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
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*
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

- \( ET = K_c \times E_{To} \times \text{DAY} \)
  - \( ET \) = crop ET
  - \( K_c \) = crop coefficient
  - \( E_{To} \) = CIMIS reference crop ET
  - \( \text{DAY} \) = 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 \times \text{width of canopy} \div \text{furrow spacing}

K_c = 0.126 + 0.0172 \times C - 0.0000776 \times C^2; r^2 = 0.96; P = <0.0001
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

- Clay loam
- Sandy loam, loam

Applied water (inches):
- 100% - 6.5
- 75% - 5.1
- 50% - 3.9
- 25% - 2.8

Relative yield (%)

Cutback amount (%):
- 100
- 75
- 50
- 25

Don May (1996)
Furrow irrigation: effect of stress during the first part of the crop season and cutoff time on yield (clay loam)

![Bar chart showing relative yield (%) for different stress levels and cutoff times.]

- **No stress**
  - Cutoff time: 20 days before harvest
  - Relative yield: 90%
  - Cutoff time: 40 days before harvest
  - Relative yield: 80%
  - Cutoff time: 60 days before harvest
  - Relative yield: 70%

- **Considerable stress**
  - Cutoff time: 20 days before harvest
  - Relative yield: 80%
  - Cutoff time: 40 days before harvest
  - Relative yield: 70%
  - Cutoff time: 60 days before harvest
  - Relative yield: 60%

**Water stress level before cutoff**

- **Note**: Stress was induced by decreasing the number of furrow irrigations.

**Don May, 1996**
Furrow irrigation: effect of cutoff time on yield (clay loam)

<table>
<thead>
<tr>
<th>Days before harvest</th>
<th>Water application after layby (inches)</th>
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<tr>
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<td>15.1</td>
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<tr>
<td>60</td>
<td>8.8</td>
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<td>80</td>
<td>2.5</td>
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Cutoff time (days before harvest)

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