Irrigating Processing Tomatoes under Limited Water Supply Conditions

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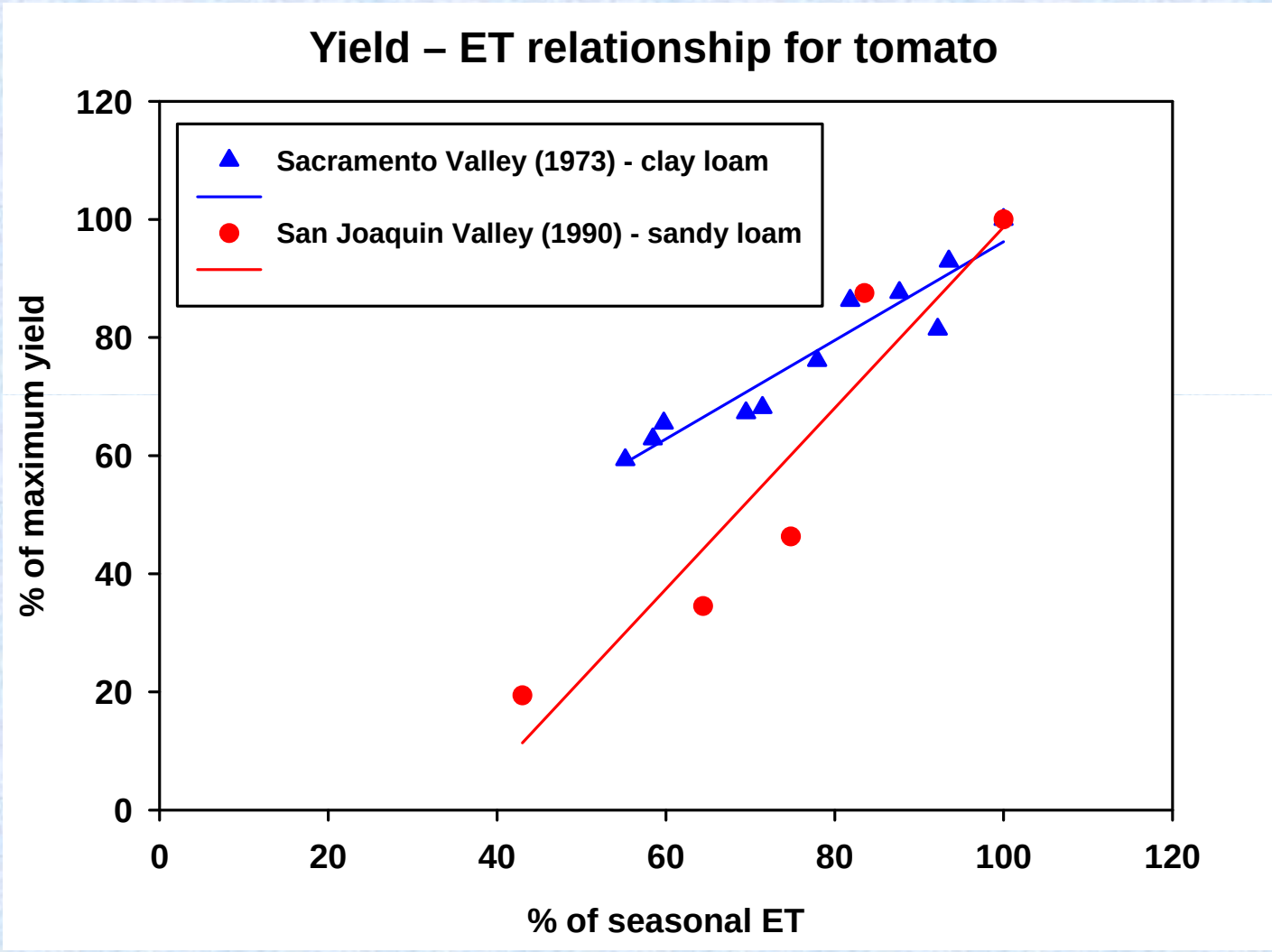
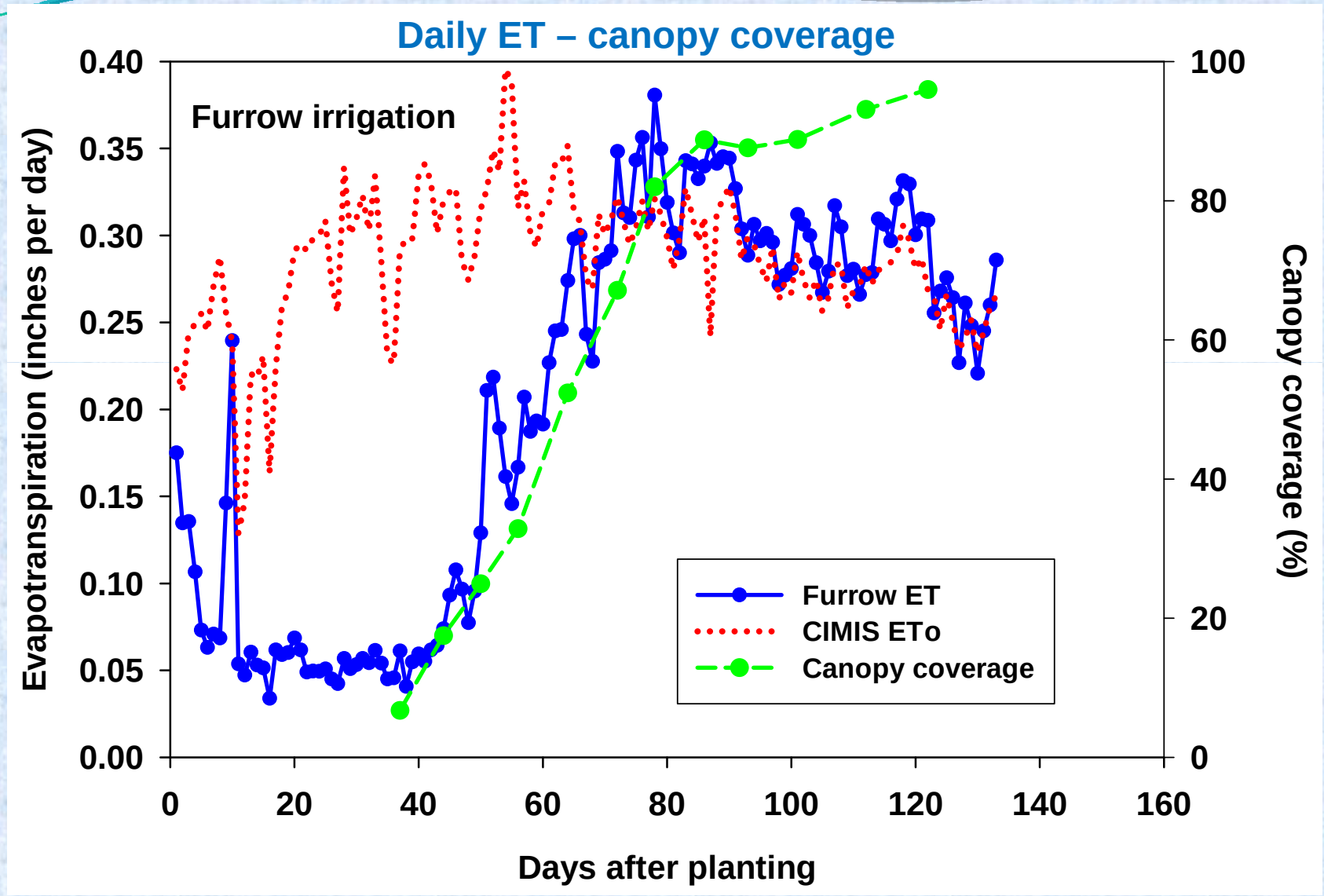
Definitions

- Evapotranspiration (ET) – crop water use
  - Evaporation from plant leaves – transpiration
  - Evaporation from soil surface
  - ET varies with stage of growth and time of year
- Reference crop ET (ETo) – evapotranspiration of well-watered grass
  - California Irrigation Management Information System (State Department of Water Resources)
  - Calculated using site specific climate and soil data and complex equations
- Units of ET: inches, centimeters, millimeters
  - One inch of ET = one acre-inch of water (27,160 gallons) ÷ one acre
  - Standardizes ET – independent of field size
- Applied water = ET ÷ irrigation efficiency


Yield – ET relationship for tomato
Sacramento Valley (1973) - clay loam
San Joaquin Valley (1990) - sandy loam
% of maximum yield
% of seasonal ET
0
20
40
60
80
100
120

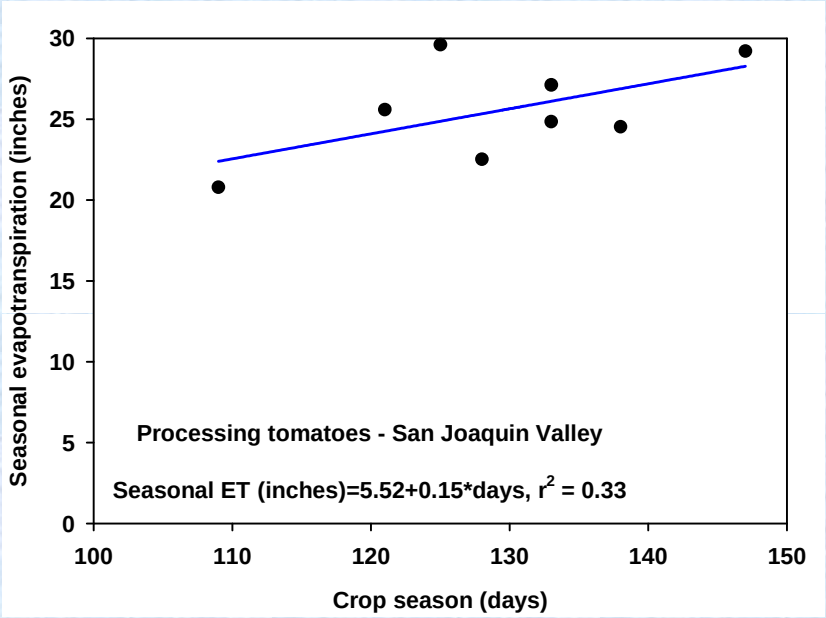
Evapotranspiration of processing tomatoes (fully irrigated)

- Westlands Water District – western Fresno County
- Eight commercial tomato fields – drip and furrow irrigation
- Different cultural practices
  - plant rows per bed
  - stand establishment – drip, sprinkle
  - planting times – early to late plantings
  - varieties
- Growers' normal irrigation practices
- Published in *California Agriculture*


Daily ET – canopy coverage
Furrow irrigation
Evapotranspiration (inches per day)
Canopy coverage (%)
Days after planting
Furrow ET
CIMIS ETo
Canopy coverage
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0
20
40
60
80
100
120
140
160

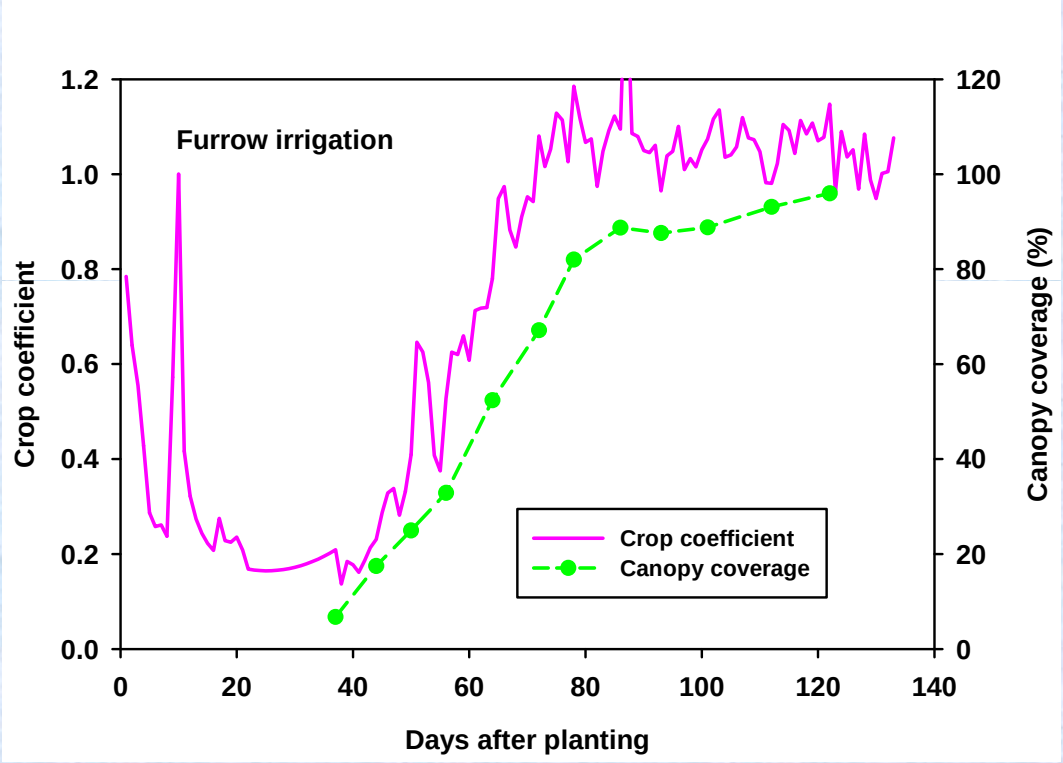
Seasonal ET

- Average seasonal ET = 25.5 inches
- Range = 21 – 30 inches (depends on crop season)
- Little difference between furrow and drip irrigation
- Similar to historical values calculated in 1981
- Similar to Sacramento Valley values
  - 1972 – 26.8 inches
  - 1973 - 29.9 inches

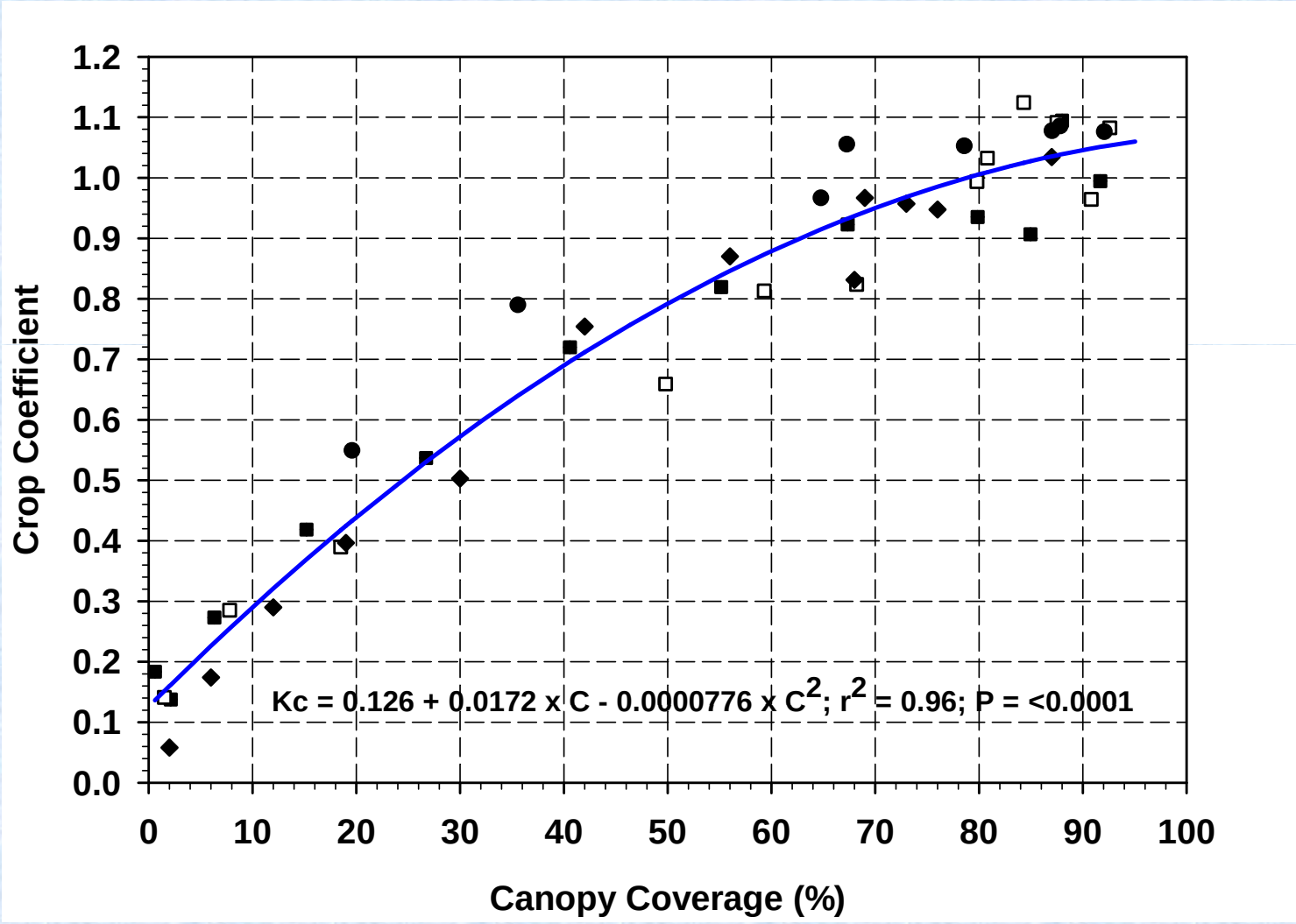


Calculating evapotranspiration between irrigations

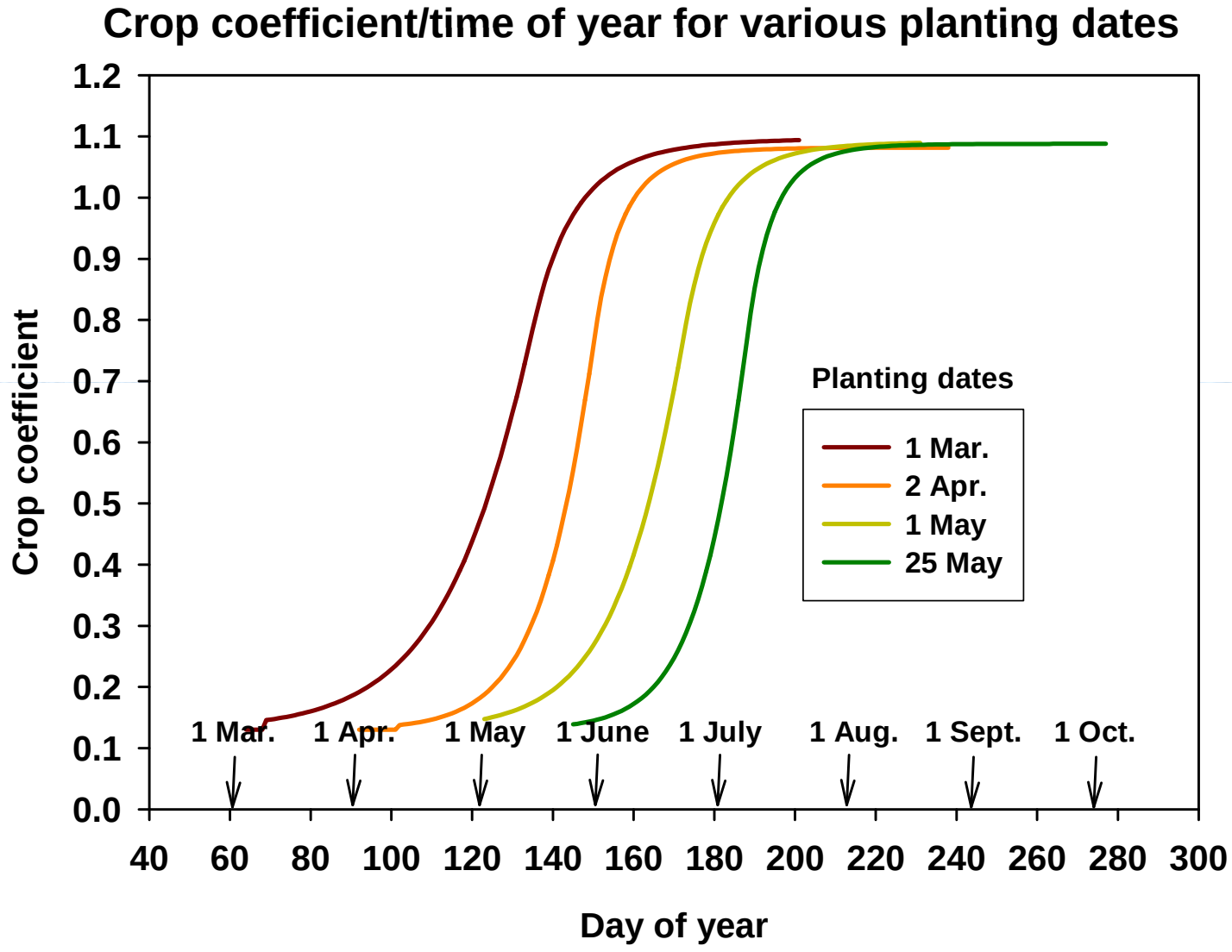
- ET = Kc x ETo x DAY
  - ET = crop ET
  - Kc = crop coefficient
  - ETo = CIMIS reference crop ET
  - DAY = days between irrigation
- Crop coefficient
  - Relates crop ET to reference crop ET
  - Varies with stage of growth
- Appropriate after stand establishment



Crop coefficient – canopy coverage relationship



Canopy coverage = 100 x width of canopy ÷ furrow spacing


Crop coefficient/time of year for various planting dates
Crop coefficient
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Planting dates
1 Mar.
2 Apr.
1 May
25 May
1 Mar.
1 Apr.
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Day of year

Using ET data for irrigation water management

- **Furrow irrigation**
  - **Estimate the amount of soil moisture depletion that can occur without reducing yield (allowable depletion)**
  - **Calculate the daily ET (ET = Kc x ETo) and keep track of the total values since the last irrigation**
  - **Irrigate when the total ET since the last irrigation is about equal to the allowable depletion**
- **Drip irrigation**
  - **Determine the desired interval between irrigations (grower preference)**
  - **Calculate the total ET between irrigations**
  - **Apply an amount of water equal to the total ET ÷ 0.80**

Late season water management

- Objective: increase soluble solids of processing tomatoes
- Options: cutoff time of irrigation; cutback – timing and amount
- Furrow irrigation
  - Cutoff - terminate irrigation at predetermined time before harvest
  - Cutback
    - Reduce number of irrigations
    - Difficult to apply small amounts of water per irrigation: amount of water required to get the water to the end of the field; cracked soil
- Drip irrigation
  - Cutback – apply small amounts of water per irrigation up to harvest time
  - Recommendation (T. K. Hartz) – applications of 30 to 70% of ETo starting about 6 weeks before harvest

Irrigation water management options under limited water supply conditions

- Reduce irrigated acres – normal irrigations
- Full irrigation as much as possible, particularly during early growth stages; deficit or no irrigation thereafter
- Deficit irrigate during crop season regardless of growth stage
- Concern: allocation of the irrigation water by the irrigation/water district throughout the crop season

Reduce irrigated acres

- Fully irrigate the reduced acres using normal irrigation practices
- Amount of acreage reduction depends on the amount of irrigation water
- Late season irrigation water management
- No irrigation on remaining acres
- Yield loss
- Stretch the limited water supply by efficient irrigation
  - Determine ET between irrigation
  - Apply water efficiently

Full irrigation period followed by no irrigation or deficit irrigation

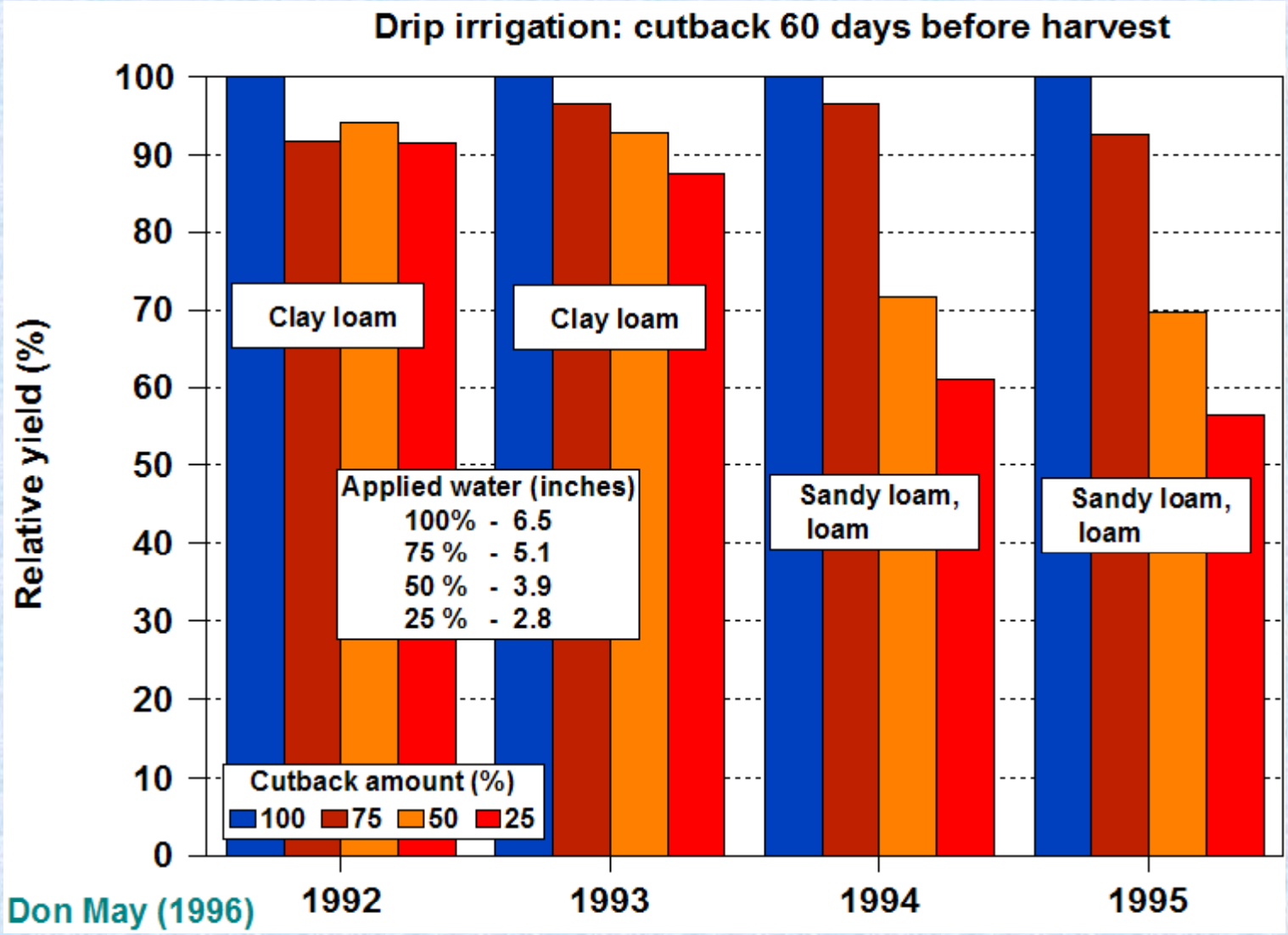
- Growth stage considerations (T. C. Hsiao, UC Davis)
  - Water stress during any growth stage will reduce yield
  - Earlier growth stages – more sensitive to water stress
  - Later growth stages – less sensitive to water stress
- Full irrigation to develop an adequate canopy cover (about 70 to 80 % coverage), followed by cutoff (no irrigation) or cutback (deficit irrigation) for the remainder of the crop season
  - Irrigate normal acres
  - Irrigate efficiently to stretch the limited water supply
  - Days after planting needed for full canopy coverage generally about 60 to 80 days
  - Amount of ET needed to develop an adequate canopy coverage generally about 6 to 10 inches of water (about 24 to 40 percent of the average normal seasonal ET)
  - Remainder of crop season generally between 50 to 70 days
  - Data from 18 commercial fields

Full irrigation period followed by no irrigation or deficit irrigation (continued)

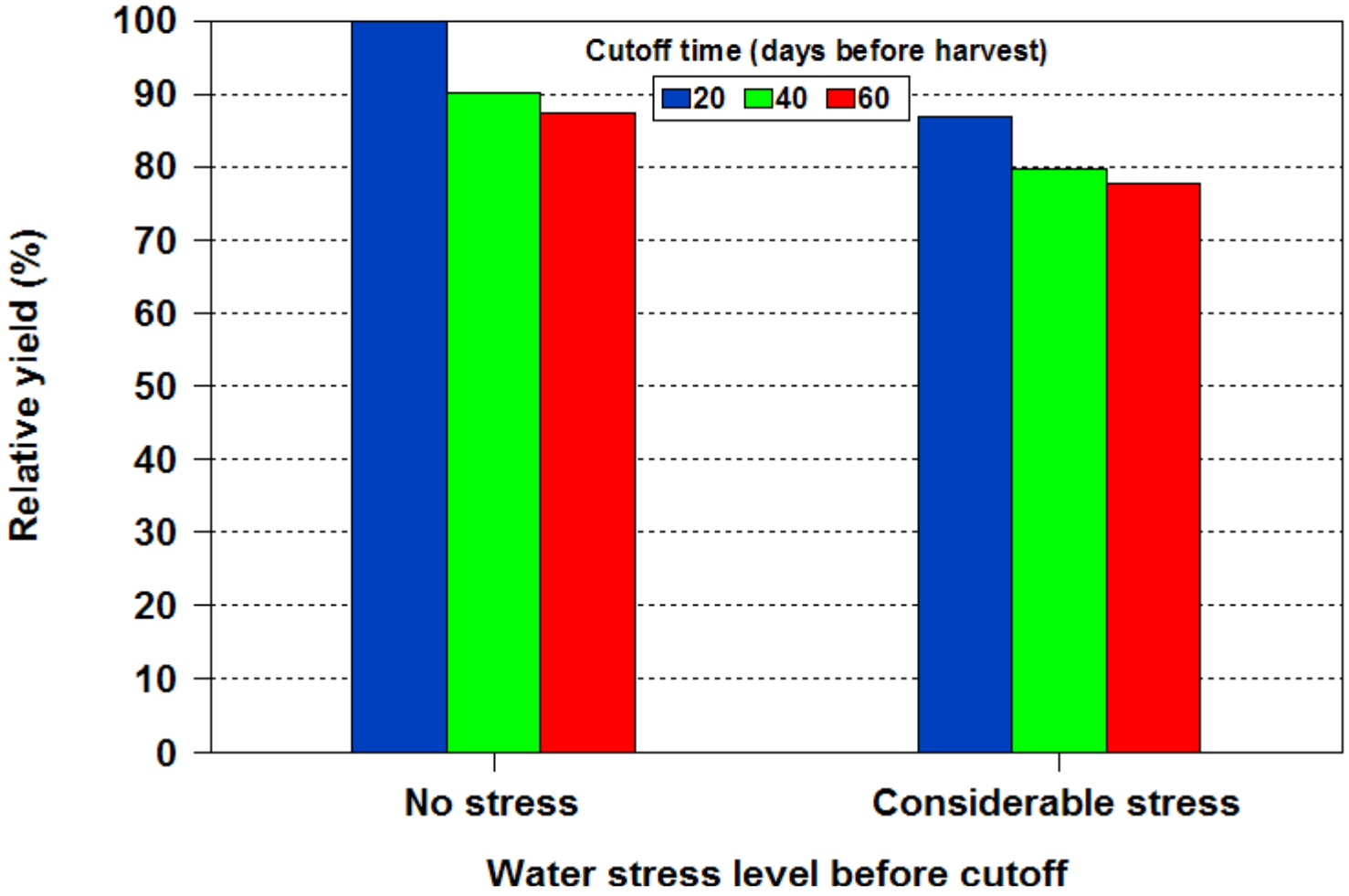
- Strategy best suited for clay loam soil with no root depth restrictions
  - Large amount of stored soil moisture, deep roots
  - Potential for a minimal yield loss
- Restricted root depth; sandy loam or loam soil
  - Potential for a considerable yield loss
  - Consider using the reduced acres option

Full irrigation period followed by no irrigation or deficit irrigation (continued)

- General guidelines
  - Start the crop season with a soil profile fully replenished with soil moisture
  - Full irrigations if possible for the first 60 to 80 days after planting to develop the canopy size
  - Drip irrigation
    - Full irrigations as long as possible followed by cutback of irrigation water
    - Cutback: continue to supply small amounts of water
    - Requires allocating the limited water supply between the period of full irrigation and the cutback period.
  - Furrow irrigation
    - Full irrigations as long as possible
    - Last irrigation should fully replenish soil moisture in root zone
    - Cutoff
    - Cutback approach is difficult to implement with furrow irrigation
    - May need to reduce acres, particularly in sandy soil


Drip irrigation: cutback 60 days before harvest
Relative yield (%)
100
90
80
70
60
50
40
30
20
10
0
Clay loam
Clay loam
Sandy loam, loam
Sandy loam, loam
Applied water (inches)
100% - 6.5
75 % - 5.1
50 % - 3.9
25 % - 2.8
Cutback amount (%)
100 75 50 25
1992
1993
1994
1995
Don May (1996)

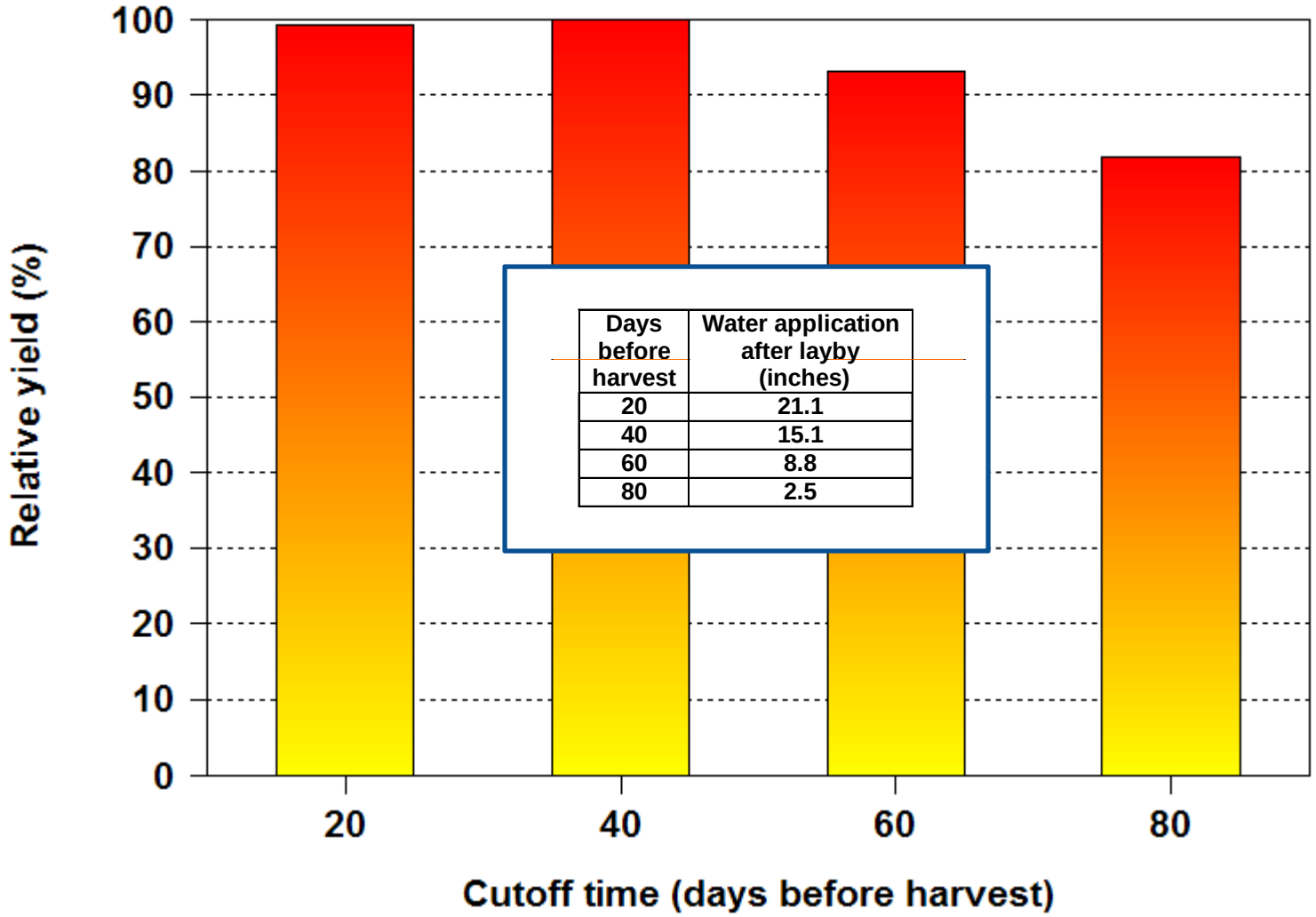
Furrow irrigation: effect of stress during the first part of the crop season and cutoff time on yield (clay loam)



Don May, 1996

Note: stress was induced by decreasing the number of furrow irrigations

Furrow irrigation: effect of cutoff time on yield (clay loam)

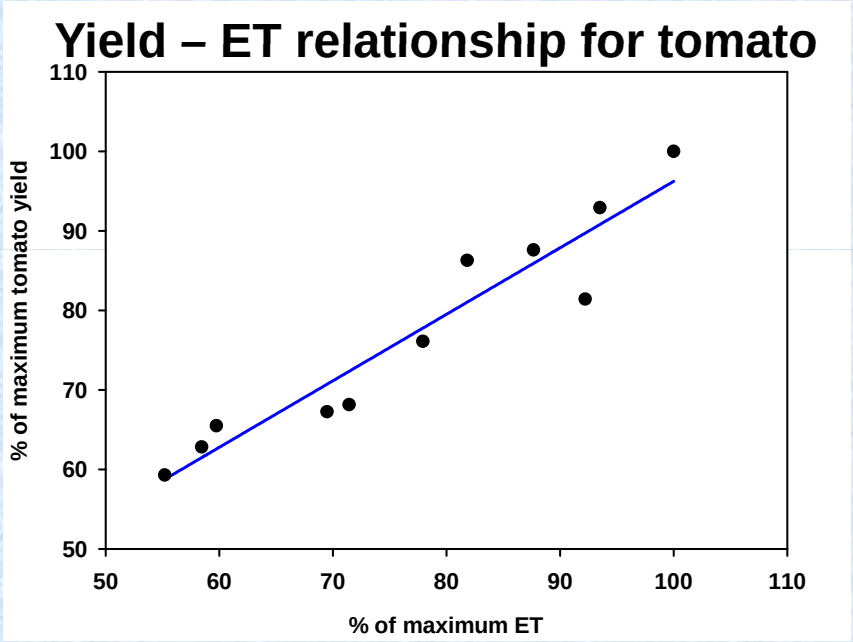


Days before harvest	Water application after layby (inches)
20	21.1
40	15.1
60	8.8
80	2.5

Don May, 1998

Deficit irrigate throughout the crop season regardless of growth stage

- Spread the limited amount of water over the crop season
  - Reduce number of irrigations – all irrigation methods
  - Reduce amount applied per irrigation – sprinkle and drip irrigation
- Irrigate entire field or part of the field
- Yield loss
- Not feasible for small amounts of available irrigation water – economical yields?



Which option is the best?

- Normal irrigated acres = 160; drip irrigation; clay loam soil; crop season = 130 days; normal yield = 40 tons per acre
- Sufficient irrigation water to supply 50% of the normal ET = 13 inches of ET
- Reduce acres option
  - 80 fully-irrigated acres
  - Total tons = 80 acres x 40 tons per acre = 3,200 tons
  - Smaller risk compared to full/deficit option
- Full/deficit option
  - 160 irrigated acres
  - ET needed to develop the canopy = 10 inches of ET
  - Water application during cutback period (60 days before harvest) = 3 inches (25% cutback application)
  - Potential yield = 90% (based on research results) = 36 tons per acre
  - Total tons = 160 acres x 36 tons per acre = 5,760 tons
  - Larger risk compared to reduced acres option

Stretching a limited water supply during periods of full irrigation

- Amount of applied water will exceed the ET due to irrigation system inefficiencies
- Drip irrigation
  - Precise application of water throughout the field
  - Use CIMIS ETo and crop coefficients
  - Potential for applying an amount of water about equal to the total ET between irrigations
- Furrow irrigation
  - Losses – surface runoff, deep percolation
  - Reduce surface runoff from field
    - Decrease the irrigation set time
    - Recover and reuse surface runoff
      - Field recirculation system
      - Farm tail water reuse system
- Monitor soil moisture
  - Watermark electrical resistance blocks
  - Other types of sensors

The End