Water Use of Strawberries on the Central Coast

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As acreage of strawberries has steadily increased in central coast valleys, concerns about the impacts of production on water supplies have been raised. Since most of the central coast is reliant on ground water, a major commodity such as strawberries can affect regional water supplies. In the Pajaro Basin, where ground water is currently in over-draft, conservation by agriculture is considered one of several paths to restoring parity between pumping and ground water recharge. To determine if conservation is possible without reducing economic returns, it is important to examine the present water-use patterns of major crops such as strawberries. Many of the practices that growers currently use such as drip irrigation and soil moisture monitoring, would suggest that strawberry producers are already efficient users of water. We conducted a 2-year study measuring water use in commercial strawberry fields in Monterey and Santa Cruz counties. Our objective was to determine the amount of water currently used to grow strawberries and to identify strategies that could help growers improve water management of their crops and potentially conserve water. The following describes the 2nd year of the study and compares the results with the first year.

Procedures

Flow meters were installed in approximately 0.5 to 1-acre sections of 35 commercial strawberry fields located in the Salinas-Watsonville production region during January and February of 2011. Fields with a proprietary day-neutral variety and UC Albion were included in the study. Planting configurations ranged from 48-inch and 52-inch wide beds with 2 plant rows, and 64-inch wide beds with 4 plant rows. Drip tape discharge rates in fields ranged from low flow (0.34 gpm/100 ft) to high flow (0.67 gpm/100 ft) and drip systems varied between either 1 or 2 drip lines per bed. Soil texture among sites varied from clay to loamy sand and the salinity of the irrigation water ranged from 0.3 to 0.9 dS/m.

Applied water was monitored with flow meters until the end of the crop in October 2011. In 14 of the 35 fields, flow meters were connected to dataloggers to record the irrigation scheduling pattern and granular matrix blocks (irrometer watermark) were installed to monitor soil moisture tension at 6 and 12 inch depths. Infra-red photos of the canopy were taken at each of the 14 field sites at monthly intervals, and used to estimate crop coefficients of strawberry and to determine crop evapotranspiration (ETc) from reference evapotranspiration data available from the California Irrigation Management and Information System (CIMIS). Samples of irrigation water were collected for analysis of nitrate and salinity content. Undisturbed cores of soil were collected for determining the water retention pattern for each soil type. Collected data was analyzed to determine if water-use was consistent with the water requirements of the crops. In addition to the fields monitored during the 2011 production season, flow meters were installed at 3 additional sites in October 2011 so that the volume of water used for transplant establishment could be determined.

Results

Average water applied to strawberries between January and October 2011 for the 35 sites ranged from 12 to 42 inches of water and averaged 24.8 inches (Fig. 1). Average seasonal volume applied for the 14 intensively monitored fields was 25.5 inches and ranged from 13 to 40 inches (Fig 2.). Although the average applied water for the 2011 season was greater than the average volume (21 inches) applied during the 2010 season, less rainfall occurred between January – mid February in 2011, which required supplemental irrigation to maintain adequate moisture around the root balls of the young transplants. Applied water during the period between January and May 2011 averaged 8 inches, 32% of the total applied water for the season. Rainfall averaged 11.7 inches between January and May 2011. Although some rainfall likely satisfied the water needs of the crops, 90% of the precipitation occurred between January and end of March when crop water needs were minimal due to low evapotranspirational demand. Much of the rainfall would have likely contributed to drainage and run-off during the winter months.

Crop ET estimates for the sites, developed from measures of canopy cover and spatial CIMIS reference ET data, averaged 17.5 inches and ranged from 11.4 to 22.9 inches. Growers applied an average of 146% of crop ET from January – October, with a range of 116% to 186% of crop ET (Fig. 3). From June – October, applied water averaged 123% of Crop ET (Fig. 4), indicating that most of the application of water above ET occurred during the winter months when evapotranspiration demand of the crop was low. Applied water during the winter and early spring (January – April) averaged 276% of crop ET and ranged from 112% to 576% of crop ET. In addition, rain contributed significantly to the applied water to the crop.

Soil moisture data recorded with watermark sensors provided a cross-check of flow meter and ET data. Average monthly soil moisture tensions were low (< 15 cbars) during January – March when applied water and rainfall exceeded crop ET (Table 3). Soil tensions increased during the production season when crop ET increased. Sites 1 and 6, where more than 150% of crop ET was applied during June through October (Fig. 4), had soil water tensions averaging less than 15 cbars at the 6 and 12 inch depths (Table 1). In contrast, sites 3, 7, 10 and 11, where less than 100% of crop ET was applied during June through October (Table 1) had soil water tensions averaging greater than 15 cbars at the 6 and/or 12 inch depths. Across all sites, soil moisture tension was related to applied water, expressed as a percentage of crop ET. Figure 5 shows that average monthly soil moisture tension was often greater than 30 cbars, indicating depleted soil moisture, when the average volume of applied water was less than 125% of crop ET.

The volume of water applied per irrigation event during the production season (June – October) was usually less than the water holding capacity of the soil; and therefore would presumably not cause excessive drainage. The average volume of water applied per irrigation for all 14 sites was 0.27 inches (Table 2), and the average water holding capacity of the soil between 5 and 30 cbars of tension was 0.35 inches per foot of depth for the top soil layer (Table 3).

The volume of water applied for crop establishment was evaluated in 3 fields between November 2011 and March 2012 (Table 4). An average of 6.2 inches was applied to establish transplants during November and December 2011. In 2010, the amount of water applied to establish transplants averaged 4 inches for 6 monitored fields. The lower amount of water used in 2010 was presumably due to early rain events that supplemented crop water demands during November and December. In addition to the establishment water in November and December, an average of 5.6 inches was applied between January and March 2012 (Table 4). In 2010, an average of 2.4 inches of water was applied during the same months. Rainfall ranged from 5.1 to 8 inches for these 3 sites between November 2011 and March 2012.

Conclusions

The results of the 2011 season are consistent with results reported for the 2010 season demonstrating that many growers under-irrigated during the production season. Because only 2 fields (14% of total) were irrigated with more than 150% of crop ET during the production season, the potential to conserve water may be limited during this period. In addition, nitrate leaching may not be a significant issue during the production season. The volume of water applied per irrigation was generally small (averaging 0.27 inches), and would be unlikely to exceed the water holding capacity of the soil. Our previous study has shown that soil nitrate levels are often less than 10 ppm nitrate-N between May and October. The combination of minimal drainage and low soil nitrate levels during the production season would suggest that a majority of growers were unlikely to leach significant amounts of nitrate beyond the root zone.

The greatest opportunity to conserve water appeared to be during the winter months, when applied water amounts greatly exceeded crop ET. Approximately one third of the irrigation water was applied during the winter and early spring when evapotranspirational demand of the crop was minimal. In 12 of the 14 monitored fields an average of 300% of crop ET was applied during this period. Although ET is low during the winter, growers may be challenged to reduce water applications because of concerns with maintaining sufficient soil moisture to establish young transplants and leach salts. They may also need to irrigate for the purpose of fertigating, and to maintain sufficient moisture in beds to protect the crop from frost damage. However the combination of monitoring soil moisture status and following the crop ET demand would be useful ways to determine if applied water could be reduced. Finally, because soil nitrate levels are generally higher during the fall and winter than during the summer, and applied water and rainfall greatly exceed crop water demand, the greatest potential for nitrate leaching would be during the winter.

Table 1. Average monthly soil moisture tension at the 6- and 12-inch depths for 11 commercial strawberry fields during the 2011 season.

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9		Site 10		Site 11		AVG		Max		Min	
Month	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"
					soil moisture tension (cbars)																							
Jan	7	4	2	2	17	10	10	7	6	4	--	--	--	--	--	--	--	--	7	7	--	--	8	6	17	10	2	2
Feb	5	4	6	1	16	9	13	8	12	13	5	4	1	5	10	2	--	--	7	12	14	2	9	6	16	13	1	1
Mar	8	4	12	1	25	14	16	16	13	16	9	7	6	8	14	8	13	4	9	19	13	5	12	9	25	19	6	1
Apr	14	1	9	0	15	9	8	8	30	12	4	8	0	1	10	7	16	13	6	14	6	0	11	7	30	14	0	0
May	13	1	9	0	17	10	17	10	30	14	9	6	5	1	11	4	15	7	19	19	16	2	15	7	30	19	5	0
Jun	8	1	2	0	20	11	14	7	23	17	12	7	9	1	10	3	16	8	52	29	9	3	16	8	52	29	2	0
Jul	4	0	0	0	23	9	14	6	13	5	6	3	18	0	10	2	18	7	85	25	17	13	19	6	85	25	0	0
Aug	3	0	0	0	23	9	5	4	10	4	4	1	16	2	10	1	18	6	80	43	10	18	16	8	80	43	0	0
Sep	2	0	0	0	23	14	10	5	10	3	5	1	15	1	11	1	28	4	90	115	6	17	18	15	90	115	0	0
Oct	8	2	0	1	21	14	41	14	18	4	21	3	17	2	20	7	30	6	55	51	43	41	25	13	55	51	0	1

Table 2. Volume of water applied per irrigation in commercial strawberry fields between June and October 2011.

Site Number	Irrigation Volume Average	Maximum	Minimum
	inches		
1	0.37	1.14	0.06
2	0.25	0.67	0.06
3	0.46	0.83	0.19
4	0.20	0.33	0.11
5	0.51	1.26	0.09
6	0.33	0.67	0.15
7	0.36	0.54	0.14
8	0.30	0.43	0.16
9	0.18	0.37	0.07
10	0.10	0.18	0.06
11	0.15	0.34	0.07
12	0.14	0.33	0.05
13	0.27	0.46	0.07
14	0.20	0.34	0.11
AVG	0.27	0.56	0.10

Table 3. Available soil moisture at 2011 monitoring sites.

Site	Soil	Available soil water (5 to 30 cbars) 0-1 foot	1-2 feet
		inches of moisture per foot of depth	
2	loam	0.34	0.18
4	clay	0.20	0.13
7	sandy loam	0.49	0.19
8	loam	0.33	0.27
9	fine sandy loam	0.30	0.23
10	sandy loam	0.42	0.32
AVG		0.35	0.22

Table 4. Water used for establishment and post-establishment of strawberries.

Location	Transplant Establishment Method	volume	Post Establishment method	volume	Applied Water by Month Nov	Dec	Jan	Feb	Mar
		inches		inches	------------inches-------------				
Watsonville	sprinkler/drip	5.6	sprinkler/drip	9.9	0.0	5.6	3.5	3.5	2.9
Castroville	sprinkler/drip	6.1	drip	2.5	1.2	4.9	1.0	0.0	1.4
Salinas	sprinkler/drip	7.0	sprinkler/drip	4.3	3.8	3.2	0.4	1.4	2.5
Average		6.2		5.6	1.7	4.6	1.7	1.6	2.3

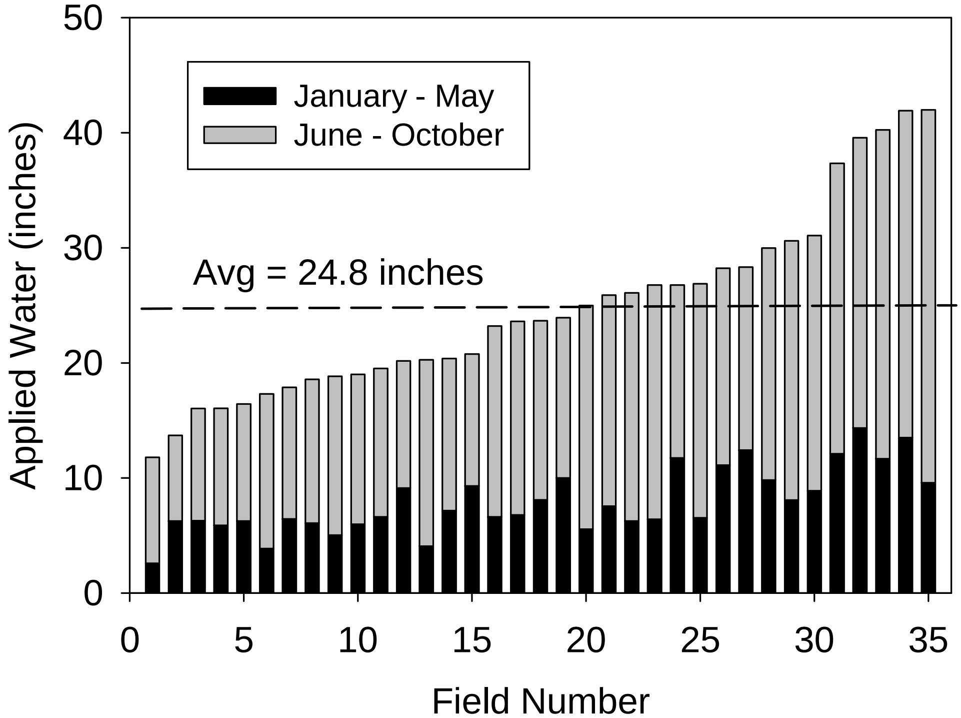

Figure 1. Seasonal volumes of irrigation water applied to 35 commercial strawberry fields (January – October 2011).

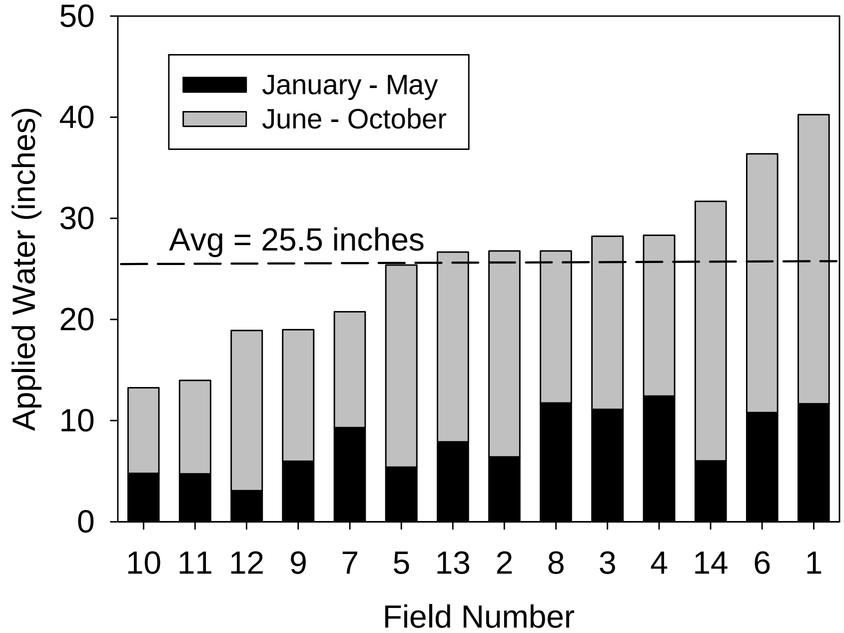

Figure 2. Seasonal applied water to 14 strawberry fields intensively monitored (January – October 2011).

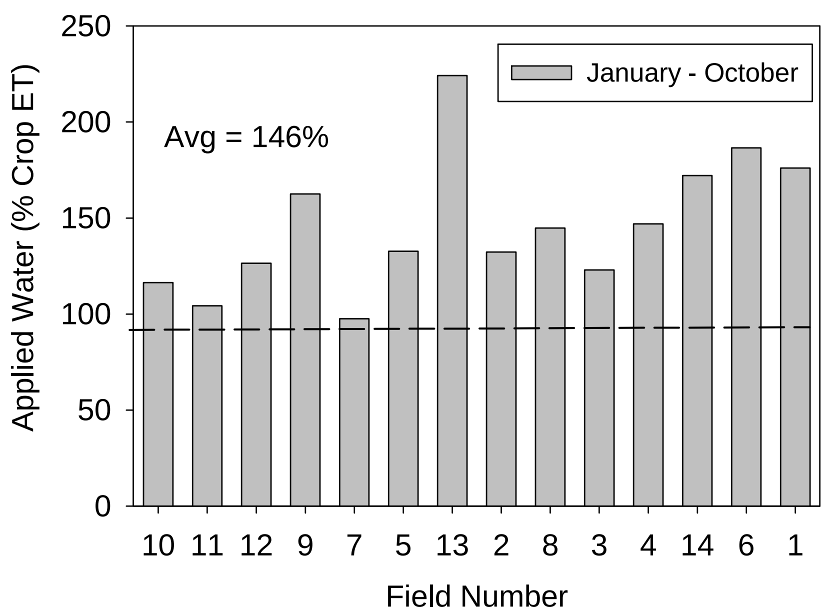

Figure 3. Seasonal applied water as a percentage of crop ET for 14 strawberry fields (January – October 2011).

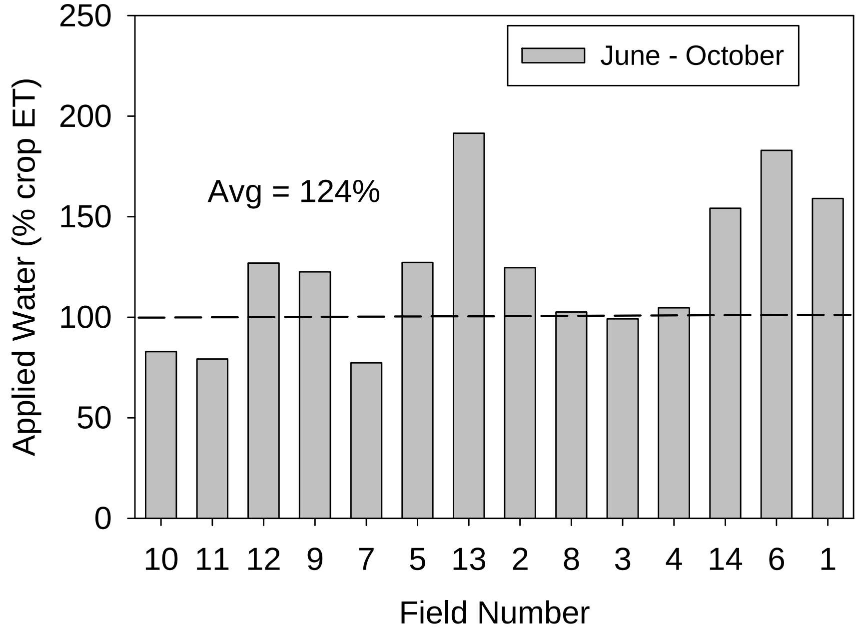

Figure 4. Seasonal applied water as a percentage of crop ET for 14 strawberry fields (June – October 2011).

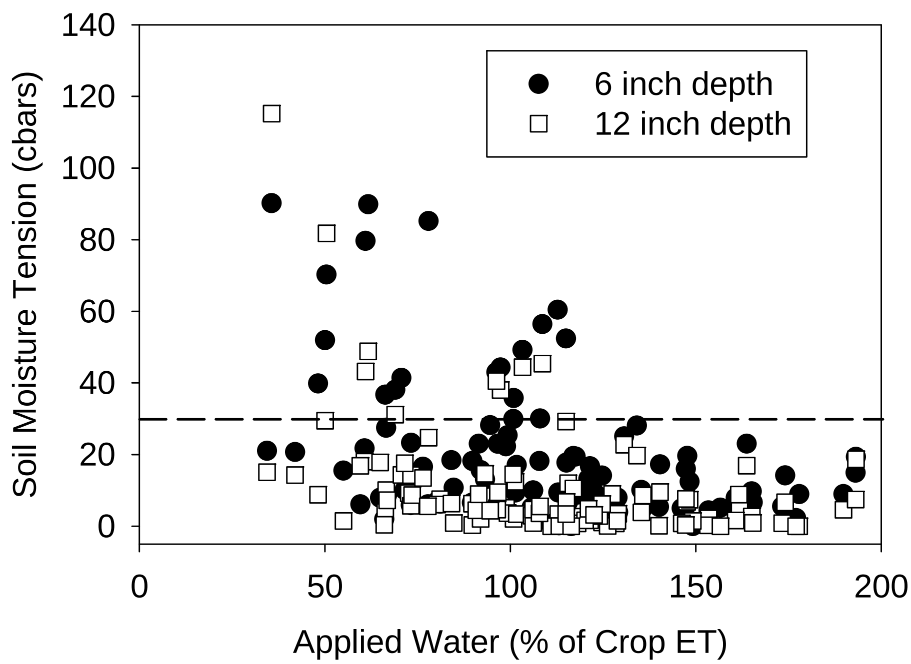

Figure 5. Average monthly soil moisture tension *vs* average monthly applied water expressed as a percentage of crop ET (May – October 2011).