Irrigation Evaluation Report

Prepared by:
Tom Lockhart* and Michael Cahn, UC Cooperative Extension;
*Contact information: (831) 759-7365, trlockhart@ucdavis.edu

Report #46

This project was a cooperative effort between the University of California Cooperative Extension, the Central Coast Ag Water Quality Coalition, the Resource Conservation District of Monterey County, and the Natural Resources Conservation Service.

Summary Information

Grower ID number:	**Ag Water Quality Coalition 2013-17-46**
Confidential Information (not to be included in published reports)	**Confidential Information**
Date of Evaluation	**3/15/13**
Grower Name	[redacted]
Ranch	[redacted]
Crop Type	**Raspberries**
Block Evaluated	**1**
Acres in Evaluated Block	**4.1**
Irrigation system type	**Surface Drip Tape**
Designed tape discharge rate at 8.0 psi	**0.67 gpm/100 ft of tape**
Average measured pressure within the field	**11.7 psi**
Average measured tape discharge rate	**0.77 gpm/100 ft of tape**
DU	**87%**

Recommendations

1. Adjust pressure to be equal among submains

2. Install pressure reducing valves to minimize pressure variation among submains.

3. Treat the irrigation system with acid to control algae.

Contents

Introduction

This project is a collaboration of cooperating growers, University of California Cooperative Extension, Central Coast Agricultural Water Quality Coalition and the Resource Conservation District of Monterey County. The project was made possible through funding from the USDA Natural Resources Conservation Service (NRCS). The main goals of the project are to evaluate performance and distribution uniformity (DU) of on-farm irrigation systems and recommend improvements.

This report is designed to assist growers as well as irrigation professionals. The report summarizes data collected during the irrigation system evaluation, and includes a description of the irrigation system and a map showing where measurements were recorded. Individual measurements are compiled at the end of the report. An analysis of system performance and recommendations for improvements to design and operation are also provided.

Irrigation Distribution Uniformity and System Evaluation

Description of the irrigation system and crop

We conducted an irrigation evaluation in [redacted] raspberries at the [redacted] on 3/15/13. The evaluation was conducted on the northern-most block, across a 4.1 acre area. Slope of the field was 5.5%. The soil was Conejo loam (NRCS web soil survey). A well, located 2,100 feet (ft) southwest of the block, was used to irrigate during the evaluation. The well was equipped with a flow meter and a pressure gauge. A 6 inch diameter mainline conveyed water from the well to the block and connected to the submains (Figure 1). Water from the mainline was distributed to 4 submains, each made of two-inch diameter PVC pipe, and 225 feet in length (Figure 1).

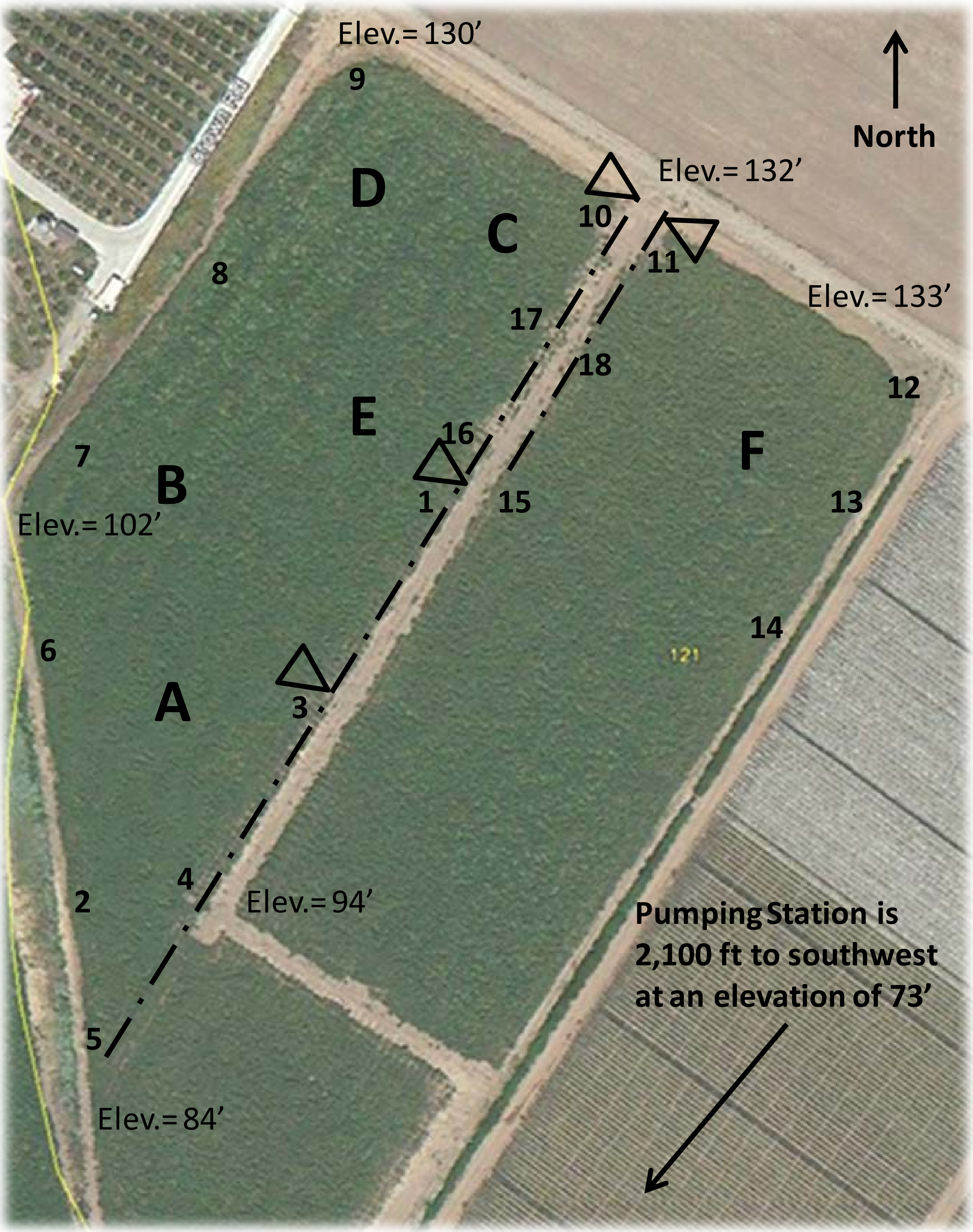

Figure 1. Map of field, with letters showing locations of the DU measurements, numbers showing the pressure check-points, triangles showing valves and dashed lines the sub-mains.

The evaluated block consisted of 120, 7 foot wide rows. The raspberries had been planted in single rows and trained on trellises. One drip tape per row was attached to the trellis at 24 inches above the soil surface. Drip tapes were attached to the submains via 3/8 inch diameter polyethylene leads, of 48 inch or greater length. The drip tape was 5/8 inch in diameter with emitters spaced 8 inches apart, and had a manufacturers' discharge rate of 0.67 gal/min/100 feet of tape (gpm/100ft) at 8.0 psi.

Distribution Uniformity Evaluation

Discharge uniformity of the drip tape was evaluated at 6 locations (Figure 1) to assess the distribution uniformity (DU) of the irrigation system. Discharge rate of 10 individual drip tape emitters and pressure was measured at each location (A-F). Pressure was also monitored at the well, at 4 locations on the mainline, and at 9 locations along the submains and 8 locations along the ends of the drip tapes (Figure 1). Two of the hose leads were also evaluated for pressure loss.

Excellent uniformity was found at all six of the DU locations and the overall DU was 87% (Table 1). A DU of 85% is an industry standard for a well designed and operated drip system. The tape discharge rate column in Table 1 shows that the measured flow rate varied from 0.67 to 1.04 gpm/100 ft in the different test areas. The highest emitter discharge rates were in areas with the highest pressure in the tape. An even higher DU would be achieved if the pressure was more evenly distributed to the different submains. Figure 2 shows the relationship between emitter discharge rate and pressure of the tape.

Table 1. Uniformity and flow characteristics of the drip irrigation system.

Area	DUlq	DU10%	SC10%	CU	Emitter discharge rate	Tape discharge rate	System flow rate	Field application rate	Avg Pressure
	%	%		%	gal/hr	gpm/100 ft	gpm/acre	inches/hour	psi
Area A	97.4	97.4	1.03	98.4	0.42	1.04	64.9	0.143	20.7
Area B	97.5	95.3	1.05	98.8	0.29	0.72	44.6	0.098	10.3
Area C	94.2	92.0	1.09	97.4	0.30	0.74	46.2	0.102	10.8
Area D	92.8	92.3	1.08	96.0	0.29	0.72	45.0	0.099	9.8
Area E	94.3	94.3	1.06	96.3	0.27	0.67	41.9	0.093	9.3
Area F	94.5	94.5	1.06	95.9	0.29	0.71	44.4	0.098	9.1
Overall	86.5	84.6	1.18	87.7	0.31	0.77	47.9	0.106	11.7

DU_{lq} = Distribution uniformity of the lowest quarter

$DU_{10\%}$ = Distribution uniformity of the lowest 10%

$SC_{10\%}$ - Scheduling coefficient for the lowest 10%

CU = Christensen coefficient

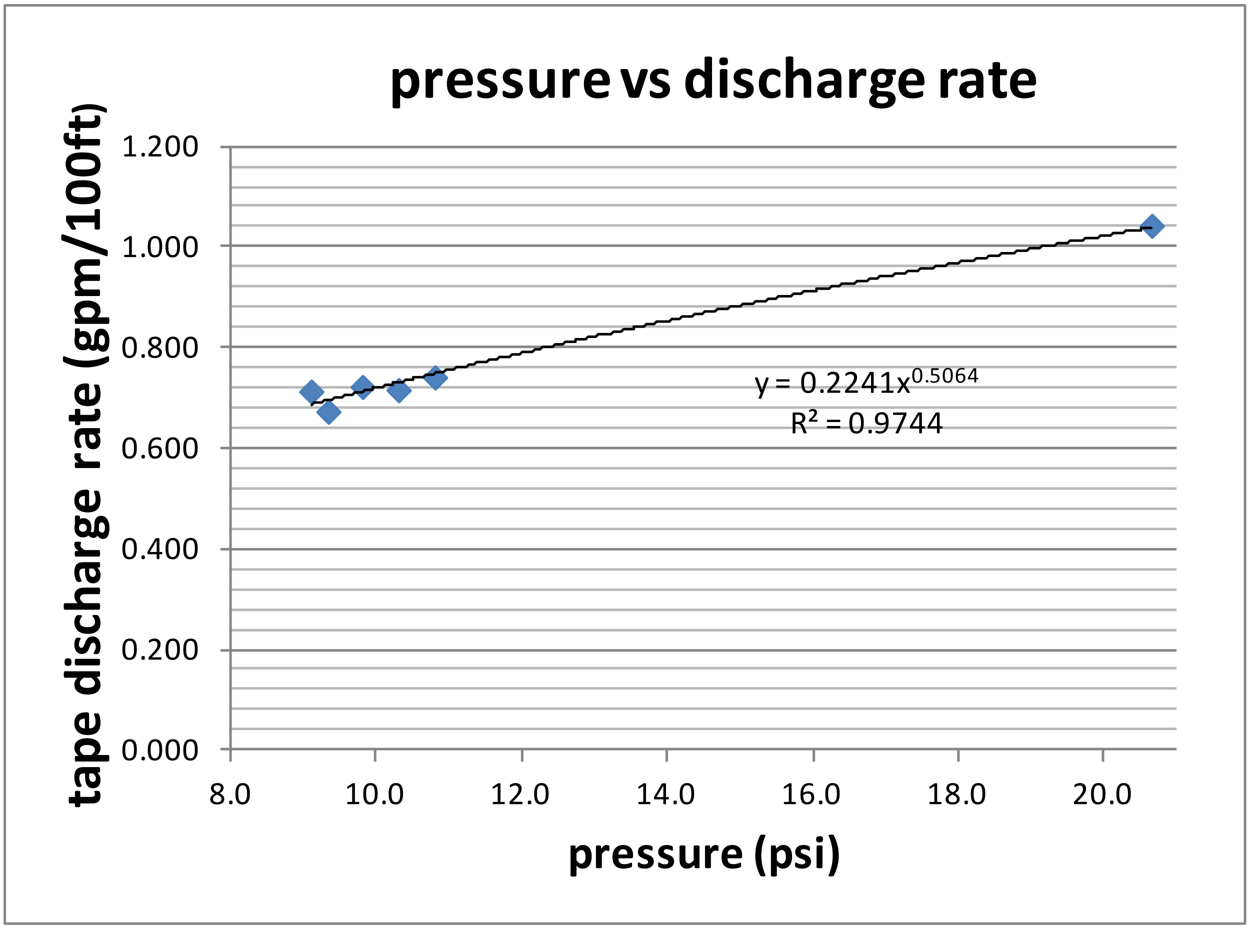

Figure 2. The relationship between changes in pressure in the drip lines and emitter discharge rate.

Evaluation of system design and operation

The drip system was very well designed and operated. Pressure did not fluctuate at the DU locations and fluctuated by less than 1.0 psi at ends of the drip tapes (Table 2). Variation of pressure within the field, along submains, and at ends of the drip tape was 38.2%, 42.50%, and 64.5%, respectively (Table 2), which were related to the steepness of the field. The DU, though high, would have been even higher if pressure been adjusted at each valve. Pressure reducing valves could be installed at each submain to make those adjustments.

Pressure loss between the submains and the ends of the drip tapes averaged 9.8 psi, indicating that the flow rates and diameter of the tape were adequate for the length of the beds. The lead hoses caused 3.7 psi pressure decrease between the submains and the drip tapes (Table 2). One leak was observed on a submain. Six leaks were observed in the 30 drip lines checked. A very small amount of dark sediment, possibly algal material, was found in each of the six drip lines that were flushed.

Table 2. Summary of pressure measurements.

Measurement	Time 1	Time 2	Time 3	Average
average mainline pressure (psi)	21.1	22.1	21.7	21.6
variation in mainline pressure (%)	27.5	20.4	20.9	22.9
average submain pressure before leads (psi)	21.5	22.1	21.9	21.8
variation in submain pressure before leads (%)	21.5	16.5	17.5	18.5
average submain pressure after leads (psi)	16.0	15.6	16.3	16.0
variation in submain pressure after leads (%)	44.6	38.2	44.8	42.5
average pressure loss across 2 leads (psi)	3.2	4.0	3.9	3.7
average tail pressure (psi)	11.5	12.2	12.3	12.0
variation in tail pressure (%)	70.6	61.8	61.1	64.5
pressure loss along the drip tape lines (psi)	10.0	10.0	9.6	9.8
average within field pressure (psi)	11.5	11.8	-	11.7
variation in within field measurements (%)	38.6	37.7	-	38.2

Recommendations

1. Adjust pressure to be equal among submains
2. Install pressure reducing valves to minimize pressure variation among submains.
3. Treat the irrigation system with acid to control algae.

Glossary of Concepts and Terminology

Irrigation Efficiency

Irrigation efficiency (IE) is the amount of water that is used to grow a crop compared as a ratio to the total amount of water applied:

$$IE = \frac{Amount\ of\ water\ used\ for\ crop\ production}{Total\ water\ applied}$$

Irrigation efficiency greater than 0.9 or 90% is considered high, and an IE of less than 0.6 or 60% is considered low. An IE of 0.6 would mean that 60% of the applied water is used in the production of the crop, and that 40% of the applied water is lost to evaporation, deep percolation and run-off. In most cases deep percolation and run-off represent a majority of these losses. The objective this project is to help growers attain an IE of 80% or higher.

The main factors that influence irrigation efficiency are: 1. distribution uniformity, 2. irrigation scheduling, 3. maintenance and management, and 4. soil variability. Addressing any or all of these factors can lead to a more efficient use of water, but it is important to consider which of these factors most influences IE and which can be addressed most affordably. For example, though converting from a sprinkler to a drip system can be a costly, but effective strategy to improve distribution uniformity, but improving the maintenance and operation of a sprinkler system might also provide as much improvement in irrigation efficiency as switching to drip for much less cost.

Incorporating DU results into an irrigation schedule

A well designed and maintained irrigation system will uniformly distribute water to a crop. Furrow, sprinkler, and drip systems can be designed and operated to maximize distribution uniformity (DU), but often poor management or design limitations reduce the uniformity of these systems. The DU of a system is often evaluated by measuring the application rate at 20 or more locations in a field. These data are used to calculate the distribution uniformity of the lowest quarter (DU_{lq}), which is the average application rate of the lowest 25% of the measurements divided by the average of all the application rates measured:

$$DU_{lq} = \frac{average\ of\ lowest\ 25\%\ of\ application\ rates\ measured}{average\ of\ all\ application\ rates\ measured}$$

Much like irrigation efficiency, a high DU_{lq} (>0.9 or 90%) indicates that a system has a high distribution uniformity. As DU becomes higher (approaching 1.0 or 100%), the irrigation requirement is lower:

Irrigation requirement = Crop ET/DU

In other words, systems with a high DU need less water to assure that all areas of a field receive the desired amount of water. If crop ET is 2 inches and the DU of a system is 0.75 (75%), then to assure that 2 inches of water is applied to the driest area of a field, 2.67 inches must be applied:

2.67 = 2 inches/0.75

By improving the DU from 75% to 85%, 2.35 inches are needed to assure that 2 inches of water are applied to the driest quarter of the field, a 13% savings in applied water. The improvement in uniformity will also minimize over-irrigating other areas of the field, reducing the risk of water logging the crop.

$DU_{10\%}$ is similar to DU_{lq}, except that the average of the lowest 10% of measurements is divided by the average of all of the measurements. This is a more specific way of analyzing the DU of the field.

$$DU_{10\%} = \frac{\textit{average of lowest 10\% of application rates measured}}{\textit{average of all application rates measured}}$$