Drip and Furrow on Processing Tomato - Field Performance

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Abstract: Data were collected from 187 conventional furrow-irrigated fields, as well as from 164 drip tape-irrigated fields in Westlands Water District. The study found that there is a significantly lower deep percolation with drip irrigated than with furrow irrigated fields. However, there was no significant difference in tomato yields between furrow and drip irrigated fields. This was not a before/after comparison of individual fields, but rather a comparison of data from distinct fields.

Introduction

In the spring of 2005, the Irrigation Training and Research Center (ITRC) of California Polytechnic State University, San Luis Obispo (Cal Poly) began a study into reducing drainage problems by using drip irrigation on tomatoes rather than using conventional sprinkler/furrow, or furrow irrigation.

The study was prompted by the environmental and economic concerns that arise from drainage disposal challenges. There is currently no known economical, technically feasible, and environmentally friendly drain water disposal method available for the west side of the San Joaquin Valley (Hanson and Ayars, 2002), although searches for solutions have been on-going for several decades. In Westlands Water District alone, more than

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200,000 acres have saline groundwater within 10 feet of the soil surface (WWD, 2004). Westlands Water District and other neighboring areas have recently seen a large movement by farmers towards subsurface drip irrigation (SDI) on processing tomatoes. SDI is expensive to install and maintain, but farmers have been convinced by considerable anecdotal evidence that using drip irrigation might improve yields and reduce applied water – thereby providing more “crop per drop” while simultaneously reducing drainage volumes.

Processing tomatoes grown in areas with a high water table, under high soil salinity, have yields that can be considerably higher than expected using conventional salt tolerance tables (Hanson, et al, 2006). Previous research in the San Joaquin Valley has found that drip systems can increase yields and reduce percolation below the root zone (Hanson and May, 2003a; Hanson et al 2006). Hanson and May (2003b) found that drip irrigation could significantly increase yield and profit on processing tomatoes. Internationally, similar results have been found in research comparing drip irrigation and other methods on tomatoes in the North China Plain (Wang et al, 2007), Ethiopia (Yohannes and Tadesse, 1998), and the Ebro Valley, Spain (Vasquez et al, 2006).

Prior to beginning the study, it was recognized that although one field under hypothetical irrigation treatment “A” might have better yield than another field under hypothetical treatment “B”, the yield differences may have nothing to do with the treatments, themselves. Rather, yield differences may be due to soil variability, water table fluctuation, salinity, irrigation management, tomato variety, tomato planting date, etc.

differences. However, the budget and time did not allow for a standard research design with all variables controlled except irrigation treatment. Even if a standard replicated research design were to be used, the data would be limited to one or two fields.

In general, farmers have reported to us that when they convert to drip on processing tomatoes and have worked out the problems, yields under drip will outperform historical yields – in particular on problematic fields. But this study does not have the data to make that comparison of one field before (with conventional irrigation) and then afterward (with SDI). We definitely attempted to find fields with such data, but because there are so many different tomato varieties with such different harvesting/planting dates and such different yields (see **Table 1**), we found that we were not able to make that comparison.

Table 1. Processing tomato yields in 2004 with SDI from one grower.

Field	Variety	Reported Paid Tons/Acre
A	1	53.6
	1	54.4
B	2	57.4
	3	57.9
	4	49.5
C	5	57.5
D	6	60.3
	2	52.6
E	7	61.9
	3	58.3
F	8	53.9

However, we did obtain data from several hundred fields with a wide range of conditions, over multiple years. Those data do provide some interesting insights into drainage volume, water applications, and yields.

Data Collection/Organization

Fields

The sites selected for this study were all commercial processing tomato fields, located within the boundaries of Westlands Water District.

Typically, fields were treated with a sprinkler pre-irrigation, and sprinklers were used as the first irrigation after direct seeding or transplanting. After the initial irrigation, the fields were irrigated with the following irrigation methods:

- Furrow (gated pipe)
- Drip
    - Permanent Subsurface Drip (SDI)
    - Surface Drip (every row)
    - Surface Drip (every other row)

Data were collected from 187 conventionally-irrigated (furrow) fields, as well as 164 drip-irrigated fields. **Table 2** shows the number of fields examined, by year.

Table 2. Numbers of fields analyzed by irrigation method

			Drip					
	Furrow		Surface – Every Row		Surface – Every Other Row		SDI	
Year	Direct Seed	Transplant	Direct Seed	Transplant	Direct Seed	Transplant	Direct Seed	Transplant
2000	18							
2001	17							
2002	28						5	
2003	36						7	3
2004	62	5	8	0	31	5	24	3
2005	17	4	0	0	14	18	30	16
Totals	178	9	8	0	45	23	66	22

Estimating Deep Percolation

A water balance was developed for each field using the soil moisture depletion data collected in the field, the soil and water table maps, CIMIS data, crop coefficients developed at ITRC that account for soil evaporation as well as crop transpiration, etc. The water balance was only considered to be valid on fields that had a water table of more than five feet deep on sandy loam, and more than seven feet on clay loams, because the ET contribution of water from a high water table was deemed too difficult to quantify accurately.

Final Results

Deep Percolation

Table 3 provides the summarized values of deep percolation for various irrigation methods. There is a **highly significant** difference in the average Deep Percolation across the four methods. A one-way ANOVA rejects equality of means (F=4.344, df1=3, df2=349, p=.005) in favor of differing means.

Table 3. Deep percolation (DP) for different irrigation methods in Westlands WD.

Irrigation Method	Sub-category	# of Fields	Average D.P. (in)	Std. Error
Furrow	Furrow	187	8.1	.45
Drip	Surface Every Row**	8	3.9	.95
	Surface Every Other Row	68	6.4	.46
	Sub-Surface (SDI)	88	6.3	.53

**One grower with this method

Yields

An argument might be made that if drip yields are higher than furrow yields, then even if both irrigation methods use the same amount of water, there is true water conservation in the sense that more product is produced per unit of water consumed – i.e., “more crop per drop”. However, there was not a **significant** difference in the average yield across the four methods. **Table 4** provides the summarized values of processing tomato yields. A one-way ANOVA cannot reject equality of means (F=1.493, df1=3, df2=349, p=.216) in favor of differing means. Again, one must realize that this was not the type of research design that compares identical fields and only changes one variable.

Table 4. Processing tomato yields.

Irrigation Method	Sub-Category	Number of Fields	Average Paid tons/acre	Std. Error
Furrow	Furrow	187	40.0	.58
Drip	Surface Every Row	8	45.2	2.60
	Surface Every Other Row	68	38.7	.26
	Sub-Surface	88	40.5	1.25

Yield vs. Water Applied

Figure 1 illustrates how Yield varied with Water Applied on the fields, comparing Furrow vs. Drip. The figure indicates that extreme cases of high irrigation water application tend to be more prevalent among Furrow fields than Drip-irrigated fields.

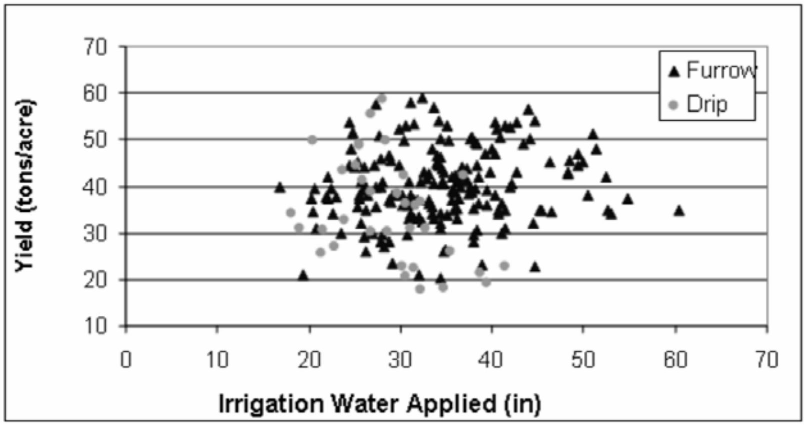

Figure 1. Tomato Yield vs. Irrigation Water Applied.

Conclusions

Data from a large number of commercial processing tomato fields in Westlands Water District in California showed that for these fields:

1. There was no significant difference in tomato yields, between furrow and drip.
2. There was less deep percolation with drip irrigation than with furrow irrigation.
3. Less grossly over-irrigated fields were found with drip than with furrow.
4. There is a large difference in yield between different tomato varieties, which indicates the importance of not extrapolating tomato yield data from a small number of fields.

Discussion

The second and third conclusions match common perceptions among farmers and the irrigation industry. Nevertheless, there is a relatively small difference in average water applied between the furrow and drip fields, and many furrow fields had excellent yields with low water applications.

The first conclusion will be troublesome to some farmers (who invest approximately $1000 - $1400/acre for drip systems on processing tomatoes) and many irrigation industry folks. There are several points to be made:

1. As mentioned several times, this data set is not equivalent to a data set that would be obtained from research that could eliminate all variability except the irrigation method. The data contained a wide range of farming techniques, tomato varieties, dates of planting and harvest, soils, water table depths, salinities, etc.

2. It is popular belief among farmers (and the senior author agrees without having good research data to back this up) that if one takes a field on poor soils and with a high water table, and shifts from furrow to drip, the yields tend to increase. The senior author knows several farmers who have consistently increased their average tomato yields from about 35-40 tons/acre to 50-60 tons/acre by shifting to drip on such fields.
3. One can conclusively state that:
    a. Having drip irrigation does not guarantee high yields or water savings.
    b. Some farmers have excellent yields with furrow irrigation, with excellent irrigation efficiencies.
    c. Some farmers have excellent yields with drip irrigation, with excellent irrigation efficiencies.
    d. Many farmers are convinced that drip irrigation has substantially increased their processing tomato yields on problem fields that were previously irrigated with furrow irrigation.

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