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Tomato

Irrigation of Processing Tomatoes

(Reviewed 1/07, updated 1/07, corrected 1/09)

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Irrigation is required in California to meet the crop water use or crop evapotranspiration (ETc) requirements of processing tomatoes. Components of ETc are evaporation of water from the soil and transpiration of water from plant leaves. Seasonal amounts of ETc mainly depend on climatic conditions, planting time, and crop season. The average seasonal ETc of processing tomatoes in California is 25 inches. However, measured seasonal ETc amounts have ranged from 21 to 30 inches of water, depending on site-specific field conditions.

Furrow irrigation is the most common irrigation method for processing tomatoes. Sprinkle irrigation is commonly used to establish seeded or transplanted stands and is sometimes used for marginal soils or in regions with high water tables. In the San Joaquin Valley, hand-moved sprinklers are used, while in the Sacramento Valley, wheel-line sprinklers are common.

The use of drip irrigation in processing tomatoes is increasing, particularly in the San Joaquin Valley. Subsurface drip irrigation in salt-affected soil is highly profitable compared to furrow and sprinkler irrigation. Surface drip irrigation is also used with drip lines placed directly in the furrow. The use of surface drip irrigation appears to reduce the *Phytophthora* problems caused by furrow irrigation in fine-textured soil.

Estimating ETc. Adequate irrigation facilitates rapid canopy growth and avoids plant stress as well as root rot problems caused by excessive wetting of the soil. To determine the amount of water needed and when to apply it, calculate the ETc (crop water use) between irrigations with the following equation, where Kc is the crop coefficient and ETo is the reference crop evapotranspiration: ETc = Kc x ETo.

The crop coefficient (Kc) of tomatoes depends on the canopy size and increases as the canopy coverage increases. Information on the reference crop evapotranspiration (ETo) can be obtained from the California Irrigation Management Information System (CIMIS) for many areas of California. ETo is provided in daily, real-time, or monthly average values. For the climate conditions of the Central Valley, average values have been found to provide satisfactory estimates of crop water use.

Irrigation intervals. Irrigate often enough so that the soil moisture depletion between irrigations does not reduce crop yield. A major factor in determining the allowable soil moisture depletions is soil texture; clay loam soils hold more water than do sandy loams and, therefore, have longer intervals between irrigations. Detailed information on determining allowable soil moisture depletions and on developing an irrigation schedule are in *Scheduling Irrigations: When and How Much Water to Apply*, UC ANR Publication No. 3396.

Use caution in applying generalized guidelines for allowable soil moisture depletions to all situations. For example, experience shows that cracked clay loam soils can cause *Phytophthora* problems in processing tomatoes because water can flow through cracks into the bed and saturate the soil near the middle of the bed. To reduce soil cracking, some furrow irrigators irrigate as frequently as every 3 to 5 days -- an approach that requires reduced amounts of water per irrigation.

Another factor influencing irrigation intervals is whether the field is well-drained or has a shallow water table. In the Sacramento Valley where good quality, shallow groundwater exists, crop use of this groundwater can be substantial, and the crop may require fewer irrigations with less water applied per irrigation as compared to fields that are well drained. In the San Joaquin Valley where many areas have shallow, saline groundwater, try to minimize the use of groundwater by the crop. This is usually easiest to achieve with high-frequency drip irrigation, whereas it is usually not possible with low-frequency furrow or sprinkle irrigation. Drip irrigate at least two to three times per week, except under certain saline groundwater conditions where daily drip irrigations are recommended.

Calculating the irrigation time. Irrigation time is the time required to apply the desired amount of water in a field. Calculating irrigation times for sprinkle or drip irrigation is relatively easy using the following equation where T is the hours of irrigation needed for a set, A is the acres irrigated per set, D is the inches of water to be applied, and Q is the irrigation system flow rate in gallons per minute: $T = 449 \times A \times D/Q$.

Values for D include the ETc between irrigations divided by an amount to account for the irrigation efficiency (IE), or D = ETc/IE. It is recommended that an IE of 0.85 be used for drip irrigation systems and an IE of 0.75 be used for sprinkler systems.

Determining the irrigation time for furrow irrigation is more complicated than the other two methods of irrigation and involves factors that cannot be measured under field conditions. The irrigation time includes the time required for water to reach the end of the furrow, commonly called the advance time, and the time required for the desired amount of water to infiltrate along the lower end of the field. The factors affecting the advance and infiltration times are difficult or impossible to measure in a field, so the best approach to determine irrigation time for furrow irrigation is one of trial-and-error.

Because of the advance time , more water can infiltrate along the upper part of the furrow than along the lower part. Many growers use furrow lengths of 600 to 800 feet to reduce differences in infiltrated water along the furrow length. In addition, the irrigation system needs to be managed so that the water flow to the end of the field is rapid enough to reduce the differences in infiltrated water along the furrow length. One approach is to use a high rate of water inflow during the initial phase of irrigation to reduce the advance time and then to reduce the inflow rate to decrease problems with surface runoff.

Monitoring soil moisture. Because of uncertainty in managing irrigation systems (particularly furrow irrigation), monitoring soil moisture is helpful in determining what is going on in the soil. Many sensors are available for monitoring soil moisture; these sensors range from inexpensive and easy-to-use to expensive and difficult to install. A popular sensor used by many irrigators is the Watermark electrical resistance block (Irrometer, Inc., Riverside, CA). It is easy to install, read, and requires no maintenance. The readout meter used with this block provides readings of soil moisture tension, which is the tenacity at which water is retained in the soil. The drier the soil is, the higher the soil moisture tension. Soil moisture tension differs over time for furrow and drip irrigated fields.

IRRIGATING THE CROP

Preplant. Preplant sprinkle irrigations of about 6 inches are common in areas such as the southern San Joaquin Valley where winter rainfall frequently is insufficient to replenish the soil moisture content in the 3- to 4-foot soil profile. In areas where rainfall is sufficient, such as the Sacramento Valley, preplant irrigations are not applied. Preplant irrigations may also be used for leaching of salts in the salt-affected soil of the San Joaquin Valley.

Planting to prebloom. During this growth stage, ETc is small and consists mostly of evaporation from the soil. Initially, however, the daily ETc may be relatively high (0.15 inches per day) because of the soil surface wetting by sprinkle irrigation, but once the soil surface dried, the ETc decreased to about 0.05 inches per day until about 40 days after planting.

In areas such as the west side of the San Joaquin Valley, one to two sprinkle irrigations are used for stand establishment over a 3- to 4-week period. The irrigations start immediately after planting. After sprinkle irrigation, a cultivation period of 3 to 4 weeks may follow, depending on the particular grower. Where subsurface drip irrigation is used, the drip system may be used for stand establishment of transplanted tomatoes, but sprinkle irrigation is used for direct-seeded tomatoes.

In the Sacramento Valley irrigation for stand establishment may be omitted, depending on spring rainfall. Sprinkle irrigation may be used for stand establishment during the last half of the planting season. In some cases, split furrows are used for stand establishment, which bring the furrows close to the plant row.

Bloom to early fruit set. The crop canopy grows rapidly during the period from bloom to early fruit set. Crop water use is small at the beginning of this growth stage but increases with time to near-maximum water use.

Late fruit set to first color/20% color. During this mid-season growth stage, crop water use, which primarily consists of transpiration, is at its maximum. Crop evapotranspiration (Etc) rates remain high, generally between 0.3 and 0.35 inches per day. The crop canopy and plant height are also at their maximum, and irrigation water management is focused on enhancing fruit development until the first sign of color in sound fruit (excluding fruit damaged by insects or blossom end rot). At this point, the focus of irrigation management shifts from minimizing crop water stress to maximizing yield factors as described in the next section.

Red fruit/preharvest. During the period of color development, ETc can decrease with time although not always. Use irrigation water management practices to improve the soluble solids of the fruit while minimizing yield reductions. Maintaining the canopy coverage to protect fruit from sunburn is also desirable; however, field studies show that the canopy coverage under both furrow and drip irrigation changes little during this stage, but the canopy height will decrease from nearly 24 inches to 12 inches or less.

For sprinkle, furrow, and surface drip irrigation, the timing of the last irrigation should provide adequate drying of the soil before harvest by cutting off the irrigations. For subsurface drip irrigation, irrigation applications should be cut back to improve the solids content. However, irrigations can continue up to nearly the harvest time for drip irrigation systems with buried mainlines, submains, and manifolds.

With furrow or sprinkler irrigation, growers have found that cutting off irrigation 3 to 4 weeks before harvest usually achieves these goals, but this general guideline should be modified to fit specific field conditions. Studies indicate that determining the soluble solids content of a representative sample of 15 to 20 early ripening fruit can provide an indication of the need for an earlier irrigation reduction or cutoff (Johnstone et al., 2005). If the fruit sample is considerably below the target soluble solids content for that variety, an earlier irrigation cutoff might be required; if the soluble solids content is high, then the date of irrigation cutoff can be based solely on the need to dry the field for harvest. For maintenance of the plant canopy, irrigation cutoff in light-textured soil should be closer to harvest than in heavier textured soil, based on the difference in available water storage.

Postharvest. Fields are not generally irrigated after harvest. In some cases, a sprinkle irrigation might occur after the beds are listed for the next crop season for weed control.

MEASURES TO REDUCE ADVERSE WATER QUALITY PROBLEMS

There is increasing concern about chemicals moving in surface runoff from irrigated fields and the impact on water quality in rivers, sloughs, and creeks. Chemicals of concern include both pesticides and nutrients. Some of these chemicals, such as organophosphates and nitrogen, are water soluble while others, such as pyrethroids and phosphorus, are less water soluble but strongly adhere to soil particles. The measures used to reduce adverse water quality effects from surface runoff will depend to some degree on the nature of the chemicals of concern.

Water Soluble Chemicals

Where water soluble chemicals (organophosphates, nitrogen) are used and their concentrations in the runoff are toxic, surface runoff must be prevented from leaving the farm using one of several approaches:

- For a given single field, a recirculation system can be used to collect the surface runoff in a small reservoir at the lower end of the field and then recirculate the water back onto the field being irrigated. The recirculated water should be used to irrigate another area of the field in order to infiltrate the runoff into the untreated soil. Simply recirculating the runoff into the same irrigation set that generated the runoff will only temporarily store the water on the field and eventually result in an increased rate of runoff. Using a recirculation system requires a tailwater pond with enough volume to store the surface runoff from an irrigation set.
- For farms with multiple adjacent fields, a storage and reuse system can be used to store all of the surface runoff from a field in a reservoir and then use the water to irrigate another field at an appropriate time. In order for this approach to work effectively the farm must have multiple fields close together, a relatively large reservoir, and a distribution system that can convey surface runoff to the storage reservoir and then back out to other fields for irrigation.
- Convert to subsurface drip irrigation. This irrigation method eliminates surface runoff.

Soil-Adsorbed Chemicals

Use a different approach for chemicals (pyrethroids and phosphorus) that are not water soluble but instead are strongly attached (adsorbed) to soil particles; erosion during irrigation is the main source of pollution from these chemicals. For furrow-irrigated fields, erosion occurs along the field length; however, significant erosion occurs as the water flows from the furrow into the tailwater ditch because the bottom of the tailwater ditch is lower than the bottom of the furrow. One study in Idaho shows this erosion to contribute to nearly 50% of the total sediment load leaving a field (Carter and Berg, 1983). Where sediments leaving tomato fields are contributing to water quality problems, take measures to reduce the sediment load of the surface runoff. Options available for reducing the sediment load include:

- Reducing furrow inflow rates after the water has reached the end of the field or early cutoff of irrigation water.
- Redesigning inlets into tailwater ditches to reduce erosion of the last 5 to 10 feet of the furrow.
- Lining tailwater ditches. In some areas, erosion in the tailwater ditch has contributed to the sediment load leaving a field. Lining the ditch coupled with a redesigned inlet from the furrow would reduce the erosion.
- Injecting polyacrylamides (PAM), which causes fine soil particles suspended in water to flocculate and settle out of the water, into the surface runoff. Methods of applying PAM are injecting an emulsified PAM solution directly into the irrigation water, injecting a stock solution of PAM into the irrigation water, or placing PAM granules or tablets in the furrow. The stock solution consists of dissolving PAM granules in water. Applying PAM directly into the irrigation water has the potential of reducing the suspended sediment load to nearly zero. Additional research is needed on applying PAM using granules or tablets. Injecting PAM into the irrigation water is probably the easiest measure for growers to implement and is the most effective measure for reducing sediment in the surface runoff.
- Using sediment basins to allow sediments to settle out of the water. The basins should be long enough to allow sufficient time for particles to settle out. Design ratios of length to wide range from 3 to 6. A ratio of 6 may be needed to remove finer particles. However, questions remain about the ability of sediment basins to remove the clay particles to which the chemicals of concern are attached. Injection of PAM into the surface runoff before it reaches the basin may be needed to remove these clay particles.
- Allowing grass to grown in drainage ditches or tailwater ditches.
- Using recirculation systems or storage/reuse systems to prevent the runoff from leaving the field.
- Converting to subsurface drip irrigation.

References

Carter, D.L. and R.D. Berg. 1983. A buried pipe system for controlling erosion and sediment loss on irrigated land. *Soil Science Society of American Journal* 47(4): 749-752.

Johnstone, P.R., T.K. Hartz, M. LeStrange, J.J. Nunez, and E.M. Miyao. 2005. Managing fruit soluble solids with late-season deficit irrigation in drip-irrigated processing tomato production. *HortScience* 40 (6): 1857-1861.

IMPORTANT LINKS

- California Irrigation Management Information System

PUBLICATION

UC PEER REVIEWED *UC IPM Pest Management Guidelines: Tomato*
UC ANR Publication 3470
General Information
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