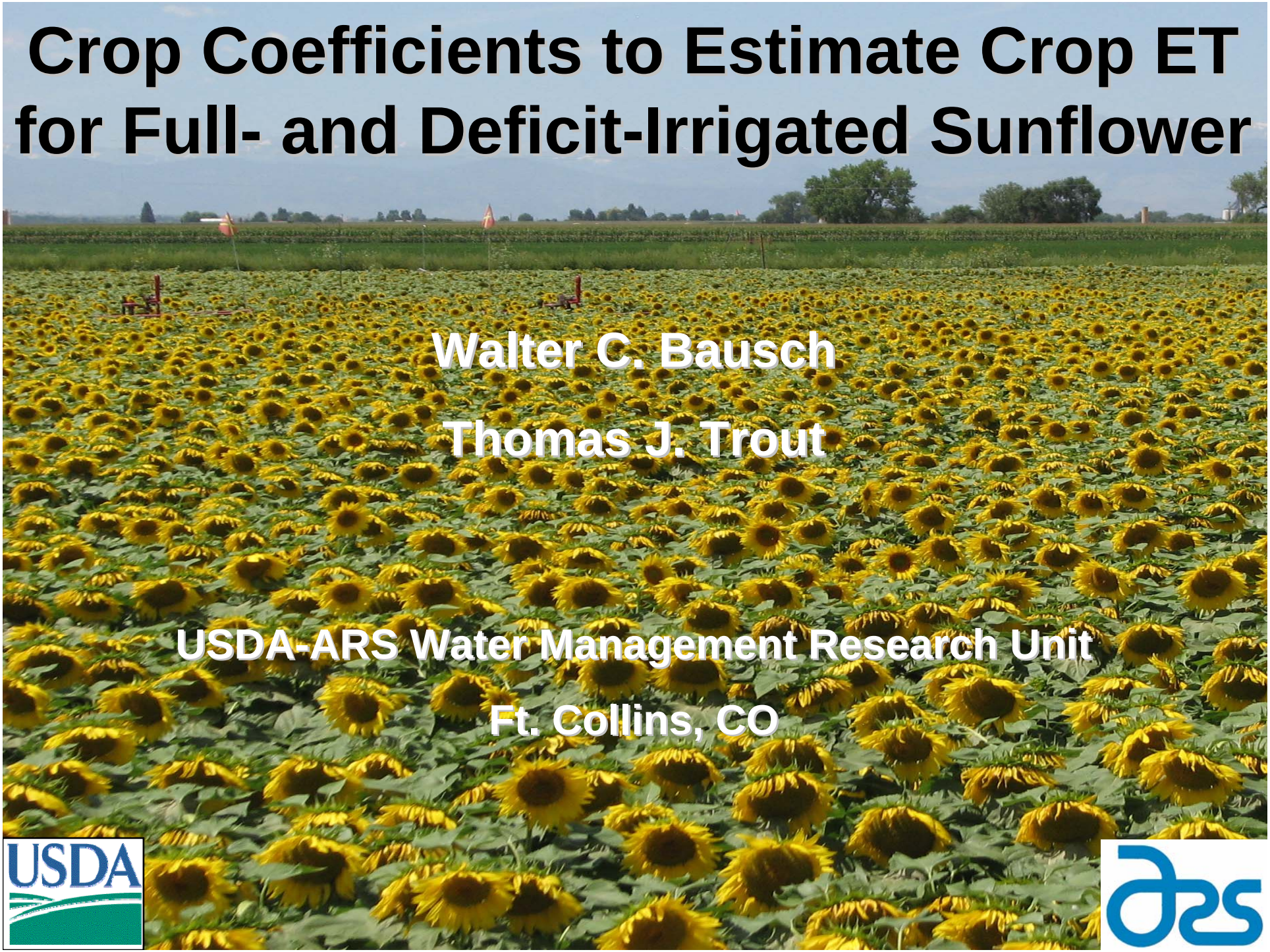
Crop Coefficients to Estimate Crop ET for Full- and Deficit-Irrigated Sunflower



Walter C. Bausch

Thomas J. Trout

USDA-ARS Water Management Research Unit

Ft. Collins, CO

Problem: Sustainability of irrigated agriculture with declining water supplies is a critical issue

- crop production through full irrigation may no longer be a best management practice

- need to strongly consider imposing water deficits on crops during non-critical growth periods

Canopy temperature based irrigation timing techniques exist that determine "when" to irrigate

- none indicate "how much" to irrigate

Hypothesis: Reference ET-crop coefficient concept used in fully irrigated crops may be practical to determine irrigation amount for deficit irrigated crops

$$ET_c = \left(K_{cb} * K_s + K_e \right) * ET_{ref}$$

where

ET_c is estimated crop ET

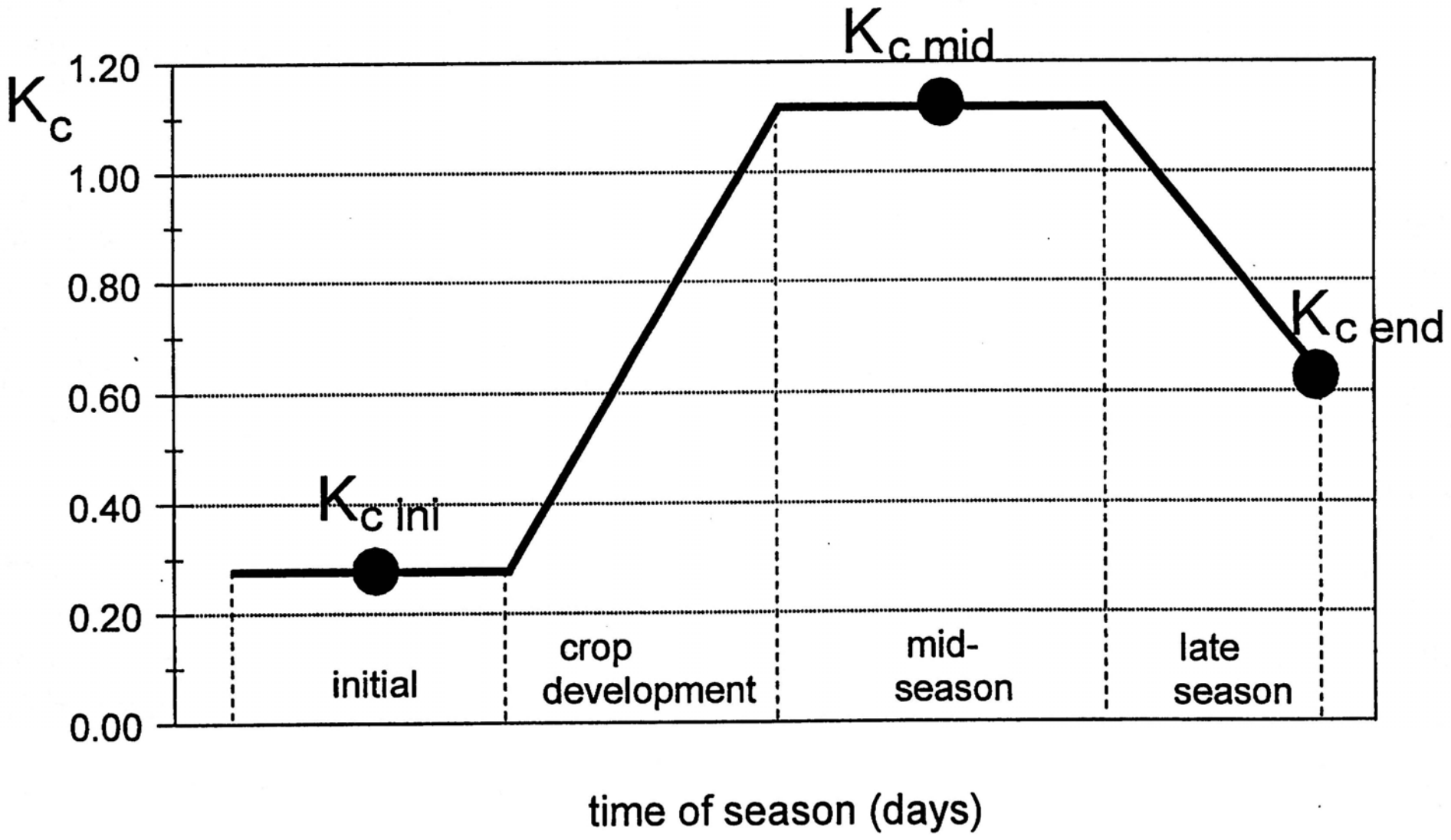
K_{cb} is the basal crop coefficient

K_s is a water stress coefficient

K_e is a coefficient to adjust for increased evaporation from wet soil

ET_{ref} is reference ET

Idealized Crop Coefficient Curve – FAO56



Objective: Evaluate various plant based measurements to refine sunflower crop coefficients to improve ET estimates of deficit irrigated sunflower

Methods:

Limited Irrigation Research Farm, LIRF

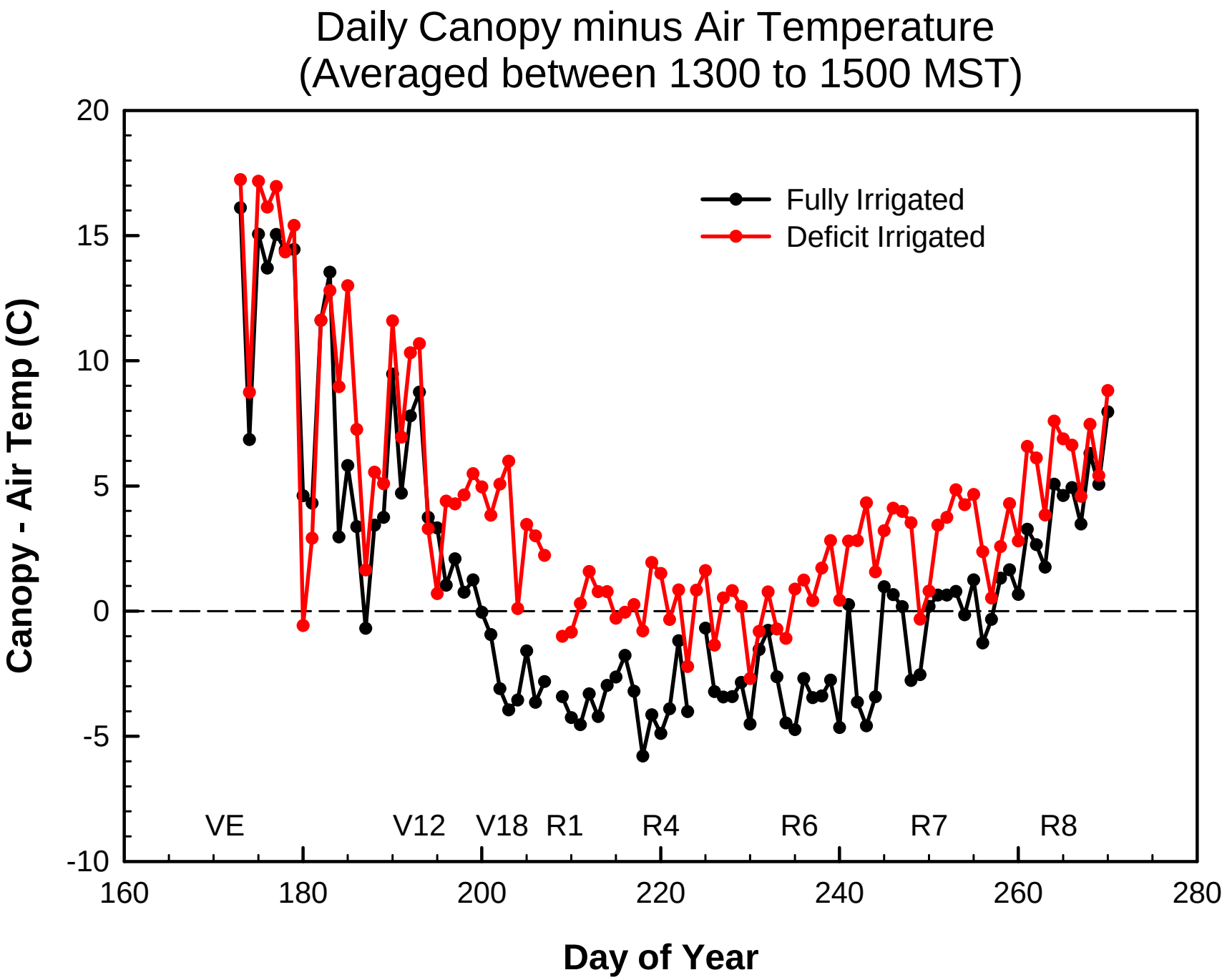
- Fields were strip tilled early spring
- Sunflower (DKF38-45 HO) planted into corn residue – June 6 (DOY 157)
- Row direction – N/S on 30 in spacing
- Emergence – June 20 (171)
- Surface drip irrigated

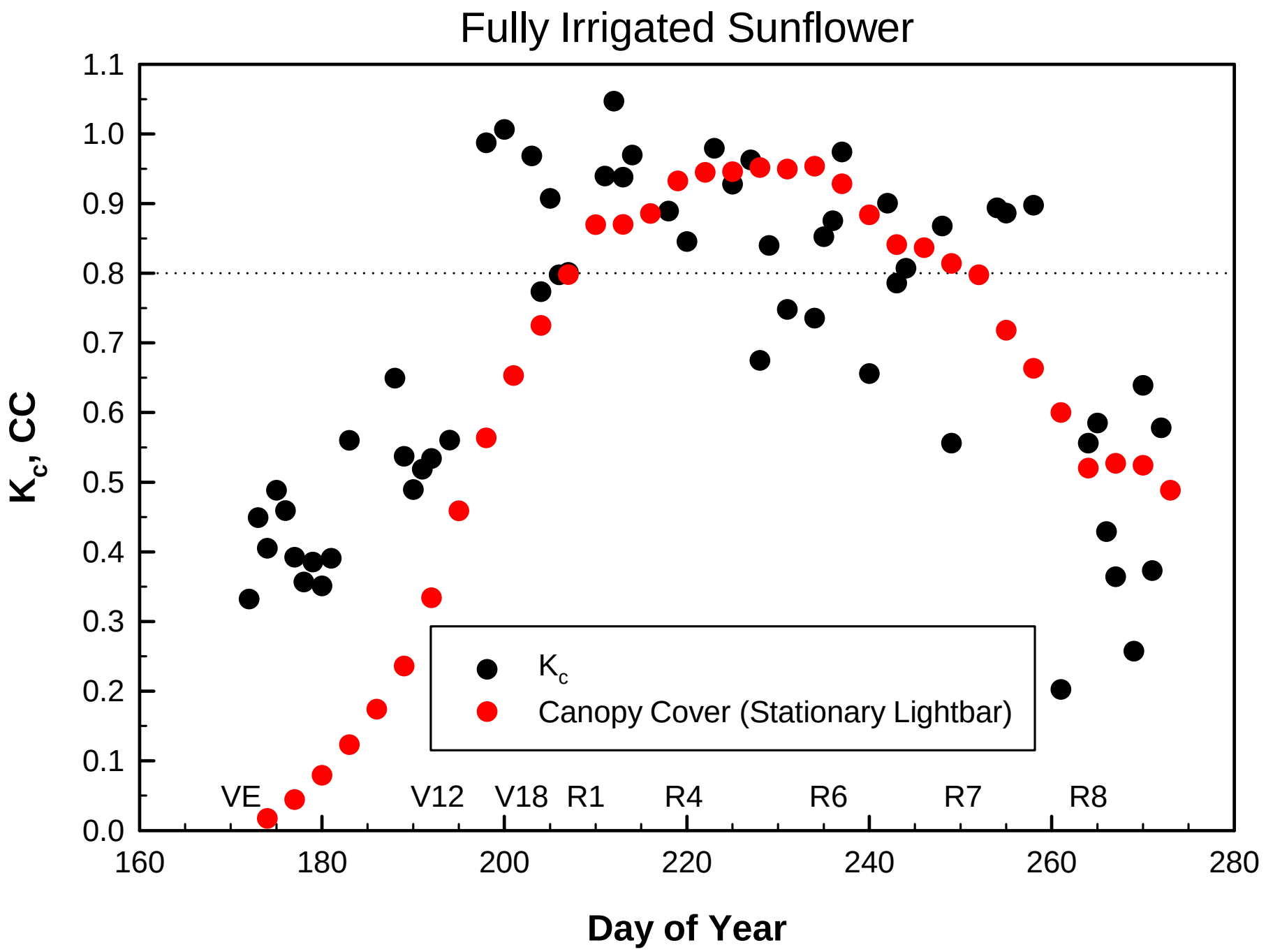
Results:

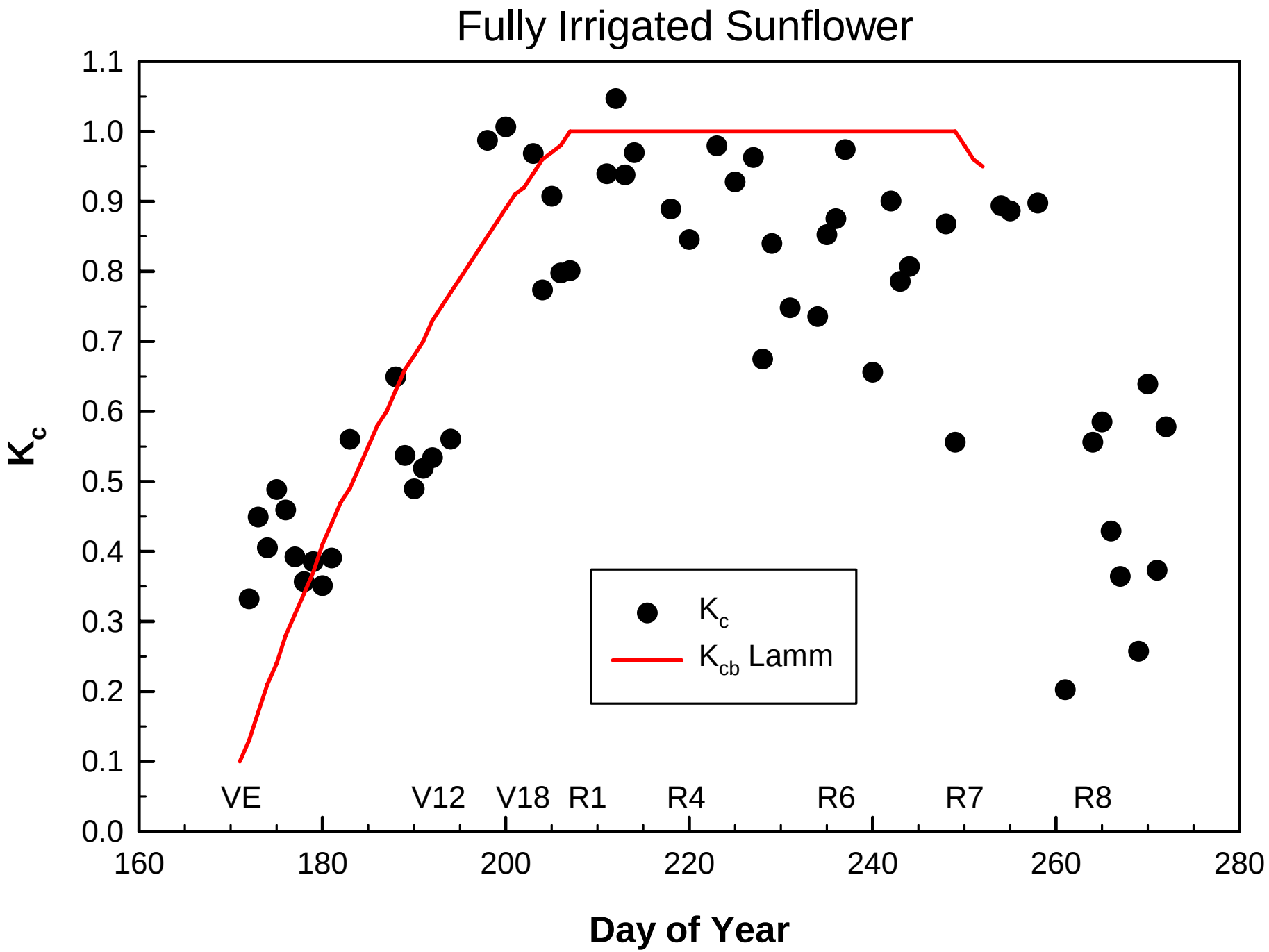
Growing Season Outcomes

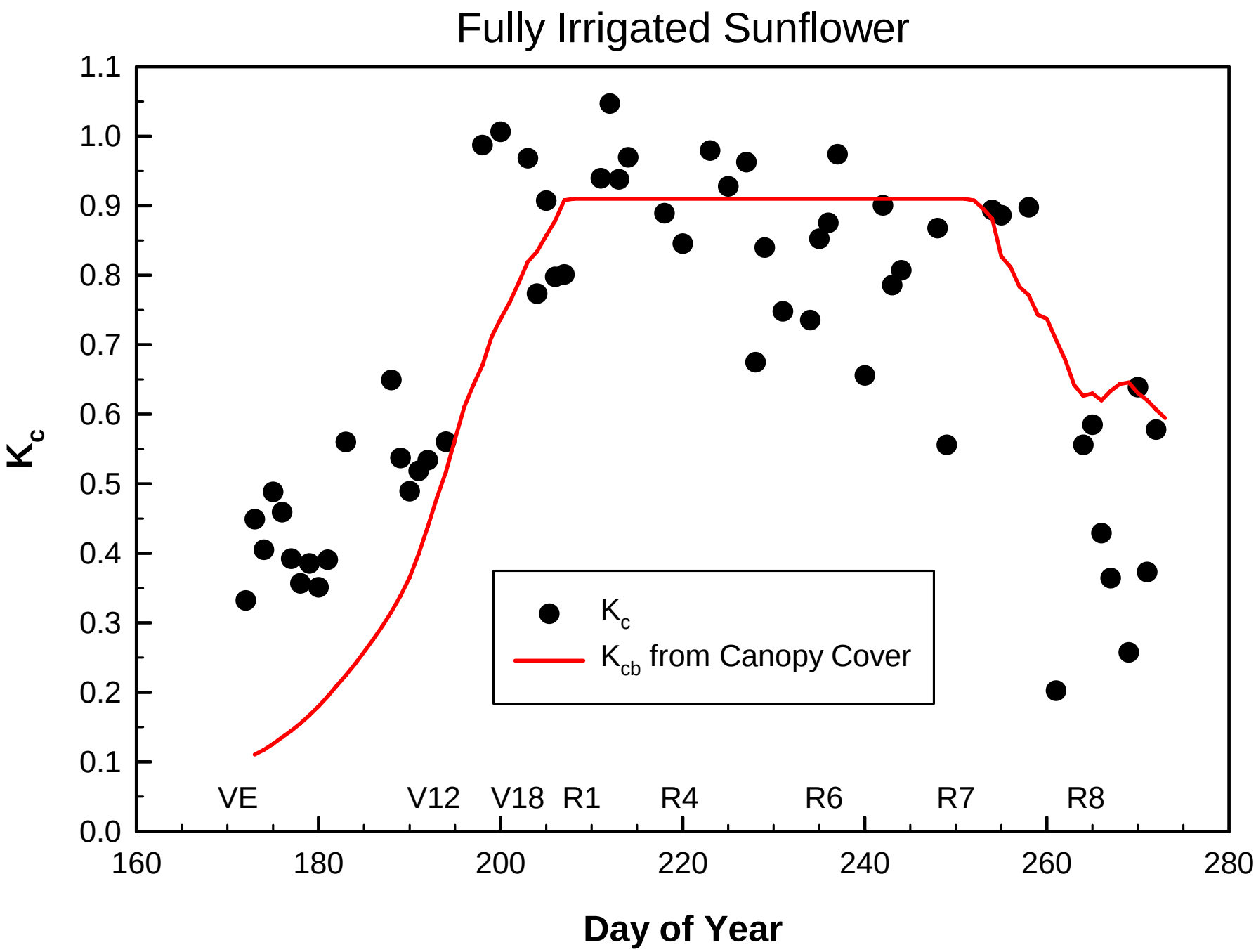
- Fully Irrigated
  - 10 irrigations (12.9 in)
  - Biomass (9710 lb/ac)
  - Yield (2938 lb/ac)
  - Max. plant ht. (5.2 ft)
  - LAI @ R4 (3.47)
- Deficit Irrigated
  - 6 irrigations (6.5 in)
  - Biomass (6090 lb/ac)
  - Yield (2083 lb/ac)
  - Max. plant ht. (4.2 ft)
  - LAI @ R4 (1.77)

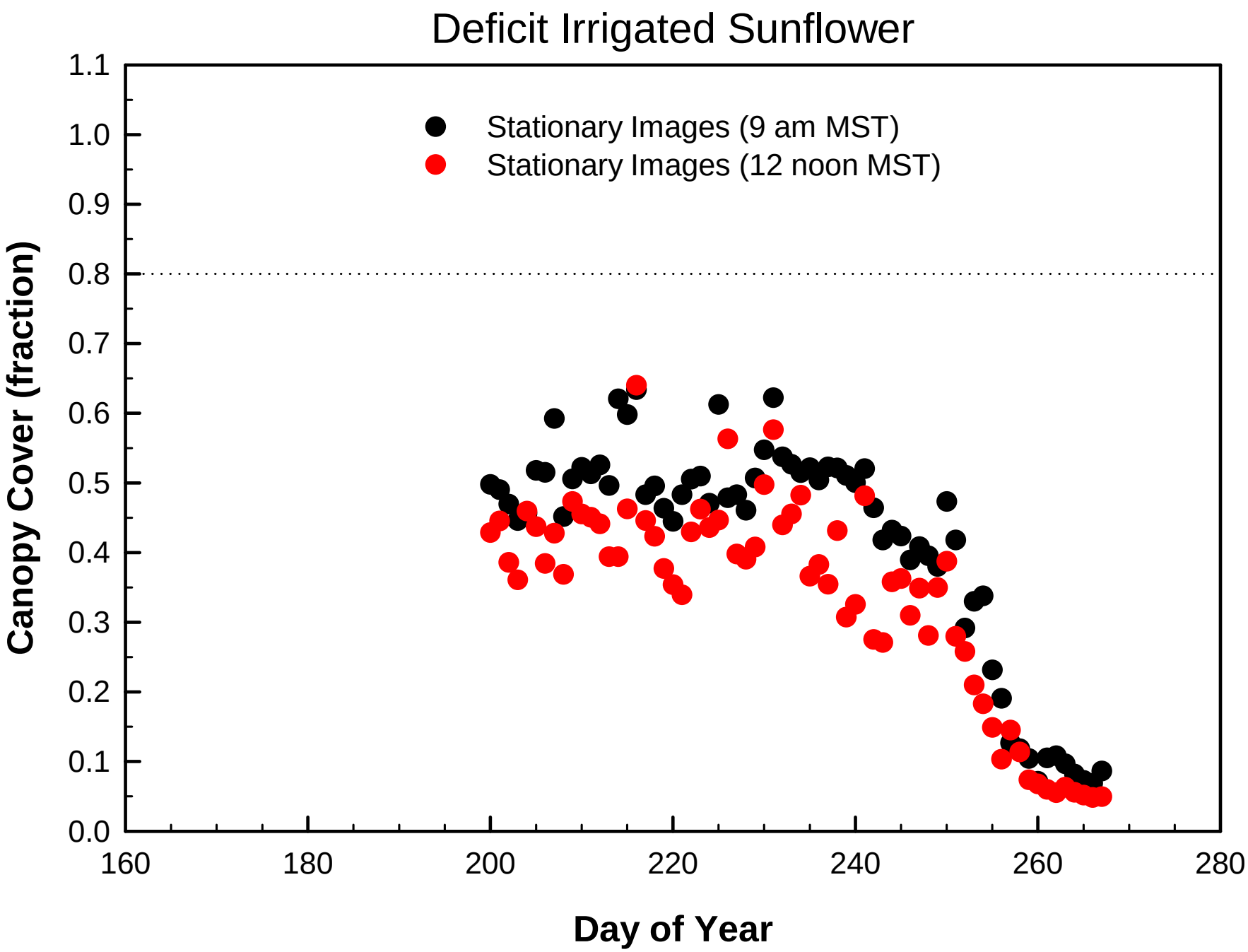
Precipitation during growing season – 3.2 in

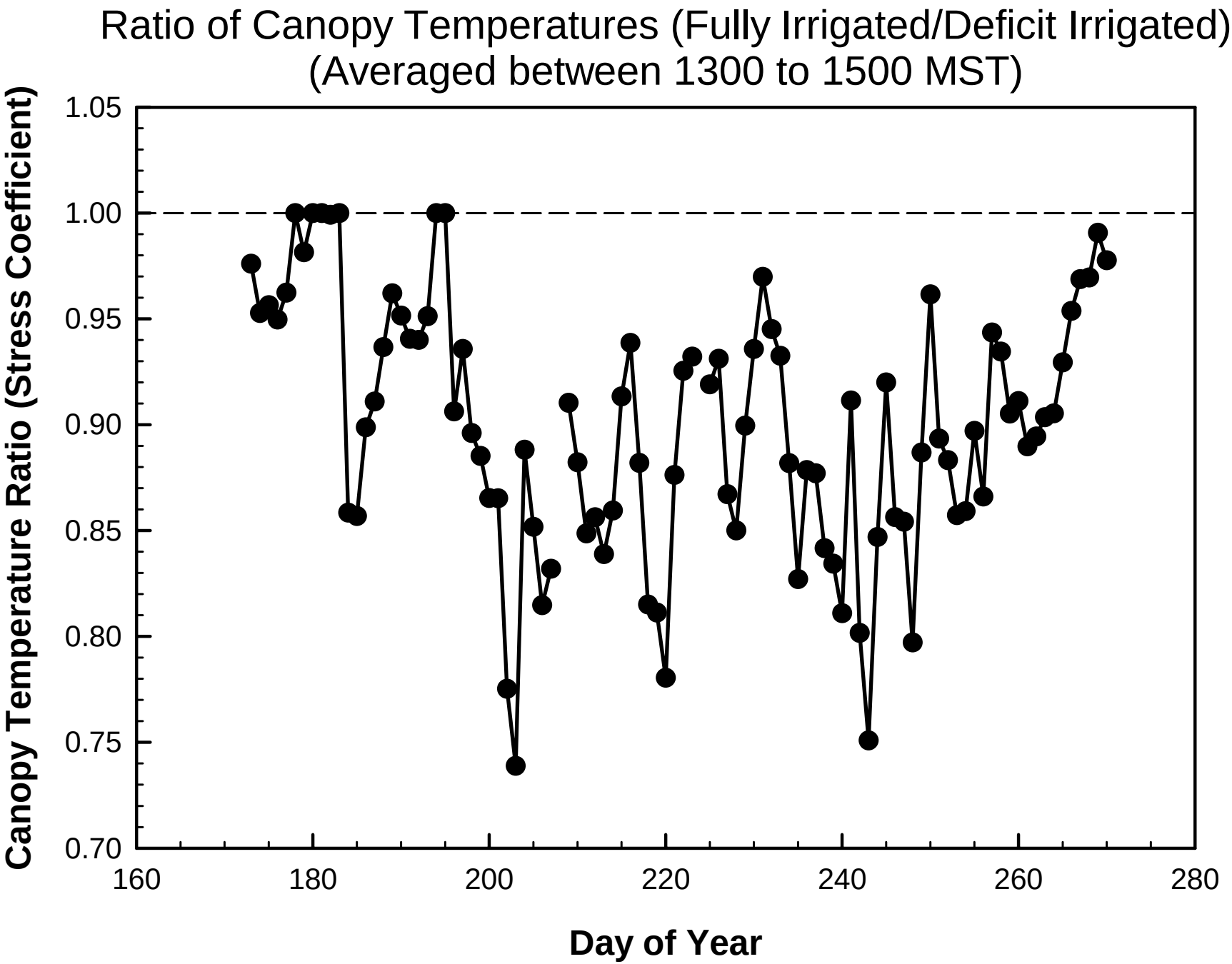

Daily Canopy minus Air Temperature
(Averaged between 1300 to 1500 MST)
Canopy - Air Temp (C)
Day of Year
Fully Irrigated
Deficit Irrigated
VE
V12
V18
R1
R4
R6
R7
R8
20
15
10
5
0
-5
-10
160
180
200
220
240
260
280


Fully Irrigated Sunflower
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
K_c, CC
160
180
200
220
240
260
280
Day of Year
K_c
Canopy Cover (Stationary Lightbar)
VE
V12
V18
R1
R4
R6
R7
R8


Fully Irrigated Sunflower
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
K_c
VE
V12
V18
R1
R4
R6
R7
R8
160
180
200
220
240
260
280
Day of Year
K_c
K_{cb} Lamm


Fully Irrigated Sunflower
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
K_c
160
180
200
220
240
260
280
Day of Year
VE
V12
V18
R1
R4
R6
R7
R8
K_c
K_{cb} from Canopy Cover


Deficit Irrigated Sunflower
Stationary Images (9 am MST)
Stationary Images (12 noon MST)
Canopy Cover (fraction)
Day of Year
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
160
180
200
220
240
260
280


Ratio of Canopy Temperatures (Fully Irrigated/Deficit Irrigated)
(Averaged between 1300 to 1500 MST)
Canopy Temperature Ratio (Stress Coefficient)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
160
180
200
220
240
260
280
Day of Year

Deficit Irrigated Sunflower - K_{cb} based on canopy cover calculated from stationary images acquired at 9 am MST