University of California
Agriculture and Natural Resources

UC Cooperative Extension

Efficient Irrigation of Pistachio:

System Selection, Maintenance, and Evaluation

2017 Advances in Pistachio Production Short Course

Visalia (CA), November 14, 2017

Daniele Zaccaria, Ph.D.

Agricultural Water Management Specialist, UC Cooperative Extension

Ph.: (530) 219-7502   Email: dzaccaria@ucdavis.edu

PRESENTATION OUTLINE

1) Basics about Irrigation Efficiency

2) Adequate Irrigation Methods for Pistachio

3) Water and Energy Requirements – Practical Examples

4) Main Design Parameters for Micro-Irrigation Systems

5) Irrigation System Evaluation & Maintenance Recommendations

Beneficial is the water used for crop production & health

- ✓Transpiration (T) of water through the canopy
- ✓Apply chemicals for pest & weeds control, fertilizers & nutrients
- ✓Frost Protection & Canopy Cooling
- ✓Leaching salts + soil amendments (gypsum, humic/fulvic acids and others)

$$Irr.Eff. = \frac{Water\ used\ by\ the\ crop\ for\ ET + Other\ Beneficial\ Uses}{Total\ water\ applied\ onto\ the\ field}$$

Water Applied to the field

- ✓Replenish Soil Moisture Depleted since the last irrigation event (ETc)
- ✓Soil Evaporation + Deep Percolation + Surface Runoff + Wind Drift
- ✓Leakages from pipes, canal, ditches + valves/gates stuck-open, wrong commands, operational losses, irrigation over-run, etc.
- ✓Water draining out of pipes and hoses after irrigation shut-off (pulsing on-off)
- ✓Pipe flushing + Screen cleaning & Filters back-flush
- ✓Pipe & hose chemical injection (keep the pipe system clean and functional)

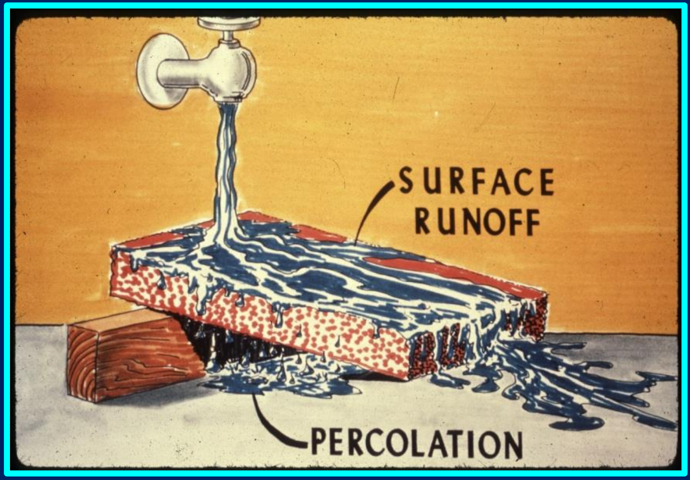
Application Efficiency (A.E.) vs. Irrigation Efficiency (I.E.)

single irrigation event

entire irrigation season

$$A.E. = \frac{Water\ stored\ in\ the\ soil\ root\ zone}{Total\ water\ applied\ onto\ the\ field}$$

$$I.E. = \frac{Water\ beneficially\ used\ by\ the\ crop}{Total\ water\ applied\ onto\ the\ field}$$



Distribution Uniformity (D.U.) vs. Irrigation Efficiency (I.E.)

Distribution Uniformity: is a number (%) describing how evenly water is distributed across the field/plants

Irrigation Efficiency: is the fraction of the applied water that is beneficially used by the crop

EXAMPLE

2 gallons per tree in July

The trees will use every drop of the applied water

D.U. = 100%; I.E. = 100%

200 gallons per tree in July

Trees will use only a fraction of the applied water

D.U. = 100%; I.E. << 100%

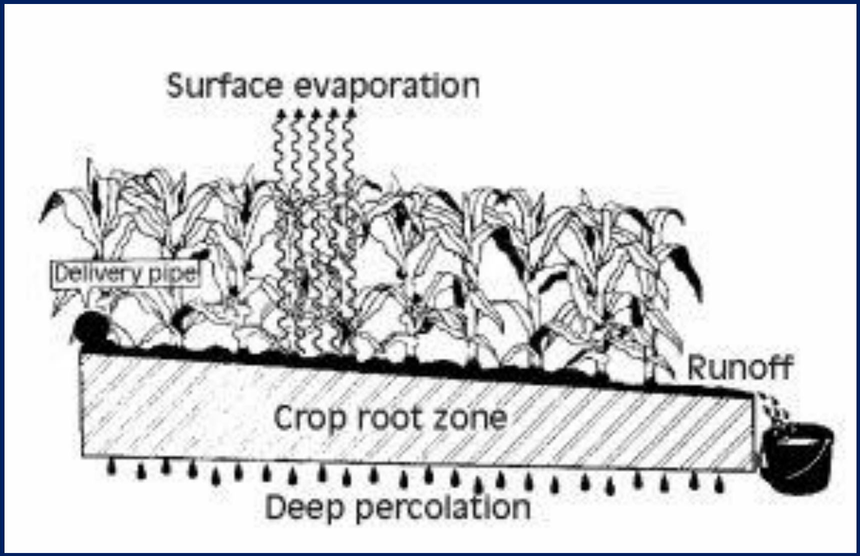
Irrigation Efficiency Components

Irrigation Application

- ✓Adequacy of application (depth or volume infiltrated)
- ✓Application Uniformity (DU)

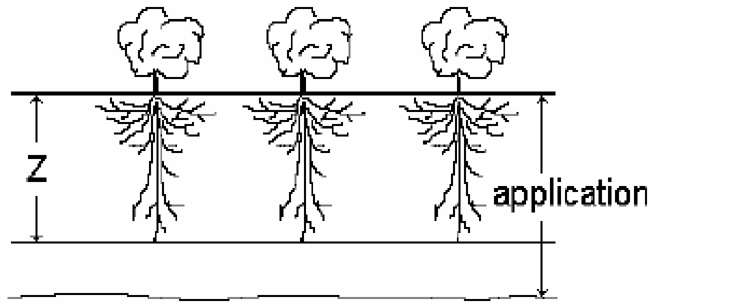
Irrigation Losses

- ✓Deep percolation
- ✓Soil Evaporation
- ✓Runoff
- ✓Wind drift (sprinkler)



Adequacy of application refers to the depth or volume of water that infiltrates in the root zone and is available for plant use (T)

ADEQUACY OF APPLICATION



Uniform, but average depth applied exceeds the soil water deficit (too much deep percolation)

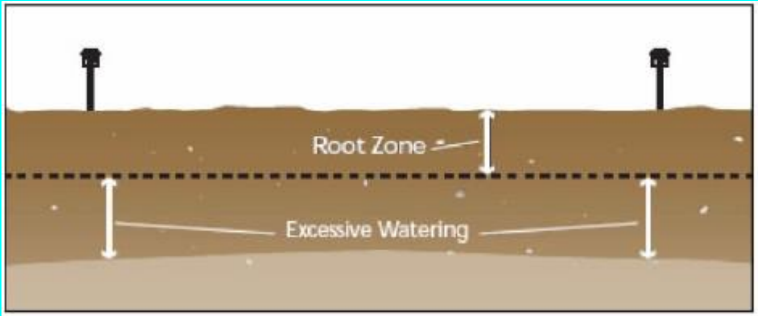


FIGURE 3: Depiction of irrigation resulting in good DU but poor irrigation efficiency

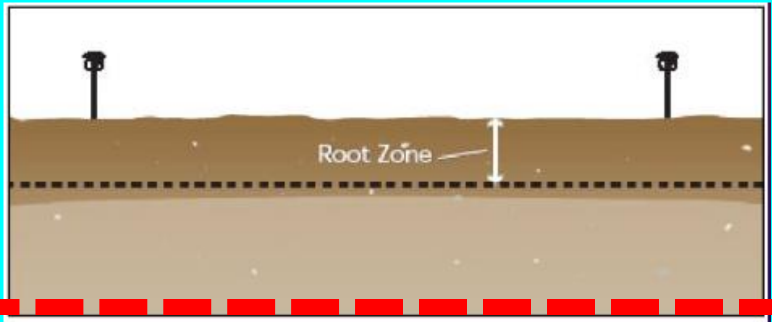
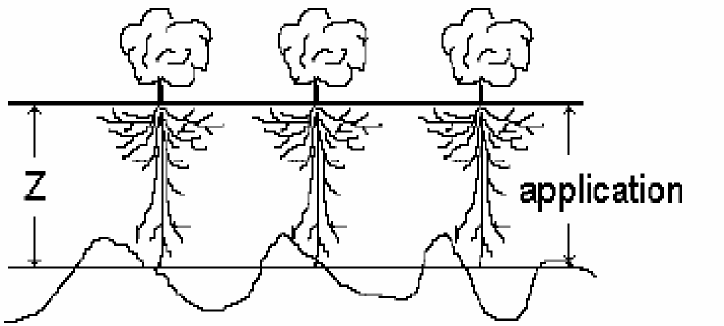


FIGURE 4: Depiction of irrigation sufficiently watering the entire field with good DU and irrigation efficiency

Whether an irrigation is adequate or not depends on the irrigation set-time & soil moisture status/depletion @ irrigation start

Whether water is distributed evenly among plants (D.U.) mainly depends on proper system design, operation & maintenance

UNIFORMITY OF APPLICATION



Average depth is correct, but application is highly nonuniform, with underirrigation and DP

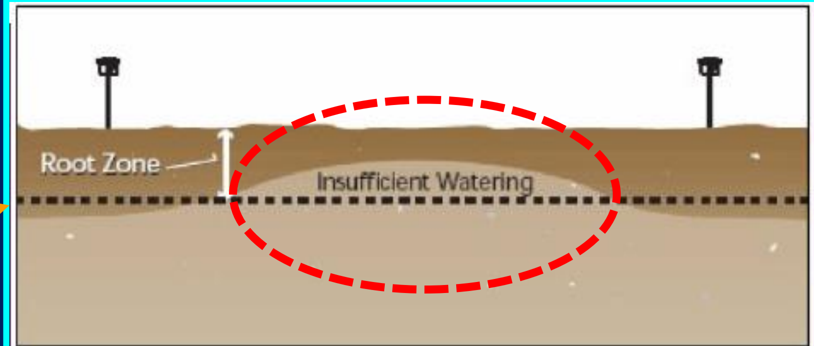


FIGURE 2: Depiction of irrigation resulting in poor DU and insufficient irrigation in parts of the field

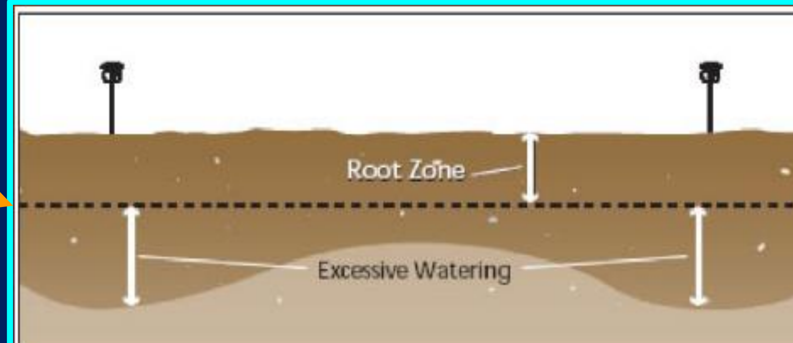
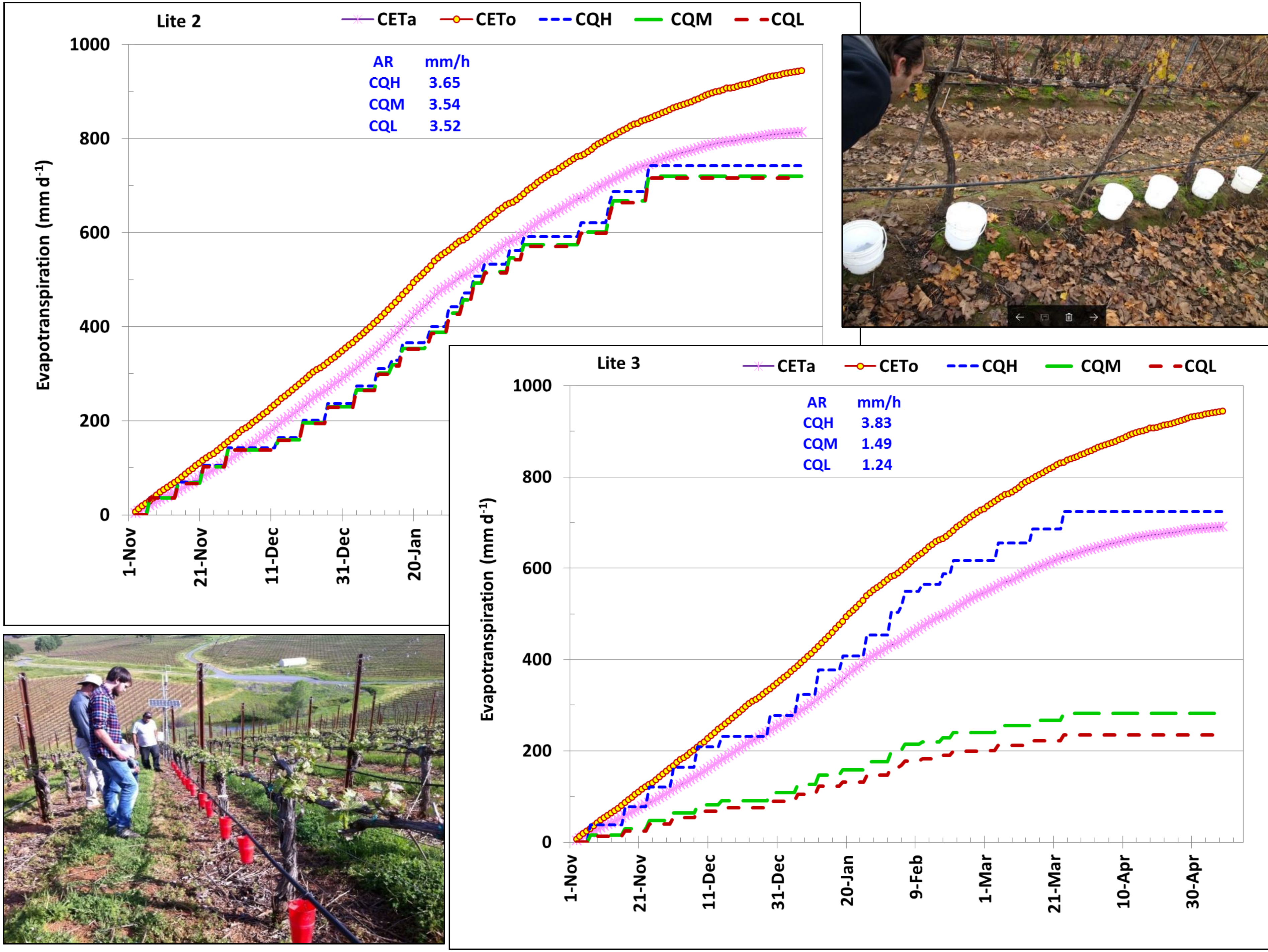


FIGURE 1: Depiction of irrigation resulting in poor DU and excessive watering

Uniformity is mainly related to adequate system design & system maintenance

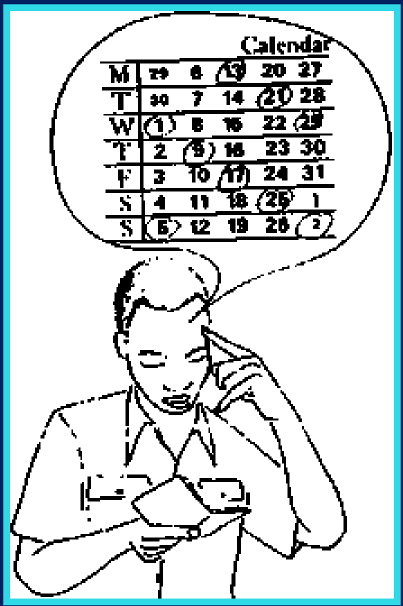


Lite 2
CETa
CETo
CQH
CQM
CQL
AR mm/h
CQH 3.65
CQM 3.54
CQL 3.52
Evapotranspiration (mm d-1)
1000
800
600
400
200
0
1-Nov
21-Nov
11-Dec
31-Dec
20-Jan
Lite 3
CETa
CETo
CQH
CQM
CQL
AR mm/h
CQH 3.83
CQM 1.49
CQL 1.24
Evapotranspiration (mm d-1)
1000
800
600
400
200
0
1-Nov
21-Nov
11-Dec
31-Dec
20-Jan
9-Feb
1-Mar
21-Mar
10-Apr
30-Apr

WHAT IT TAKES TO BE EFFICIENT?

Good System Design

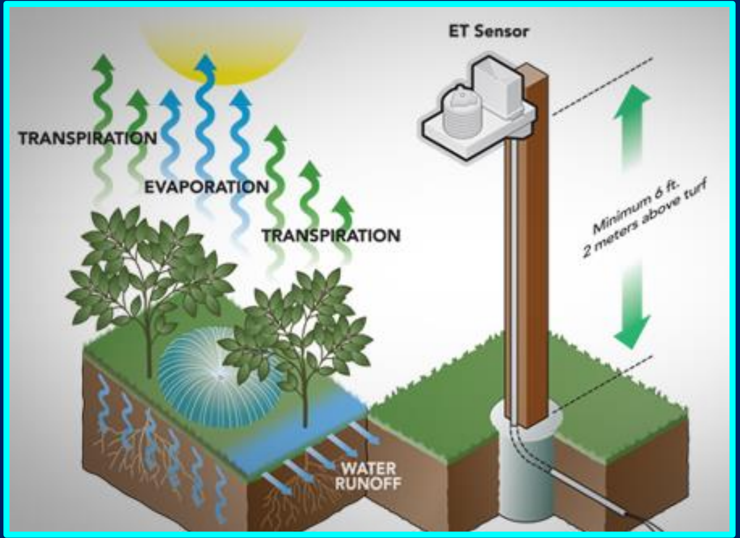
✓Accurate & Skilled
✓Flexible Operation



Proper Installation
Regular Maintenance
System Evaluation

Defined Irrigation Strategy

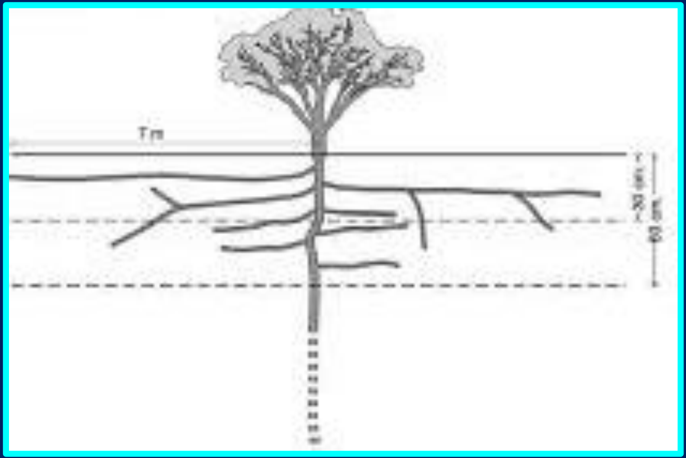
Accurate Irrigation Scheduling

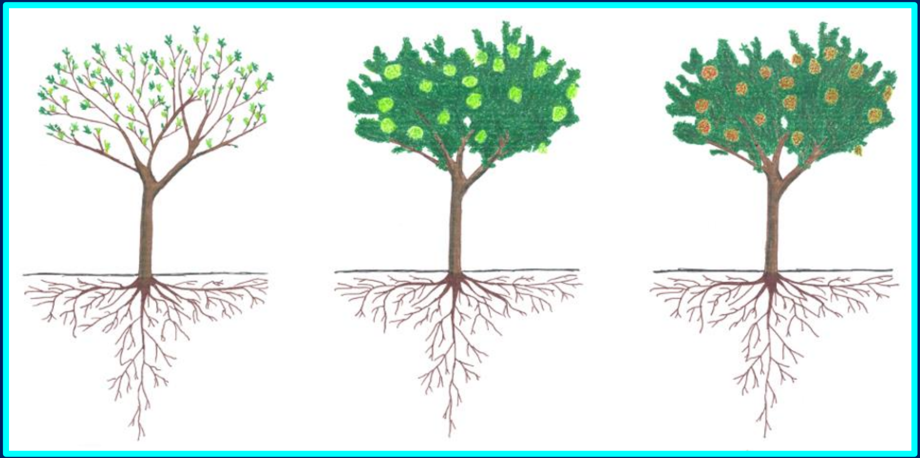


ADEQUATE IRRIGATION METHOD FOR PISTACHIO

Pistachio is a Phreatophyte

- ✓ have extensive roots systems mining the soil deeply and horizontally
- ✓ thrive in soils with good balance between water and air (un-saturated soils)
- ✓ do not benefit from soil compaction, saturation and wetting-drying cycles





Low volume irrigation (micro-irrigation) is mostly used for pistachios, as it allows careful management of quantity and timing of irrigation applications.

<u>Sprinkler irrigation</u> has been associated with increased incidence of fungal diseases (*Alternaria*, *Botryosphaeria)* to leaf, canopy and nut clusters.

With micro-irrigation water is applied in relatively **precise quantities,** at **precise times** and at **precise locations**

Drip Irrigation

Micro-spray Irrigation

- Water is discharged in small amounts the vicinity of each plant and roots with high distribution uniformity (DU)
- Allows excellent control of the amount and timing of irrigation. Small, frequent irrigations allow matching the tree's water needs and minimize the risk of saturation, root asphyxia, runoff and deep percolation.
- Weed growth is minimized (only a portion of the orchard floor is wetted)
- Fertilizers and other chemicals can be injected through the micro-irrigation system, targeting the applications to the active root zone, increasing the application safety and the chemical use efficiency

BETTER DRIP OR MICRO-SPINKLERS?

Pistachio trees perform well when the wetted soil is 30% (young trees) to 60 % (mature trees)

Surface Drip

Advantages:

✓Usually the least expensive

✓Less weed growth than micro-sprinklers

✓Easier to monitor and repair

Disadvantages:

✓Does not wet a very large area

✓Can clog more easily than micro-sprinklers

SINGLE OR DUAL DRIPLINE?

Two lateral line systems:

✓Wet a larger area - appropriate for soils which don’t sub water laterally well.

✓Increase the application rate, thus reduce the set time.

✓Increase the flow rate, and load requirement for each block (>> energy @ the pump)

✓Increase the fixed cost.

SUB-SURFACE DRIP (SDI)

Advantages:

✓Protected from damage by above-ground sources

✓Reduced weed growth

✓Can irrigate just about anytime

✓Minimize soil evaporation

Disadvantages:

✓Can’t be inspected by observation

✓Root intrusion & varmit damage

✓Single line doesn’t wet a large area

✓Costs more if use herbicide-protected driplines

MICRO SPRINKLER AND FAN JET

Advantages:

✓Wet a larger area

✓Easy visual inspection

✓Larger orifice openings may have less clogging

✓Higher application rates

Disadvantages:

✓Insects can clog orifices

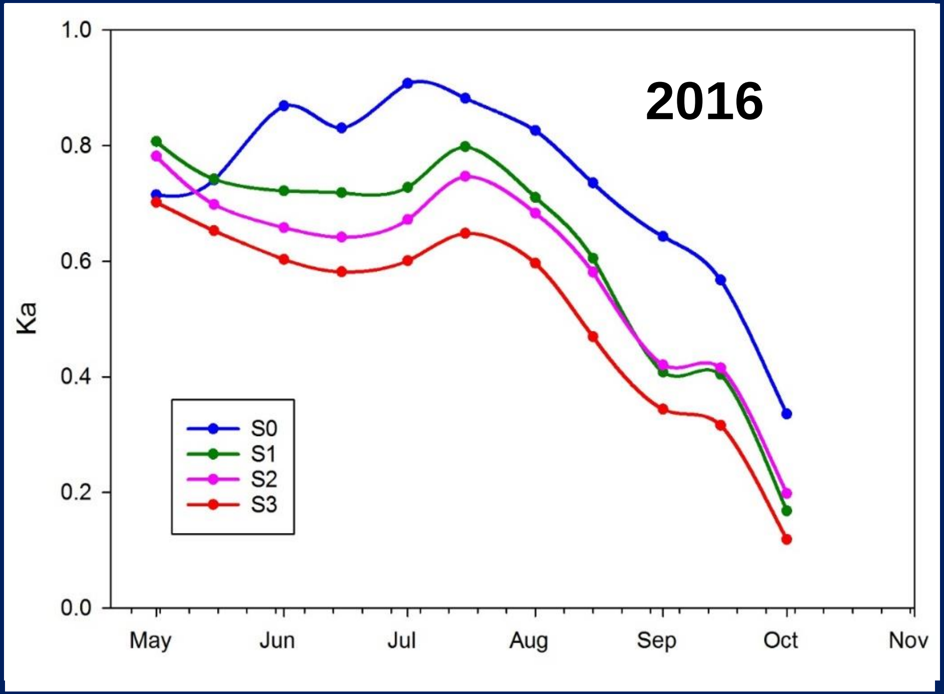
✓More weed growth

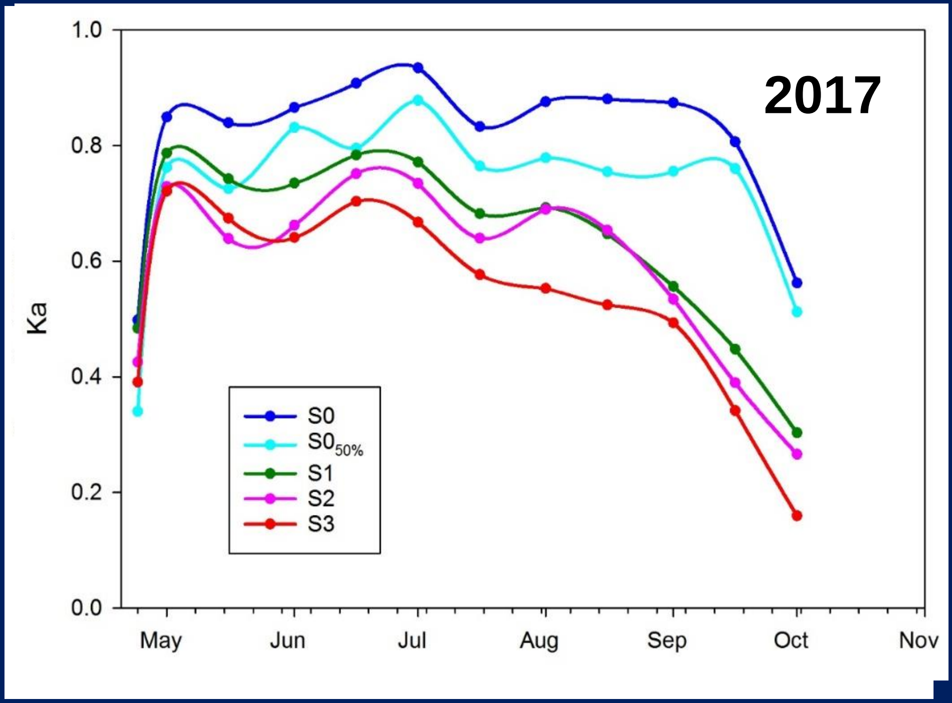
✓Wind & Evap. effects

✓Higher cost

WATER REQUIREMENTS TO IRRIGATE PISTACHIO

1. Non salt-affected mature orchards (~80% canopy cover) under micro-irrigation have seasonal ET of about **36-40 inches (May-Oct.)** and **max Kc of 0.95**
2. Salt-affected orchards have **significantly lower ET and Kc** (30-50%) than non salt-affected orchards, depending on the level of salinity





AMOUNT OF WATER TO APPLY

$A_{pp.}W_{ater} = ET_a/AE_{AVE}$ ⇒

System	AE
Gravity (Surface Irr)	70-85%
Drip	85-90%
Micro-sprinkler	80-90%
Sprinkler	70-90%

AW = 40 in/0.85 = 47 in

Max ET_{Daily} = 0.4 in => Max $AW_{3\text{-}day}$ = 1.2 in/0.85 = 1.4 in

Typical Flow Rates and Pressures

Drip & Micro-sprinkler: 0.5-30 gph @ operating pressure of 15-25 psi

- Micro-irrigation emitters require only 7-10 psi.
- Cleaning and delivering the water to the emitters on flat grounds typically require additional 15-20 psi
- Back-flushing filters are the critical components, require around 30-35 psi

ENERGY REQUIREMENTS TO IRRIGATE PISTACHIO

It takes 1.37 whp-hr/ac-ft per foot of lift

(power the pump must provide to lift 1 ac-foot of water by 1 foot)

FUEL SOURCE	PUMP OUTPUT
ELECTRICITY	0.885 whp-hr/kWh
NATURAL GAS (925 BTU)	61.7 whp-hr/MCF
NATURAL GAS (1000 BTU)	66.7 whp-hr/MCF
DIESEL	12.50 whp-hr/gal
PROPANE	6.89 whp-hr/gal

Source of Energy	Energy Units to Lift Water
Electricity	1.55 kWh/ac-ft per foot of lift
Natural Gas (925 BTU)	0.22 MCF/ac-ft per foot of lift
Natural Gas (1000 BTU)	0.20 MCF/ac-ft per foot of lift
Diesel	0.10 Gal/ac-ft per foot of lift
Propane	0.20 Gal/ac-ft per foot of lift

Source: Nebraska Pumping Plant Performance Criteria (NPPPC)

Mature Pistachio with Micro-Sprinkler vs. Drip Irrigation

Pistachio ET = 40 in. => 3.5 ft of water per season (SJV)

Area = 80 acres

Irrigation methods: Micro-Sprinkler (40 psi) Vs. Drip Irrig. (25 psi) @ pump out.

Water Lift = 100 ft (from aquifer level to ground)

$TDH_{MICRO\text{-}SPR.}$: 100 ft + (40 psi x 2.31 ft/psi) = 192 ft

TDH_{DI}: 100 ft + (25 psi x 2.31 ft/psi) = 158 ft

Total ac-ft $_{MICRO\text{-}SPR.}$ = 3.5/0.80 = 4.4 ac-ft

Total ac-ft $_{DI}$ = 3.5/0.90 = 4.0 ac-ft

Diesel => 0.10 gal/ac-ft per foot of lift

Ave. Price of Diesel for Ag.= $2.60 per gallon

System	$Eff._A$
Gravity (surface)	0.70
Drip & SDI	0.90
Micro-sprinkler	0.80
Sprinkler	0.75

Vol. Micro-Sprinkler: 80 ac x 4.4 ac-ft x 192 ft x 0.10 gal/ac-ft = 6,758 gal

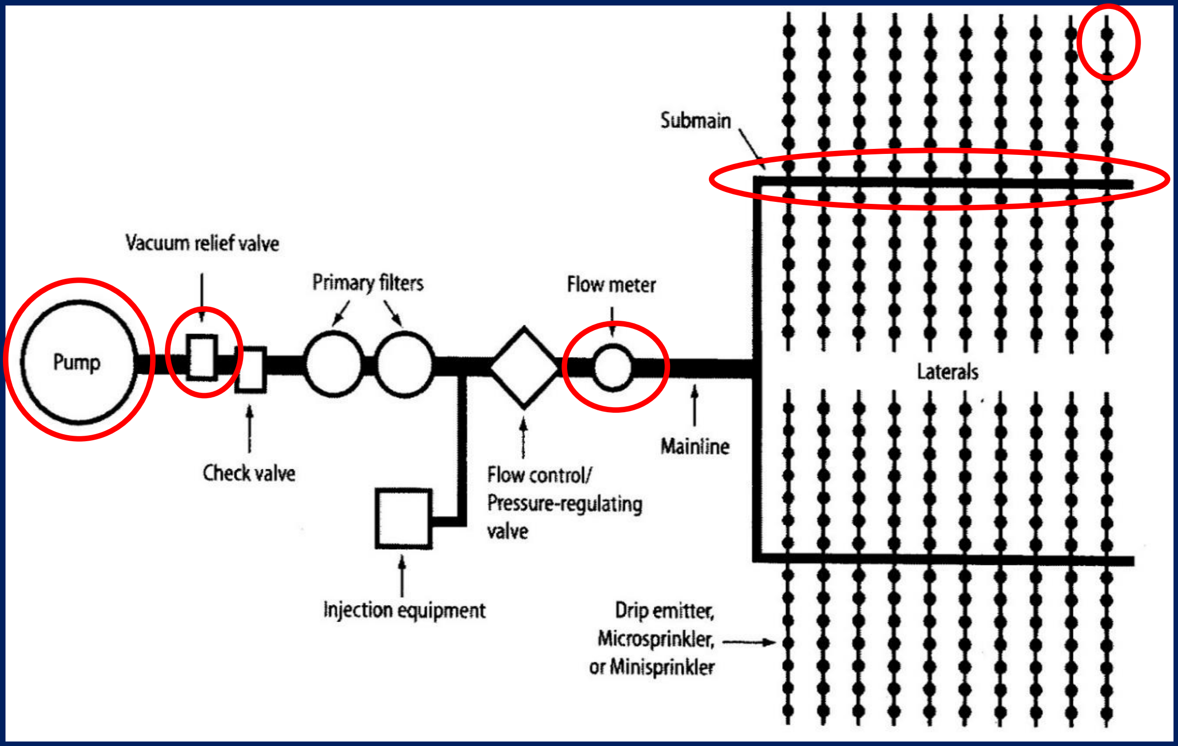
Cost for Micro-Sprinkler irrigation: 6,758 gal x $2.60 per gallon = $17,572

Vol. Drip Irrigation = 80 ac x 4.0 ac-ft x 158 ft x 0.10 gal/ac-ft = 5,056 gal

Cost for Drip Irrigation: 5,056 gal x $2.60 per gallon = $13,145

DESIGN STAGE - Important aspects where to focus attention:

1) Conduct preliminary site testing/evaluations (soil, slopes, water source, plant spacing & density, etc.)
2) Define the **water application rate** based on soil properties (**infiltration rate**; **water holding capacity**, slope, etc.) and crop water needs (ET)
3) Size the different system components from downstream to upstream
4) Ensure operational flexibility to the system



Max Irrigation depth to apply (D_{GMAX})

$$D_{G\,MAX} = \left[\left(\frac{MAD}{100} * \frac{P_W}{100} * W_a * Z_E\right) / Eff_{APPL.}\right]$$

D_{GMAX} (in.) = Max. Gross Depth of water to apply per irrigation

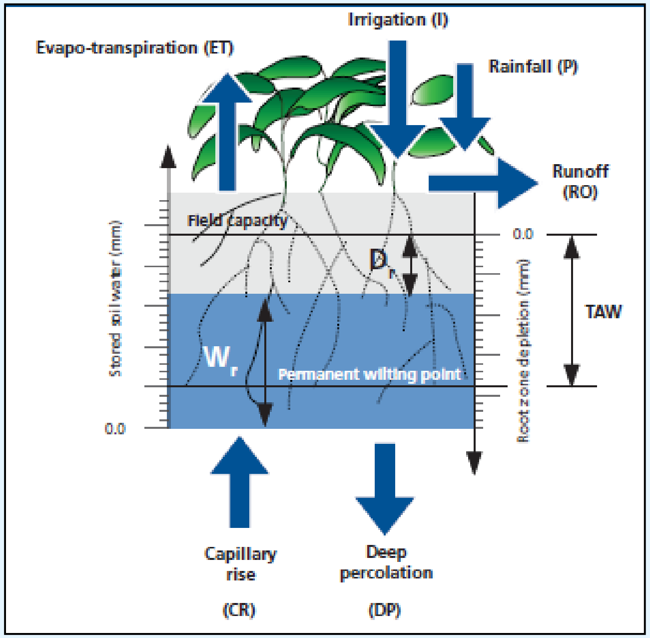
MAD = Management Allowable Depletion (depletion threshold for no stress)

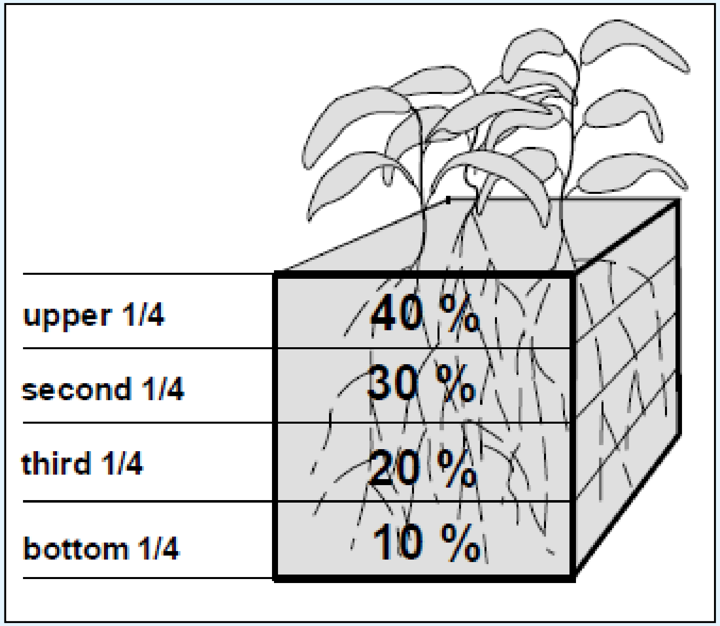
W_a (in./ft.) = Available Water-holding Capacity of the soil (FC-WP)

P_W (%) = Percent Wetted Area

Z_E (ft.) = Effective Root Depth (60-70% of actual root depth)

$Eff._{APPL.}$ = Application Efficiency of the selected irrigation method





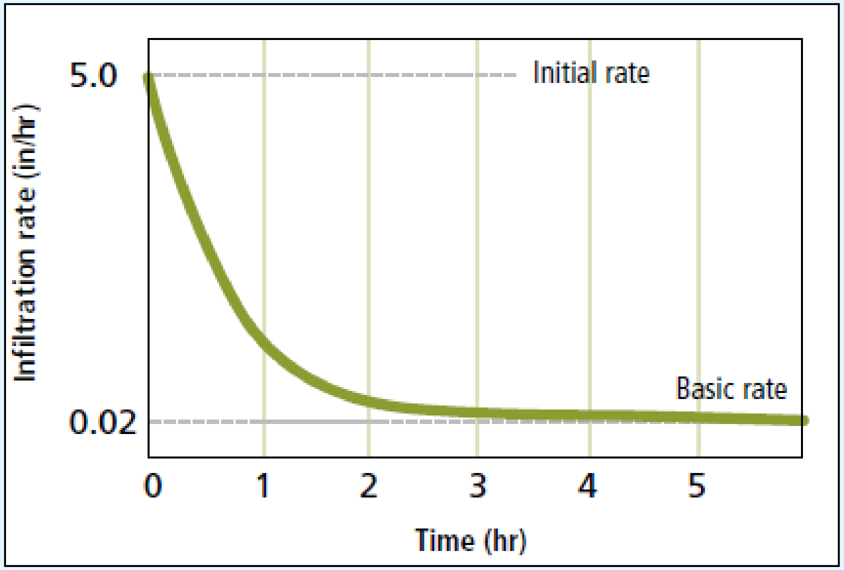
Ranges of Water-holding Capacities (W_A = FC - WP) for different soils

Soil texture	Water-holding capacity Range In./ft	Water-holding capacity Average In./ft
1. Very coarse texture—very coarse sands	0.38-0.75	0.50
2. Coarse texture—coarse sands, fine sands, and loamy sands	0.75-1.25	1.00
3. Moderately coarse texture—sandy loams	1.25-1.75	1.50
4. Medium texture—very fine sandy loams, loams, and silt loams	1.50-2.30	2.00
5. Moderately fine texture—clay loams, silty clay loams, and sandy clay loams	1.75-2.50	2.20
6. Fine texture—sandy clays, silty clays, and clays	1.60-2.50	2.30
7. Peats and mucks	2.00-3.00	2.50

NOTE: 1 mm/m = 0.012 in./ft.

Max Irrigation Set-Time, T_{IRR} (hr)

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



D_{GMAX} (in.) = Max. Gross Water Depth of water to apply per irrigation

Appl. Rate < = Soil Intake Rate (in./hr)

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

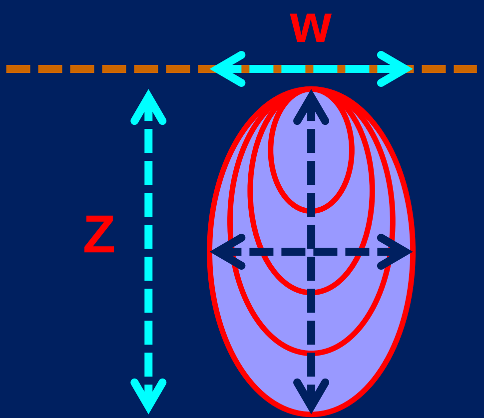
Table 1. Recommended maximum application rates for soils of various textures

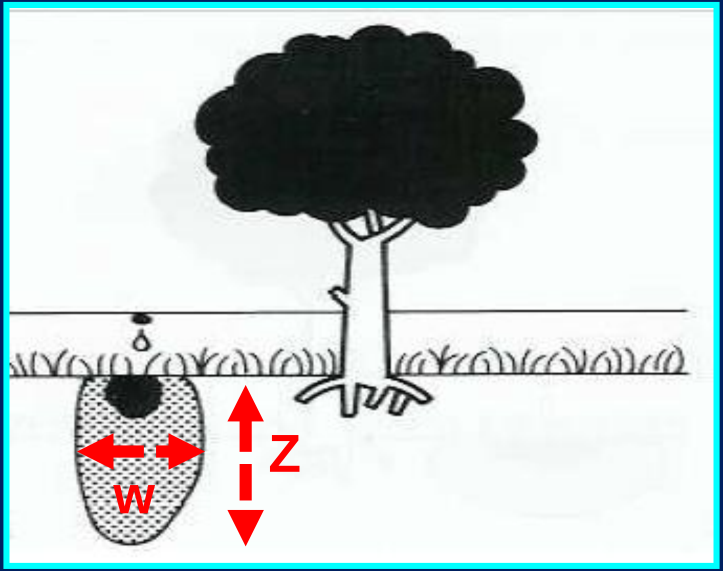
Soil type	Maximum application rate (in/hr) at slope		
	0–5%	5–8%	8–12%
coarse sandy soil	1.5–2.0	1.0–1.5	0.75–1.0
light sandy soil	0.75–1.0	0.5–0.8	0.4–0.6
silt loam	0.3–0.5	0.25–0.4	0.15–0.3
clay loam, clay	0.15	0.10	0.08

Source: NRCS 1984.

Note: Metric conversion: 1 in = 2.54 cm.

QUICK METHOD TO ESTIMATE THE HYDRAULIC FEATURES OF YOUR SOIL (k_S)





How to convert water depth (in.) to gallons per plant?

$$Water\ volume\left(gals/day\right) = Water\ Depth\ (in/day) * crop\ spacing\ (ft^2) * 0.623$$

Crop Spacing (ft^2) = row spacing × plant spacing	Evapotranspiration (inches per day) 0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
100	3	6	9	12	16	19	22	25
200	6	12	19	25	31	37	44	50
400	12	25	37	50	62	75	87	100
600	19	37	56	75	93	112	131	150
800	25	50	75	100	125	150	174	199
1000	31	62	93	125	156	187	218	249
1200	37	75	112	150	187	224	262	299
1400	44	87	131	174	218	262	305	349
1600	50	100	150	199	249	299	349	399
1800	56	112	168	224	280	336	392	449
2000	62	125	187	249	311	374	436	498
2200	69	137	206	274	343	411	480	548
2400	75	150	224	299	374	449	523	598

From Larry Schwankl, Blaine Hanson, and Terry Prichard, *Low-Volume Irrigation*. University of California, Davis, 1993.

Calculation Example

Mature pistachio orchard: planting spacing 16 ft x 16 ft => **Micro-sprinkler**

Root depth, Z = ~ 6 ft

Effective rooting depth, Z_E = 70% x 6 ft = 4.2 ft

Wetted area, P_W = 60%

Sandy loam soil

F.C. = 3.25 in./ft

P.W.P. = 1.67 in./ft

T.A.W. = 3.25 – 1.67 = 1.58 in/ft

M.A.D. = 50 % of T.A.W. = 0.5 x 1.58 in/ft = 0.80 in/ft

Max gross irrigation depth to apply

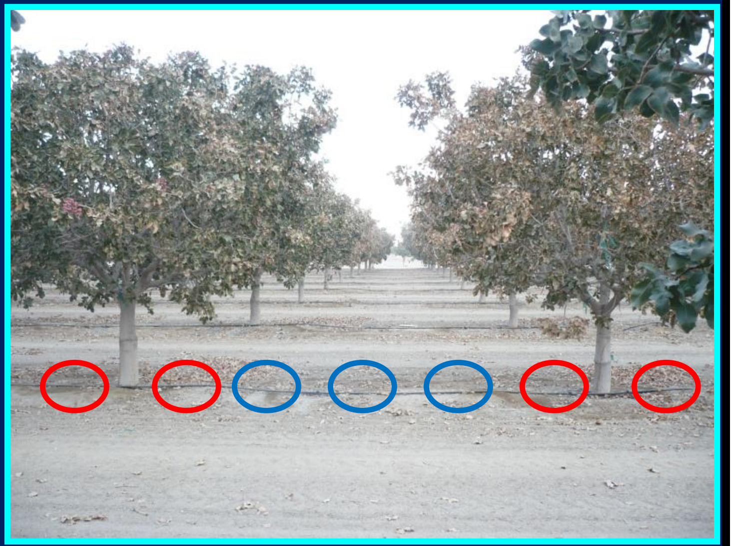
$\mathbf{D_G}$ = (MAD * TAW * Pw * Z_E)/Eff_A = (0.5 * 1.58 in/ft * 0.6 * 4.2 ft)/0.80 = **2.5 in.**

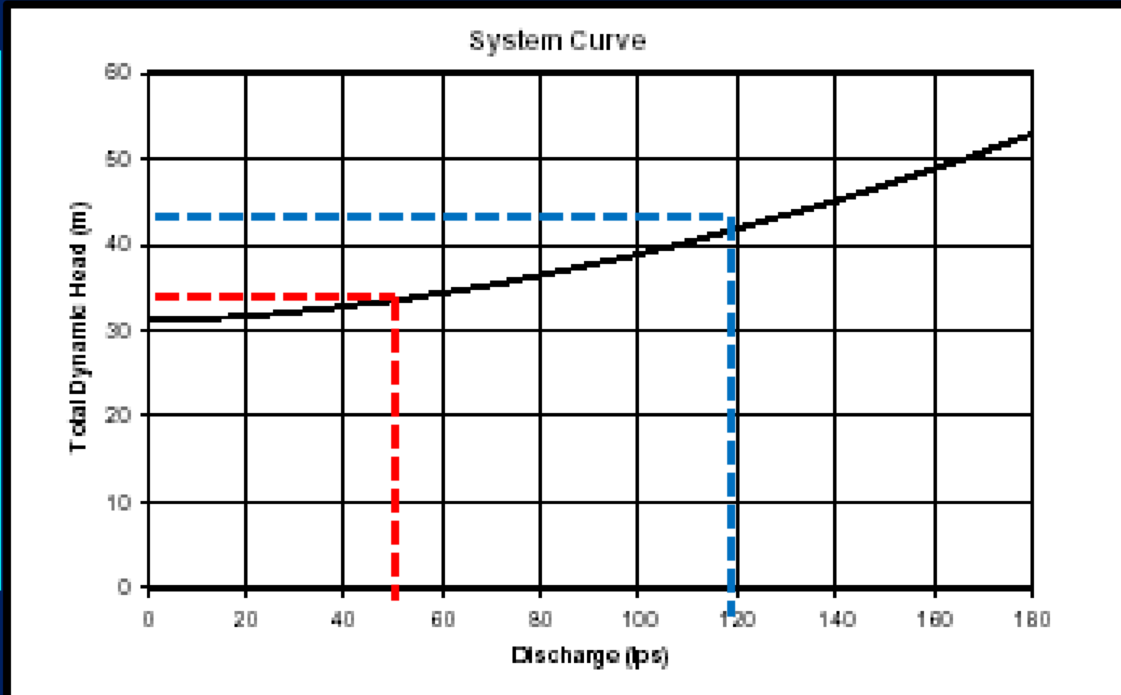
Vol (gal/plant) = D_G x Spacing x 0.623 = 2.5 in. x 16 ft x 16 ft x 0.623 **= 400 gal/pl**

Flexibility of Operation => Range of operating conditions (Q, P)

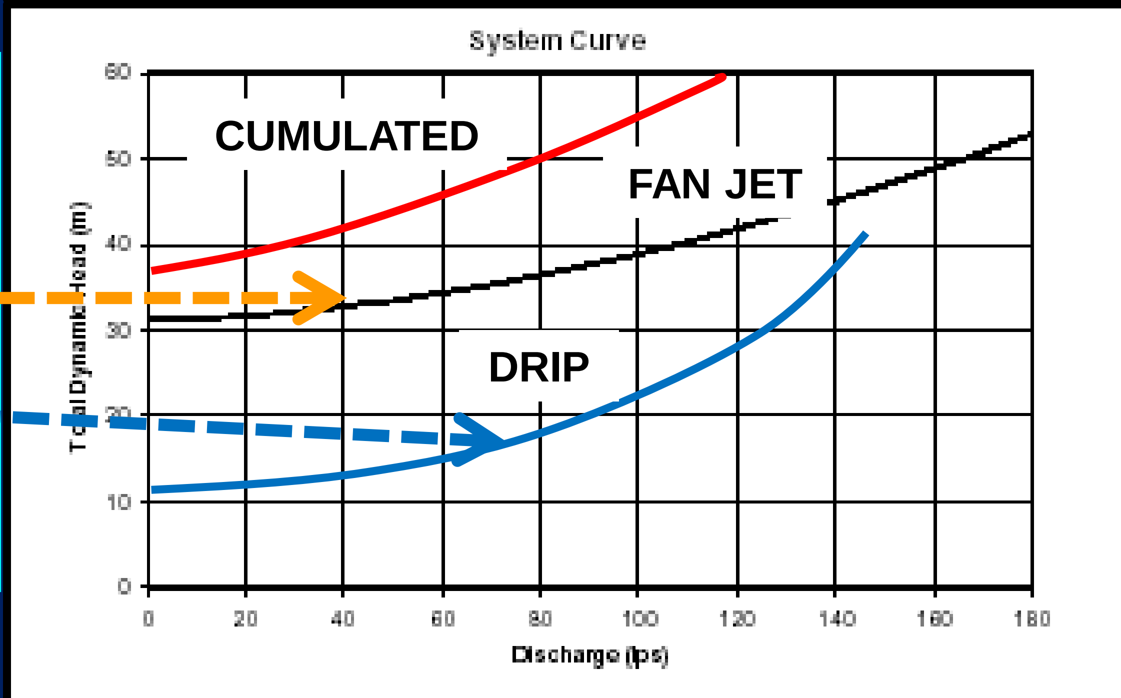
During its life the irrigation system may be operated with different conditions

- Water needs of immature trees are small, and increase with time
- Blocks at different elevations and distances from the water source
- Blocks with different irrigation systems, due to soil differences
- Composite systems (different flow rate and pressure => single and double line, drip and micro-sprinkler, alternating or all at once, etc.)
- Groundwater level decreasing with time





System Curve
60
50
40
30
20
10
0
Total Dynamic Head (m)
0
20
40
60
80
100
120
140
160
180
Discharge (lps)



System Curve
CUMULATED
FAN JET
DRIP
60
50
40
30
20
10
0
Total Dynamic Head (m)
0
20
40
60
80
100
120
140
160
180
Discharge (lps)

IRRIGATION SYSTEM EVALUATION

OBJECTIVES:

- ✓ System Distribution Uniformity, D.U. (%)
- ✓ Average Application Rate (in/hr)
- ✓ Identify main problems & corrections

STANDARDIZED SYSTEM EVALUATION

WHAT PARAMETERS ARE MEASURED IN THE FIELD?

FLOWRATE

PRESSURE

CALCULATING DISTRIBUTION UNIFORMITY

$$D.U. = \frac{average\ \ flow\ of\ \ lowest\ 25\%\ emitters\ measured}{average\ \ flow\ of\ \ all\ emitters\ measured}$$

EXAMPLE OF D.U. CALCULATION IN A VINEYARD

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)

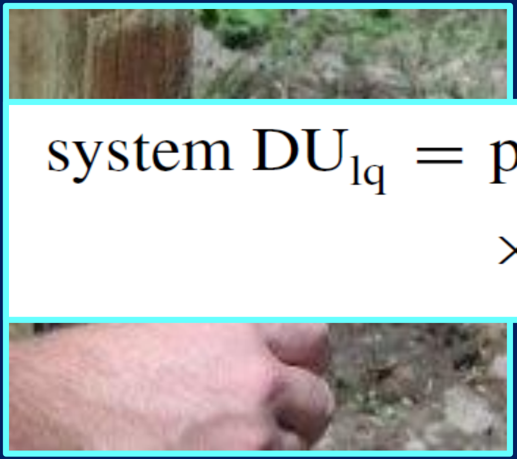
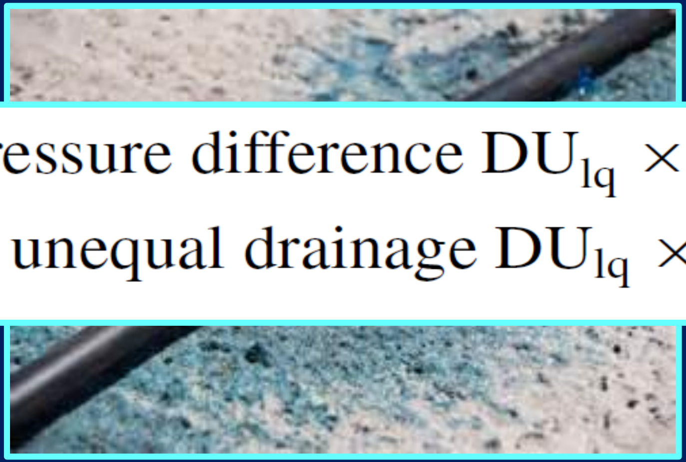
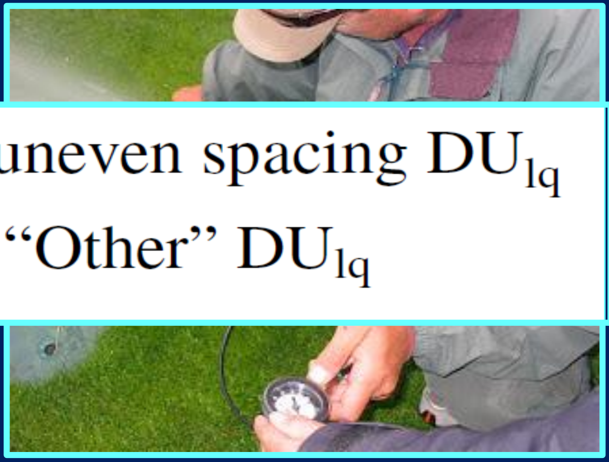
The average flow of all emitters measured: 0.97 gph

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

The Distribution Uniformity = 0.87/0.97 = 90%

What are the main factors affecting system D.U.?

- **Pressure difference between emitters** (friction losses, elevation differences, etc.) cause flow differences **[$q = k\,P^x$]**
- **Uneven spacing:** non-uniformity caused by having a different number of emitters per unit area in the field (2 or more different plant spacings)
- **Unequal drainage**: after system shut-off some emitters may continue to drain for some time while most of emitters have stopped discharging water (sloping blocks, pulsing irrigation on/off)
- **Other causes**: emitter clogging, wear (gypsum), manufacturing variations (variation in size of orifices and flowrates due to the manufacturing process)

$$\text{system } DU_{lq} = \text{pressure difference } DU_{lq} \times \text{uneven spacing } DU_{lq} \times \text{unequal drainage } DU_{lq} \times \text{“Other” } DU_{lq}$$

THE ITRC PROCEDURE COMPRISES 4 SETS OF MEASUREMENTS

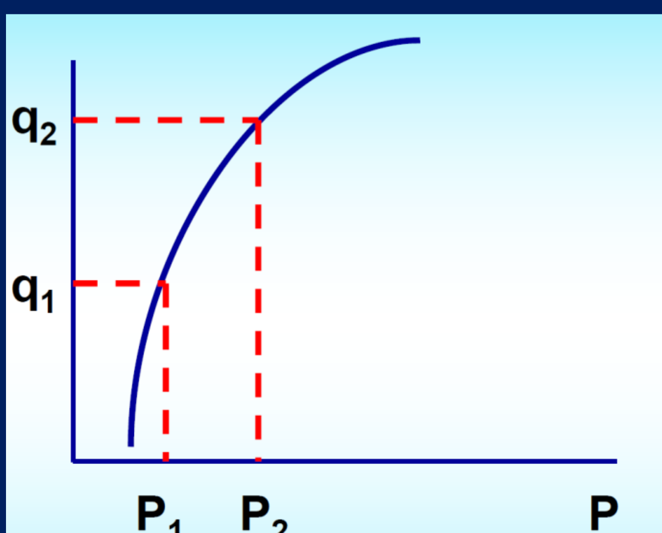
1. **Flow rate at <u>16-20 emitters</u>** close to the pump and filters at 2 different values of the pressure

$$q = k P^x$$

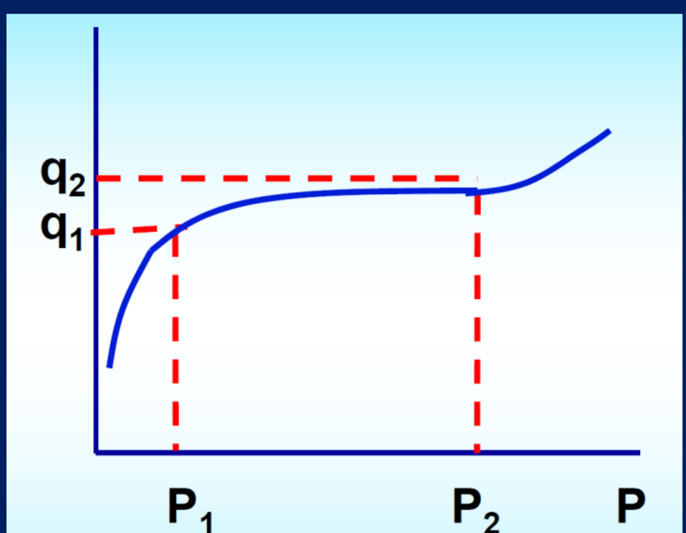
$P_{8\ PSI}$ $P_{16\ PSI}$

$$x = \frac{\log\text{ (average low flow rate/average high flow rate)}}{\log\text{ (low pressure/high pressure)}}$$

NON-PC EMITTERS (x > 0.5)

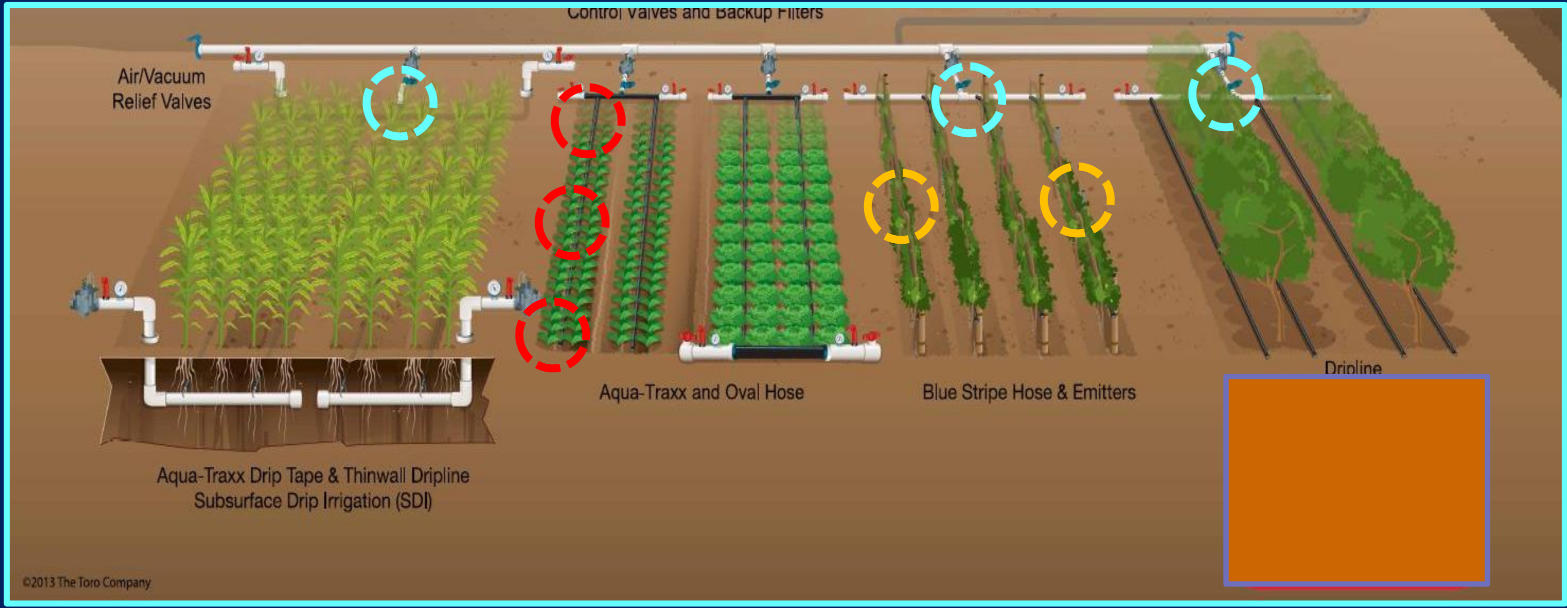


PC EMITTERS (x < 0.5)



2. DU related to pressure differences - it requires:

- **Pressure along individual driplines** (head, halfway down, tail-end)
- **Pressure between individual hoses along a single manifold – 2 hoses**: (closest to inlet, and most distant from inlet)
- **Pressure at head of each manifold – 6 manifolds** (including closest and most distant from the pump)



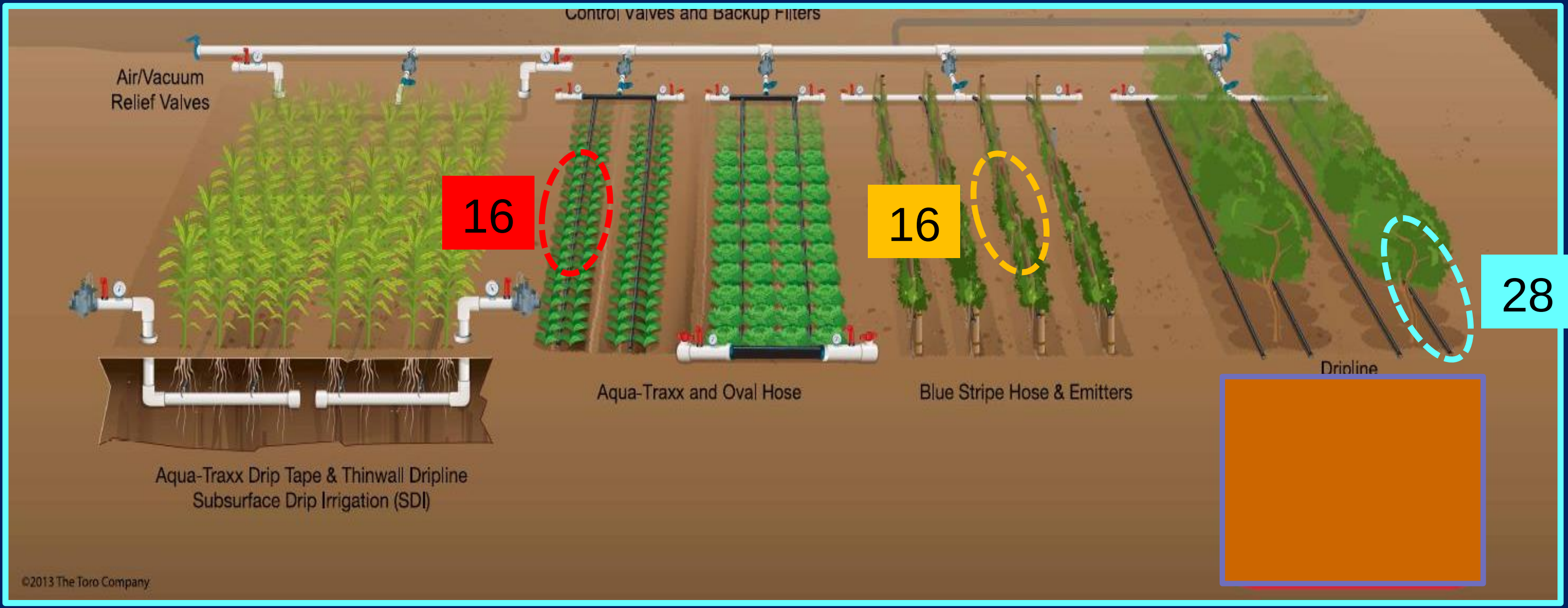
$$\mathrm{DU}_{\mathrm{lq}\Delta P} = \left(\frac{\text{average of the lowest quarter of the estimated flows}}{\text{average of all the estimated flows}}\right)$$

$$q = k\,P^x$$

3. DU related to "other causes" (clogging, wear, manufacturing variations)

Requires measuring emitter flow rates from 3 locations in the field

1. **The middle of a hose hydraulically close to the water source** (16 emitters)
2. **The middle of a hose in the middle of a manifold near the middle of the field** (16 emitters)
3. **The end of a hose at the end of the most distant manifold** (28 emitters)



$$D.U. = \frac{average\ \ flow\ of\ \ lowest\ 25\%\ emitters\ measured}{average\ \ flow\ of\ \ all\ emitters\ measured}$$

Collection time:	0.5	minutes
Hose pressure at emitters:	24.5	psi
	Collected volume:	
#1	258	mL
#2	304	mL
#3	290	mL
#4	320	mL
#5	288	mL
#6	305	mL
#7	312	mL
#8	220	mL
#9	310	mL
#10	320	mL
#11	315	mL
#12	307	mL
#13	305	mL
#14	312	mL
#15	297	mL
#16	304	mL

The average flow rate was	9.0287	gph.
The average application rate was	0.0362	in/hr.
The Flow DU for this location was	91.0248	%

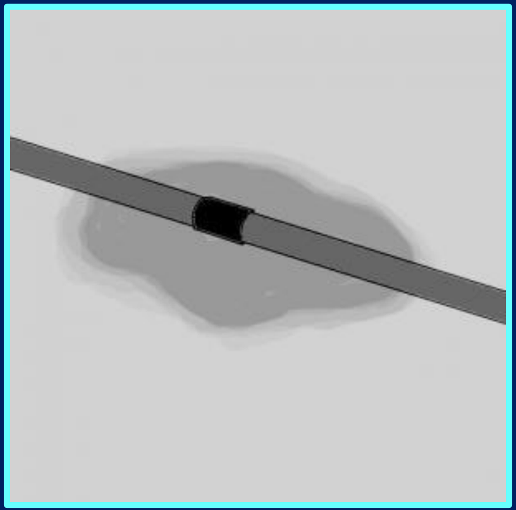
Collection time:	0.5	minutes
Hose pressure at emitters:	19.5	psi
	Collected volume:	
#1	300	mL
#2	305	mL
#3	317	mL
#4	220	mL
#5	285	mL
#6	282	mL
#7	284	mL
#8	283	mL
#9	245	mL
#10	294	mL
#11	180	mL
#12	282	mL
#13	295	mL
#14	300	mL
#15	290	mL
#16	287	mL
#17	284	mL
#18	291	mL
#19	292	mL
#20	295	mL
#21	286	mL
#22	283	mL
#23	263	mL
#24	255	mL
#25	289	mL
#26	294	mL
#27	291	mL
#28	298	mL

The average flow rate was	8.9101	gph.
The average application rate was	0.0357	in/hr.
The Flow DU for this location was	87.7764	%

4. DU related to Unequal Drainage (emitters continue draining after system shut-off => downhill edges of the field, pulsing irrigation on/off)

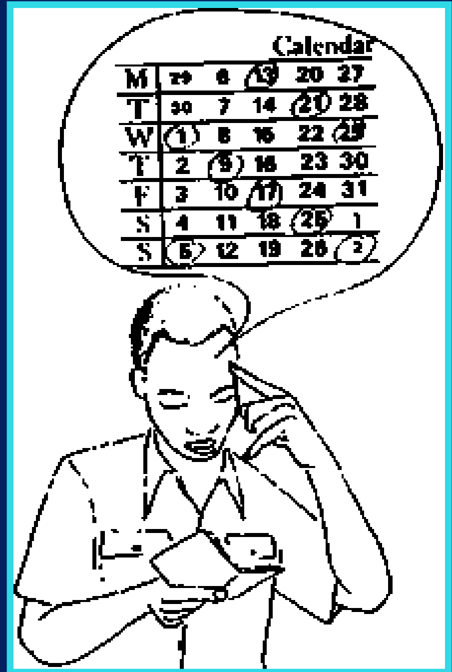
Requires observation of emitters within the field

(how long some emitters continue draining after most emitters stopped)



$$Unequal\ Drainage\ D.U. = \left(\frac{extra\ \min.\ of\ operation\ of\ some\ emitters}{average\ set\ duration\ (\min)} \right) x\ (fraction\ of\ the\ field\ with\ unequal\ drainage)$$

$$\text{system } DU_{lq} = \text{pressure difference } DU_{lq} \times \text{uneven spacing } DU_{lq} \times \text{unequal drainage } DU_{lq} \times \text{“Other” } DU_{lq}$$



Distribution Uniformity.. 85%

How your system rates:

			X	
Poor 74 or below	Fair 75-79	Good 80-84	Very Good 85-89	Excellent 90 and up

ADDITIONAL INFORMATION FROM SYSTEM EVALUATION

DRIP/MICRO EVALUATION: PROBLEMS NOTED

Ref. #

5 The field DU is considered poor

Pressure problems

Manifold inlet pressure variation is a significant problem

Possible causes of manifold inlet pressure variation include:

6 -Lack of pressure regulation;

consider installing manifold pressure regulators

Hose inlet pressure variation is a significant problem

Possible causes of hose inlet pressure variation include:

9 -Defective regulators

10 -Inlet pressure lower than pressure regulator's operating range

12 Some pressures found in the field were very low

Other problems noted

27 Fertilizer injector located downstream of filter

31 High pressure losses at pump station

34 Small wetted soil area

DRIP/MICRO EVALUATION: PROBLEMS NOTED

Ref. #

3 The field DU is considered OK

Pressure problems

Hose inlet pressure variation is a significant problem

Possible causes of hose inlet pressure variation include:

8 -Lack of pressure regulation;

consider installing hose pressure regulators

Other problems noted

27 Fertilizer injector located downstream of filter

30 No flow meter

SOME RECOMMENDATIONS

Have a professional system evaluation at least every 2-3 years
DU tends to decrease over time

Know your system application rate & DU
⇒ Key elements for irrigation efficiency

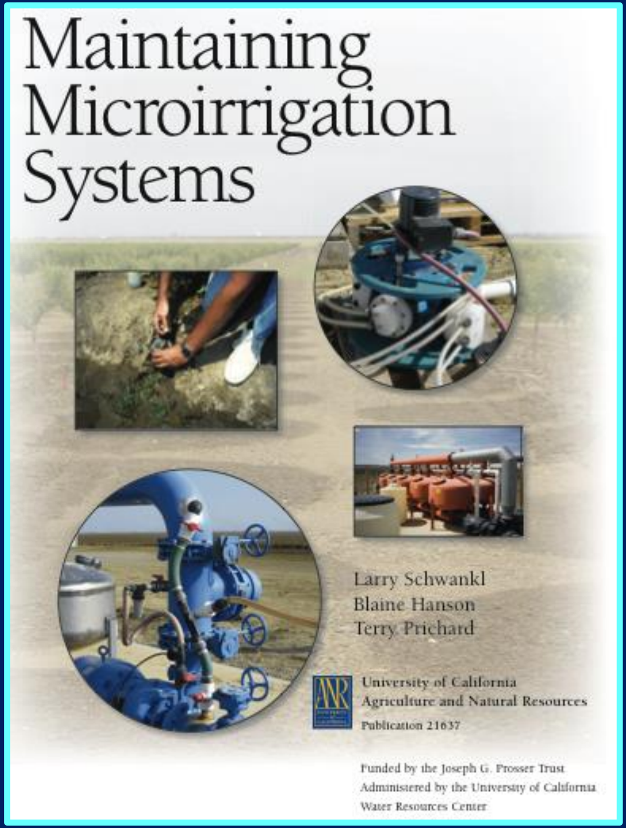
(Time to run the system = water to be applied/application rate)

Monitor the system periodically to spot and correct problems

(Check mainly flowrate and pressure at critical points)

HIGH EFFICIENCY REQUIRES SIGNIFICANT EFFORTS IN ROUTINE MAINTENANCE

- ✓ Checking for leaks (farm equipment & animals)
- ✓ Back-flushing filters (manually or automatically)
- ✓ Periodically flushing main, submain and laterals (in that order)
- ✓ Chlorinating for organic material: continuous (1-2 ppm) or periodic (10-50 ppm)
- ✓ Acidifying (lowering Ph. < 7-5) to avoid/remove precipitates
- ✓ Cleaning or replacing clogged emitters and other components



Publication available at:

http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=21637

CLOGGING IS THE MAIN CAUSE OF POOR SYSTEM D.U.

Main causes of clogging include:

- ✓ Suspended material in the irrigation water
- ✓ Chemical precipitation in emitters
- ✓ Biological growths in emitters
- ✓ Root intrusion
- ✓ Soil ingestion

Types of clogging that can be managed through injection of chemicals

Types of clogging	Action	Remedial
Slimy bacteria	grow inside pipes & emitters	chlorine, ozone, citric acid
Iron & Manganese oxides	bacteria oxidize iron and manganese	chlorine, phosphate, aeration in ponds
Iron & Manganese sulfides	toxic to plants even in small concentrations	aeration, chlorination and acid injection
Calcium & Magnesium Carbonates	clogging emitters	lowering pH to 7, sulphoric and phosphoric acid injection
Plant roots entry into underground emitters	clogging emitter from outside	acid injection, embedded herbicides

An average pipe flow velocity of 1 ft/s can be assumed. Divide this velocity into the longest pipe distance in the system (from pump to farthest emitter) and determine the right time of injection

This is the time to wait after starting the pump and the time to allow for flushing before turning the pump off

Typical recommended chlorine dosages for different organic growth and precipitation problems

For algae:

Use 0.5 to 1.0 ppm continuously or 20 ppm for 20 min at the end of each irrigation cycle

For hydrogen sulfide

Use chlorine at 3.5 to 8.5 times the hydrogen sulfide content

For iron bacteria

Use 1.0 ppm of chlorine over the number of ppm of iron content

For iron precipitation

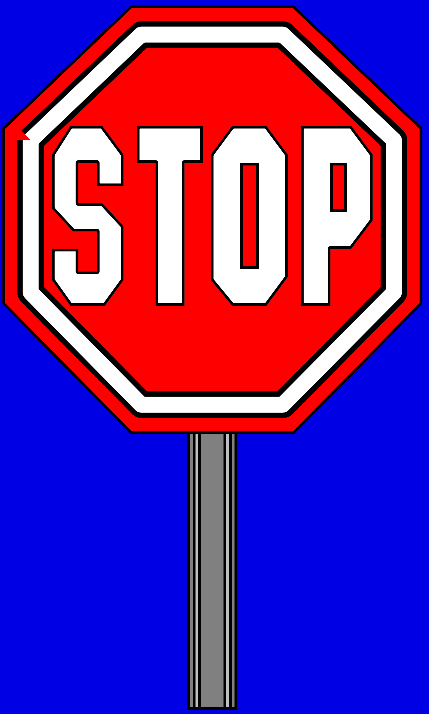
Use 0.65 times the Fe^{2+} content to maintain 1.0 ppm free residual chloride at the end of laterals

For manganese precipitation

Use chlorine at 1.3 times the Mn content

For slimes

Maintain 1.0 ppm free chlorine residual at the end of laterals



THANK YOU !!

QUESTIONS OR COMMENTS?