Strawberry water use on the Central Coast

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With few options for importing water from other areas of the state, water supplies on the Central Coast will remain limited for the foreseeable future. Since the agriculture sector accounts for more than 80% of all pumping of ground water on the Central Coast, growers are increasingly under pressure to use water efficiently, especially for cool season vegetables and berries, which need ample soil moisture to achieve commercially viable yields and quality. Additionally, careful water management is required to curtail losses of nutrients from agricultural fields and prevent nitrate from contaminating ground water supplies.

Many growers have taken steps to improve water use efficiency of their crops by employing drip irrigation, reducing water use during crop establishment, and using equipment to monitor soil moisture so that they can better match irrigations with crop water demands. Acreage of strawberries, a crop of major economic importance to the Central Coast, has steadily increased in the Pajaro and the Salinas Valleys during the last 10 years, and has received a fair amount of criticism for its high water-use requirements. However, little information is available on the water management practices that growers use in the production of strawberries grown in this region that would substantiate claims that this crop uses high volumes of water. We surveyed water use of 34 commercial strawberry fields on the Central Coast during the 2010 production season to assess seasonal water use and to identify irrigation practices that may improve water use efficiency. Specifically, we investigated if water applied to strawberries matched crop evapotranspiration requirements, and evaluated effects of variety, weather, salinity, and soil type, on water use.

Procedures Flow meters were installed in approximately 0.5 to 1-acre sections of 34 commercial strawberry fields located in the Salinas-Watsonville production region during January and February of 2010. 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 1.4 dS/m

Applied water was monitored until the end of the crop in October 2010 using 2 and 3-inch diameter flow meters. In 17 of the 34 fields, flow meters were connected to dataloggers to record the irrigation scheduling pattern and granular matrix blocks or tensiometers were installed to monitor soil moisture tension. Infra-red photos of the canopy were taken at each of the 17 field sites at monthly intervals, and used to estimate crop coefficients of strawberry and to estimate 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. Soil samples were also collected for texture analysis. Collected data was analyzed to determine if water-use was consistent with the water requirements of the crops. Seasonal fruit yield data was collected at 14 sites planted with the proprietary variety.

Results

Applied water: Total applied water for 34 sites between January and October 2010 is summarized in Fig. 1. The total volume applied ranged from a low of 10.7 inches to a high of 34.4 inches during the production season (January – October). The average amount of applied water was 21.0 inches and the median amount was 20.8 inches. The subset of intensively monitored 17 fields also had a similar range and average volumes of seasonal applied water as the full group of fields (Fig. 2). More than 90% of rainfall occurred between January and April and ranged from 11.9 to 17.6 inches, and averaged 14.2 inches across all sites. Although the amount of water applied to the crops varying significantly among sites, the variation could not be explained by differences in variety, bed width, soil type, or weather.

Crop ET: Evapotranspiration requirements of berry and vegetable crops are most dependent on the canopy cover and weather conditions. We determined that crop canopy of strawberries increased during the season from a minimum of 10% in early March to a maximum of 70% to 80% in August and September (Fig. 3). Canopy development was similar for the proprietary variety grown on both 48- and 52-inch wide beds. Albion had similar early season canopy growth as the proprietary variety but reached a slightly lower maximum value by August (Fig. 3). The similar canopy development measured among different varieties and bed widths would suggest that mainly variation in weather among fields would affect crop water use. Although crop ET did vary among sites (Fig. 4), the range between the highest and the lowest crop ET values was 5.0 inches, and therefore did not account for the more than 20 inches of variation in applied water among fields. Applied water expressed as a percentage of crop ET averaged 94%, but ranged from 55% to 161% of crop ET (Fig. 5), and had no significant effect on seasonal fruit yield at sites with the proprietary variety (data not presented).

Soil type: Soil texture differences also did not explain the variation in applied water amounts. Although the average volume of water applied per season varied somewhat among soil of different textures, the differences were small compared to variation in volumes measured within a soil type (Fig. 6).

System uniformity: Distribution uniformity of the irrigation systems may also account for variation in applied water among sites. Growers need to apply more water when irrigation systems distribute water non-uniformly to assure that the driest areas receive sufficient moisture to match crop ET requirements. We measured an average uniformity of 84% (100% is perfect uniformity) ranging from 80% to 88% in the 4 fields that we evaluated (Table 1). A distribution uniformity of 85% is average for commercial drip fields; therefore the observed variation in uniformity among fields was relatively small and unlikely to explain the differences in applied water amounts. In contrast, average pressure of the drip systems among these 4 sites varied more than ± 40% (Table 1). The drip system adjusted to a high pressure (14 psi) applied more water per period of time than the system adjusted to the low pressure (7 psi).

System flow rate: Because the discharge rate of drip tape varies with pressure, fluctuations in pressure can affect the flow rate and application rate of a drip system. Data collected at 17 of the fields confirmed that system flow rates varied an average of 17% during the season. The lowest seasonal variation in flow rate at an individual site was 7% and the highest was 29%. All sites used manually adjusted gate valves to regulate pressure to irrigation blocks rather than pressure regulating valves.

System flow rates not only fluctuated during the season but also were lower than the expected flow rate, which was calculated from the drip tape manufacturer's discharge rate. For all but 2 fields, measured flow rates were less than estimated rates, suggesting that pressures in the drip lines were less than values recommended by the manufacturer or that some of the emitters were clogged. The average seasonal flow rate was 76% of the expected rate for all 17 fields and the lowest measured flow rate was 27% of the expected flow rate. Our data confirmed that the fields with the lowest flow rates were usually where less water than crop ET was applied (Fig. 7).

Salinity: One concern about applying less water than crop ET is that the volume applied was insufficient to leach salts from the root zone of the crops. Salinity levels of the saturated paste extracted from soil sampled from the surface to a 1 ft depth increased by an average of 0.64 dS/m during the production season (Figs. 8 and 9). Highest levels of salts measured were 2.3 dS/m at the end of the season. Salt concentrations above 1.0 dS/m in soil have been shown to cause yield loss in strawberry. Fruit yield data indicated that salts may have reduced yield in this study. Though not statistically significant, fields with high soil or water EC values tended to produce less fruit yield than fields with lower EC values (Fig. 10). The combination of a low leaching fraction and high salinity levels in the irrigation water can significantly increase soil salinity levels during the production season.

Conclusions: Overall water use in strawberries on the Central Coast was close to estimated crop ET; however, the amount of water applied varied greatly among sites, with many locations applying significantly less water than the estimated crop water use requirement. The variation in water use among sites could not be explained by differences in varieties, weather conditions, or soil types, but rather a lack of control of system pressure and flow rates. Most sites had significant increases in soil salinity during the season that may have resulted from applying water with EC values above 1.0 dS/m and providing insufficient water to leach salts. Total fruit yield of the proprietary variety was not significantly affected by the amount of water applied to the crop but may have been impacted by the salinity of the irrigation water and soil.

Table 1. Distribution uniformity and average drip tape pressure for 4 strawberry sites evaluated during the 2010 production season.

	Distribution Uniformity	Tape Pressure
	%	psi
site 1	88	14.2
site 2	84	9.2
site 3	80	7.1
site 4	82	10.0
AVG	**84**	**10.1**

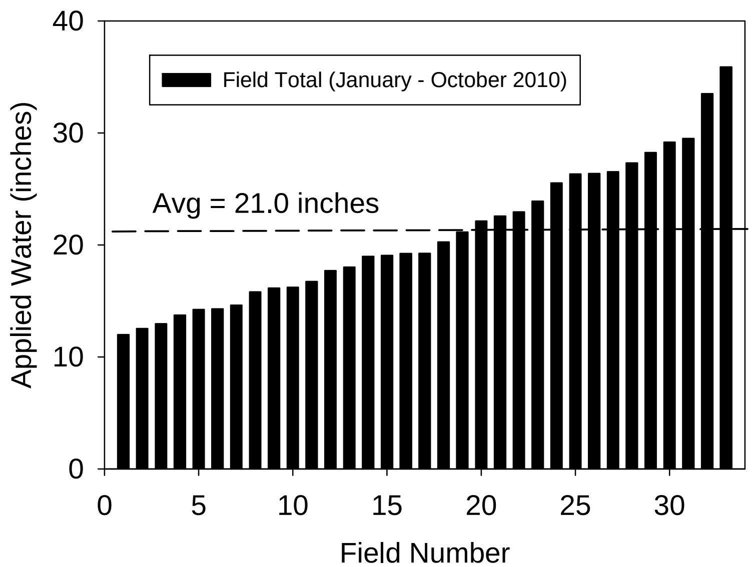

Fig. 1. Total applied water during the production season for 34 strawberry fields located in the Pajaro and Salinas Valleys.

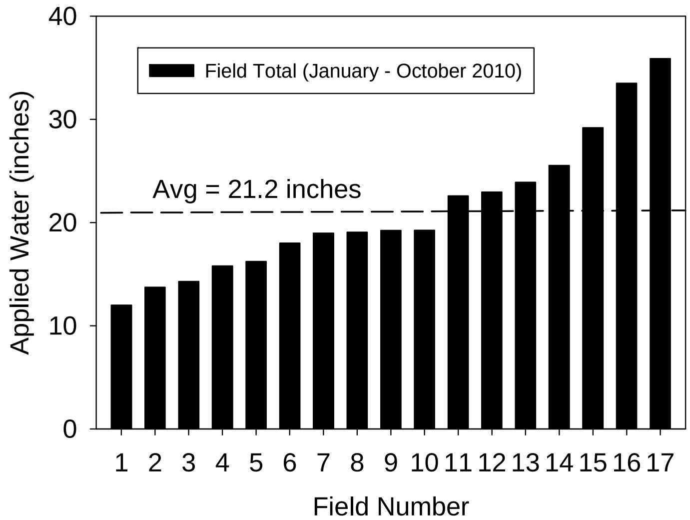

Fig. 2. Total applied water during the production season for a subset of 17 of the 34 strawberry fields that were intensively monitored.

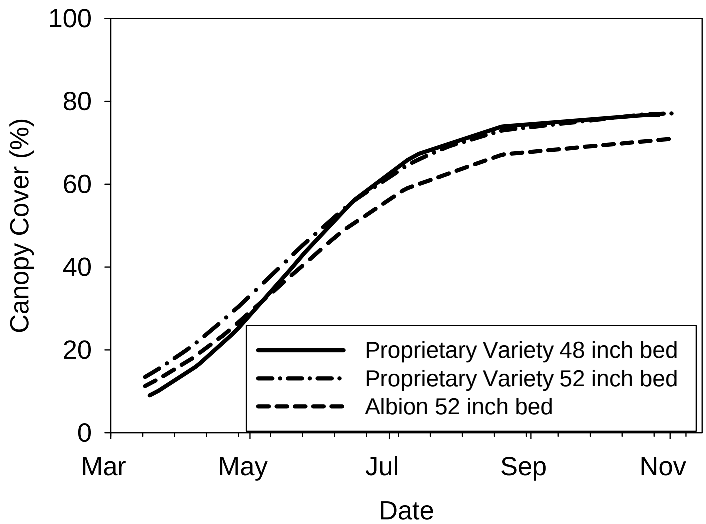

Fig. 3. Strawberry canopy cover for 2 varieties and 48 and 52 inch wide beds measured during 2010.

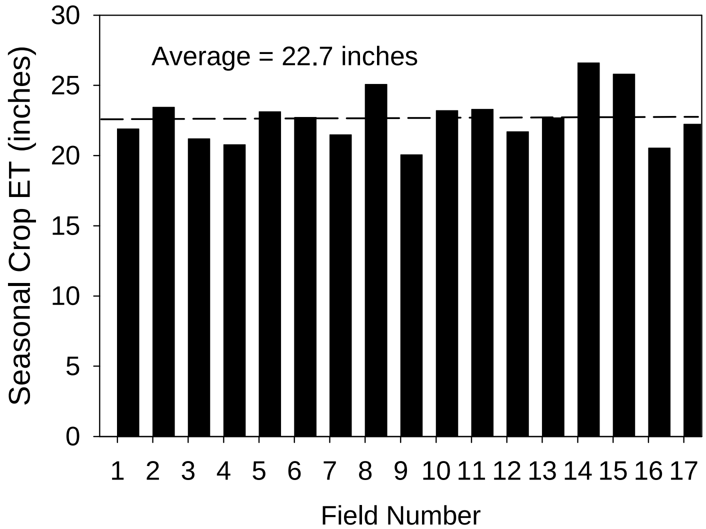

Fig. 4. Estimated crop ET of the 17 intensively monitored fields from January to October 2010.

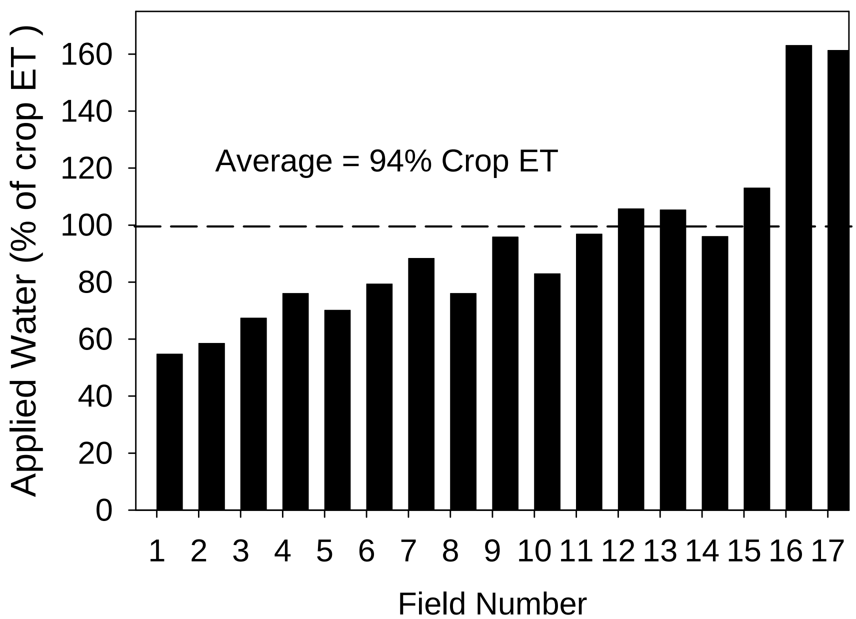

Fig. 5. Applied water expressed as a percentage of crop ET for the 17 intensively monitored fields from January to October 2010.

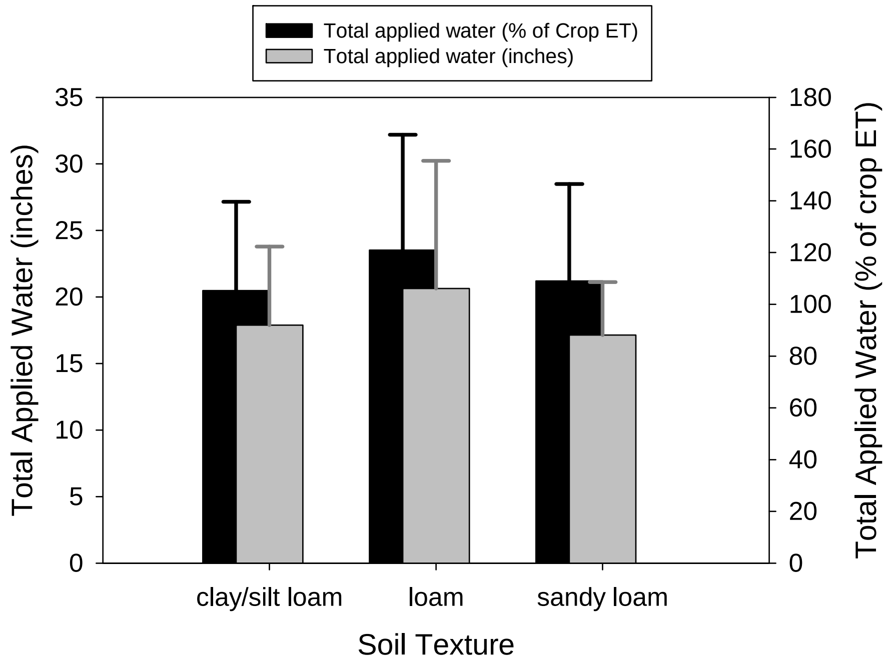

Fig. 6. Seasonal applied water compared among fields with different soil textures

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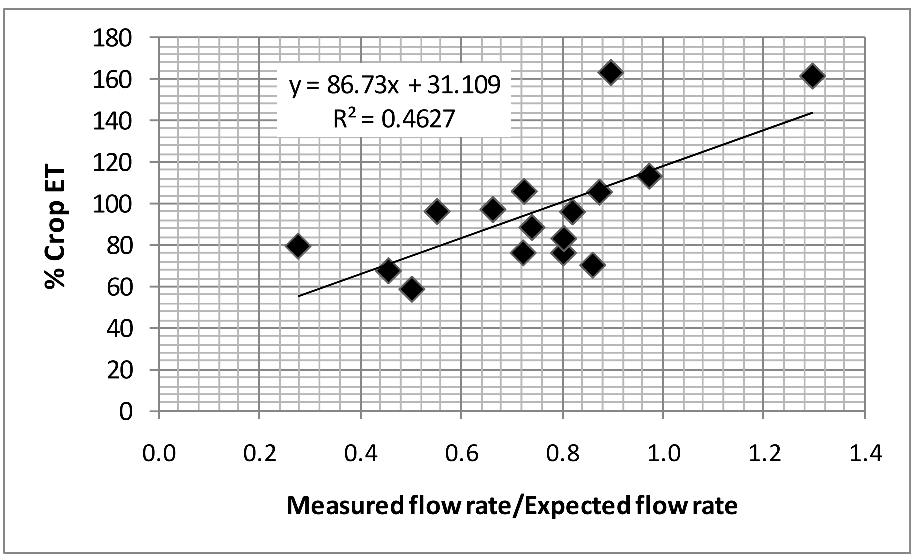

Fig. 7. Applied water expressed as a percentage of crop ET *vs* ratio of measured and expected drip system flow rates.

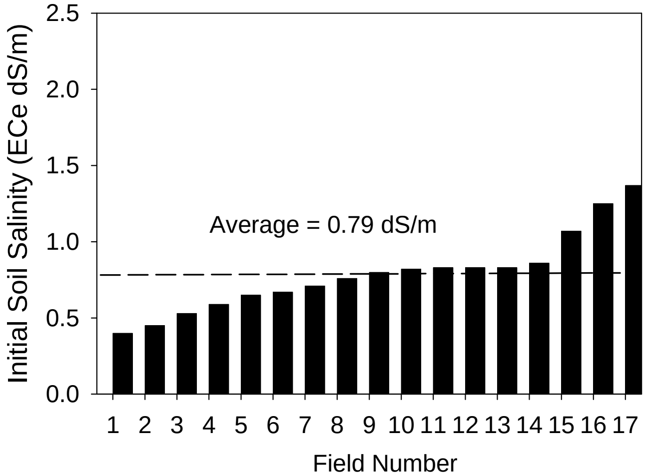

Fig. 8. Salinity values measured in the upper foot of soil at the 17 strawberry fields at the beginning of the 2010 production season.

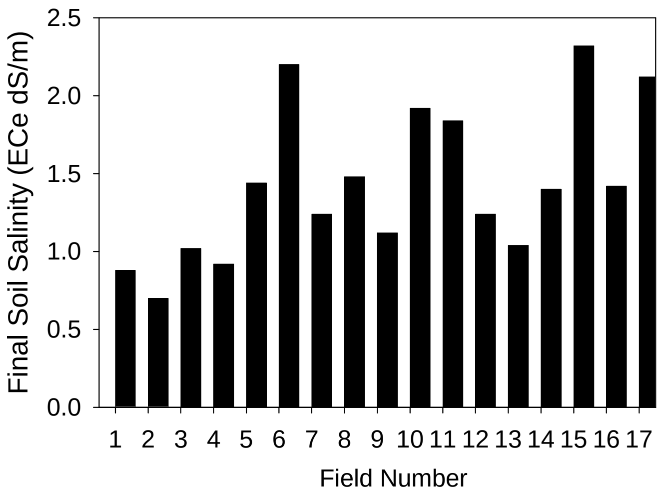

Fig. 8. Salinity values measured in the upper foot of soil at the 17 strawberry fields at the end of the 2010 production season.

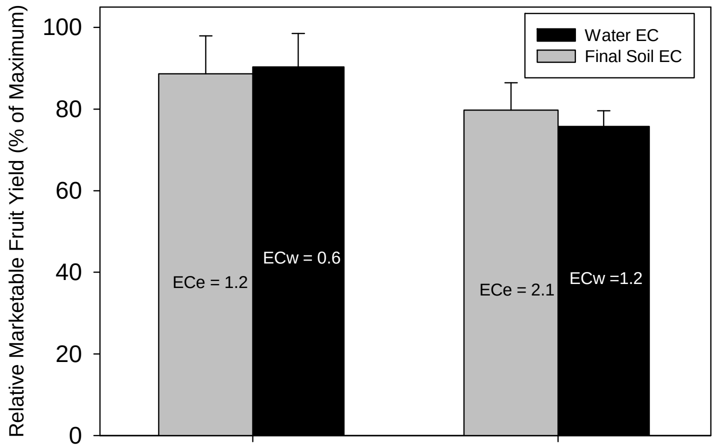

Fig. 9. Comparison of average yields from fields with water salinities below and above 1.0 dS/m and soil salinity values below and above 1.5 dS/m. EC values on bars are the average salinity values of fields.