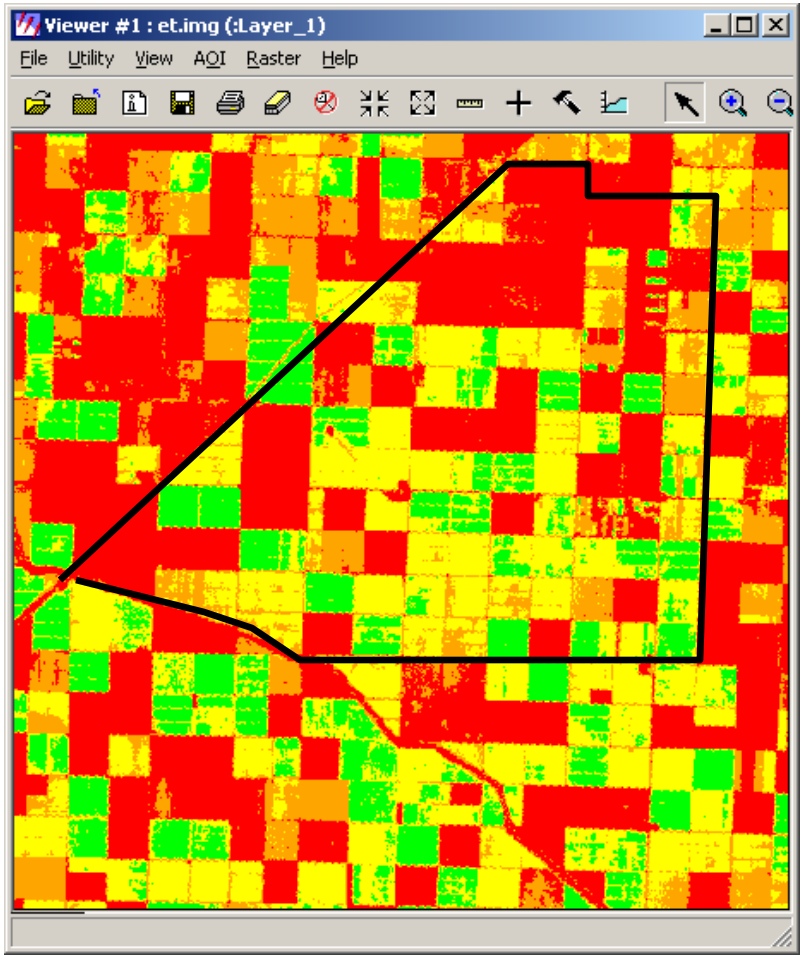
Kcb: 0.83

Kc: 0.83

ETc: 5.2 mm

Cum. Water Use: 35 mm

Irrigation District Water Use



Daily Water Use

DOY: 160

Area: 16,800 ac

ETo: 6.3 mm

Avg. CC: 75%

Avg. Kcb: 0.83

Avg. Kc: 0.85

Avg. ETc: 5.3 mm

Water Use: 2920 ac-ft

Satellite and SMS Irrigation Scheduling Service

How does SSMSISS schedule ?

- Using the FAO 56 approach

Reference water use – weather station

$$ETc = ETo \times Kc$$

Actual water use of crop

Crop Coefficient – relates your crop to the reference crop

Gaining individual crop coefficients

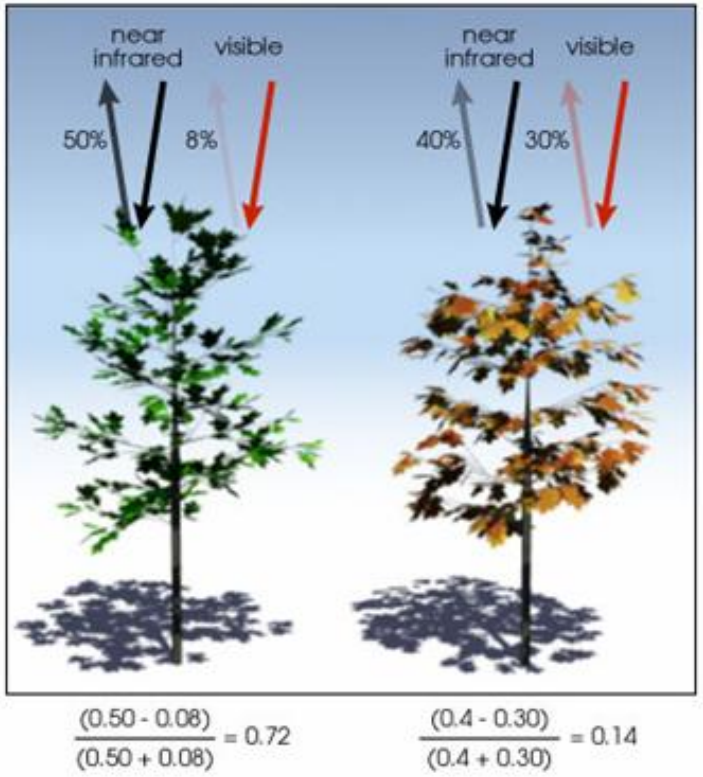
- Multi-spectral (Spot,Landsat, Iknonos) satellites cover MIA approx. every 7-14 days

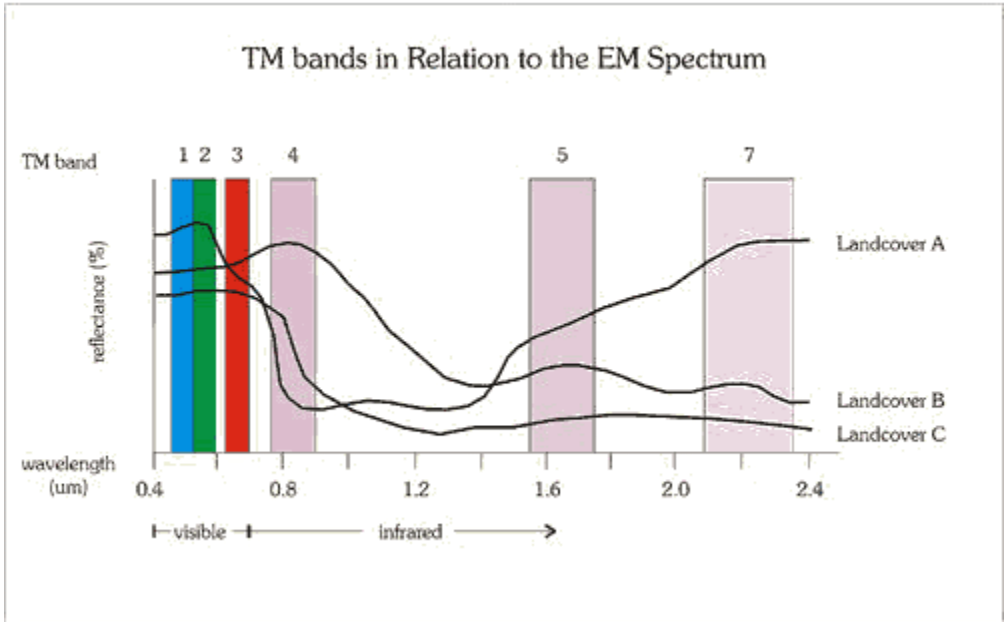
- Images of everyone's individual crop is taken with a resolution as fine as 3x3m

- This information can be used for gaining the crop coefficient

NDVI

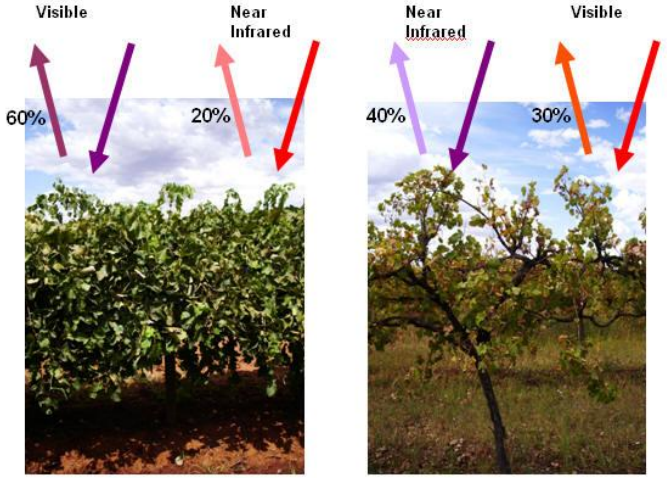
- $NDVI = (R_{NIR} - R_{red}) / (R_{NIR} + R_{red})$





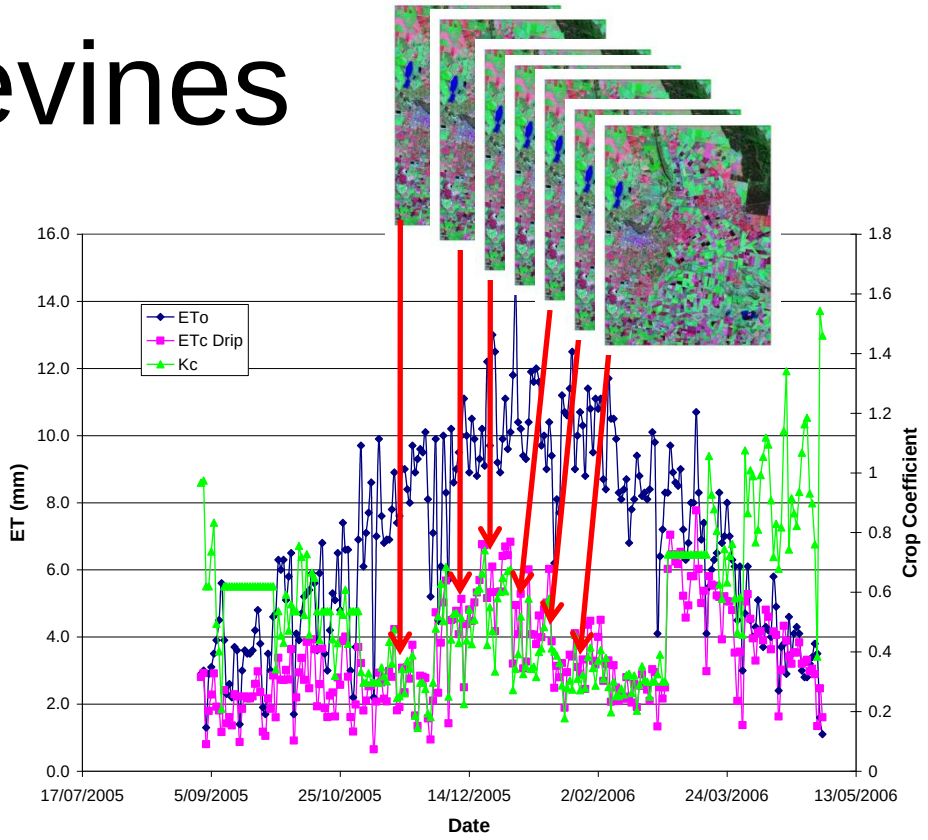
NDVI = (Band 4 - Band 3) / (Band 4 + Band 3)

Determining Kc from NDVI - grapevines



$$NDVI = \frac{R_{NIR} - R_{red}}{R_{NIR} + R_{red}} = \frac{0.6 - 0.2}{0.6 + 0.2} = 0.5$$

$$NDVI = \frac{R_{NIR} - R_{red}}{R_{NIR} + R_{red}} = \frac{0.4 - 0.3}{0.4 + 0.3} = 0.14$$



$$Kc = 2.26 \times NDVI - 0.4352$$

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How does the SSMSISS schedule ?

- Using the FAO 56 approach

Actual water use of crop

.. But still in a format that's not much use!

Making the scheduling information useful

Irrigation

Rainfall

Australian Government
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Overview of SSMSISS

Satellite Measurements

Satellite images used to determine plant performance of an irrigators crop

Incorporates management/soil/water/salinity constraints

Determination of a crop coefficient (Kc) from satellite image

Representing Individual Paddocks

On Ground

ETo from Weather Station or SILO

Potential Evaporation based on Atmospheric Demand

ETc = ETo X Kc

Crop water use determined and irrigation requirement

Daily irrigation scheduling information delivered to irrigators through SMS

Australian Government
Grape and Wine Research and Development Corporation

Thank You

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