Irrigation management for optimizing raspberry production

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Introduction

Irrigation scheduling involves deciding when and how much to irrigate to optimize production and quality. Although numerous irrigation studies have been conducted to determine how to maximize production of commodities widely grown in California, such as cotton and tomatoes, fewer studies have been conducted for specialty crops, such as raspberries. However, as the acreage and the value of raspberries have increased on the central coast, the need for information on irrigation management has become more pressing. Anecdotal reports of water use from growers suggested that between 3 to 4 feet of water (3 to 4 acre-feet per acre) was necessary for maximizing fruit production during the growing season. Because of the scarcity and high cost of water at some locations on the central coast, improved water management could lower production costs. Additionally, better water management may reduce the risk of leaching soluble nutrients, such as nitrate, into ground water.

Weather-based estimations of crop water-use

Weather-based approaches to scheduling irrigations are used for many cultivated crops. Windspeed, air temperature, relative humidity, and solar radiation affect plant water-use, or more specifically the water lost by evaporation from the soil and by transpiration from the leaves of the crop. Using evapotranspiration data (evaporation + transpiration) from the California Irrigation Management Information System (CIMIS) the consumptive water use of a crop in units of inches or mm per day, can be estimated. CIMIS ET data is available from the Department of Water Resources website (www.cimis.water.ca.gov) for more than 120 locations in California, and is generated by weather stations located on irrigated grass, which serves as a reference crop.

ET can be estimated for a specific crop by multiplying reference ET data and the appropriate crop coefficient (Kc):

$$ET_{crop} = ET_{ref} \times Kc$$

The value of Kc usually ranges from 0.1 to 1.1 and is closely related to the percentage of ground shaded by the canopy. Irrigation method and physiological stages, such as flowering and senescence are also factored into the crop coefficient. Because crop coefficients are not available for raspberries, estimates of canopy cover may serve as a close substitute for the Kc values.

By irrigating just long enough to replace water lost by evapotranspiration it is possible to optimize irrigations for production and minimize percolation below the root zone. Also, it is possible to avoid under-irrigating during periods of high water consumption, which can result in stress and reduced growth.

Commercial Field Trials

In collaboration with commercial growers we conducted 9 trials in commercial fields to examine the effect of water management on plant growth and fruit production during the 2004 and 2005 seasons. Trials were conducted for 1st –year, fall and 2nd –year, spring-harvested crops and for crops grown under and without macro-tunnels (Table 2). All crops were planted from canes and established with overhead sprinkler. The crops were subsequently irrigated by surface drip with a tape discharge rate of 0.67 gal per minute per 100 ft. The same proprietary variety was planted at all sites.

Procedures

Crops were irrigated twice per week in the early spring and then 3 times per week in the late spring, summer and fall. Irrigation treatments consisted of 50%, 75%, 100%, and 125% of crop ET, and were replicated 4 times in each trial. Plots measured 1 bed width (88 inches) × 280 to 300 ft in length, depending on the field size. We used infrared images to estimate canopy cover at various stages of development at each trial. Table 1. presents canopy cover values for a 1st-year, cane-crop harvested in fall. For trials conducted under macro-tunnels, ET was reduced by 20% to account for shading by the plastic cover. Flowmeters were used to monitor the amount of water applied to each treatment. An example of the cumulative water applied during the season for trial 5 is presented in Figure 1. Soil moisture was monitored at depths of 1, 2, and 3 feet in 2 replications of each irrigation treatment for each trial using granular matrix (watermark ™) blocks. Carton yield was measured by the cooperating growers. Effects of irrigation treatment on plant height, cane diameter, and number of laterals was measured in selected trials.

Results

Estimated water-use (~17 inches) was highest for fall-harvested crops, which were grown from December through October in 2004. The second-year spring crop in 2005 had the lowest water-use (~8.5 inches) due to late rains which delayed the need to irrigate in the early spring. For all crops the consumptive water use was estimated to be substantially less than the 3 to 4 feet of water normally applied for commercial production.

Soil moisture monitoring was used to cross-check crop ET estimates. Cutting back irrigation in the 50% and 75% ET treatments reduced soil moisture to greater than 30 centibars in the 1 and 2 foot depths (data not presented). Conversely, soil moisture was maintained between 10 and 30 centibars in the 100% and 125% ET treatments, demonstrating that the crop was adequately irrigated to maintain the soil near field capacity.

Yield results of all trials are presented in Figures 2-4. Irrigation treatments had minimal effects on carton yield for Trials 1-3, which were 2nd year spring crops that were established under well-watered, unstressed conditions during the preceding year (Figure 2). Only the 50% ET treatment significantly reduced yield in trial 3. These results demonstrate that the irrigation management of the prior year can carry over into the second year of production. In contrast, yields of trials 5-7 were significantly affected by irrigating less than crop ET in the 1st and 2nd seasons (Figures 3 and 4). At most trials, applying 50% of crop ET reduced production and applying 100% of crop ET maximized production. The effect of irrigation on production was more dramatic in the first season than the second, presumably because rainfall supplied much of the water needed by the spring crop. The 50% ET treatment also reduced fruit size in the trials harvested in the fall (data not presented).

Irrigation treatments also affected the plant growth in trials 5-7. Cutting back on irrigations (< 100% crop ET) reduced plant height (Table 2), and cane diameter (Table 3), but did not affect the number of lateral branches on the main cane (Table 4). Plant height and cane diameter were similar for the 100% and 125% ET treatments.

Conclusions

A weather-based approach to scheduling irrigations can help growers estimate water needs of raspberries so that production can be maximized without over-applying water. The results of trials conducted during the 2004 and 2005 seasons demonstrated that irrigating 2 to 3 times per week at 100% of estimated crop ET maximized production. This approach to irrigation scheduling also reduces the risk of over-irrigating which can leach mobile nutrients such as nitrate below the rooting depth of the crop. Estimates of canopy cover were useful for calculating crop ET from CIMIS reference ET data. Additionally, monitoring of soil moisture provided a useful cross-check of ET based scheduling of irrigations. The combined approach of weather and soil-based scheduling of irrigations appears to be a practical method for growers to achieve optimal use of water in raspberries.

Acknowledgements

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Table 1. Average canopy cover for first-year cane raspberries (Trials 5-7).

Fall Crop, 1st Year Canes	
Days after Leaf-Bud Break[1]	**% Canopy Cover**
67	**12**
77	**16**
87	**22**
97	**30**
107	**38**
117	**48**
127	**58**
137	**67**
147	**75**
157	**82**
167	**87**

[1.] Leaf-bud break was estimated to occur feb. 15th, for a dec. 5th planting date.

Table 2. Summary of irrigation trials.

Trial	Macro-tunnel	Harvest	Crop	Year
1	Yes	Spring	2nd	2004
2	No	Spring	2nd	2004
3	No	Spring	2nd	2004
5	No	Fall	1st	2004
6	No	Fall	1st	2004
7	Yes	Fall	1st	2004
5	Yes	Spring	2nd	2005
6	No	Spring	2nd	2005
7	Yes	Spring	2nd	2005

Table 2. Effect of irrigation management on plant height. 2^{nd} –year spring crop.

	Plant height			
ETc Treatment	Trial 5	Trial 6	Trial 7	Overall
	---------------------- feet ----------------------			
50%	4.67	5.02	4.33	4.67
75%	5.12	5.00	4.46	4.87
100%	5.23	5.17	4.66	5.02
125%	5.30	5.25	4.67	5.08
CV (%)	6.3	7.3	7.6	7.1
$LSD_{0.05}$	0.13	NS	NS	0.14

Table 3. Effect of irrigation management on cane diameter. 2nd –year, spring crop.

	Cane Diameter			
ETc Treatment	Trial 5	Trial 6	Trial 7	Overall
	------------------- mm -------------------			
50%	100	107	100	102
75%	102	110	105	106
100%	105	116	113	111
125%	112	110	113	111
CV (%)	20.7	13.2	15.6	16.9
$LSD_{0.05}$	NS	NS	8.9	7.8

Table 4. Effect of irrigation management on number of lateral branches on main cane. 2nd –year, spring crop.

	Lateral Number			
ETc Treatment	Trial 5	Trial 6	Trial 7	Overall
	------------------- #/cane -------------------			
50%	5.8	6.5	5.2	5.9
75%	4.4	6.3	6.3	5.6
100%	5.3	5.9	7.0	6.0
125%	5.0	6.2	5.9	5.7
CV (%)	46.4	36.0	36.2	39.4
$LSD_{0.05}$	NS	NS	NS	NS

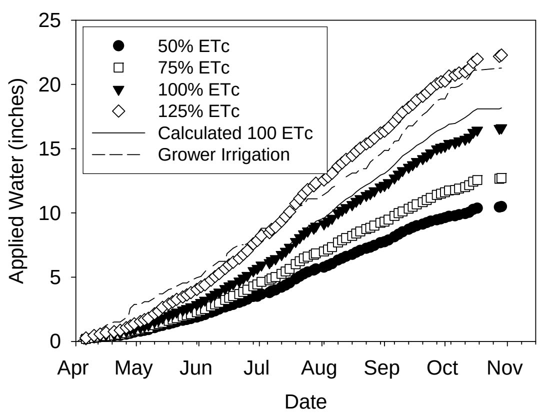

Figure 1. Cumulative applied water for 50% - 125% ETc treatments and grower treatment for trial 5, 1st -year fall crop.

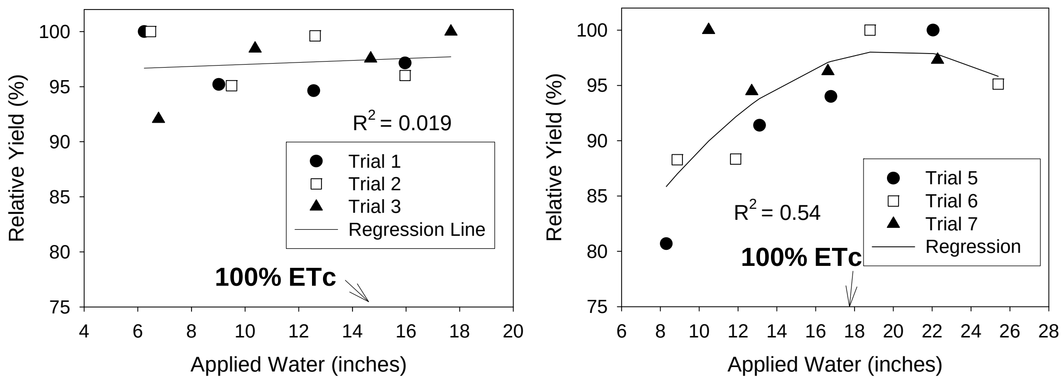

Figure 2. Relative yield response to applied water for 2nd -year spring crops and 1st year fall crops in 2004.

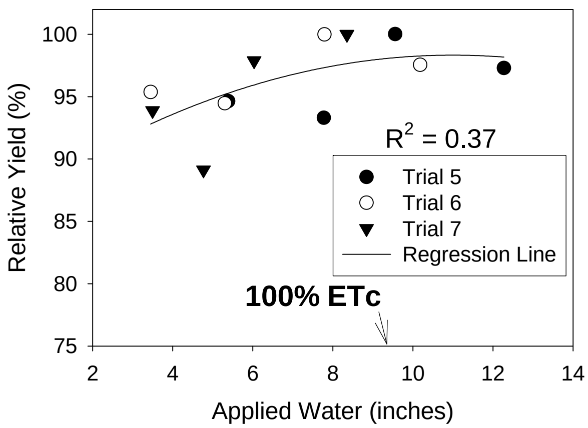

Figure 3. Relative yield response to applied water for 2nd -year spring crops in 2005.