Optimizing irrigation systems: Design, Operation, & Maintenance

DR. MALLIKA NOCCO
LAND, AIR, AND WATER RESOURCES - UC DAVIS
WWW.IRRIGATION-LAB.COM

OUTLINE

1. Irrigation Efficiency Principles
2. Optimizing Irrigation Efficiency for Pistachio
3. System Design Options, Benefits, and Drawbacks
4. Water Application Requirements
5. Irrigation System Evaluation
6. Maintenance Recommendations
Irrigation Efficiency Principles

Key concepts, definitions, relationships, and calculations for deficit optimized irrigation, efficiency, application, and distribution uniformity.

What is irrigation efficiency (IE)?

\[ IE = \frac{\text{Beneficial Water Use}}{\text{Total Applied Water}} \]
What is beneficial plant water use?

- Transpiration
- Nutrients, amendments, pest, weed inputs
- Leaching salts
- Frost protection
- Canopy cooling

Where are the inefficiencies in the system?

- Leakage from pipes, canals, ditches, valves/gates
- Operational losses, over-running irrigation
- Soil evaporation, percolation, runoff, wind losses
- Pipe flushing, screen cleaning, filter maintenance (unavoidable)
- Chemical injection to clean pipes and hoses

Why increase irrigation efficiency?

- Cost of water and energy
- Grow more acreage with water supply
- Disease management and plant health
- Stewardship and compliance with environmental regulations (e.g. ILRP, SMGA, AB 589)
Irrigation Efficiency vs. Application Efficiency

- **Application Efficiency** is event-based, while **Irrigation Efficiency** is based on the whole irrigation season. These terms are related, but not interchangeable.

\[
\begin{align*}
    I_c & = \text{Beneficial Water Use} \\
    & \div \text{Total Applied Water}
\end{align*}
\]

\[
\begin{align*}
    A_c & = \text{Water stored in root zone} \\
    & \div \text{Total Applied Water}
\end{align*}
\]

Conservation Irrigation Lab 10

Irrigation Efficiency vs. Distribution Uniformity

- **Distribution Uniformity (DU)** provides information about how evenly irrigation is being applied across a given area.

\[
DU = \frac{\text{Average Flow, Lowest 25% Emitters}}{\text{Average Flow, All Emitters}}
\]

Conservation Irrigation Lab 11

Irrigation Efficiency vs. Distribution Uniformity

- Poor DU & Poor IE
- Good DU, Poor IE
- Good DU & Good IE

Conservation Irrigation Lab 12

Lightle, 2019
Optimizing pistachio irrigation efficiency

CONSERVATION IRRIGATION LAB

How can we ensure optimal irrigation efficiency?

System Design & Installation  Maintenance & Evaluation  Strategic Scheduling

System design considerations

Microirrigation definition, system design options, benefits, and drawbacks

Lightle, 2019

CVWD, 2018

Schwankl, 2016
What is microirrigation?

Can be microsprinkler, surface drip, subsurface drip system, but all have basic design to maximize application uniformity & control of timing/amount.

Components of microirrigation system

Schwankl, 2016

System Design Options

Microsprinkler & Fanjet
Drip
Subsurface Drip
Single vs. Dual Driplines

SYSTEM DESIGN CONSIDERATIONS

Microsprinkler & Fan Jet

- Larger wetting zone (+)
- Easy to inspect/maintain (+)
- Higher application rates (+)
- Weed growth (-)
- Expensive (-)
- Wind/evaporative losses (-)
**Drip irrigation system**

- Economical (+)
- Easier maintenance (+)
- Limited weed growth (+)
- Small wetting zone (-)
- Susceptible to clogs (-)

**Subsurface drip irrigation system**

- Minimize soil evaporation (+)
- Flexibility of irrigation timing (+)
- Limited weed growth (+)
- Protected from above ground damage (+)
- Challenging to inspect/maintenance
- Small wetting zone (-)
- Root intrusion (-)
- Animal damage (-)
- Expensive for herbicide protection (-)

**Dual Driplines?**

- Larger wetting zone (+)
- Increase application rate (+)
- Challenging to inspect/maintenance (-)
- Increased energy costs (-)
- Increased fixed costs (-)
Water Application Requirements

Calculating Water Requirements, Example Cals

System | Application Efficiency Fraction
-------|-----------------------------
Drip    | 0.85-0.90
Micro-sprinkler | 0.80-0.90
Sprinkler | 0.70-0.90

Example Water Calculation

**Applied Water** = \( \frac{\text{Actual Evapotranspiration}}{\text{Application Efficiency Fraction}} \)

Example 1: Applied Water (season) = 40”/0.85 = 47”

Example 2: Max ET_{calc} for 7 days = 0.4” => Applied Water for 3 days = 2.8”/0.85 = 3.3”
**WATER APPLICATION REQUIREMENTS**

**CONSERVATION IRRIGATION LAB**

### Set time and application rate for different soils

<table>
<thead>
<tr>
<th>System</th>
<th>Appl. Rate (in./hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>0.45</td>
</tr>
<tr>
<td>Drip</td>
<td>0.05</td>
</tr>
<tr>
<td>Micro-sprinkler</td>
<td>0.05</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>0.12</td>
</tr>
</tbody>
</table>

\[ T_{iv} = \frac{D_{iv,MAX}}{Appl. Rate} < \text{Soil intake rate} \]

### Table 1: Recommended maximum application rates for soils of various textures

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Application Rate (in/hr) at Soil Intake Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy sand</td>
<td>0.04, 0.05, 0.06, 0.07</td>
</tr>
<tr>
<td>Light sandy</td>
<td>0.08, 0.09, 0.10</td>
</tr>
<tr>
<td>Silty clay</td>
<td>0.05, 0.06, 0.07</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.04, 0.05, 0.06</td>
</tr>
</tbody>
</table>

Source: UCCE 1910

### Many more detailed example calculations

[link](https://anrcatalog.ucanr.edu/pdf/8571.pdf)

**Irrigation System Evaluation**

CALCULATING WATER REQUIREMENTS, FACTORING IN SOIL VARIABILITY & SALTINESS, CALCULATING ENERGY REQUIREMENTS, EXAMPLE CALC.
How do we evaluate our irrigation system function?

Distribution Uniformity  Application Rate  Troubleshooting

Distribution Uniformity Example

\[ DU = \frac{\text{Average Flow Lowest 25\% Emitters}}{\text{Average Flow All Emitters}} \]

The total number of emitters measured: 16
\( = 20\% \times 16 \) emitters = 4 emitters in the lowest 25%
The average flow of all emitters measured: 0.87 gph
The average flow of the lowest 25\% emitters measured: 0.87 gph

The Distribution Uniformity = 0.87/0.97 = 90%
What contributes to Distribution Uniformity?

- Pressure differences between emitters
- Unequal spacing (emitters and/or plants)
- Unequal drainage of emitters
- Other (clogging, unequal wear)

Additional Distribution Uniformity Resources

https://anrcatalog.ucanr.edu/pdf/8571.pdf

Clogging causes and prevention

http://micromaintain.ucanr.edu
**Maintenance Recommendations**

1. **Check pressure and flow rates of your system regularly,** flush hoses often, clean filters, chemigation, fix breaks/leaks

2. **Know your application rate, time to run applications, and DU**

3. **Professional system evaluations 2-3 years; DU decreases over time**

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**Thanks for listening**

I would love to hear from you if you have questions or comments! Special thank you to Dr. Daniele Zaccaria for resources and photos.

manocco@ucdavis.edu // www.irrigationlab.com // @mallika_manocco

UC Davis

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Thanks for listening