9th Advances in PISTACHIO PRODUCTION

November 5, 2020

Optimizing irrigation systems: Design, Operation, & Maintenance

DR. MALLIKA NOCCO

LAND, AIR, AND WATER RESOURCES- UC DAVIS

WWW.IRRIGATIONLAB.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

CONSERVATION IRRIGATION LAB

3

~~Deficit~~ Optimized Irrigation for cobenefits

Precision management and monitoring

Regenerative irrigation

Irrigation Efficiency Principles

KEY CONCEPTS, DEFINITIONS, RELATIONSHIPS, AND CALCULATIONS RELATED TO IRRIGATION EFFICIENCY, APPLICATION, AND DISTRIBUTION UNIFORMITY

What is irrigation efficiency (IE)

IRRIGATION EFFICIENCY PRINCIPLES

$$IE = \frac{Beneficial\ Water\ Use}{Total\ Applied\ Water}$$

What is beneficial plant water use?

IRRIGATION EFFICIENCY PRINCIPLES

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

Where are the inefficiencies in the system?

IRRIGATION EFFICIENCY PRINCIPLES

- 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?

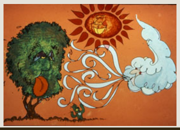
IRRIGATION EFFICIENCY PRINCIPLES

- 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

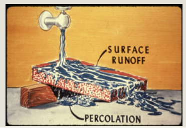
Irrigation Efficiency is seasonal

$$IE = \frac{Beneficial\ Water\ Use}{Total\ Applied\ Water}$$



Application Efficiency is event-based

$$AE = \frac{Water\ stored\ in\ root\ zone}{Total\ Applied\ Water}$$



APPLICATION EFFICIENCY IS EVENT-BASED, WHILE IRRIGATION EFFICIENCY IS BASED ON THE WHOLE IRRIGATION SEASON. THESE TERMS ARE RELATED, BUT NOT INTERCHANGEABLE.

Irrigation Efficiency vs. Distribution Uniformity

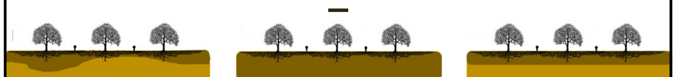
$$IE = \frac{Beneficial\ Water\ Use}{Total\ Applied\ Water}$$

$$DU = \frac{Average\ Flow\ Lowest\ 25\%\ Emitters}{Average\ Flow\ All\ Emitters}$$

DISTRIBUTION UNIFORMITY (DU) PROVIDES INFORMATION ABOUT HOW EVENLY IRRIGATION IS BEING APPLIED ACROSS A GIVEN AREA.

Irrigation Efficiency vs. Distribution Uniformity

Poor DU & Poor IE | Good DU, Poor IE | Good DU & Good IE



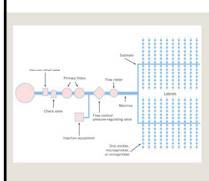
Lightle, 2019

Optimizing pistachio irrigation efficiency

SYSTEM DESIGN, INSTALLATION, MAINTENANCE, EVALUATION, AND STRATEGIC SCHEDULING

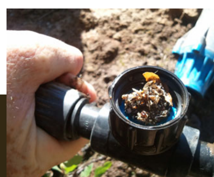
How can we ensure optimal irrigation efficiency?

System Design & Installation



Schwankl, 2016

Maintenance & Evaluation



Lightle, 2019

Strategic Scheduling

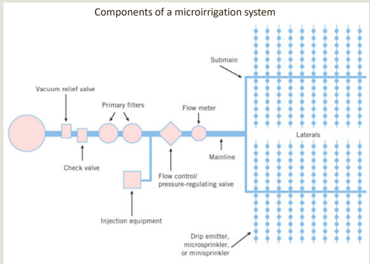
CVWD, 2018

System design considerations

MICROIRRIGATION DEFINITION, SYSTEM DESIGN OPTIONS, BENEFITS, AND DRAWBACKS

What is microirrigation?

CAN BE MICROSPRINKLER, SURFACE DRIP, SUBSURFACE DRIP SYSTEM, BUT SAME BASIC DESIGN TO MAXIMIZE APPLICATION UNIFORMITY & CONTROL OF TIMING/AMOUNT

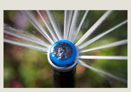


Schwankl, 2016

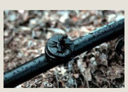
CONSERVATION IRRIGATION LAB

16

System Design Options



Microsprinkler & Fanjet



Drip

Subsurface drip

Single vs. Dual Driplines

Zaccaria, 2018

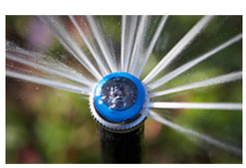
CONSERVATION IRRIGATION LAB

17

Microsprinkler & Fan Jet

SYSTEM DESIGN CONSIDERATIONS

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



CONSERVATION IRRIGATION LAB

18

Drip irrigation system

SYSTEM DESIGN CONSIDERATIONS

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

Subsurface drip irrigation system

SYSTEM DESIGN CONSIDERATIONS

- **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?

SYSTEM DESIGN CONSIDERATIONS

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

Water Application Requirements

CALCULATING WATER REQUIREMENTS, EXAMPLE CALCS

Water Application Calculation

WATER APPLICATION REQUIREMENTS

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

Example Water Calculation

WATER APPLICATION REQUIREMENTS

$$\text{Applied Water} = \frac{Actual\ Evapotranspiration}{Application\ Efficiency\ Fraction}$$

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

Example 2: Max ET_{Daily} for 7 days = 0.4" => Applied Water for 3 days= 2.8"/0.85 = 3.3"

Set time and application rate for different soils

WATER APPLICATION REQUIREMENTS

System	Appl. Rate (in./hr)
Gravity	0.43
Drip	0.03
Micro-sprinkler	0.05
Sprinkler	0.12

Table 1. Recommended maximum application rates for soils of various textures

Soil type	Maximum application rate (in/hr) at slope		
	0–5%	5–8%	8–12%
coarse sandy soil	1.5–2.0	1.0–1.5	0.75–1.0
light sandy soil	0.75–1.0	0.5–0.8	0.4–0.6
silt loam	0.3–0.5	0.25–0.4	0.15–0.3
clay loam, clay	0.15	0.10	0.08

Source: NRCS 1984.
Note: Metric conversion: 1 in = 2.54 cm.

$$T_{IRR} = \frac{D_{G\ MAX}}{Appl.\ Rate} = \frac{D_{G\ MAX}}{< Soil\ \ Intake\ \ Rate}$$

Many more detailed example calculations

WATER APPLICATION REQUIREMENTS

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

Irrigation System Evaluation

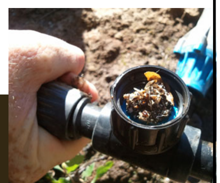
CALCULATING WATER REQUIREMENTS,
FACTORING IN SOIL VARIABILITY & SALINITY,
CALCULATING ENERGY REQUIREMENTS,
EXAMPLE CALCS

How do we evaluate our irrigation system function?

Distribution Uniformity

Application Rate

Troubleshooting



Distribution Uniformity

IRRIGATION SYSTEM EVALUATION

$$DU = \frac{Average\ Flow\ Lowest\ 25\%\ Emitters}{Average\ Flow\ All\ Emitters}$$

Distribution Uniformity Example

IRRIGATION SYSTEM EVALUATION

0.98 gph	0.89 gph	0.95 gph	0.94 gph
0.99 gph	1.05 gph	0.99 gph	1.00 gph
1.15 gph	0.70 gph	1.05 gph	1.01 gph
0.98 gph	0.97 gph	0.96 gph	0.94 gph

The total number of emitters measured: 16
=> 25% * 16 emitters = 4 emitters in the lowest 25%

The average flow of all emitters measured: 0.97 gph
The average flow of the lowest 25% emitters measured: 0.87 gph

The Distribution Uniformity = 0.87/0.97 = 90%

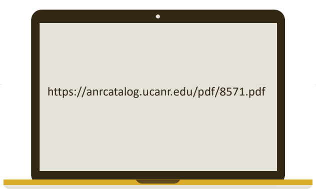
What contributes to Distribution Uniformity?

IRRIGATION SYSTEM EVALUATION

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

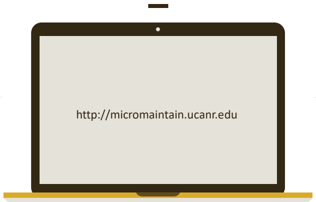
Additional Distribution Uniformity Resources

IRRIGATION SYSTEM EVALUATION



Clogging causes and prevention

IRRIGATION SYSTEM EVALUATION



Maintenance Recommendations

ENSURING OPTIMAL IRRIGATION SYSTEM FUNCTION

01
Check pressure and flow rate of your system regularly, flush hoses often, clean filters, chemigation, fix breaks/leaks

02
Know your application rate, time to run applications, and DU

03
Professional system evaluations 2-3 years; DU decreases over time

CONSERVATION IRRIGATION LAB

34

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_NOCCO

UC DAVIS